CBI fMRI Equipment and E-Prime Guide

Getting Started

1. Meet with CBI staff about your experimental needs – the most important questions are:
    A. What tasks do you want to run?
    B. What level of timing precision does your experiment require?
    C. What software environment do you prefer?
    D. What peripheral equipment do you require?
    E. Do you have experience with experiment development in E-Prime or other software environment you want to use? CBI's biomedical engineer can provide technical assistance if needed.
2. CBI's biomedical engineer will set you up with a login/password for the presentation computers.
3. If you want to do general E-Prime development, you can use a computer located in the back of the scanner control room with an E-Prime 2 and E-Prime 3 license. Please schedule the E-Prime computer on Calpendo, since others may want to use it. BACKUP ANYTHING MADE ON THIS COMPUTER! Your E-Prime development files are your own responsibility.
4. If you have never used E-Prime before, there are many resources available:
    A. In E-Prime, there is a "Getting Started Guide" accessible through the help menu.
    B. Youtube has over 100 E-Prime tutorials available for free. The following link will take you to the various playlists (i.e., Basic Topics, Experiment Designs, etc):
       https://www.youtube.com/user/PSTNET/playlists
    C. Psychology Software Tools (PST) now offers Basic E-Prime webinars for FREE! 14-day access to 10 advanced webinars can also be purchased: http://www.pstnet.com/E-Primetraining.cfm
    D. PST also has a very comprehensive support page, with about 50 example programs demonstrating how to do just about every kind of common task in E-Prime. You will need to make an account with them to access everything: http://www.pstnet.com/support/kb.asp
5. Once you have your experiment working, we will need to schedule scanner time to make sure it works with all ancillary systems (button boxes, etc.). There is information below that outlines most of the changes required.
6. **TEST, TEST, TEST!** Validate button responses in your data files, check triggers, timing, audio volume loud enough, audio recording working well, display looks correct, etc.
7. Once you are satisfied with your task, we will need to make a matching functional ep2d MRI sequence on the scanner.
    A. You do not need to account for dummy scans if you use a trigger – the MRI runs a few scans at the start of the sequence, but the data is discarded. It then sends a trigger pulse on the start of the 1st real scan, which will start your experiment.
    B. The most commonly used TR is 2200 ms, because our optimized sequence that minimizes artifacts uses this. Other TRs are possible, but you MUST test your sequences very, very carefully on PEOPLE, not just phantoms, for artifacts.
    C. Once you know your desired TR (ex: 2200 ms) and how long your task takes (ex: 600 s), just divide the task time by the TR (with appropriate units) and round up (ex: 273). This number corresponds to the # of measurements you want in your sequence.
    D. If you want to know more about fMRI on a Tim Trio, you can visit these excellent resources from UC Berkley and Harvard (just ignore the special sequence info):
       http://bic.berkeley.edu/sites/default/files/3T_user_training_FAQ_08Mar2012.doc
       http://cbs.fas.harvard.edu/science/core-facilities/neuroimaging/information-investigators/MRphysicsfaq

8. **TEST, TEST, TEST (again)!** Make sure you are fully satisfied with image data (artifacts, etc.), response data, physio data, timing, etc.

Presentation Computers Data Policies

All users have administrator privileges (required to build/run E-Prime software). Be aware that any changes made (e.g. changing port settings or device drivers) can impact other users! **DO NOT MAKE SYSTEM CHANGES OR INSTALL SOFTWARE WITHOUT CBI PERMISSION!**

USERS ARE RESPONSIBLE FOR BACKING UP THEIR OWN PARADIGMS AND E-PRIME DATA!

CBI makes a nightly backup of E-Prime data files to the research repository. We also periodically make a clone of the entire computer that the E-Prime programs are run from, but this is primarily to preserve system configuration, not individual data files. It is your responsibility to copy/move your E-Prime data files to make sure you have them in the case of a hardware malfunction. If a hard drive crashes and your data files are not on the backup, then there is no chance of recovery; thus, **BACKUP OFTEN!** Information on how to preform backups can be obtained from the CBI information technology staff.

All experiment and data files must be stored on the D: drives of the Presentation computers, NOT on the desktop or C: drive.

Flash drives are physically blocked on the MRI Scanner computer and the old Presentation-1 computer. To transfer files from these computers, see CBI's biomedical engineer or CBI's information technology manager for network drive instructions. You can use flash drives on the other computers.

30 Bee St Presentation Equipment:

1. **Computers:**
    A. **Presentation-0:**
        i. Primary fMRI Presentation Computer
        ii. 2 parallel port PCIe card install – one is for trigger input, TMS firing, and firing of secondary stimulus devices, while the second one is for EEG event marking. Hardware addresses are:
        iii. COM1 port should be used for PST Button Box – connected via Prolific USB-Serial adapter
        iv. COM3 port should be used for MRA button box – also USB-serial adapter
        v. Connected to Black Box Toolkit USB TTL Module – used for Biopac system event marking – address should be COM6.
        vi. Windows 10 Enterprise 64 Bit
            1. Runs E-Prime 2.0.10.356 E-Prime 3.0, MATLAB 2018 B
            2. Hooked up to Projector, Button Boxes, Audio Systems, Eyetracker, Trigger Box, TMS firing, EEG and Biopac event marking.
        vii. Ubuntu Linux 18.04, 64-bit installed in 2nd partition
    B. **Presentation-2:**

   i. Secondary Presentation computer for simultaneous use with Pres-0 or Pres-1 (usually for audio experiments or Turbo Brain Voyager)

   ii. Windows 10 Enterprise 64 Bit

    1. Runs E-Prime 2.0.10.356 E-Prime 3.0, MATLAB 2018 B

   iii. Hooked up to trigger box, Eckert Sensimetrics earbuds, and audio recording.

   iv. NOT hooked up to projector, eyetracker, button boxes, tms, etc

C. Realtime Mac Laptop:
  i. Mac OSX 10.8.5
  ii. Runs MATLAB, Psychtoolbox, MIST and Xcode experiments
  iii. Connected to trigger and PYKA button box by default

D. Eyetracker Host PC:
  i. Used ONLY for Eyetracking (host PC)
  ii. Dual Boot – Eyelink RTOS (for data acquisition) and Windows 7 32 bit (for getting data files)
  iii. ONLY connected to Eyetracker camera and Presentation-0 PC. No network access, all data transfers must happen by USB.

