AN OPERATING MANUAL

The Vision Laboratory
Volen Center for Complex Systems
Brandeis University, Waltham MA

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Contents

1 Purpose of this document.

This document is meant to ease newcomers' integration into the operation of the Vision Laboratory at Brandeis University's Volen Center. The document presents a lot of information, but there may be only one truly essential thing for new lab members to know: "If you are uncertain, ask." A corollary? "If you're working on a document and are not sure how it's progressing, ask someone to look it over." In other words, don't hesitate to take advantage of other lab members' knowledge; if there is something you don't know, or are not sure about, and have made a good faith effort to work out on your own, it makes good sense to ask. And as you identify things that you think should be added to this document, please share them.

1.1 Writing a manual is futile, but reading one is not.

Any written document, including this Operating Manual, can do only so much to present new information. As Plato put it in *Phaedrus* (275d-e),

> Then anyone who leaves behind him a written manual, and likewise anyone who takes it over from him, on the supposition that such writing will provide something reliable and permanent, must be exceedingly simple-minded; he must really be ignorant.... if he imagines that written words can do anything more than remind one who knows that which the writing is concerned with.

Plato's cynicism about written documents such as manuals may be justified, or not. The writer of this manual may be, as Plato might put it, "exceedingly simple-minded." But there is no denying that this Operating Manual can achieve its purpose only if it is read, re-read, and kept near for ready reference. Word up!

2 Research projects.

Current projects include research into

- Sensory memory. How we remember, forget, mis-remember, or distort what we see or hear
- Imitation. How we can observe and then imitate the actions and gestures of others
- Perception of visual motion. Particularly multimodal and cognitive influences on visual motion
- EEG/ERP studies. Characterizing the neural circuits that participate in cognitive control of visual memory
- Vision and visual memory in aging

3 Funding sources

The lab's operation is supported by three grants, one from the National Institutes of Health (NIMH), and two from the National Science Foundation (NSF). One NSF grant is part of

the Foundation's support for the Center for Excellence in Learning, Education, Science and Technology (CELEST), the other NSF grant is part of the Foundation's special initiative on human spatial dynamics. Lab members should be mindful of the strong, generous support the lab receives from funding agencies. All manuscripts, posters, conference presentations, and technical reports from the lab should acknowledge the relevant source of support, as well as sources of support for any external collaborators on the project.

The NIH grant's title is "Short Term Visual Episodic Recognition Memory;" the NSF grants' titles are "Modeling and analyzing individual and collective human spatial behavior" and "Imitation and Human Skill Learning."

4 Research

In addition to collaborative research with other life science faculty at Brandeis, several projects in the lab are being carried out in cooperation with researchers at other institutions. These researchers include: Hugh Wilson (York University, Toronto), Allison Sekuler and Pat Bennett (McMaster University, Hamilton, Ontario), Dan Bullock (Boston University), Barbara Shinn-Cunningham (Boston University) Marc Pomplun (University of Massachusetts, Boston), Sohee Park (Vanderbilt University), Ennio Mingolla (Boston University) and Michael J. Kahana (University of Pennsylvania). These people are not only colleagues, they are also valuable intellectual resources for the laboratory; as a courtesy, all initial contacts with lab collaborators should be cleared with the lab director.

5 Current/recent publications

Current versions of lab publications, including papers that are under review, can be downloaded from the Publications link on the lab director's website: http://www.brandeis.edu/~sekuler

6 Communication

Most of the lab's work is collaborative, so easy, free communication among lab members is crucial. In addition to the obvious face-to-face discussions, casual chats and debates, and e-mail, we use several other means to foster communication.

6.1 Scheduling

At http://homepage.mac.com/sekulerlab you will find the lab's official calendar, which is used to reserve testing rooms A, B (in the main lab), C and D (in room 216), the EEG testing facility (in room 251) and the Imitation Laboratory in room 214. The testing rooms in Volen 216 have decent sound resistance, which is important for many of our experiments. On the calendar, you will also see announcements of upcoming events, including colloquia of special

interest, and topics for our weekly s. For instructions on modifying the calendar –adding items or reserving time in a testing room– see Jie Huang.

6.2 Mailing list

For broadcast communication to all its members, the lab uses the *VisionLab* mailing list (visionlab@lists.brandeis.edu). Jie Huang adminsters the list.

6.3 Lab meetings

Lab personnel meet as a group once each week, either to discuss some new, interesting publication, and/or to discuss a project ongoing in the lab. Attendance and active participation are mandatory. Lab meetings are held on Thursdays, and start at 2 pm. The official lab calendar has current information on meetings, topics, papers, and presenters.

7 Bi-weekly progress reports.

Every two weeks, each member of the lab prepares a brief report of the progress that has been made (or not made) on his or her project. These reports, which are submitted as a pdf via e-mail to the Lab Director on the second and fourth Fridays of each month, are meant to promote good planning, organization and productivity in all the lab's activities. The reports are to be prepared in LaTeX (see Section 13.3), using the template that has been devised for this purpose. The template can be downloaded from http://www.brandeis.edu/~sekuler/progressReportTemplate.tex. Lab members are advised to edit and then aggregate their progress reports into a basis for longer documents, such as manuscripts.

8 Experimental subjects.

The lab draws most of its subjects from three sources. Subjects drawn from special populations are not described here.

8.1 Intro Psych pool

For pilot studies that require >10 subjects, each for a short time, we can use subjects from the Intro Psych pool. They are not paid, receiving course credit instead. Because availability of such subjects is limited, if you anticipate drawing on the pool, this must be arranged at the start of a semester, through Brian Gold, who will arrange the hours needed. Note that usually we do not use the Psych 1A pool for EEG, motion capture, or any other studies requiring more than an hour.

8.2 Lab members and friends

For pilot studies requiring a few subjects, it is easiest to entice volunteers from the lab or from the graduate programs. Reciprocity is expected. There's a downside to taking this

easy path to subject recruitment: For some studies, subjects who are well versed in what you're trying to do may not yield data that can be trusted.

8.3 Paid subjects

For studies that require many hours per subject, we prefer to recruit paid subjects. Payment is usually $9-10 per hour, occasionally with a performance-based bonus designed to promote good cooperation and effort. Subjects in EEG experiments are paid a higher rate, typically $12 per hour. Paid subjects are recruited in various ways, notably by means of posted notices in the "Help Wanted" section of *my*Brandeis' Classified Categories. If you post a notice on *myBrandeis*, be aware that the text will be visible to anyone on the internet anywhere, not just Brandeis students.

8.3.1 Groundrules for paid subjects

Subjects are not to be paid if they do not complete all sessions that were agreed to in advance. Subjects should be informed in advance that missed appointments or lateness will be grounds for termination. This is an important policy: experience teaches that subjects who are late or miss appointments in an experiment's beginning stages, will continue to do so. Subjects who show up, but are extremely tired or whine are unlikely to give their "all" during testing, which wastes money and, worse, noises up your data.

8.3.2 Verify compliance and understanding.

It is a good idea to verify a subject's understanding and full compliance with instructions as early in an experiment as possible. Some lab members find it useful to monitor and verify subject compliance online, via a webcam. Whatever means you adopt, do not wait until several sessions have passed, only to discover from a subject's miraculously short response times and/or chance level performance, that the subject was, to put it kindly, taking the experiment far less seriously than you'd like.

8.3.3 Get it in writing.

All arrangements you make with paid subjects must be communicated in writing, and subjects must sign off on their understanding and agreement. This is important in order to avoid misunderstandings, e.g., what happens when a must be terminated.

8.3.4 Paying subjects.

Jie Huang manages all funds for paying subjects. If you are testing paid subjects, you must maintain a list of all subjects, their dates of service, the amount paid, their social security numbers, and signatures. All for human subjects must be reconciled on a timely basis, that is, we must provide Winnie Huie (grants manager in Psychology office) with documentation on the disbursement of the advance. Jie Huang can advise you on recruiting and scheduling subjects.

8.3.5 Human subjects certification.

Do **not** test any human subject until you are certified to do so. Certification is obtained by taking an internet-based course/exam, which takes about 90 minutes to complete: http://cme.nci.nih.gov/. Certification that you have taken the exam will be sent automatically to Brandeis' Office of Sponsored Programs, where it will be kept on file. Print two copies of your certification; give one to Brian Gold, and retain the other for your own records.

8.3.6 Mandatory record keeping

The United States government requires that we report the gender and ethnic characteristics of all subjects whom we test. The least burdensome way to collect the necessary data is by including two questions at the end of each consent form. Then, at the end of each calendar quarter (March 31, June 30, September 30 and December 31), each lab member who's tested any subjects during that quarter should give his or her consent forms to Jie Huang, who will collate the information for reporting purposes.

8.4 Copying and lab supplies.

For lab-related copying that must be done in one of the university libraries, borrow the lab's copy card from Jie Huang. Requests for supplies such as pens, notebooks, dry markers for white boards, file folders, etc. should be directed to Jie. Everyone is responsible for insuring that shared equipment is in good order. If you see that the lab printer is running low on toner, please put a new cartridge in; ask for help if you're not certain how to do this.

