

Configuring a Computer for Stimulus Presentation During DOT Scans

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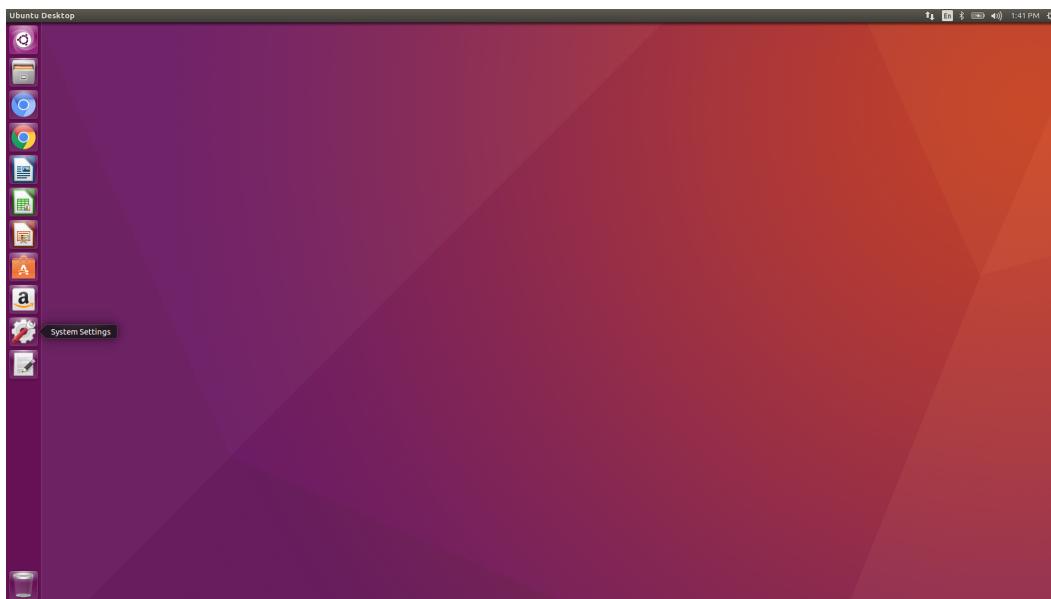
Culver Lab, Optical Radiology Laboratory | Washington University in St. Louis