E. Biopac Physio Acquisition Laptop:
  i. Dell
  ii. Hooked up to Ethernet port, crossover cable, USB-ethernet adapter, and power, and license key – no other connections. Network is OK.
  iii. Just used for biopac data acquisition – MP150 system is in rear equipment room, hooked up to Ethernet crossover cable, also trigger from scanner through extender, and parallel port signal through rack from BBTK.

F. Laptop Support:
  i. While we strongly encourage using one of our computers for your experiments (since we support Windows, Mac, and Linux), we also have laptop hookups for the scanner trigger, button boxes, projector, and audio systems if you prefer to run off your own hardware.

2. **Supported Software:**
 A. E-Prime 3
 B. E-Prime 2.0.10.242
 C. Psychtoolbox 3
 D. MATLAB 2018 B
 E. SR Research Experiment Builder / Pylink – for eyetracker
 F. Other software environments can be installed, contact CBI's biomedical engineer if interested.

3. **Supported Coils:**
 A. 32-channel Head Coil (Siemens) – recommended for most new studies due to improved SNR. However, it is a tighter fit for many subjects.
 B. 20-channel Head/Neck Coil (Siemens)
 C. 12-channel TMS Head Coil – for use only when performing TMS in scanner
 D. Spine 32 (Siemens)
 E. Flex Large 4 and Flex Small 4 Coils (Siemens)
 F. Body 18 Coil (Siemens)
 G. Hand/wrist 16 (Siemens)
 H. QED TxRx 15 Channel Knee Coil
 I. For more information on the use of each of these, contact CBI techs (CBItech@musc.edu).

4. **Visual Presentation**:
   A. New MRI-compatible **Hyperion Projector** from Psychology Software Tools. There is also custom mirror projection.
   B. Uses DVI input
   C. **Requires a minimum resolution of 800 x 600 for E-Prime display**
   D. Can support up to 1920 x 1080 images
   E. Controlled by **ConnectPro KVM switch** located in rack above console. Use remote or buttons on front of switch to change computer input to Pres-0, Pres-1, Mac, or Laptop computers.
5. **Audio Presentation**:
   A. **3 Audio Systems:**
      i. Avotec Headphones Earbuds and Microphone. This system is used with most studies except those focused on Auditory.
      ii. **Standard Siemens Intercom** – This can be used to communicate with subjects with all head coils. However, subjects may have a more difficult time hearing with this system than the Avotec system.
      iii. **Sensimetrics S14 Earbuds –** Owned and used by Dr. Mark Eckert's Lab. Please contact him to inquire about the use of this equipment. These will fit in any headcoil and requires a special audio amplifier and transformer. This system offers exceptional sound quality but requires extra time and expertise to set up.
   B. **Audio Control Box –** Audio system selection is controlled by a box at the front of the scanner console. Hit the buttons to select the computer you are playing audio from (Pres-0, Pres-1, Mac, or Laptop) and move the audio jacks to select your audio system.
6. **Audio Recording:**
   A. **Resonance Technology Serene Sound Headphones** – they have a microphone attached (make sure it is very close to the subject's mouth). Can be used with either Presentation-0 or Presentation-2 computer for recording in E-Prime or Audacity. Make sure Recording Volume is at 60 minimum.
7. **Handpad Response:**
   A. **3 Button Box Systems:**
      i. **CURDES fORP 932 interface and Pyka handpad –** Owned and supported by CBI. Primary interface is a 5 button grip style handpad to be used in either the left or right hand. This is what most groups currently use. Other labs have peripherals that work with the 932 interface, including a 2 button box, a joystick and grip force dynamometers.
      ii. **MRA fMRI Button Box –** Owned by Jane Joseph's lab, includes individual, single finger button boxes. Great for use with kids or individuals with small hands that PST box does not work with.
      iii. **Psychology Software Tools (PST) / Brainlogics Fiberoptic BRU –** Owned by CBI, offers left and right handpads for making button responses. This is used to be the most used handpads but the company no longer supports these so we are encouraging all groups to move to the PYKA handpad (#1 above) as we will not be able to fix it when it breaks. Realize that it has 2 possible outputs – Serial and USB. 99% of groups use the serial output (COM1) due to better latency (~3ms). Laptop and Mac users must use the USB (HID) output, which has worse latency (~50ms) but works. Contact CBI's biomedical engineer for details.

8. **Trigger Boxes:**
   A. **3 peripheral devices:**

i. **PYKA** - The primary trigger box is located in the scanner console rack. This box send out the letter "t" for TTL triggering and is connected to the computer monitor switch.
        ii. **Trigger Box –** The legacy trigger box is located in the scanner console rack, and has 5 BNC connectors on it. 2 are for E-Prime specific TTL outputs, 2 are for general TTL outputs, and 1 is for the trigger simulator box. This box is connected to the Presentation-0 and 2 computers via the parallel port.
        iii. **Trigger Simulator –** This is located in a box on the racks in the console room – used for testing stimulus program without having to run the scanner to generate triggers.
9. **Eyetracking:**
    A. **SR Research Eyelink 1000 –** MRI-compatible eyetracking system, works extremely well for adults, more difficult for populations with smaller heads, like children. Uses custom front surface mirrors that mount onto the 32 or 12 channel head coils and interfaces with Presentation-0 display computer (Windows or Linux).
10. **TMS:**
    A. **Magstim Super Rapid 2 TMS Stimulator –**Adapted to work in the MRI environment via a filter and special coil backing. Firing controlled by E-Prime from Pres-0 computer.
11. **Olfactometer:**
    A. **Emerging Tech Trans (ETT) Olfactometer –** Owned by Bernadette Cortese, used for olfactory stimulus in MRI.
12. **MRI Goggles:**
    A. **Cambridge Research Systems Medigoggles (2 sets) –** These are MRI-compatible goggles with push-in lenses so people that normally use glasses can see in the MRI. We have 1 set for adults and 1 set for children.
13. **Mock Scanner:**
    A. **Custom Made –** Mock scanner was custom made by local contractor, and matches bore dimensions of real scanner. You can use it to test subjects for claustrophobia (or see if they'll fit in the bore), or pre-run tasks to improve performance in the scanner.
14. **Physiological Monitoring:**
    A. **MRI-compatible physio system used to record heart rate, respiration, 3 lead ECG and EDA data. This is the most used physio system on the scanner.**
    B. **Medrad Veris 8600 –** MRI-compatible physio monitor, can measure SPO2. Wireless receiver box (Millenia) is NOT MRI-compatible and stays just inside MRI room (as far away from scanner as possible). Only used for monitoring patients (primarily babies), NOT for recording data.
    C. **Siemens Wireless Physio Monitors –** Physio monitors that came with the Siemens MRI console. Support 3 lead EKG, pulse, and respiratory effort monitoring (chest strap). By default, data is **NOT** recorded, but can be. See CBI's biomedical engineer for details.