8.5 Laboratory notebooks.

It is important to keep full, accurate, contemporaneous records of experimental details, plans, ideas, background reading, analyses and research-related discussions. Computer records can be used, of course, for some of these functions, but members of the lab are encouraged to maintain s. The lab has a supply of permanently bound books suitable for this purpose. Additional lab books can be obtained from the Kalman Science stockroom. When you begin a new lab notebook, be sure to reserve the first page or two for use as a table of contents. Be sure to date each entry, and, of course, keep the book in a safe place.

9 Equipment.

9.1 EyeTracker.

The lab owns an EyeLink II, head-mounted, video-based eye tracker, with scene camera. See http://www.eyelinkinfo.com. It is located in Testing Room B, and can run experiments with displays generated either on a Windows computer or on a Mac. For Mac-based experiments, most people in the lab use Frans Cornelissen's EyeLink toolbox for Matlab http://cornelis.med.rug.nl/pub/EyelinkToolbox/ The EyeLink toolbox was described in a paper published in 2002 in *Behavior Research, Methods, Instrumentation & Computers*. A .pdf of this paper is

available for download from the EyeLink home page (above). The EyeLink Toolbox makes it possible to measure eye movements and fixations, while also presenting and manipulating stimuli via display routines implemented in the . The EyeLink Toolbox's output is an ASCII file. Although such files are easily read into Matlab for analysis, they can be quite large.

9.1.1 Eliminating blink artifacts

If you want to analyze EyeLink output in Matlab, as we often do, rather than using EyeLink's limited, built-in functions, you must deal with format issues. Matlab cannot read files in EyeLink's native output format (.edf), but can read them after they've been transformed to ASCII, which is an option with the EyeLink. Preprocessing of ASCII files should include identification and elimination of peri-blink artifacts, during the brief period when the EyeLink has lost the subject's pupil. Brian Gold wrote a Perl script for this purpose; his code is wicked fast, operating on an entire 30Mb file in about 5 seconds on a 1.5 MHz CPU. Brian's script is available on one of the lab servers. For a quick online tutorial on Perl, which stands for "Practical Extraction and Report Language", go to http://archive.ncsa.uiuc.edu/General/Training/PerlIntro/.

9.2 Electroencephalography.

For EEG/ERP (event-related potential) studies the lab uses powerful EEG system: an EGI dense geodesic array System 250, which uses high impedance electrodes. (EGI, by the way, is Electrical Geodesics, Inc.) With this Macintosh-based system, the time required to set up a subject, and to confirm the impedances for the 128 electrodes, is ∼10-12 minutes. The lab also owns a license for BESA (Brain Electrical Source Analysis), a powerful software system for analyzing EEG/ERP data. In addition, the lab owns two excellent books that introduce readers to the fine art of recording, analyzing, and making sense of ERPs.: Todd Handy's edited volume Event Related Potentials: A Methods Handbook (MIT Press, 2005), and Steve Luck's An Introduction to the Event-Related Potential Technique (MIT Press, 2005).

9.3 Motion Capture and Virtual Reality.

For work on human imitation, the lab uses two systems that capture, stores, and quantifies the hand and arm gestures made by human subjects. In its main research application, the more advanced of these systems presents a gesture visually, on a flat display or in virtual reality with a heads up display, and then quantifies the accuracy with which the gesture is imitated. Gestures used in our experiments are demonstrated either by realistic, animated human characters, or by real human subjects themselves.

9.4 Photometers and Matters Photometric

The lab owns a Minolta LS-100 , which is used to calibrate and linearize stimulus displays. For use, the photometer is typically mounted on the lab's large aluminum tripod for stability. After finishing with the instrument, the photometer **must** be turned off and returned to its

case, with its lens cap replaced. This is essential for the protection of the photometer, and so that its battery will not run down, making the photometer unusable by the next person who needs it. Luminance measurements should always be reported in candelas/m^2. A second, more compact device is available for calibrating displays, an Eye-One Display 2 from Greatagmacbeth. Section 9.4.1 describes one important application of the Eye-One Display.

9.4.1 Display Linearity.

A cathode ray tube display's luminance depends upon the analog signal the CRT receives from the computer; that signal, in turn, depends upon a numerical value in the computer's digital to analog converter (DAC). Display luminance is a highly non-linear function of the DAC value. As a result, if a series of values passed to the DAC are sinusoidal, for example, the screen luminance will *not* vary sinusoidally. To fix this problem, a user must linearize the display by creating a table whose values compensate for the display's inherent non-linearity. This table, called a lookup table (LUT), can be generated in OS9 and Matlab 5.x, using the lab's Minolta 1000 photometer, together with a Matlab® routine called "calibration." That routine is found in JMGtoolbox. In OSX and Matlab 7.x, calibration requires the lab's GretaMacbeth *Eye-One Display 2* colorimeter, which can profile the luminance output of CRT, LCD, and laptop displays. The steps needed to produce an OSX LUT with this colorimeter are outlined in a document prepared by Kristina Visscher. For details on and lookup tables, see R Carpenter & JG Robson's book *Vision Research: A Practical Guide to Laboratory Methods*, a copy of which is kept in the lab. A brief introduction to display technology, lookup tables, display specification can be found in DH Brainard, DG Pelli, and T Robson (2002) Display characterization. In the *Encylopedia of Imaging Science and Technology*. J. Hornak (ed.), Wiley. 172-188. This chapter can be freely downloaded from http://www.psych.nyu.edu/pelli/pubs/brainard2002display.pdf.

9.4.2 Photometry vs. Radiometry.

What is the quantity that the lab's Minolta photometer measures, and why does it matter? To understand, we must start with *radiometry*, the determination of the power of electromagnetic radiation over a wide range of wavelengths, from gamma rays (wavelength $\approx 10^{-6}$ nm) to radio waves (wavelength $\approx$1 kM). Typical units used in radiometry include watts. The human eye is insensitive to most of this range (typically, sensitivity of human eye spans only 400-700 nm), so most of the watts in the electromagnetic spectrum can have no *visual* effect. Photometry, then, is a system that evaluates or weights a radiometric quantity by taking into account the eye's sensitivity. Two light sources, then, can have the same *photometric* value –and will have same effect on the eye– despite differing in *radiometric* quantity.

9.5 Computers.

Most of the laboratory's two-dozen computers are Apple Macintoshes of one kind or another. We also own five or six Dell computers, one of which is the host machine for our Eyelink II Eye-Tracker; another of which is sometimes used to display stimuli for use with the

Eye-Tracker (See Section 9.1); the remaining Dells are used in our electroencephalographic research (See Section 9.2) and in some of our imitation/virtual reality research.

9.5.1 Lab Computers

As most of the lab computers have LCD (liquid crystal display) rather than CRT displays, they may be unsuitable for luminance/contrast crucial applications. LCD displays have a strong angular dependence: even small changes in viewing angle alter the retinal illuminance; additionally, LCDs have sluggish luminance response, and require long warmup time before reaching luminance stability.

9.5.2 Laptops.

The lab owns a herd of Macintosh laptops, iBooks, PowerBooks, MacBooks and MacBook Pros. These are assigned to lab members with particular long-term need for such machines.

9.5.3 Scheduling lab computers.

When you need regular access to a particular computer, such as for running subjects, please use the lab's web calendar to reserve the testing room you need. For instructions on how to do this, see section 6.1.

9.5.4 Backup. Backup. Backup. Backup. Backup.

Backing up data and programs is a very good idea, and should be done regularly –obsessively, even. If you have even the slightest doubt about the wisdom of backing up, talk to someone who has suffered a catastrophic loss of data or programs that were not backed up. And such victims are very easy to find. Lab members have several different ways to backup, including backups to CD. In addition, a bank of hard drives in the lab is dedicated to this purpose. To access the most heavily-used of these servers, either from on or off campus, use Mac OSX's "connect to server menu" (under the Finder's *Go* tab), and enter afp://fzhou.ccs.brandeis.edu/visionlab2. If you're using a PC to access the server, make sure that a Windows-based SSH client is installed (both SSH and WinSCP are used in the lab). Log in to "fzhou.ccs.brandeis.edu" with the appropriate username and password as usual. For SSH's Secure File Transfer Client, in the textbox atop the "remote" directory side of the screen, type "/volumes/visionlab2/" and hit enter. For WinSCP, navigate up to the remote root directory, and then down to "volumes" and then "visionlab2".
One backup volume/folder is *visionlab2*, another is *VisionLab4*. Authorized users can get username and password information from Jie Huang

9.6 Contrast sensitivity charts.

To screen and characterize subjects for experiments, we use either the Pelli-Robson or the newer, Lighthouse charts, which are more convenient and possibly more reliable than the Pelli-Robson charts.

10 Important laboratory software.

The lab's experiments, modeling, data analysis, and manuscript preparation exploit several different categories of software.

10.1 MATLAB.

Most of the lab's studies make use of MATLAB, often in concert with the PsychToolbox. The PsychToolbox's hundreds of functions afford excellent low-level control over displays, gray scale, stimulus timing, chromatic properties, and the like. The current version of the PsychToolbox is 3.08; its Wiki site explains the advantages of the PsychToolbox, and gives a short tutorial introduction.