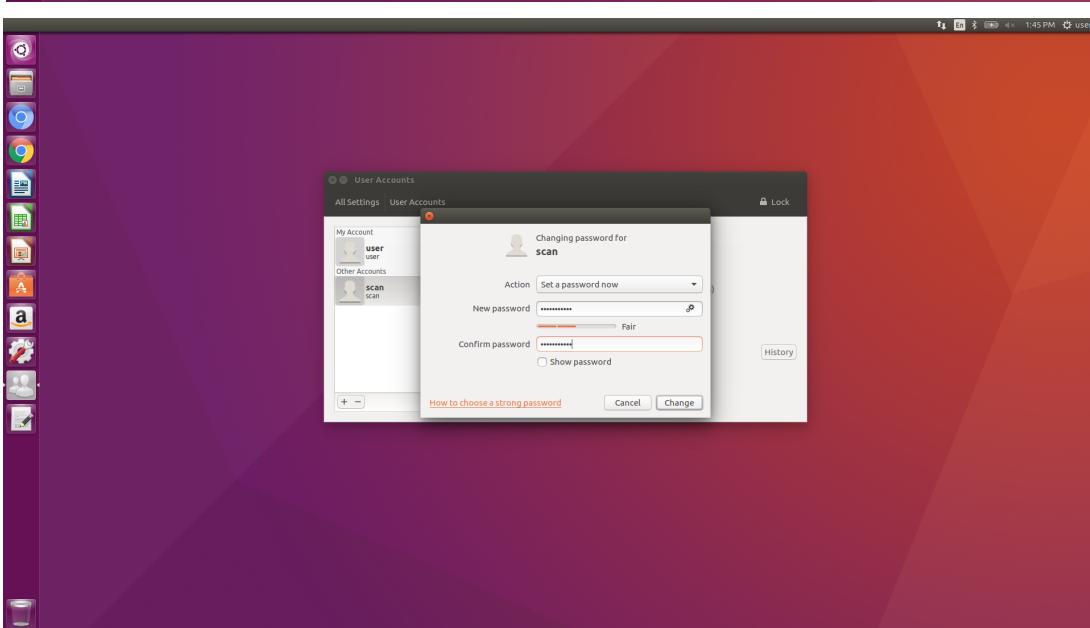
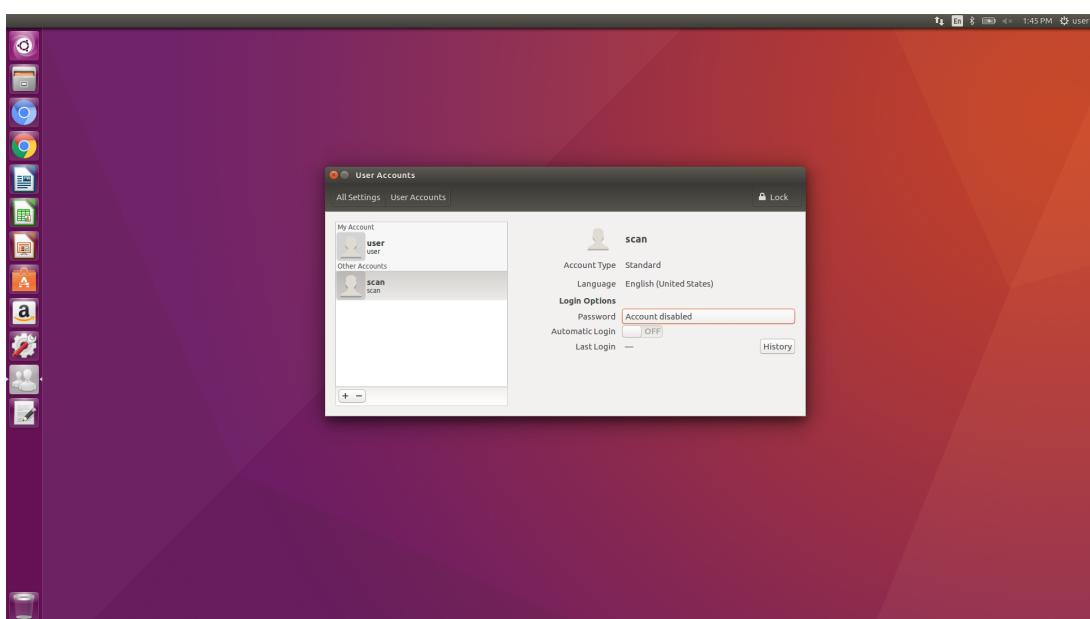
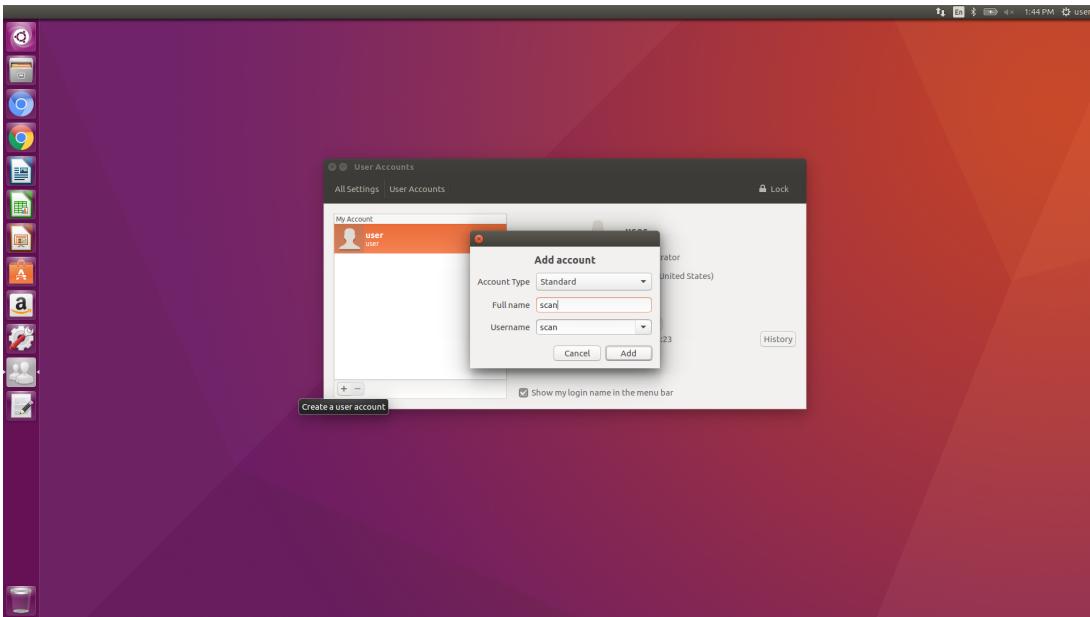
First, obtain the following equipment:

- Stimulus computer:
 - Manufacturer: SuperLogics
 - Model: SL-DK-AH270I-IH
 - Operating system: Ubuntu Desktop 16.04 LTS
 - CPU: 1x 4-core 3.6-GHz Intel i7-7700 with 8-MB cache, HD Graphics 630 (65W)
 - RAM: 16 GB (2x 4-GB DDR4 2133 MHz)
 - OS/Boot Hard Drive: 500-GB NVMe SSD M.2 Samsung 960 Evo
 - Video card: AMD FIREPRO W4100 Workstation Graphics Card - DirectX12, OpenGL 4.4, with 4 mini-DisplayPort outputs.
- Monitors: 2 Dell P2417H 24-inch monitors (1920x1080, 60-Hz refresh rate).
- 2 mini-DisplayPort-to-DisplayPort cables with male ends for connecting video card outputs to monitors.
- Audio/sound card: Focusrite Scarlett 6i6 USB
- 2 audio speakers with 0.25-inch-diameter input jacks/ports.

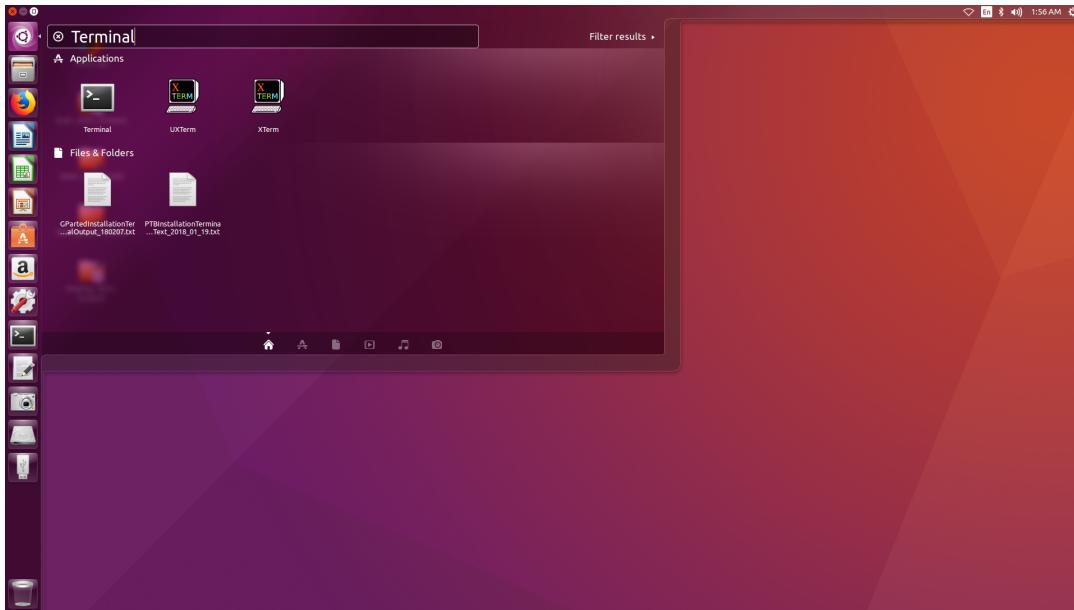
Process for configuring Ubuntu 16.04 LTS systems with AMD graphics cards:

1. I recommend that you have or set up the ability to restore the computer to its exact current state (e.g., factory reset/restore) before proceeding because Psychtoolbox setup will alter some system files and configuration options.
2. Log in as a system administrator (specifically someone with sudo privileges) but not root. The first user account that you created during Ubuntu 16.04 LTS operating system setup should meet this description.
3. In System Settings > Users, create a non-administrator user account called "scan" (for real scan sessions) and a separate non-administrator account called "stimdev" (for developing new stimulus code). Also create any other user accounts that will need to use Psychtoolbox. Be sure to enable and set a password for each user account.

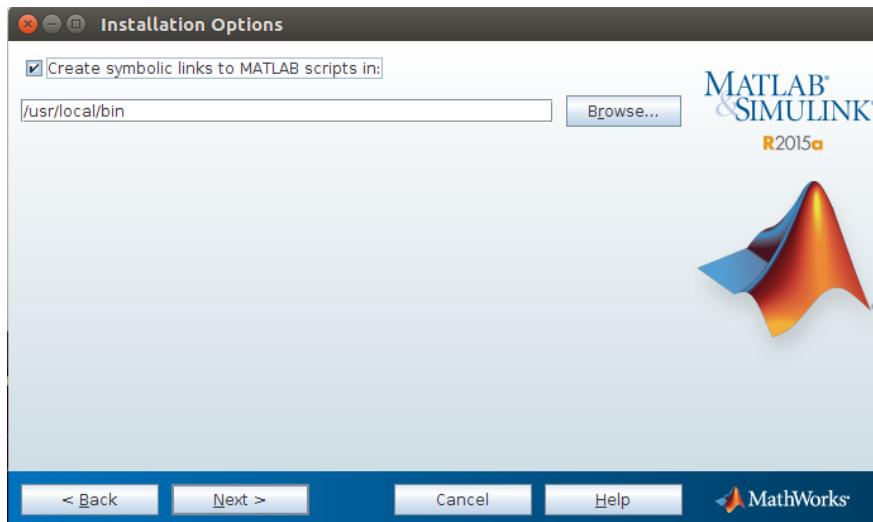




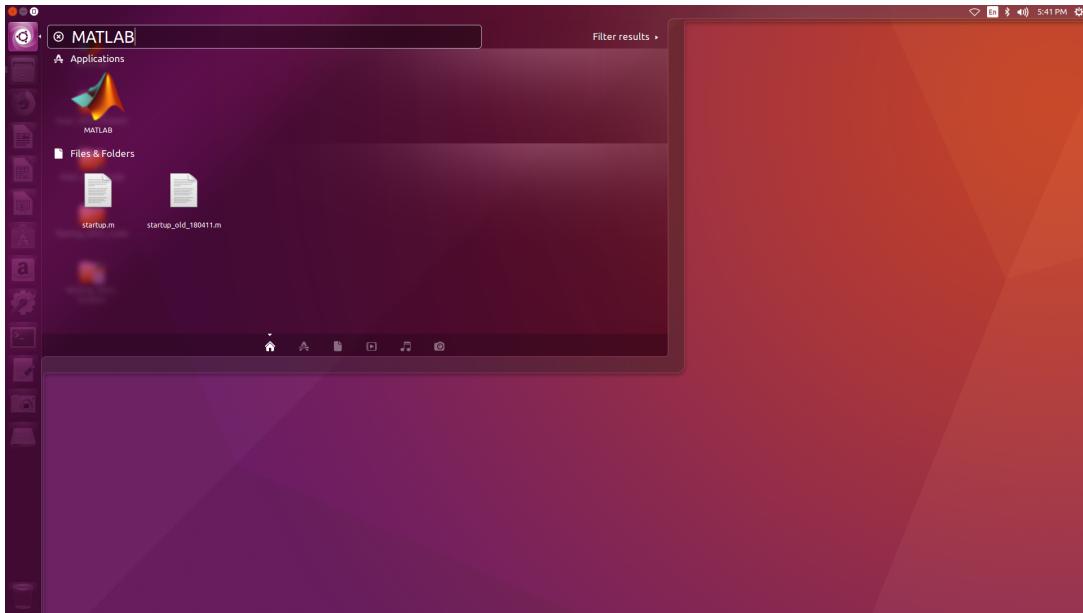
4. Connect to the Internet.
5. Install MATLAB.
 - a. Remember to run the installer with root privileges by using "sudo" (navigate to unzipped downloaded MATLAB directory in Terminal and run "sudo ./install" without quotes). To find Terminal on the Ubuntu Desktop, click on the Launcher search button in the upper left of the screen and search for "Terminal".