How to Setup Your E-Prime Experiments for use on MRI Presentation Computers
(Note that File Paths in E-Prime use '/' NOT '\'!!)
(Also, to terminate your experiment while running, hit ctrl-alt-shift, NOT ctrl-alt-del!!)

1. **Setting Display Resolution:**

a. You can set your experiment display resolution in E-Prime by double clicking on **"Experiment"** at the root of the tree in the "Structure" window in Estudio. Then double click on **"display"** and change your **"width"** and **"height"** to what you want (see below). Leave all other parameters at the default settings.
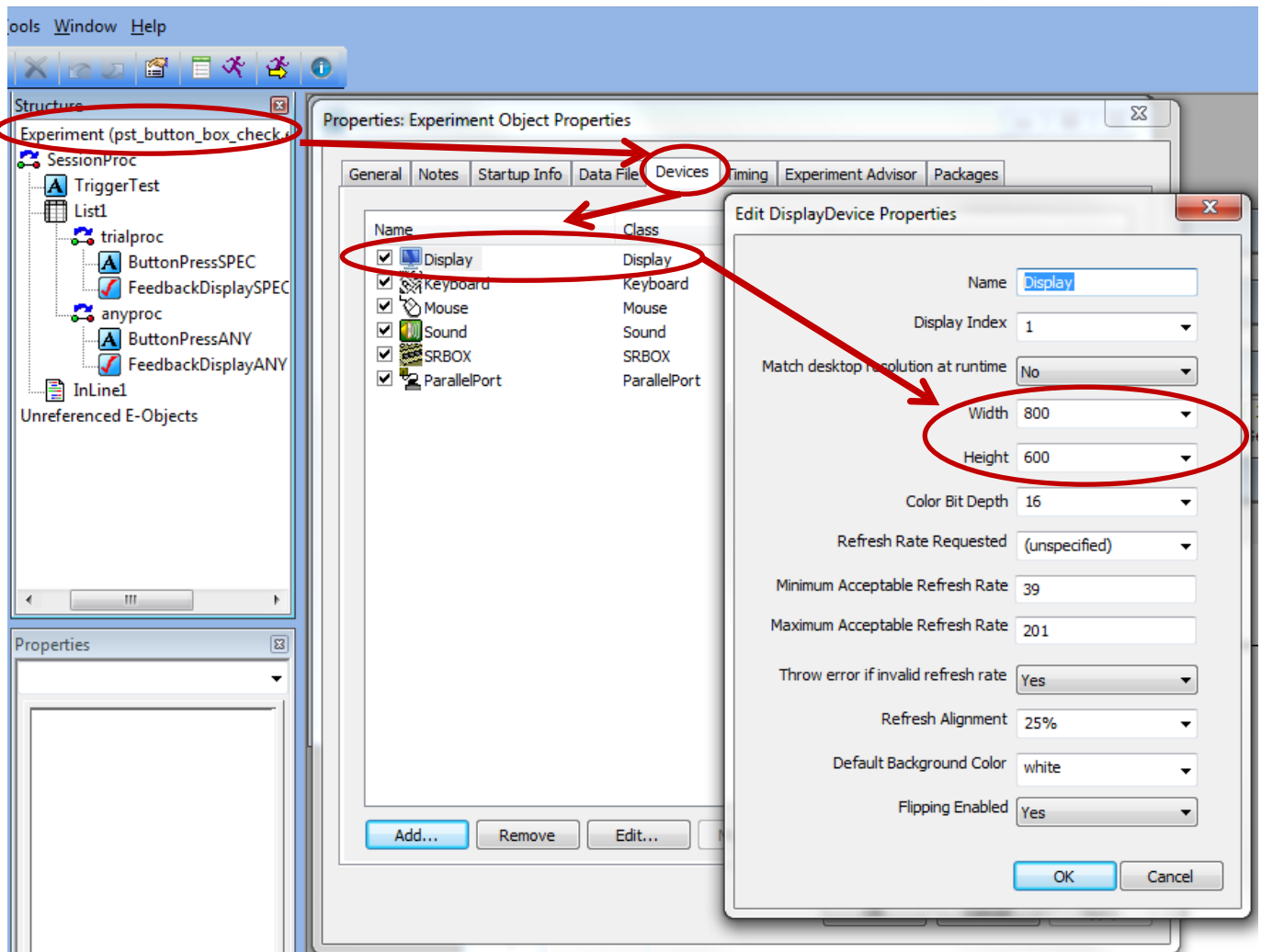

b. **The Screens on the Presentation computers will NOT support display resolutions below 800 x 600.** If you try to run an E-Prime experiment below that resolution, you will likely get a timing error.

c. The Projector / Screens will support up to 1920 x 1080 resolutions. Make sure that your images are scaled appropriately for your display resolution. If you have a bunch of pictures that are 600 x 400 resolution and you set your E-Prime display to 1920 x 1080, the pictures will appear VERY small (because you are only occupying a small section of the screen). Conversely, if you have images that are 800 x 600 and you set your E-Prime display resolution to 800 x 600, the images will appear to take up the entire screen. So the size of your images matter!