10.1.1 MATLAB reference books.

Outside of the several web-based tutorials, the single best introduction to MATLAB, hands down, is David Rosenbaum's *MATLAB for Behavioral Scientists* (2007, Lawrence Erlbaum Publishers). Rosenbaum is a leader in cognitive psychology, an expert in motor control, so the examples he gives are super useful and salient for lab members. Rosenbaum's book is a fine way to learn how to use MATLAB in order to control sound and image stimuli for experiments. A close second on the list of useful MATLAB books is *Matlab for Neuroscientists: An Introduction to Scientific Computing in Matlab* (Academic Press, 2008) by Pascal Wallisch, Michael Lusignan, Marc Benayoun, Tanya I. Baker, Adam Seth Dickey, and Nicho Hatsopoulos. This book is especially useful as for learning how MATLAB can be used for data collection and analysis of neurophysiological signals, including signals from EEG. In the realm of more plain-vanilla, but good introductions, the lab owns several copies of *Mastering Matlab*, by Duane Hanselman & Bruce Littlefield.

10.1.2 Debugging MATLAB.

A good deal of program development time and effort is spent debugging and fine-tuning code. Matlab has a number of built-in tools that are meant to expedite eradicating all three major types of bugs, typographic errors (typos), syntax errors, and algorithmic errors; for a brief, but useful introduction to these tools, go to the Matlab debugging introduction page on the web.

10.1.3 MATLAB-PsychToolbox introductions.

Keith Schneider (University of Missouri) has written an terrific, short, five-part introduction to generating vision experiments using MATLAB and the Psychtoolbox. Schneider's introduction is appropriate for people with no experience programming, or no experience with computer graphics or animation. Schneider's document can be downloaded from his website: http://web.missouri.edu/~schneiderkei/ptb.htm. Mario Kleiner (Tuebingen University) has produced a very worthwhile tutorial on the current version of Psychtoolbox: http://www.kyb.tuebingen.mpg.de/bu/people/kleinerm/ptbosx/ptbdocu-1.0.5MK4R1.html.

10.1.4 MATLAB 7

MATLAB 7 runs natively on Macintosh computers under Tiger (OS 10.4.x) and Leopard (OS 10.5.x). This version of MATLAB affords many advantages over its predecessors, including greater ease of making graphical user interfaces, and increased control over graphing functions. For a good, painless way to see what these recent versions of MATLAB can do, run the demonstrations included in any standard MATLAB installation.

10.2 Vision Lab coding norms

Because much of our work is collaborative, it is very important to make sure that coding, as in *MATLAB*, is done in a way to facilitates collaboration. In that spirit, Brian Gold, a lab alumnus, put together a set of norms that should be followed when coding. The aim is to facilitate debugging, and to aid understanding of previously-generated code. Here are the highlights; a more detailed description is available on the web, at http://brandeis.edu/~sekuler/codingCommandments.html.

- Thou shalt give meaningful, descriptive names to program- and analysis-files.
- In Matlab code, thou shalt use the SmartIndent feature.
- In Matlab code, thou shalt begin each program with a descriptive set of comments.
- In Matlab, thou shalt use the change log.
- Thou shalt comment thy code with generosity of spirit.
- Thou shalt make liberal use of white space to make code easier to read/follow/decipher.
- If thy code uses regular expressions or is written in PERL, thou shall comment thy code immediately.
- If thou should encounter a problem related to the PsychToolbox, thou shalt make sure thy version of PsychToolbox is up-to-date.
- Before asking others for help with code, make sure that you have followed all the preceding commandments.

10.3 Skim: PDF reading, filing and annotating

Currently at version 1.3.1, *Skim* is brilliant Mac-only software that can be used for reading, annotating, searching and organizing PDFs. *Skim* works and plays well with *BibDesk*, which is a big plus. You can search, scan, and zoom through PDFs, but you also get many custom features for your workflow, including:

- Adding and editing notes
- Highlighting important text
- Making "snapshots" for reference
- Reading in full screen
- Giving presentations

10.4 Inspect your data; inspect your data; inspect your data

Some data analysis software actually makes data analysis too easy. You enter in your data, and out pops nicely-formatted tables of numerical summaries. The temptation is to base your interpretation of your data on these summaries, without ever actually taking the time to inspect the data. The result can be disastrous –those numerical summaries can be extremely misleading. To appreciate this point, consider the three sets of data that are plotted in Figure 1. (These data were taken from 1973 paper by F. J. Anscombe in *American Statistician*). If your software computed a simple linear regression for each of the data sets, for all three the software would give you identical numerical summary values (regression equation, r^2). In each case, the best-fit regression equation is y=3 + 0.5X, and $r^2 = 0.82$. But if you looked at the plots you would realize that equal r^2 values or not, there are substantial differences among what the different data sets say about the relationship between **X** and **Y**. Incidentally, Anscombe's paper presented not three, but four data sets, which Wikipedia refers to as Anscombe's quartet. As John Fox[1] put it, "Statistical graphs are central to effective data analysis, both in the early stages of an investigation and in statistical modeling."

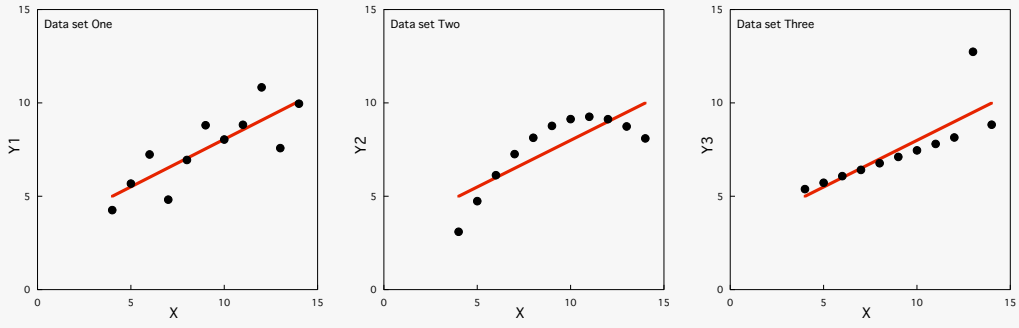

Figure 1: Plots of three data sets generated by Anscombe

10.5 Graphing software.

OK, so graphs are important, very important. But how best to make the ones you need? Graphs can be generated in Kaleidagraph (KG) or in PLOT, either of which can produce very good looking publication-quality graphs of many different types, including "box and whisker" plots. The current version of KG, 4.03, can export graphs in a variety of file formats. For publication or presentation purposes, save a KG graph as a .pict file, which can be imported into Canvas or other drawing program for final tweaking. In a drawing program, the KG graph's elements can be ungrouped and edited as needed. Note also that KG can do basic curve fitting, and simple statistics, including t-tests, basic non-parametric tests, and least squares regression. Most of KG's features are fairly intuitive, but a few (error bars and box plots) are less so. The lab has hardcopy KG manuals, including one that gives a brief introduction to KG. If you've unfamiliar with KG, this introduction can be an good way to learn what the program can do for you. Tip: Novice users tend to overlook one powerful feature of KG, its formula entry capability, which makes it easy to generate, plot

[1] *Applied Regression Analysis, Linear Models, and Related Methods*, Sage Publications, 1997)

and analyze derived stats, such as values that represent the difference between two variables, or stats much more complicated than that. Incidentally, no matter how you choose to graph your data, when preparing graphs, be careful *never* to commit either of the following two venial sins[2]

10.5.1 Venial Sin 1: Scale/size of y-axis.

It is difficult to compare graphs whose y-axes cover different ranges or cover different sizes. In fact, such graphs, which are the default output of many programs, can be downright misleading.

10.5.2 Venial Sin 2: Metric continuum.

If the x-axis does not actually represent a proper metric dimension, it is not appropriate to incorporate that dimension into a line graph; a bar graph or box plots are the preferred alternatives. Note that ordinal values, such as "first", "second", and "third", or "high", "medium", and "low", do *not* comprise a proper metric dimension.

10.5.3 Matlab graphs

Matlab makes it easy, very easy, to plot your data. So easy, that's easy to overlook the fact that the results often look sub-standard. The following two paragraphs may help to enhance the appearance of Matlab-produced graphs.

Making decent-looking ones On OS X, *Matlab* uses X11 windows to display plots. These plots often have jagged lines, and are rendered far less smoothly than in a .pdf exported version of the same plot. In fact, these *Matlab* plots look, sorry to say, downright crummy. The following snippet of Matlab code shows how to get *Matlab* to convert a figure to .pdf, and then display it in *TeXShop* (See Section 13.3.4), which auto-refreshes the .pdf (unlike *Preview*). This creates far better looking graphs, with smoother lines, etc., than one ordinarily gets from *Matlab*:

```
figure(1);
set(gcf, 'Visible', 'off');
plot(x, y);
print(gcf, '-dpdf', 'figure1.pdf');
system('open -a Texshop figure1.pdf');
```

Making more-effective ones Matlab affords control over every feature of a graph –color, linewidth, text size, and so on. There are two ways to take advantage of this potential. One is to make the changes from the plain-vanilla unattractive, standard, default format via

[2]As Wikipedia explains, a venial sin entails a partial loss of grace and requires some penance; this class of sin is distinct from a mortal sin, which entails eternal damnation in Hell –not good.

interactive manipulation of the features you want to change. For an explanation of how to do this, check Matlab's help. Another way is to hard-code the features you want, either in your calling program or with a function called after the initial, plain plot has been generated. This latter approach is especially good when you've got to generate several graphs and you want to impose a common, attractive format on all of them. Figure 2 shows examples of a plain vanilla plot from a Matlab simulation and a slightly embellished plot of the same simulation. Just a few lines of code can make a substantial difference in a graph's appearance and its effectiveness. For some simple, customizable code that will embellish a plain-vanilla Matlab plot, check this webpage.