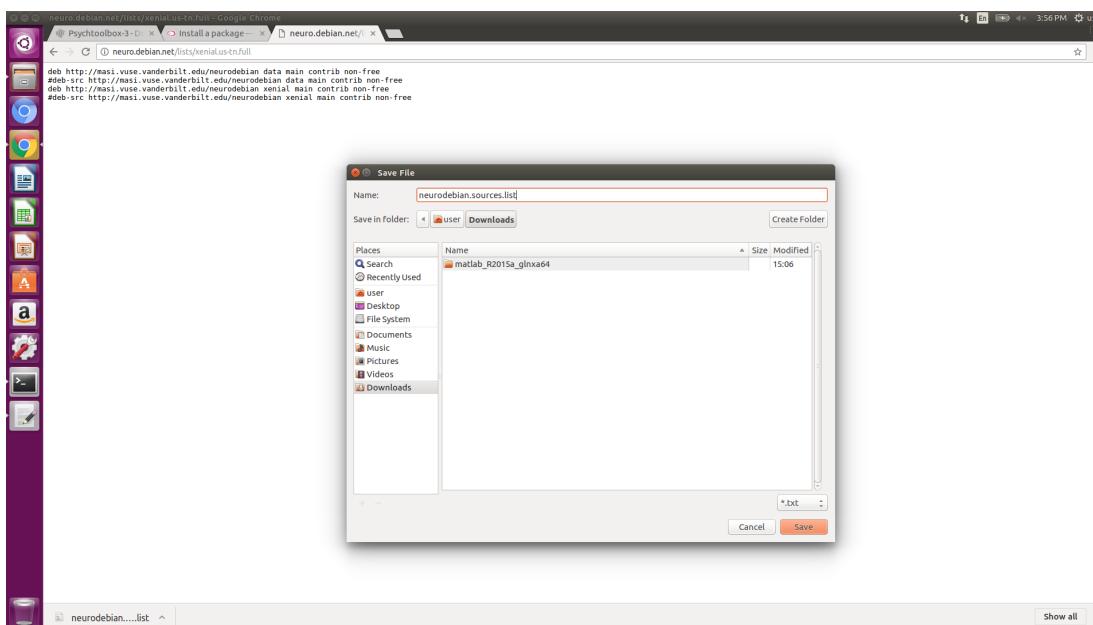
- b. We have tested MATLAB R2015a non-SP1 but probably could use more recent versions.
- c. During installation, tell MATLAB to create symbolic links to MATLAB scripts in /usr/local/bin when prompted (see screen photo below), so that you can create a desktop launcher shortcut and use a launcher button that can be found by searching for "MATLAB" with the Ubuntu taskbar's/launcher's search button.