2. **Triggering From the Scanner**
   a. Triggers are sent from the MRI scanner at the start of each image acquisition (i.e., TR interval) via a fiber optic wire to the trigger box. Most people use this to start their experiments (that way it is not necessary to worry about dummy images at the start of scans). This method will

be described below. Some people will also "lock" their experimental phases to each scanner TR – if you want to do this, talk to CBI's biomedical engineer.

b. Every time the trigger box receives a pulse, the RED LED on it will blink.

c. To enable triggers on Pres-0 and 2 (NOT PRES 1), double click on **"Experiment"** under the "Structure" window in E-Prime. Click on the **"Devices"** tab and **"Add…"** at the bottom. Select **"ParallelPort"** by double clicking on it, and edit the properties to match the image below EXACTLY. Then click OK, and APPLY.
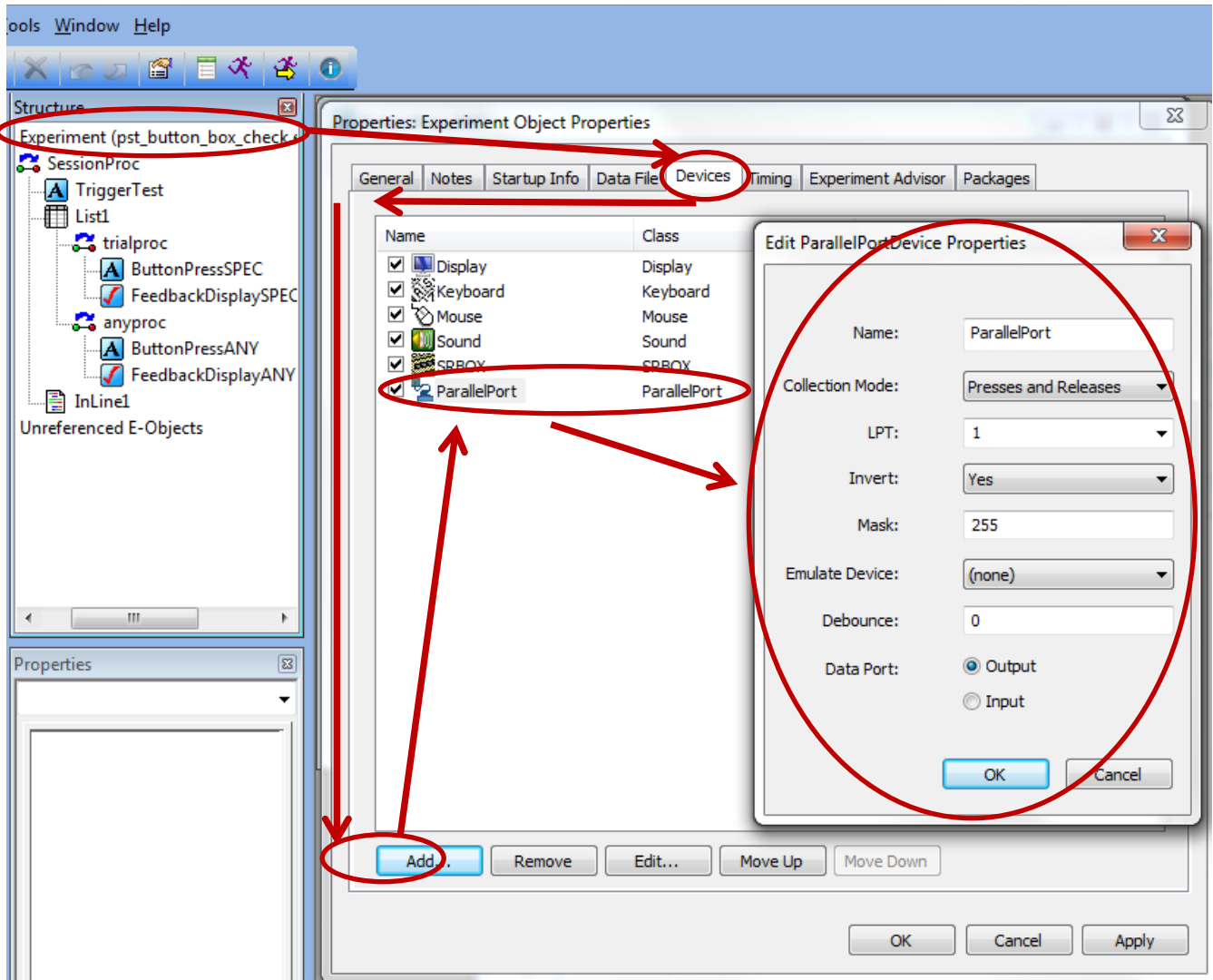
d. Next you will need to create a slide in E-Prime that will only terminate when it receives a trigger pulse. You will use this slide to start your experiment.

e. In the image below, there is a slide called **"TriggerTest"** at the beginning of my experiment. Open up your slide by double clicking on it, then click on the **"Properties Page"** icon. Go to the **"Duration / Input"** tab and set
   i. Duration: (infinite)
   ii. Under **"Input Masks"** click **"Add"** and add **"ParallelPort"** and also **"Keyboard."**
   iii. After adding, click on ParallelPort and edit the Response Options on the right side.
   iv. Change **"Allowable"** to **{ANY}** and **"Time Limit"** to **(same as duration)** and **"End Action"** to **Terminate**