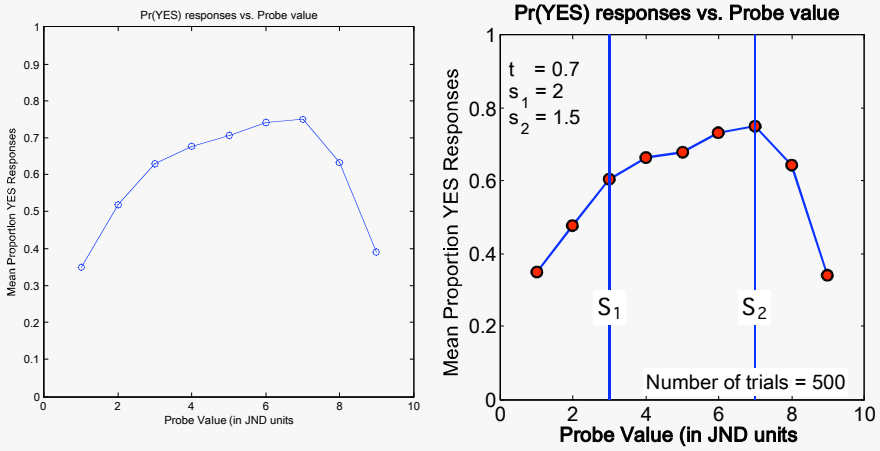

Figure 2: Graphs produced by a Matlab simulation of a recognition memory model. Left: A "plain vanilla" plot generated using default plot parameters; Right: A slightly-embellished plot generated by adding just a few lines of code to the plotting program. Of particular value are labels that specify the model's parameter values used by the simulation.

10.6 Software for drawing/image editing.

The lab's standard drawing/illustration program is *Canvas X*, a powerful and flexible piece of software. This program is definitely worth learning to use. *Canvas X* can save output in many different formats, including .tiff, which is useful for import into PowerPoint for presentations. (.tiff stands for "Tagged Image File Format".) A powerful, freely downloadable, opensource alternative is *GIMP*, which is described in the next section.

10.6.1 Graphics editing.

Simple editing, reformatting, and resizing of graphics are conveniently done in *Graphic Converter*, a wonderful shareware program developed by Thorsten Lemke. This relatively small, but powerful program is easy to use. If you need to crop excess white space from around a figure, *Graphic Converter* is one vehicle; Adobe Acrobat, not Acrobat Reader, is another; *Preview* is a third. Cropping comes in handy when for trimming .pdf figures that are to be inserted into LaTeX documents (see section 13.3). Unless the .pdf figure is not cropped, there is a good chance that too much white space will surround the resulting figure. *GIMP*, an acronym for "GNU Image Manipulation Program", is a powerful, freely downloadable, open

source program for tasks including photo retouching, image composition, edge detection, image measurement, and image authoring. The OSX version of this omni-platform program comes with a set of "plug-in"s that are nothing short of amazing. To learn if GIMP might serve your needs, look over the many beautifully illustrated step by step tutorials.

10.6.2 Fonts.

When generating graphs for publication or presentation, use standard, sans serif fonts, such as Geneva and Helvetica. Text in some other fonts may be "messed up" when graphics are transformed into .pdf or .tiff.

10.6.3 ftp'ing.

FTP stands for "file transfer protocol." As the term suggests, ftp'ing involves transferring files from one computer to another. For Macs, FETCH is the lab's standard client for *secure* file transfer protocol (sftp), which is the only file transfer protocol allowed for accessing Brandeis' servers. The current version of FETCH is 5.3.

10.7 Statistics: Matlab, SPSS and R.

Matlab's Statistics Toolbox supports many different statistical analyses, including multi-dimensional scaling (in Matlab 7 and up). Standard Matlab installations do not provide routines for doing some of the statistics that are important in the lab, e.g., repeated-measures ANOVAs. However, good routines for one-way, two-way, three-way repeated measure ANOVAs are available from the Mathworks' fileExchange. To find the appropriate Matlab routine, do a search for ANOVA on http://www.mathworks.com/matlabcentral/fileexchange/loadCategory.do?objectType=category&objectId=6. For common statistics, such as ANOVA, regression, and multidimensional scaling, the lab members can avail themselves of Brandeis' site-wide license for SPSS. If you use SPSS, be warned that the graphs it produces are likely to be well-below lab standards.

Adventuresome members of the lab should learn to use **R**, a powerful, flexible statistics/graphical environment. **R** is freely downloadable from the web, and is very easy to install on Macintosh computers running OS X, or on any other platform for that matter. **R** is tested and maintained by some of the world's leading statisticians, which means that you can rely on **R**'s output to be correct. The current version of **R** is 2.90. Among **R**'s many virtues are its really good data visualization techniques, including sophisticated graphs that are perfect for inspecting and visualizing your data (see section 10.4. **R** also boasts superb routines for bootstrapping and permutation statistics (see section 10.7.1. **R** can be downloaded from http://www.r-project.org/, where you can also download manuals. Jonathan Baron (University of Pennsylvania) has prepared a brief introduction to **R**, which includes detailed, explanations of how to do ANOVAs and other analyses with data from within-subject designs. *Using R for psychological research: A simple guide to an elegant package* is just what its title claims: An excellent introduction to **R**. This guide, created by Bill Revelle (Northwestern University), was recently updated and expanded. Revelle's guide contains many

useful **R** templates for some of the lab's common data analysis tasks, including repeated measures ANOVA, and pretty nice box and whisker plots.

10.7.1 Normality and other convenient myths

In a 1989 Psychological Bulletin article provocatively titled, "The unicorn, the normal curve, and other improbable creatures," Theodore Micceri reported his examination of 440 large-sample data sets from the fields of education and psychology. Micceri concluded that "No distributions among thoseinvestigated passed all tests of normality, and very few seem to be even reasonably close approximations to the Gaussian." Before dismissing this discovery, remember that standard parametric statistics –such as the F and t tests– are called "parametric" because they are based on particular assumptions about the population from which the sampled data have been drawn. These assumptions usually include the assumption of normality. Gail Fahoome, an editor of the (online) *Journal of Modern Statistics Methods*, quoted one statistician as saying, "Indeed, in some quarters the normal distribution seems to have been regarded as embodying metaphysical and awe inspiring properties suggestive of Divine Intervention."

Bootstrapping, Permutation Tests and Robust statistics When data are not normally distributed (which is almost all the time for samples of reasonable size) or when sets of data do have not have equal variance, the application of standard methods (ANOVA, t-test, etc.) can produce seriously wrong results. For a thorough, but depressing description of the problem, consult the lab's copy of Rand Wilcox's little book *Fundamentals of Modern Statistical Methods: Substantially Improving Power and Accuracy* (2002). Wilcox also describes one way of addressing the problem, robust statistics. These include the use of sophisticated, so-called M-statistics or even garden variety medians as measures of central tendency, rather than means. Other approaches commonly used in the lab are various *resampling methods* such as bootstrapping and permutation tests. Simple introductions to these methods can be found at http://bcs.whfreeman.com/pbs/cat_160/PBS18.pdf, and in a web-book by Julian Simon. Note that these two sources are *introductory*, with all the limitations implied by that adjective.

10.7.2 Error bars & confidence intervals.

Graphs of results are difficult or impossible to interpret without error bars. Usually, we prefer to have each data point surrounded by ± 1 standard error of the mean (SeM), that is, $\mathrm{SD}/\sqrt{n}$, where n is the number of subjects. Off the shelf software produces incorrect values of SD, and therefore of SeM. Basically, such software conflates between-subject and within-subject variance –we want only within-subject variance, with between-subject variance factored out. Explanations of how to compute and use such estimates can be found in a paper by Denis Cousineau, and in publications by Geoff Loftus.

11 Experimental design.

Without good, smart, efficient experimental design, an experiment is pretty much worthless. The subject of good design is way too large to accommodate here –it requires books (and courses), but it is vital that you think long and hard about experimental design well before starting to collect data. The most common fatal errors involve confounds –where two independent variables co-vary, so that one cannot partition resulting effects cleanly between those variables. The second most common error is to implement a design that is bloated, loaded down with conditions and manipulations are not required to address the hypothesis of interest. There is much more to say about this crucial issue; nearly every lab meetings touches on issues related to experimental design –how some design's efficiency and power could be improved.

12 Literature sources.

12.1 Electronic databases.

Two online databases are particularly useful for most of our lab's research: PubMed and PsycINFO. These are described in the following sections.