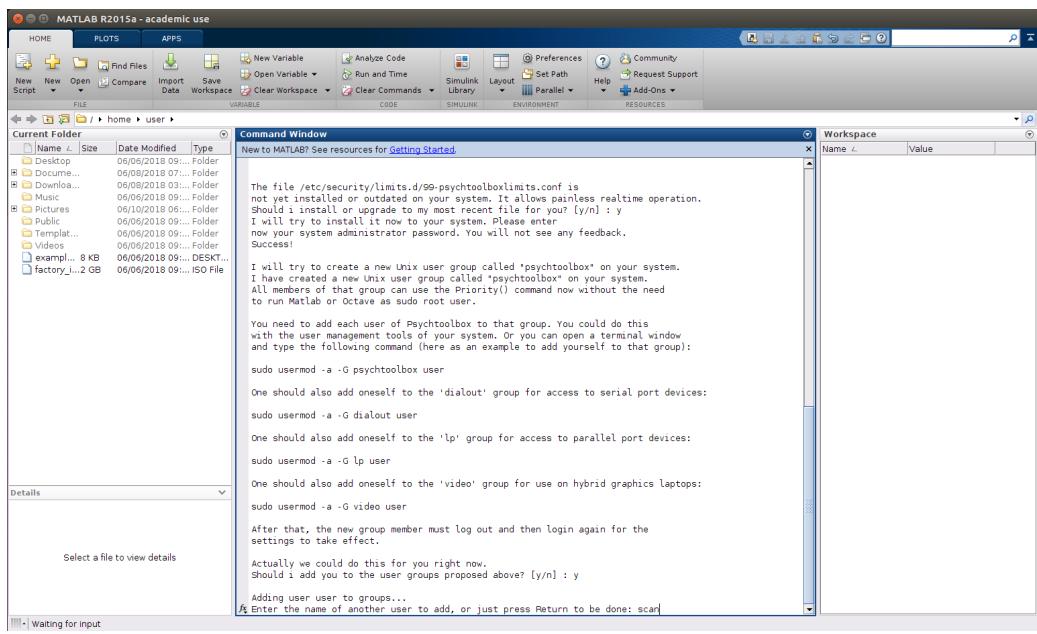


6. Open MATLAB once so that it will create remaining important directories that it uses. This can be done by running "matlab" in Terminal or by searching for MATLAB with the Ubuntu taskbar's/launcher's search button.



7. Ensure that all monitors that you plan to use are connected to the computer.
8. Follow the instructions at <http://psychtoolbox.org/download/> and the "Additional tips for Linux" page (<http://psychtoolbox.org/linux/>) to download, install, and configure Psychtoolbox for Linux and MATLAB via the NeuroDebian repository, ***with the following important exceptions and notes:***
 - a. I obtained the all-inclusive ("full") version of the software package, not just the version that only has DFSG-compliant software (definition of DFSG-compliant: http://www.debian.org/social_contract#guidelines). I used the Vanderbilt University download server.
 - b. The "wget -O- ... | sudo tee ..." command listed on the NeuroDebian site did not work for me. So instead, in a web browser, manually go to the URL provided between "wget -O-" and "| sudo tee" (currently <http://neuro.debian.net/lists/xenial.us-tn.full> for the Vanderbilt University download server). This should be a short plain-text file that displays in your web browser. If you are viewing this page in Firefox or Chrome, use File menu > "Save Page As" (Ctrl+S) to save the page as a plain-text file called neurodebian.sources.list .