v. Finally, click on "Keyboard" under Devices and set "Allowable" to {F6}. This allows you to manually trigger by pressing the F6 key on the keyboard for testing purposes.
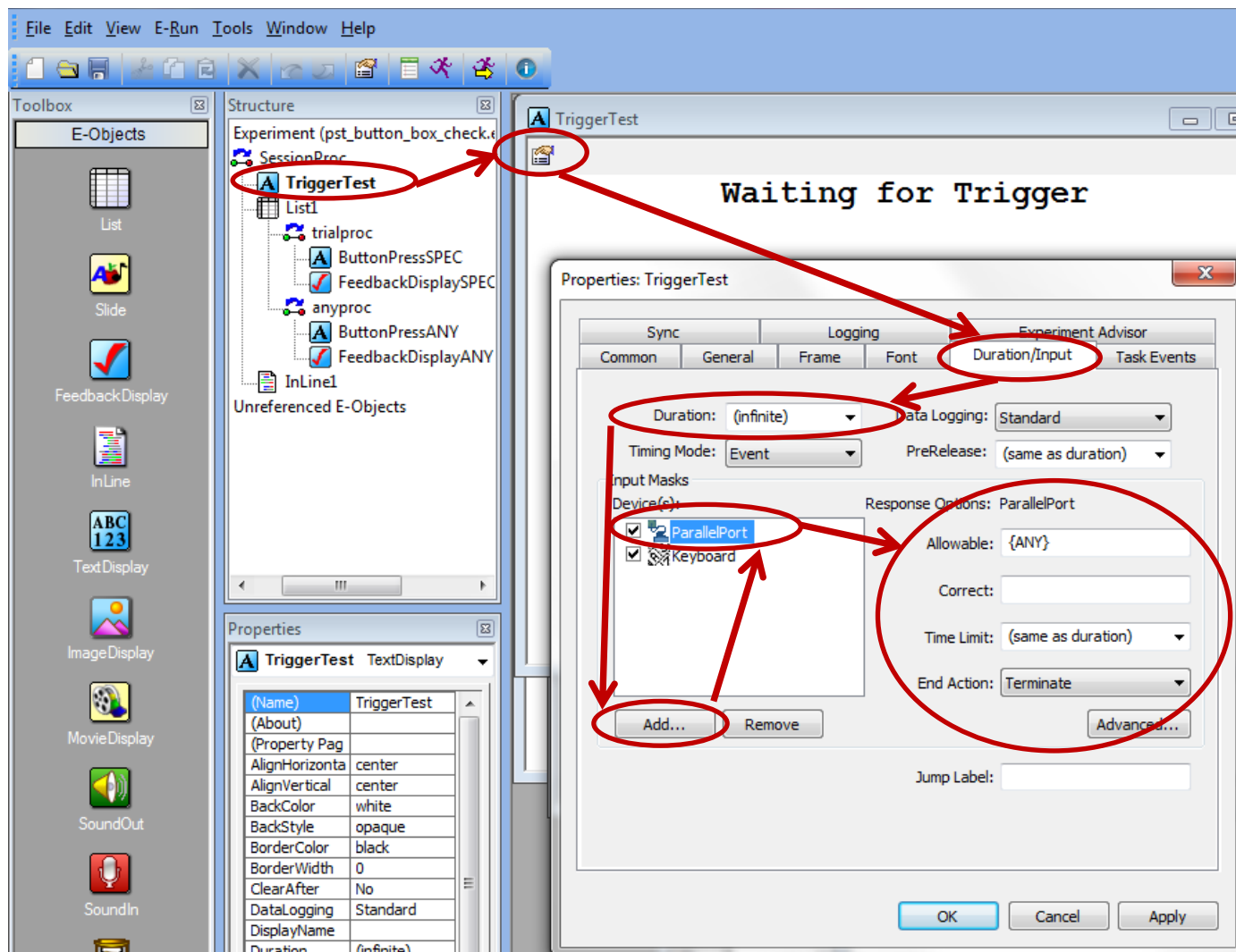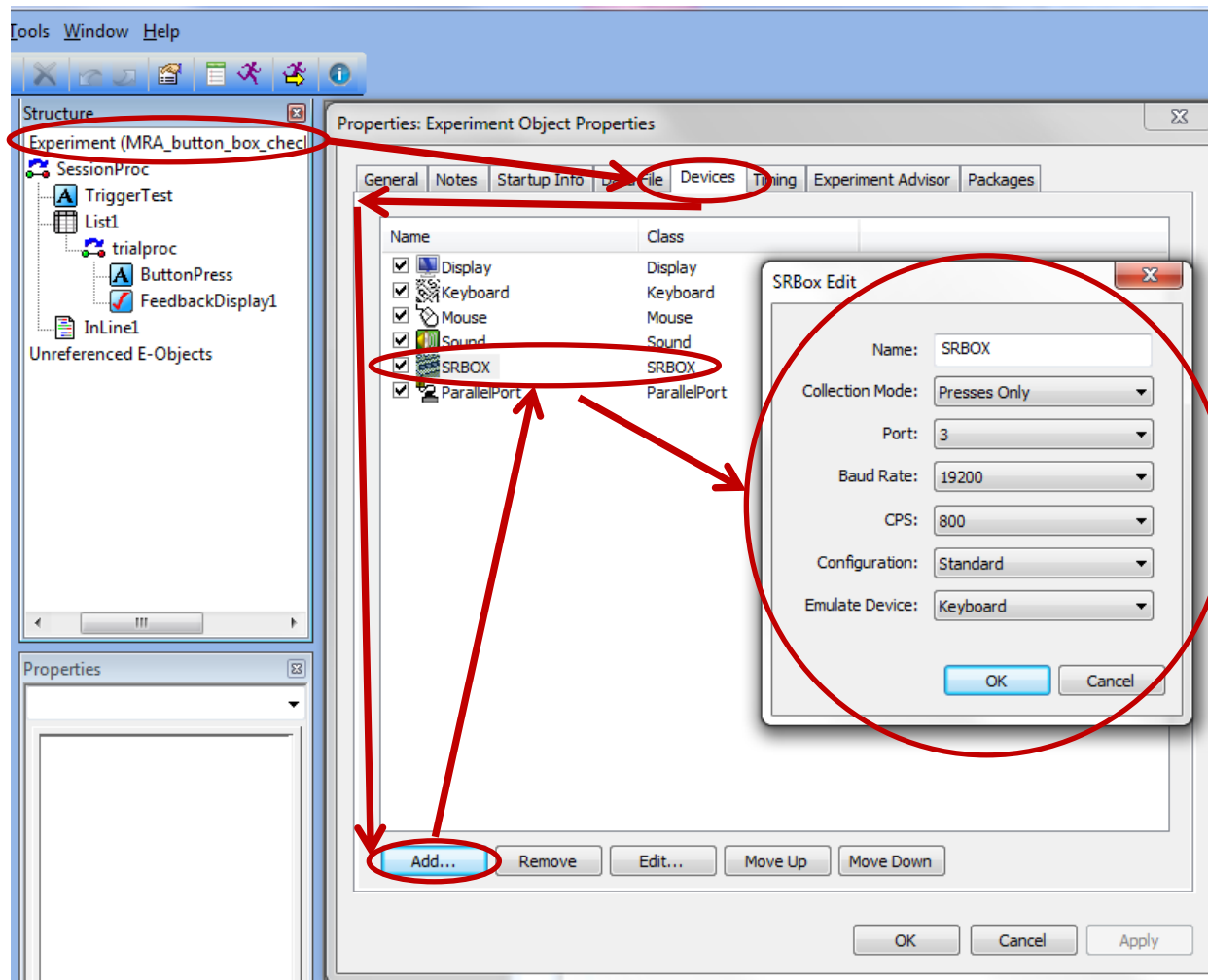