12.1.1 PubMed

PubMed http://www.ncbi.nlm.nih.gov/entrez/query.fcgi. PubMed is freely accessible portal to the Medline database. It can be accessed via web browser from just about anywhere there's a connection to the internets[3], off-campus, on-campus, at a beach, on a mountaintop, etc. It can also be searched from within BibDesk, as explained in Section 13.6. HubMed is an alternative, browser-accessible gateway to the same Medline database; HubMed offers some useful novel features not available in PubMed. These include a graphic, tree-like display of conceptual relationships among references, and easy export in .bib format, which is used with LaTeX (see Section 13.3). To reveal a conceptual tree in HubMed, select the reference for which you want to see related articles, and click "TouchGraph." This invokes a Java applet. Once the reference you selected appears on the screen, double click it to expand that item into a conceptual network. You will be rewarded by seeing conceptual relationships that you had not thought of before. For illustrations of this process in action, go to http://www.brandeis.edu/~sekuler/hubMedOutput.html.

12.1.2 PsycINFO.

Another online database of interest is PsycINFO, which can be accessed from the Brandeis Library homepage –under Find articles & databases. PsycINFO includes article and books from psychology sources; these books and many of the journal articles are not available in PubMed. To access PsychINFO from off campus, your web browser's proxy settings should be set according to instructions on the library's homepage.

[3]This term follows the usage pioneered by the forty-third President of the United States

12.1.3 CogNet.

This database maintained by MIT http://cognet.mit.edu/ is accessible through Brandeis' license with MIT. CogNet includes full text versions of key MIT journals, and books in both neuroscience and cognitive science, e.g. Michael Gazzaniga's edited volume *The Cognitive Neurosciences, 3e* (2004), and *The MIT Encyclopedia of Cognitive Sciences*. The site is also a source of information about upcoming meetings and seminars.

12.2 Lab database of current literature.

The broad range of work in the lab means that many, many journals publish material that is directly relevant to our research. In order to keep up with the latest information from these journals, the lab uses a *journal watch* system. The journal watch allows lab members to stay up to date on relevant current research, but requires each individual lab to spend only a modest time on this effort.

Each lab member is responsible for scanning the abstracts of a few journals, searching for articles that may be of interest to themselves or to other members of the lab. When an interesting article is identified, the people who might be interested in it are alerted, using the website CiteULike.org as a repository for articles found in this way. The article's finder uploads the information to the website, and attaches to the article a meaningful label, or 'tag,' indicating the lab research area to which the article applies. Tags are important because they can be used as filters for quick searches of the database. The tags work best if their relevance to one or more areas of the lab's research is clear. Example tags include terms such as imitation, memory, attention, modeling, and motion-capture. The full set of currently used tags can be seen on the website. The set of journal currently being watched can be viewed at http://www.brandeis.edu/~sekuler/WatchlistAssignments.htm.

12.2.1 Signing up for CiteULike.

To open a new account, go to http://www.citeulike.org and sign up, logging in with your preferred username. Then go to http://www.citeulike.org/group, scroll down to the lab's group name, *VisionLab*, and click the link next to it "ask to join this group." Tell Jie Huang you have done this, so he can add you to the lab watch group. Jie Huang, with username *sekulerlab* is the 'owner' of this group and its gatekeeper.

12.2.2 Reading citations on the site.

http://www.citeulike.org/group/VisionLab is the repository for all articles that the lab posts. Scroll through the posts to see ones in which you have interest. Below each title, the highlighted tags reflect the research focus of the article, as determined by the lab member who posted it. Alternatively, make direct use the 'tag' feature. To the right of the screen is a list of tags used for our group, *VisionLab*. Clicking on any tag brings up all articles that have been labeled with that tag (unfortunately, at the moment, this action brings up articles submitted by non-group members as well, but this bug will be fixed soon). If you would like to see only articles that have been given both the tags "gestures" and "imitation", for

example, you must type the following in the search box in the upper right hand corner of the screen: "+tag:imitation +tag:gestures". Boolean permutations are endless, of course. Finally, *CiteULike* can automatically export *BibDesK*-ready citations, which can be very useful in document preparation. For a description of *BibDesK* does and how it works, see Section 13.6.

12.2.3 Posting new items to the site.

See http://www.citeulike.org/post for instructions on how to post citations. In most cases, posting an article should take only two mouse clicks –it's that easy. However, some journal websites are relatively difficult to post from (that is, requires more than two clicks). An alternative is to look at these articles from PubMed.org, which allows easy posting. (To see all the database's articles from a journal of interest, with most recent article first, put the journal title in the search box followed by "[ta]", for example, "cerebral cortex[ta]". For more information, see http://www.ncbi.nlm.nih.gov/books/bv.fcgi?rid=helppubmed.table.pubmedhelp.T37). When you add tags to your citations, whenever possible, try to use the same tags other members of our group have used. Unnecessary proliferation of tags reduces the usefulness of the database.

13 Document preparation

13.1 General advice

Some people prefer to work and re-work a manuscript until, in their view, it is absolutely, guaranteed, 100% perfect –or at least within ϵ of absolute perfection. Because the Vision Lab operates in an open, collaborative mode, keeping a manuscript all to yourself until you think it is perfect is almost always suboptimal. It is a better idea, once a first draft of a document or document sections has been prepared, to seek comments and feedback from other people in the lab. People should not hesitate to share "rough" drafts with other lab members; advice and fresh eyes can be extremely valuable.

13.2 Subversion

When you give someone a draft for comments, suggestions or editing help, be sure to avoid "version creep;" refrain from making additional changes until you get comments back, otherwise the value of the comments/suggestions could be diminished, and some or all of the reader's effort made on your behalf will have been wasted. And of course, if you are doing document preparation on more than one computer it's important to keep very careful track of changes made to various versions of the document. To solve the twin problems of version creep and the lose of synchronization among multiple versions of a document, the lab uses Subversion, a version control system. SVN, as it's called, keeps people from stepping on one another's authorial toes, and makes it easy to track changes and revisions in a document. Like CVS, an earlier system for version control, SVN uses a copy-modify-merge model, which allows multiple users to work simultaneously and independently on

the same document. For access to the system contact the laboratory director. For general instructions on SVN, you can download and read the excellent "how to" book from http://svnbook.red-bean.com/. For a very brief explanation of how to use SVN download the lab document http://www.brandeis.edu/ sekuler/svn4visionLab.pdf.

13.3 LaTeX

LaTeX is the lab's official system for preparing, editing, and revising documents. LaTeX is not a word processor; it is a document preparation and typesetting system, which excels in producing high-quality documents. LaTeX intentionally separates two functions that word processors, like Microsoft Word, conflate: (1) the generation and revision of words sentences, and paragraphs, and (2) the formatting of those words, sentences and paragraphs. LaTeX allows authors to leave document design to document designers, while focusing on writing, editing and revising. Information about LaTeX for Macintosh OSX is available from the wiki, http://mactex-wiki.tug.org/wiki/index.php?title=Main_Page. LaTeX does have a bit of a learning curve, but users in the lab will confirm that the return is really worth the effort, particularly for long or complicated documents: manuscripts, theses, dissertations, grant proposals. It is also excellent for generating useful, reader-friendly cross-references and clickable hyperlinks to internet URLs, and during revisions of manuscripts, both of which greatly enhance a document's readability. These features are well-illustrated by this very document, which was generated, of course, in LaTeX. For advice about starting to work with LaTeX, ask Bob or any other of the lab's experienced users. A .pdf of an *extremely* brief introductory talk on LaTeX by R. Sekuler is available at http://www.brandeis.edu/~sekuler/latex4visionLab.pdf.

13.3.1 Obtaining and installing LaTeX on a Macintosh computer.

There are three or four ways to obtain and install LaTeX–assuming a clean install, that is, an installation on a computer that has no already-existing LaTeX installation. The easiest path to a functional LaTeXsystem is to download the MacTeX install package http://www.tug.org/~koch, which is maintained by Richard Koch (University of Oregon). The package includes all the components needed for a well functioning LaTeX system. The MacTeX site even offers a movie that illustrates the steps to install the package once download has completed. Incidentally, the download is big, but well worth the bandwidth. Finally, Mac OS has a facility that automatically keeps a LaTeX installation up to date. Instructions on using this facility are available at http://www.tug.org/mactex/tlmgr/TlmgrMacTeX.pdf.

13.3.2 Where do LaTeXcomponents and packages belong?

When MacTex's installer is used for a clean install, the installer has the smarts to know where various components and packages should be put, and puts them all in their place. That feature greatly facilitates what otherwise would be a daunting process, as LaTeX expects to find its components and packages in particular locations. If you have to install a package on your own –say, some package not included among the many that come with MacTex– files have preferred locations, which vary with the type of package or file. Because the names of different types of files contain characteristic suffixes, the rules can be described in terms of

suffix. Any file with the suffix *.sty* should be installed in ~/Library/texmf/tex/latex/misc; any file with the suffix *.cls* should be installed in ~/Library/texmf/tex/latex; any file with suffixes *.bib* or *.bst* should be installed in ~/Library/texmf/bibtex. (~ signifies the user's root directory.)

13.3.3 Reference books and resources.

The lab owns some excellent reference books on LaTeX, including Daly and Kopka's *Guide to LaTeX* (3rd edition), and Mittelbach, Goossens, Braams, Carlisle, and Rowley's huge volume, *The LaTeX Companion* (2d edition). Recommendation: look first in Daly and Kopka; although The *LaTeX Companion* is far more comprehensive, its bulk (>1000 pages) can make it difficult find the answer to your particular question –unless, of course, you swallow your pride and turn to the index! Finally, the internet is a treasure trove of valuable LaTeX-related resources. To identify just one, good hypertext help with LaTeX, questions can be found at http://www-h.eng.cam.ac.uk/help/tpl/textprocessing/teTeX/latex/latex2e-html/ltx-2.html.