- c. Then move this neurodebian.sources.list file into the /etc/apt/sources.list.d directory using sudo (in Terminal, "cd" to the directory with that text file, and then run "sudo mv neurodebian.sources.list /etc/apt/sources.list.d/").
 - d. Then proceed with "sudo apt-key adv..." and "sudo apt-get update" as instructed by NeuroDebian's website, and then run "sudo apt-get install matlab-psychtoolbox-3" as instructed by the Psychtoolbox website's supplementary information page about installing Psychtoolbox on Linux (<http://psychtoolbox.org/linux/>).
 - e. When you start MATLAB via the "ptb3-matlab" command in Terminal, run Psychtoolbox's MATLAB script PsychLinuxConfiguration. You can and should do this within the MATLAB command window GUI; according to the comments in that script, the GUI is only problematic if you are using Octave instead of MATLAB. Answer "y" (yes) to all "yes-or-no" questions that PsychLinuxConfiguration asks while running. During this process, the script will also ask for the usernames of other user accounts that will need to run Psychtoolbox, other than the account that you are currently using; when prompted, enter each such username (e.g., "scan", "stimdev", without quotes). You should do this one at a time, pressing Enter after each username.
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- f. When PsychLinuxConfiguration is finished running, restart the computer. After the computer restarts, log in again as a system administrator, launch MATLAB with ptb3-matlab, and run Psychtoolbox's MATLAB script XOrgConfCreator to create an xorg.conf configuration file that will show the system desktop and MATLAB windows on one monitor screen and will present stimuli on the other monitor screen. Then run Psychtoolbox's MATLAB script XOrgConfSelector to select the configuration file that you created with XOrgConfCreator, close MATLAB, log out, and log back in again for the multi-screen configuration to take effect.
 - g. I do not yet recommend downloading the low-latency kernel for extremely high-precision timing, only because we have not yet tested a configuration with that kernel. For DOT, it is OK to have the stimulus timing precision be around 50-100 ms instead of 1-10 ms because the hemoglobin signal fluctuations being imaged are much slower (time scale ≥ 1 second). However, the Psychtoolbox website does recommend the low-latency kernel, and there is likely no harm in installing that kernel if you have a system backup and/or the ability to restore the system to a functional state, in case of problems with the kernel.
9. Create a shared folder called "/usr/share/stim" (e.g., via "cd /usr/share; sudo mkdir stim" in Terminal). Run "sudo chmod 777 /usr/share/stim" in Terminal to ensure that you can place files into this folder, and then copy the stimulus code and all subfolders into this folder. Then ensure that this folder and all

subfolders and files give at least read and execute permissions to all users who will need to present stimuli.

- a. To grant such permissions to all users on the system, you should run "sudo chmod -R 755 /usr/share/stim" in Terminal. If users will need to modify these files, then use 777 instead of 755 in that Terminal command.
- b. If you ran the version with 755 because you do not want everyone to be able to modify the files in /usr/share/stim , then you should also run "sudo chown -R root:root /usr/share/stim" to ensure that root is the owner and group to which those files belong.

10. Configure the custom function "dostim2.m" to identify and use the audio card attached to the computer. To do this:

- a. Close MATLAB if it is open, and make sure that the audio card is turned on.
- b. Then open MATLAB using ptb3-matlab and run the Psychtoolbox command "deviceInfo = PsychPortAudio('GetDevices');".
- c. Check the deviceInfo data structure for the name of the audio card according to Psychtoolbox. If you are using the audio card in the equipment list at the beginning of this document, then the name should begin with 'Scarlett 6i6 USB: USB Audio'.
- d. In dostim2.m, set the variable "expectedSoundCardNameMainPart" to a text string that will match a main part of the audio card's name (but no other device names) according to Psychtoolbox. A "main part" is a part that does not refer to a specific USB port or port group (e.g., a main part does not include "hw:2,0" or "hw:1,0"). For the audio card in the equipment list at the beginning of this document, a main part of the name should be 'Scarlett 6i6 USB: USB Audio'.

11. Make another copy of the stimulus code and stimulus files for code development and testing purposes if desired (e.g., in a folder called "/usr/share/stimdev", for use by the "stimdev" user account discussed above).

12. Create a folder called "Scan_Stim_Output" in the "scan" user's home directory.

- a. If also using a separate "stimdev" account, then create a "Testing_Stim_Output" folder in the stimdev user's home directory.

13. Place a symbolic link (shortcut) to the MATLAB launcher onto each user's desktop. For example, for the user with username "scan", this can be done via "sudo ln --symbolic -T /usr/share/applications/matlab.desktop /home/scan/Desktop/MATLAB.desktop" in Terminal.