3. **Setting Up Button Boxes**

a. **CURDES fORP Button Box (Pyka handpad)**
   i. Using this device with E-Prime does not require any special setup – it is recognized as just another keyboard, so as long as you have the default E-Prime keyboard set up on the devices tab, it will work.
   ii. Change the "Allowable" field in the to the buttons users will be pressing during the experiment. This box is mapped as (pinky to thumb) 1,2,3,4,5 and triggers are sent as the letter 't'
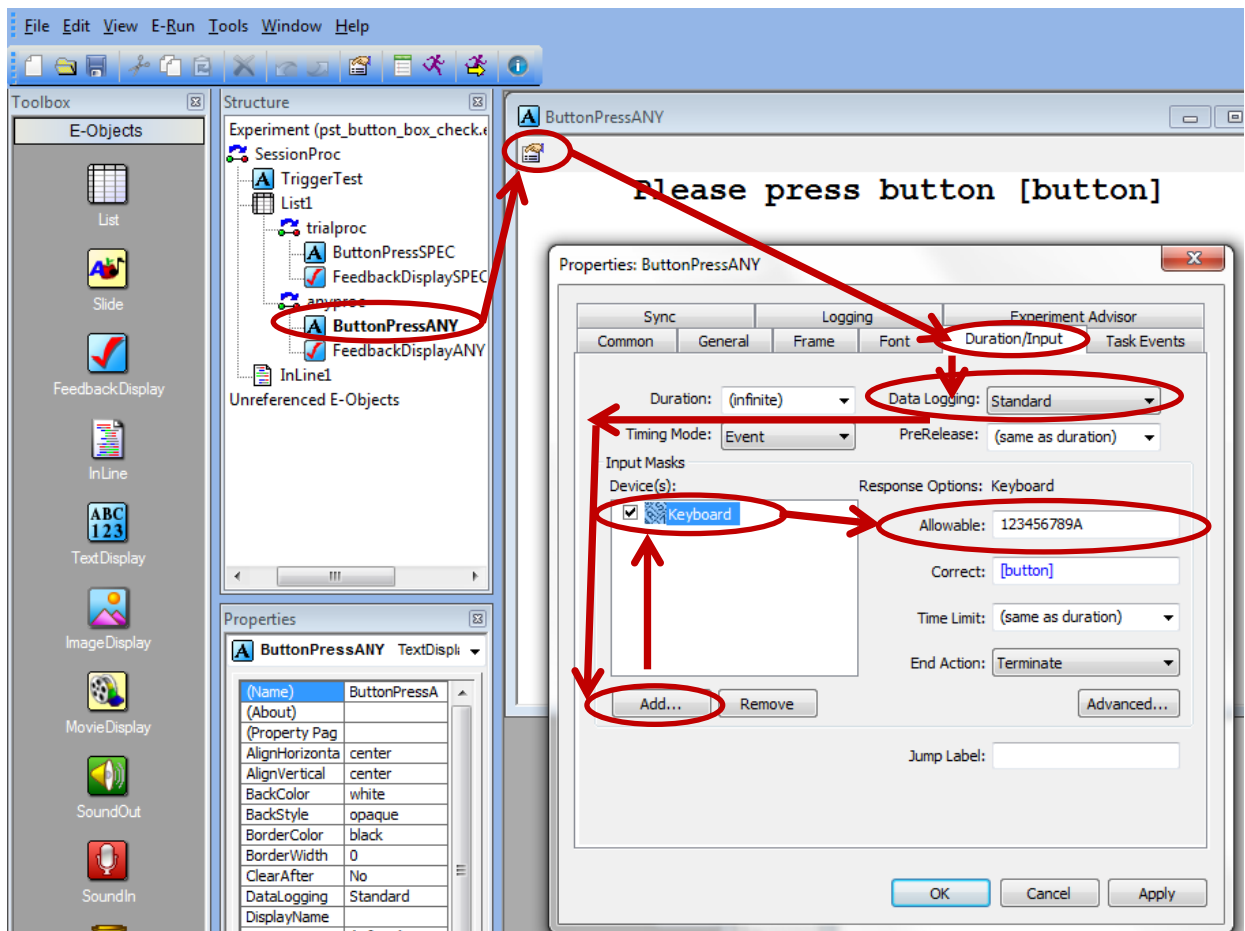
b. **MRA Button Box**
   i. This button box is owned by Jane Joseph and is more commonly used for children (since individual boxes can detached from each other, making it easy to size to small hands). Setup is the same as for the PST Button Box (see image below), except that:
      1. **Port** is set to **3**
      2. **Configuration** is set to **Standard**
   ii. Each individual box is mapped as 1,2,3,4,5

c. **Setting up slide for button response logging (works for PST, MRA, and fORP boxes)**

    i. After setting up your device properties, go to the slide in your experiment you would like to log button presses on, then open it up, and click on the "Properties Page" icon in the top left corner.

    ii. Go to the "Duration/Input" tab and click "Add" under "Input Masks." Add a keyboard device.

    iii. Change the "Allowable" field to the buttons users will be pressing during the experiment. If this is the PST box, it will be 123456789A, as shown below, all strung together. If it is the MRA or fORP boxes, it will just be 12345 all strung together.