13.3.4 LaTeX editors and previewers.

There are several good Mac OSX LaTeX implementations. The least complicated is TeXShop, which is actively maintained and supported by Richard Koch (University of Oregon) and an army of dedicated, diligent volunteers. Despite its simplicity, TeXShop is very powerful. The current version of TeXShop for Mac OSX 10.4.X or 10.5.X is 2.26, and can either be downloaded separately, or installed automatically as part of the MacTeX package described above, in Section 13.3.1.

Macros and other goodies TeXShop comes complete with many useful macros, and facilities for generating tables and mathematical symbols (for example, $\not<, \in, \pm$). The macros, which can save users considerable time, are quite easily edited to suit individual users' tastes and needs. Another of TeXShop's useful features tends to be overlooked: the Matrix (table) Panel and the LaTeX Panel. These can be found under the Window menu. The Matrix Panel eases the pain of generating decent tables or matrices; the LaTeX Panel offers numerous clickable macros for generating symbols, as well as mathematic expressions and functions. It also offer an alternative way of accessing some nearly 50 frequently-used macros. Definitely worth knowing about. Finally, TeXShop affords a limited automatic backup of .tex files. To activate this capability, open terminal and enter *defaults write TeXShop KeepBackup YES*. Change *YES* to *NO* to turn off the auto backup.

Templates A limited number of templates come with the TeXShop installation; other templates are easily added to the TeXShop framework. One template commonly used in the Vision Laboratory is an APA style template produced by Athanassios Protopapas and John R. Vokey. Starting a manuscript from this template eliminates the burden of having to remember the arcane details, rules, and idiosyncrasies of APA style; you're guaranteed to get all that right. The APA template can be downloaded from http://www.brandeis.edu/~sekuler/APATemplate.tex. This version of the template has been modified slightly to permit highlighting and ~~strikeouts~~ during manuscript editing (see section 13.4.2).

13.4 LaTeX line numbers.

Line numbers in a document make it easier for readers to offer comments or corrections. Inserted into a revision of an article or chapter, line numbers help editors or reviewers identify places where key changes were made during revision. Editors and reviewers are human beings, so, like all of us, they appreciate having their jobs made easier, which is what line numbers can do. Several LaTeX packages can do the job of inserting line numbers. The most common of the packages is *lineno.sty*. It can be found, along with hundreds of other add-on packages, on the CTAN (Comprehenive TeX Archive Network) site http://www.ctan.org/. One warning: *lineno.sty* works fine with APATemplate mentioned in the previous section, but can create problems if that template is used in *jou* mode, which produces double-column text that looks like a journal reprint.

13.4.1 LaTeX symbols, math and otherwise

Often, when you're preparing a doc in LaTeX, you'll need to insert a symbol such as $\otimes$, $\cup$, $\pm$ or $\sim$. You know what it looks like (and what it means), but you don't know how to get LaTeXto produce it. You could do it the hard way, by sorting through long, long lists of LaTeXsymbol calls, which can be found on the web or in any standard LaTeXref book. Or you could do it the easy way, going to the detexify website. Once at the site, you draw the symbol you had in mind, and the site will tell you how to call if from within LaTeX. Finally, for many symbols, you could do it an even easier way. The *TeXShop* editor's Window menu includes an item called LaTeXPanel. Once opened, the panel gives you access to the calls for many mathematical symbols and function names. Very nice.

13.4.2 LaTeX highlighting and/or strike outs

A readily available LaTeX package, *soul*, enables convenient highlighting in any color of the user's choice and/or strike outs of text. These features are useful during document revision, as versions pass back and forth between separate hands. *soul* is part of the standard LaTeX installation for MacOS X. To use *soul*'s features, you must include that package and the color package (for highlighting in color).

```
To highlight some text, embed it inside \hl{ }; to strikeout some text,
embed it inside \st{ }.
```

Yellow is the default hightlighting color, but other colors, too, can be used. Here are preamble inclusions that enable user-defined, light red color highlighting.

```
\usepackage{color,soul} %Allow colored highlighting and strikeout
\definecolor{myRed}{rgb}{1.0,.5,.5}
\sethlcolor{myRed} % Make LIGHT red the highlighting color
```

```
If you are OK with a standard color, such as yellow or red, omit \definecolor,  and simp
```

13.5 LaTeX template for insertion of highly-visible notes for revision

The following template makes it easy to insert highly visible author's or reviewer's notes into a LaTeX document. MacOS X users may want to add this template to their TeXShop templates collection. The template, which is based on an original by Dylan Shell (USC), is easily modified as needed. Here's the text of the code for the preamble section of foo.tex

```
\usepackage{color}
\newcommand{\comment}[1]{
\noindent
\vspace{0.3cm}\begin{minipage}{\textwidth}
{\vspace{0.3cm}\sf\textcolor{blue}{#1}}
\end{minipage} }
```

This code allows you to generate distinctive notes useful for inserting highly visible editorial comments or reminders into a .txt file. For example,

```
\comment{RS:This point should be expanded in next draft, and the reference needs to be d
```

inserts the following blue comment into foo.txt:

Colin:You've made an interesting point here, but it must be expanded in the next draft –and do verify that reference, please.

Using this feature becomes even more convenient with a TexShop macro that, with a single keystroke, selects the comment's text, and embeds that text in the appropriate command and bracket structure.

13.5.1 Conversions between LaTeX and RTF

If you need to convert in either direction between LaTeX and RTF (rich text format, readable in Word), you can use *latex2rtf* or *rtf2latex*, programs designed to do exactly what their names imply. *latex2rtf* does not much "like" some special LaTeX packages, but once those offending packages are stripped out of the .tex file, *latex2rtf* does a great job. If your LaTeX code generates single-column output (as opposed to so-called "jou" formatted output) there's an easy way to produce decent, but not letter-by-letter perfect conversion to Word or RTF. Open the LaTeX's .pdf output in Adobe Acrobat and save the file as .htm. Then copy and paste the .htm to yourself. Most mail clients will automatically reformat the .htm into something that closely approximates useful rich text format, which is what the name RTF stands for. Finally, although rarely needed by lab members, NeoOffice, an open source suite, has an export to .tex option that is a straightforward way to convert .rtf to .tex.

13.5.2 Preparing a dissertation in LaTeX.

Brandeis' Graduate School of Arts and Sciences commisioned the production of *.cls* file to help users produce a properly formatted dissertation. This file can be downloaded http://

www.brandeis.edu/gsas/students/Dissertationguidelines.html. On that webpage, "style guide" provides the necessary .cls file; the "class specification document" is a .pdf that explains use of the dissertation class. Note that this .cls file is not a template, but with the .pdf document in hand, it is the next best thing. The choice of reference/citation format is up to the user. For standard APA format citations and references, include in the preamble

`\bibliographystyle{apacite}`.

13.6 Managing your literature references.

BibDesk for MacOS X is an excellent freeware tool for managing bibliographical reference files. *BibDesk* has a very nice graphical user interface, and is upgraded frequently by a group of talented, dedicated volunteers. *BibDesk* integrates smoothly with LaTeX documents, and, properly used, ensures that no cited reference is omitted from the bibliography, and that no item in the bibliography has not been cited. That feature minimizes a reader's or a reviewer's frustration and annoyance at coming across an unmatched citation in a manuscript, thesis or grant proposal.

Download *BibDesk*'s current release (version 1.3.21) from http://bibdesk.sourceforge.net/. *BibDesk* can import references saved from PubMed, preview how references will look as LaTeX output, perform Boolean searches, and automatically generate citekeys (identifiers for items) in custom formats. In addition, *BibDesk* can autocomplete partial references in a .tex file (you type the first several letters of the citekey, and *BibDesk* completes the citation, drawing from your database of references). Autocompletion is a very convenient, but too-little used feature, which makes it very easy to add references to a .tex document. Begin by using*BibDesk* to open your .bib file(s) on your desktop. Then in your .tex document, start typing a reference, for example,

`\cite{Sek`

and hit the F5 key. *Bibdesk* will go your open .bib file(s), find and display all references whose citekeys match

`\cite{Sek`

Choose the reference you meant to include, and its full citekey will be inserted into your .tex document. Among its other obvious advantages, this Autocompletion function protects you from typos. The Autocompletion feature is particularly convenient if you have consistently used an easily-remembered system for citekey naming, such as making citekeys that comprise the first four letters of each authors' name plus the year of publication. (Incidentally, once you hit upon a citekey naming scheme that's best for you, *BibDesk* can automatically make such citekeys for all the items in your .bib file.) To learn more about *BibDesk*'s Autocompletion feature, open *BibDesk* and go to its Help window.

To import search results from a browser pointed to PubMed, check the box(es) next to reference(s) you want to import, change the *Display option* to MEDLINE, and change the *Send to* option to FILE. This will do two things. First, it places a file *pubmed-result.txt* onto your

hard disk. If you drag and drop that file to an open *BibDesk* bibliography, *BibDesk* will automatically add the item to the bibliography. I said that changing the *Send to* option to FILE did two things. The second? it generates and opens a plain text file on your browser. If you have a *BibDesk* bibliography already open, you can select that text and use the *BibDesk* item under File's Services menu to insert the text directly into the open bibliography.