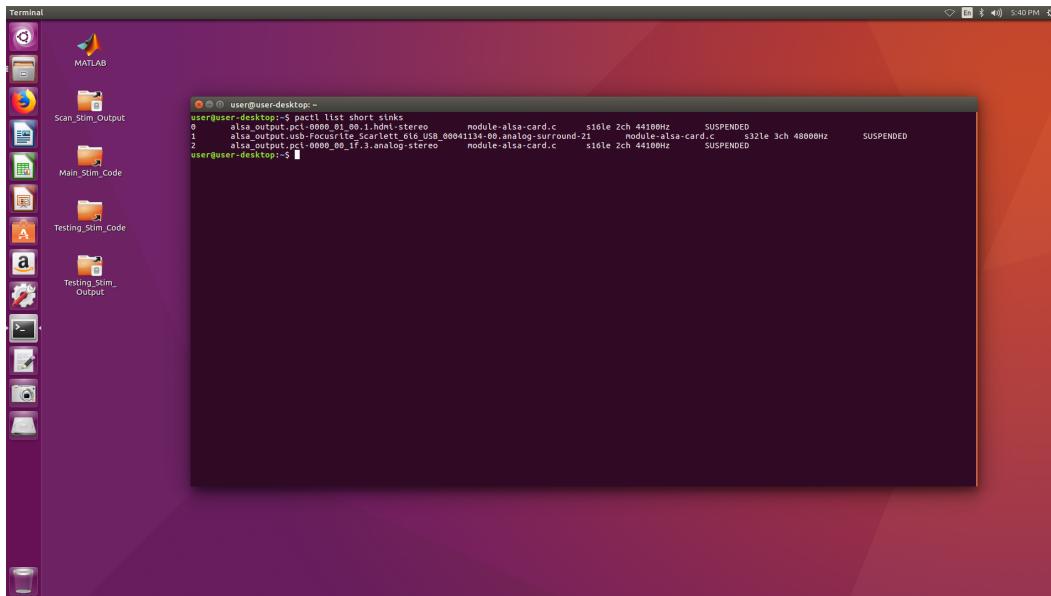
14. Use "sudo ln --symbolic -T" to place additional shortcuts onto each user's desktop as desired. For example, to place a shortcut called "Main_Stim_Code" to the main stimulus code folder "/usr/share/stim" on the "scan" user's desktop, run "sudo ln --symbolic -T /usr/share/stim /home/scan/Desktop/Main_Stim_Code".

15. I recommend going to System Settings > Software & Updates and disabling all automatic updates to avoid situations where a faulty updated version is installed in the background during or immediately before a scheduled imaging session.

16. For each user account (including the administrator account with sudo privileges used for the steps above):

- a. Log in.
- b. If you have not yet started MATLAB in this user account, then start MATLAB (not using ptb3-matlab) so that MATLAB initializes its user-specific files and directories for this user.
- c. Close MATLAB.

- d. Copy the appropriate startup.m file to the location /home/username/Documents/MATLAB/startup.m (replace "username" with username: e.g., /home/scan/Documents... for user "scan").
 - i. The startup.m files can be found in the folder "startup_m_files_MATLAB" in the code package. The administrator account on our stimulus computer is called "user", which corresponds to startup_user.m in the code package.
- e. Check the sound card's PulseAudio name by running "pactl list short sinks" in a Terminal window when the sound card is on and connected to the computer. Then set the variable soundCardNamePortion_PA in startup.m to a text string identical to a main portion of the sound card's PulseAudio name. For the equipment and configuration described in this document, soundCardNamePortion_PA should likely be set to 'Focusrite_Scarlett_6i6_USB'. This is similar to how the dostim2 function must be configured, but this process uses the sound card's PulseAudio name instead of its PsychPortAudio/Psychtoolbox name.



- f. Restart MATLAB and check that the Psychtoolbox script "SimpleMovieDemo" and the custom stimulus presentation functions run correctly.