iv. I **DO NOT** RECOMMEND PUTTING {ANY} IN THE ALLOWABLE FIELD FOR THE KEYBOARD! IT IS MUCH BETTER IF YOU JUST PUT THE BUTTONS THE BUTTON BOX CAN PRODUCE / YOU ARE INTERESTED IN.
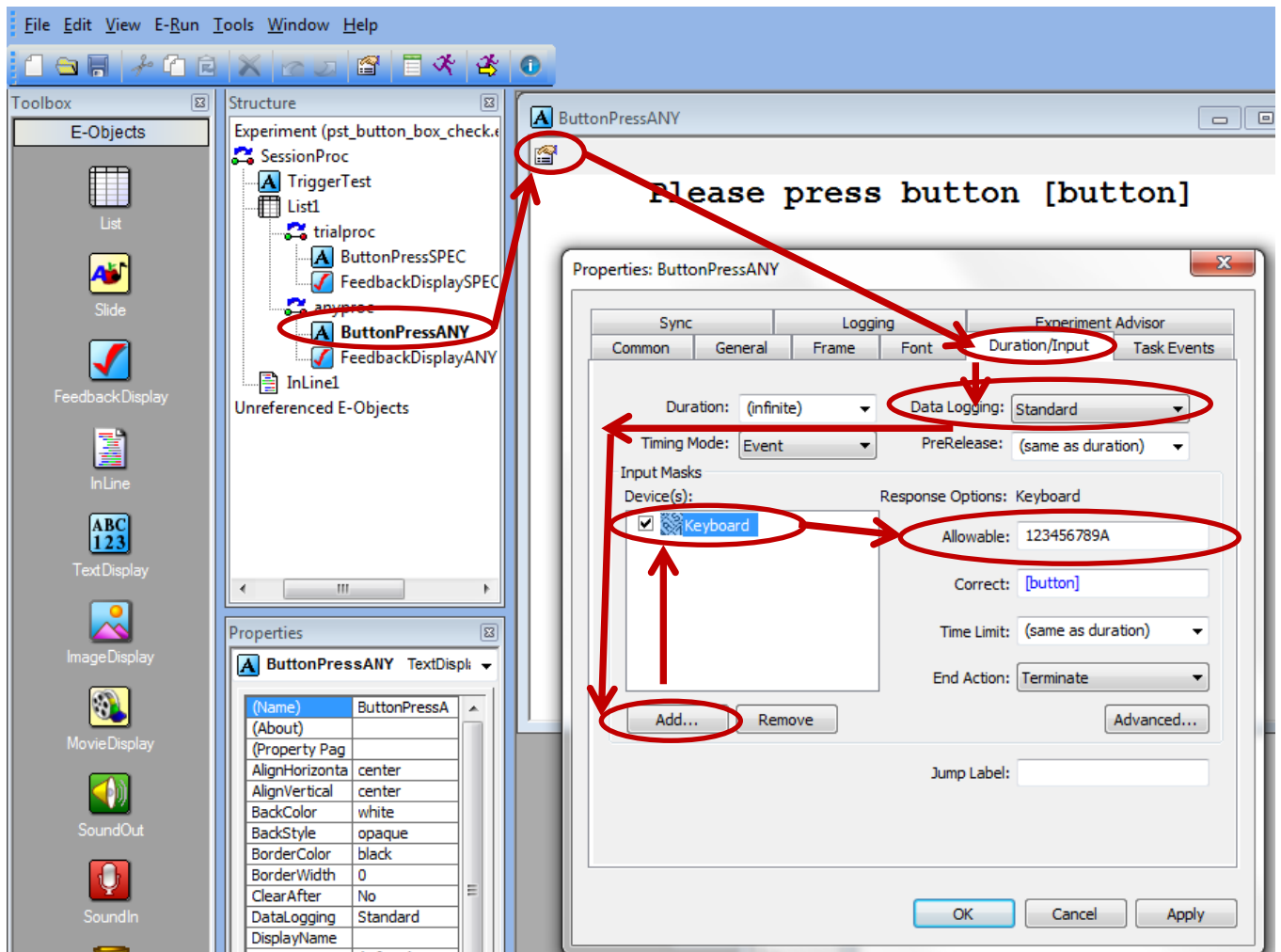
v. Make sure to set **"Data Logging"** to **STANDARD!** The default is NONE, and if you leave it on that, it will LOG NOTHING!!

vi. You can set your duration to whatever you need, and most people will change the **"End Action"** field to **"Nothing"** rather than "Terminate" but it depends on what you want to do. Ask CBI's biomedical engineer for tips.
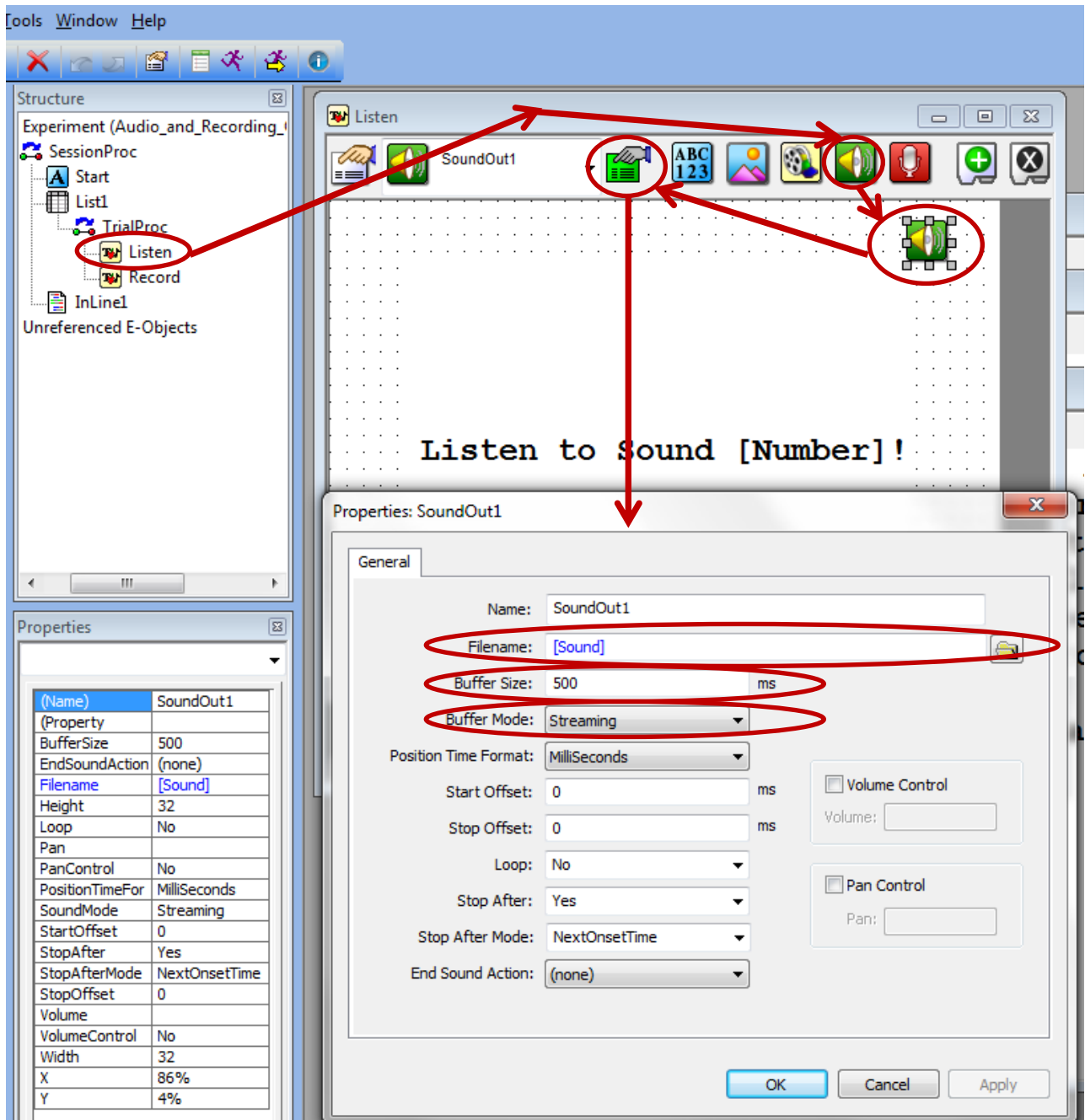
4. **Setting up Audio Output**