Note that *BibDesk* supports direct searches of PubMed, Library of Congress, and Web of Science –including Boolean searches[4]. To search PubMed from within BibDesk, select the "PubMed" item under the Searches menu, and enter your search terms in the lower of the two search windows. A maximum of 50 items per search will be retrieved; to retrieve additional items and add them to your search set, click the Search button and repeat as needed. When the Search button is grayed out, you know you have retrieved all the items relevant to your search terms. Move the items you want to retain into a library by clicking the Import button next to an item, and save the library.

13.7 Reference formats

When references have been stored in a .bib file, LaTeX citations can be configured to produce just about any citation format that you want, as the following examples show:

COMMAND FORMAT	RESULTING CITATION
`\cite<e.g.,>[p. ~15]{Lash51,Hebb49}`	(e.g., Lashley, 1951; Hebb, 1949, p.15)
`\cite<e.g.,>[p. 11]{Lash51,Hebb49}`	(e.g., Lashley, 1951, p. 11; Hebb, 1949)
`\citeNP<e.g.,>[p. ~15]{Lash51,Hebb49}`	e.g., Lashley, 1951; Hebb, 1949, p.15
`\citeA{Lash51,Hebb49}`	Lashley (1951); Hebb (1949)
`\citeauthor<e.g.,>[p. ~15]{Lash51,Hebb49}`	e.g., Lashley; Hebb, p.15
`\citeyear<e.g.,>[p. ~15]{Lash51,Hebb49}`	(e.g., 1951; 1949, p. 15)
`\citeyearNP<e.g.,>[p. ~15]{Lash51,Hebb49}`	e.g., 1951; 1949, p. 15

14 Scientific meetings

It is important to present the lab's work to our fellow researchers in talks, colloquia or at scientific meetings. Recently, members of the lab have made presentations at meetings of the Psychonomic Society (usually, early in November; rotating locations), the Cognitive Neuroscience Society (mid-late April; rotating locations), the Visual Sciences Society (early in May; Sarasota FL), COSYNE (Computational and Systems Neuroscience) (early March, Snowbird, UT), the Cognitive Aging Conference (rotating locations; April), the Society for Neuroscience (early November; rotating locations). For some useful tips on giving a talk at a meeting (or elsewhere) go to http://chronicle.com/free/v50/i14/14b01501.htm or to http://www.swarthmore.edu/NatSci/cpurrin1/powerpointadvice.htm.
Assuming that your talk uses Microsoft's PowerPoint or Apple's Keynote presentation software, remember that your audience will try to read every word on each and every slide you

[4] *BibDesk*'s Help screens provide detailed instructions on all of *BibDesk*'s functions, including Boolean searches. For an AND operation, insert + between search terms; for an OR operation insert |.

show –they're human and therefore just can't help themselves. Cognitive studies teach us that your audience's reading what you've shown them will keep them from giving full attention to what you are saying. If you want the audience to *listen* to you, get rid of all text that is not 100%-essential.

14.1 Preparation of posters

When a poster is to be presented at a scientific meeting, the poster is generated using PowerPoint and is then printed on campus, using a large format printer. Detailed instructions for generating a poster can be found at http://www.brandeis.edu/~sekuler/powerpointPoster.html. PowerPoint generated in the lab can be used as templates for your poster. Sample PowerPoint templates can be downloaded from http://www.brandeis.edu/~sekuler/POSTERS/VSS04posterRev1.ppt or from http://www.brandeis.edu/~sekuler/POSTERS/Yuko_VSS_draft3.ppt. Savvy, well-illustrated advice on poster making and poster presenting is available on the Swarthmore College website of Colin Purrington. And whatever you do, make sure that you know exactly what size poster is needed for your scientific meeting; it is not good when you arrive at a meeting with a poster that is larger than the space allowed.

15 Some essential background knowledge

15.1 How to *read* a journal article.

Jody Culham (University of Western Ontario) offers excellent advice for students who are relatively new to the business of journal reading –or who may need a reminder of how to read journal articles most effectively. Her advice is given in a document at http://defiant.ssc.uwo.ca/Jody_web/Culham_Lab_Docs/Advice/how_to_read_a_journal_article.htm.

15.2 How to *write* a journal article.

Writing a good article may be a lot harder than reading one. Fortunately, there is plenty of advice about writing a journal article, though different sources of advice seem to contradict one another. Here is one suggestion that may be especially valuable, and non-intuitive. However formal and filled with equations and exotic statistics it may be, a journal article ultimately is a device for communicating a story. As a result, an article should be built around a strong, clear narrative (a storyline). The communication of the story requires that the author recognize what is central, and what is secondary or tertiary. Downplaying what is less important can be hard, in part because of the hard work that may have gone into producing that less-important material. But do not imagine for even a moment that just because you (the author) find something to be utterly fascinating, that all readers will, too –at least not without some skillful guidance from you. You have to work to get readers interested enough to read beyond the article's title or abstract, which means that those two items are make or break features for your article. Assuming that you have a good title and abstract, the next step is to generate a compelling opener, that all-important framing device represented by the article's first sentence or paragraph. For a thoughtful analysis of effective openers check out the examples and suggestions at this website at San Jose State University.

There's no getting around the fact that effective writing requires extensive reading. Only by reading, analyzing and imitating successful models, you can become a better, more effective writer. Michael Alley, a professor of mechanical engineering at Virginia Tech, maintains an website, which offers great, practical advice on scientific writing and powerful presentations. Alley's examples of good, better and best Powerpoint slides alone are worth the price of admission.

15.3 Some mathematics.

Linear systems and frequency analysis play a key role in many areas of vision science. One very good, practical treatment is Larry Thibos' *Fourier Analysis for Beginners*. Available by download from the library of the Visual Sciences Group at Indiana University School of Optometry, Thibos' webbook starts with a simple review of vectors and matrices, and works its way up to spectral (frequency) analysis and an introduction to circular or directional data. It's available at http://research.opt.indiana.edu/Library/FourierBook/title.html.

For more extensive review of topics in linear/matrix algebra, which is the principal brand of mathematics used in our lab, check out the lab's copy of Ali Hadi's little book *Matrix Algebra as a Tool*. A super introduction to linear systems in vision science can be found in Brian Wandell's book *Foundations of Vision: Behavior, Neuroscience and Computation* (1995). Bob has used the Wandell book twice as the text in a graduate vision course. Some parts of the book can be hard slogging, but, for an excellent grounding in vision, the effort is definitely worth it.

15.3.1 Key numbers.

Wandell has also produced a brief list of key numbers in vision science, e.g., the area of area V1 in each hemisphere of the human brain (24 cm), the visual angle subtended by the sun (0.5 deg), the minimum number of photon absorptions required for seeing (1-5 under scotopic conditions). Many of these numbers are good to know, or at least to know where they can be found.

15.3.2 More numbers.

A superset of Wandell's numbers can be found at http://www.neuro.psychologie.uni-oldenburg.de/~rutschmann/forschung/optic_numbers.html. This expanded list contains memorable gems such as "The human eye is exactly the same size as a quarter. The rod-free, capillary-free foveola is 1/2 deg in diameter, same as the sun, the moon, and the pinky fingernail at arm's length. One deg is about 0.3 mm (∼300 microns) on the retina. The eyes are half-way down the head."

15.4 Early vision.

Robert Rodieck's clear, beautifully illustrated book *First Steps in Seeing* (1998) is hands down the best ever introduction to optics of the eye, retinal anatomy and physiology, and

vision's earliest steps, including absorbtion and transduction of photon catch. A bonus is its short, highly accessible technical appendices, which are good refreshers on topics such as logarithms and probability theory. A close second to Rodieck in quality, with somewhat different emphasis, is Clyde Oyster's *The Human Eye* (1999). Oyster's book has more material on the embryological development of the eye and on various dysfunctions of the eye.

15.5 Visual neuroscience.

An excellent, uptodate reference work on visual neuroscience is LM Chalupa & J S Werner's two-volume work, *The Visual Neurosciences*, MIT Press (2004). These volumes, which are kept on the reference shelves of Brandeis' Science Library, comprise 114 excellent review chapters, which span the gamut of contemporary vision research.

15.6 Methodology

Several chapters in Volume 4, *Stevens' Handbook of Experimental Psychology*, 3d edition, deal with essential methodologies that are commonly used in the lab: reaction time and reaction time models, signal detection theory, selection among alternative models, multidimensional scaling, and graphical analysis of data (the last of these in Geoff Loftus' chapter). For an in-depth treatment of multidimensional scaling there is only one real source: Ingwer Borg and Patrick Groenen's *Modern Multidimensional Scaling: Theory and Application* (2nd edition, Springer, 2005). The book is clear, well-written and covers the broad range of areas in which MDS can be used. Not a substitute for Borg and Groenen, here's a brief, focused introduction to MDS that was presented at a recent meeting of our lab http://www.brandeis.edu/~sekuler/MDS4visonLab.swf. This introduction (in Flash format) was designed as background to the lab meeting discussion of a 2005 paper in Current Biology

15.6.1 Visual angle

In vision research, stimulus dimensions are expressed in units of visual angle (in degrees, or minutes, or seconds). Calculation of the visual angle subtended by some stimulus involve two data: the linear size of the stimulus (in cm) and the viewing distance (distance between viewer and the stimulus, in cm). For example, imagine that you have a stimulus 1 cm wide, and a viewing distance of 57 cm. The tangent of the visual angle subtended by this stimulus is given by the ratio of size:viewing distance. In this case, the value $= \frac{1}{57} = 0.0175$. To find the angle itself, take the arctangent (a.k.a., inverse tangent) of this value, $\arctan 0.0175 = 1$ deg.

15.7 Adaptive psychophysical techniques

Many experiments in the lab require the measurement of a threshold, that is, the value of a stimulus that produces some criterion level of performance. For sake of efficiency, we use an adaptive procedure to make such measurements. These procedures come in many different flavors, but all use some principled scheme by which the physical characteristics of stimuli

on each trial are determined by the stimuli and responses that occurred in the previous trial or sequence of trials. In the Vision lab, the two most common adaptive procedures are QUEST and UDTR (for up-down transform rule). A thorough, though not easy introduction to adaptive psychophysical techniques can be found in B Treutwein (1995). Adaptive psychophysical procedures, Vision Research, 35: 2503-2522. A shorter, more accessible introduction to adaptive procedures can be found in MR Leek (2001) Adaptive procedures in psychophysical research. Perception & Psychophysics 63: 1279-1292.

15.7.1 Signal detection theory (SDT).

This set of techniques and associated theoretical structure is a key part of many projects in the lab. It is important that everyone who works in the lab has at least some familiarity with SDT. The lab owns a copy of an excellent introduction to this important methodology: Neil MacMillan and Doug Creelman's *Detection Theory: A user's guide (2nd edition)*; we also own a copy of Tom Wickens' *Elementary Signal Detection Theory.* The ROC (receiver operating characteristic) is a key tool in SDT, and has been put to important theoretical use by researchers in vision and in memory. If you don't know exactly what a ROC is, or know why ROCs are such valuable tools, don't abandon hope just yet. One place to start might be a 1999 paper by Stanislaw and Todorov: Calculation of signal detection theory measures. *Behavior Methods, Research, Computers & Instrumentation.* Most often, ROCs generated in the Vision Lab come from the application of a rating scale, which is by far the most efficient way to produce the requisite data. The MacMillan and Creelman book (above) give a good explanation of how to proceed from rating scale data to ROCs. John Eng of The Johns Hopkins School of Medicine has produced an excellent web-based app that takes rating scale data in various formats and uses maximum likelihood to define the the best fitting ROC. Eng's app returns not only the values of usual parameters (slope and intercept of the best fitting ROC in probability-probability axes) and area under the best fitting ROC, but also the values of unusual, but highly useful ones, for example, the estimated values, in stimulus space, of the criteria that the subject used to define the rating scale categories, and the 95% confidence intervals around the points on the best-fit ROC. For a detailed explanation of the app's output, go to http://www.bio.ri.ccf.org/doc/rocfit.f.

There are also several good, **very short**, general introductions to SDT on the web. One was produced by David Heeger (NYU): http://www.cns.nyu.edu/~david/sdt/sdt.html. Another (interactive) tutorial is the product of the Web Interface for Statistics Education project. The project's SDT tutorial can be accessed at http://wise.cgu.edu/sdt/intro.html.

15.8 Labspeak[5].

Newcomers to the lab are likely to hear many unfamiliar terms, which refer to aspects of experiments and/or data analysis. Here are a few that are important to understand.

[5]This coinage, *labspeak*, was suggested by Orwell's use of the term *newspeak* in his novel 1984. Unlike *newspeak*, though, *labspeak* is meant to facilitate and sharpen thought and communication, not to inhibit them.

Additional terms and full definitions are added on a rolling basis. Suggestions for additions are invited.

Bootstrapping A statistical method for estimating the sampling distribution of some estimator (e.g., mean, median, standard deviation, confidence intervals, etc.) by sampling with replacement from the original sample. This method can also be used for hypothesis testing, particularly when the standard assumptions of parametric tests are doubtful. See *Permutation Test* (below).

BouncingStreaming A bistable percept of visual motion in which two identical objects moving along intersecting paths seem sometimes to bounce off one another, and sometimes to stream through one another.

camelCase Term referring to the practice of writing compound words by joining elements without spaces and capitalizing initial letter of second word. Examples: iBook, MisterRogers, PlayStation, ebay, SpongeBob SquarePants. This practice is useful for naming variables in computer code or in assigning computer files meaningful, easy to read names.

Forced choice In some other labs, this term is used to describe any psychophysical procedure in which the subject is forced to make a choice between n possible responses, such as "yes" or "no." In the Vision Lab, this term is restricted to a discrimination experiment in which n stimuli are presented on each trial, one containing a sample of $\mathbf{S}_1$, the remaininig *n-1* containing a sample of $\mathbf{S}_2$. The subject's task is to identify the stimulus that was the sample of $\mathbf{S}_1$. Consult a textbook on signal detection to see why this is an important distinction. If you're in doubt about whether your procedure truly comprises a forced-choice, ask yourself whether after a response you could legitimately tell the subject whether he/she is correct or not.

Leakage Term referring to intrusions from one trial of an episodic visual memory experiment into the following trial. A manifestation of proactive interference.

Lure trial A trial type in a recognition experiment; on lure trials, the probe item matches none of the study items. (See *Target trial*)

Mnemometric function Introduced by Zhou, Kahana & Sekuler (2004), the mnemometric function describes the relationship, in a recognition experiment, between the proportion of *yes* responses and the metric properties of the *probe* stimulus. The *probe* "roves" or varies along some continuum, such as spatial frequency, sweeping out a probability function that affords a snapshot of the memory strength's distribution.

Moving ripple stimuli Complex, spectro-temporal stimuli used in some of the lab's auditory memory research. These stimuli comprise a family of sounds with drifting, sinusoidal, spectral envelopes.

Museum Project Research project built around the lab's virtual museum, wayfinding environment.

Multiple object tracking (MOT) Multiple object tracking is the ability to follow simultaneously several identical moving objects based only on their spatial-temporal visual history.

NEMo The **N**oisy **E**xemplar **Mo**del introduced by Kahana & Sekuler (2002), Recognizing spatial patterns: a noisy exemplar approach. *Vision Research* **42** 2177-2912.

Permutation Test A type of statistical significance test in which some reference distribution is obtained by calculating all possible values of the test statistic under rearrangements of the labels on the observed data points, e.g., labels typically designate the conditions from which the data came. (Permutation tests are also called randomization tests, re-randomization tests, or exact tests.) See *Bootstrapping* (above).

Polhemus The lab's motion capture system that records subjects' hand postures and arm position

QUEST An efficient, Bayesian adaptive psychometric procedure for use in psychophysical experiments. This method was introduced by Andrew Watson & Denis Pelli (1983), QUEST: A Bayesian adaptive psychometric method. *Perception & Psychophysics* **33**,113-120. The method can be tricky to implement, but good practical pointers on implementing and using this procedure can be found in P. E. King-Smith, S. S. Grigsby, A. J. Vingrys, S. C. Benes, & A. Supowit (1994). Efficient and unbiased modifications of the QUEST threshold method: Theory, simulations, experimental evaluation, and practical implementation. *Vision Research* **34**, 885-912.

Roving Probe technique Described in Zhou, Kahana & Sekuler (2004), a stimulus presentation schedule that is designed to generate a mnemometric function.

ShapeHand A major component of one of the lab's motion-capture systems. ShapeHand captures hand and finger motions by means of flexible ribbons embedded in a glove. In the lab's system, ShapeHand is integrated with an analogous, arm tracking system so that we can track hand and arm movements.

Sternberg paradigm Procedure, introduced by Saul Sternberg in the late 1960's, for measuring recognition memory. In this procedure, a series of study items is followed by a probe (test) item. Subject's task is to judge whether the probe was or was not among the series of study items. Either response accuracy, response latency, or both are measured.

svn A shortened version of the term "subversion," a version control system used in the lab to facilitate collaborative preparation and refinement of manuscripts and other documents.

Target trial One type of trial in a recognition experiment; on Target trials, the probe item matches one of the study items. (See *Lure trial*)

Temporal Context Model This theoretical framework, proposed by Marc Howard and Mike Kahana in 2002, uses an evolving process called "contextual drift" to explain

recency effects and contextual retrieval in episodic recall. It is hoped that this model can extended to the case of item and source recognition.

UDTR Stands for "up-down transform rule," an algorithm for driving an adaptive psychophysical procedure. UDTR was introduced by GB Wetherill and H Levitt (1965) Sequential estimation of points on a psychometric function, *British Journal of Mathematical Psychology* 18: 1-10.

Vogel Task A change detection task developed by Ed Vogel (University of Oregon). This task is being used by the lab in order to assess working memory capacity.

wiki A website that allows visitors to add, remove, edit or change content, using a browser interface. The lab's Museum Project exploits a dedicated wiki to facilitate collaboration and collaborative writing.

Yellow cab A virtual reality "game" in which the subject takes the role of a cab driver, finding passengers and delivering them as efficiently as possible to their desired destinations. From the learning curves produced by this activity, it's possible to identify what attributes and features of the virtual city the subject-drivers used to learn their way about the city.