a. Audio setup requires proper setting of the audio switch (mentioned above) to the computer you are using, and the headphone system you are using. Most users just use the Siemens pneumatic headphones for the 12 or 32 channel headcoil.
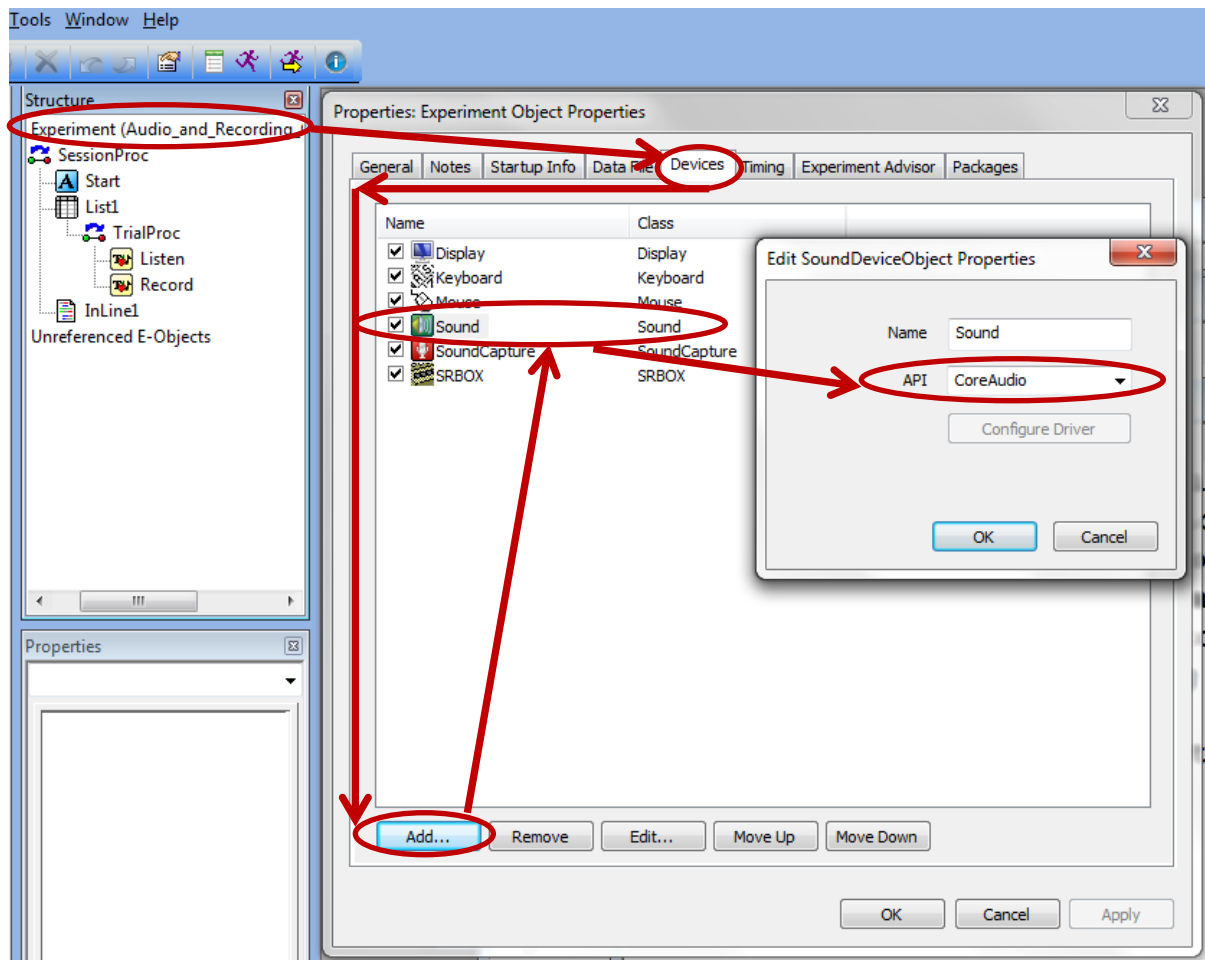
b. The most important part of setting up audio in E-Prime is making sure you choose the correct API. The recommended choice is "CoreAudio." You can change this by double clicking on "Experiment" again and going to the "Devices" tab and double clicking on the "Sound" object and changing the API. Then hit OK and Apply. This setting will minimize your sound latency.

c. Setting up Audio Output on Slide

i. On a normal slide object, add a "SoundOut" object and open up its property page by clicking on the green property page button at the top.
ii. Select the file name or set an attribute for what you want played.

iii. Next set your mode to streaming – in this mode, there is no need to worry much about your buffer size, but you can set it to 500.
iv. You can leave the other options as default unless you want to use special features.

5. Setting up Audio Recording

a. Audio is recorded through the ASUS Xonar D2X Soundcard. You need to make sure this is selected as the default recording device in windows. Verify this by going to Control Panel → Sound → Recording Tab → Verify ASUS Xonar is the device with a green checkmark next to it. The input used is "Line In."

b. To setup recording in E-Prime, you need to add a SoundCapture device on your devices tab. The default settings should be fine.
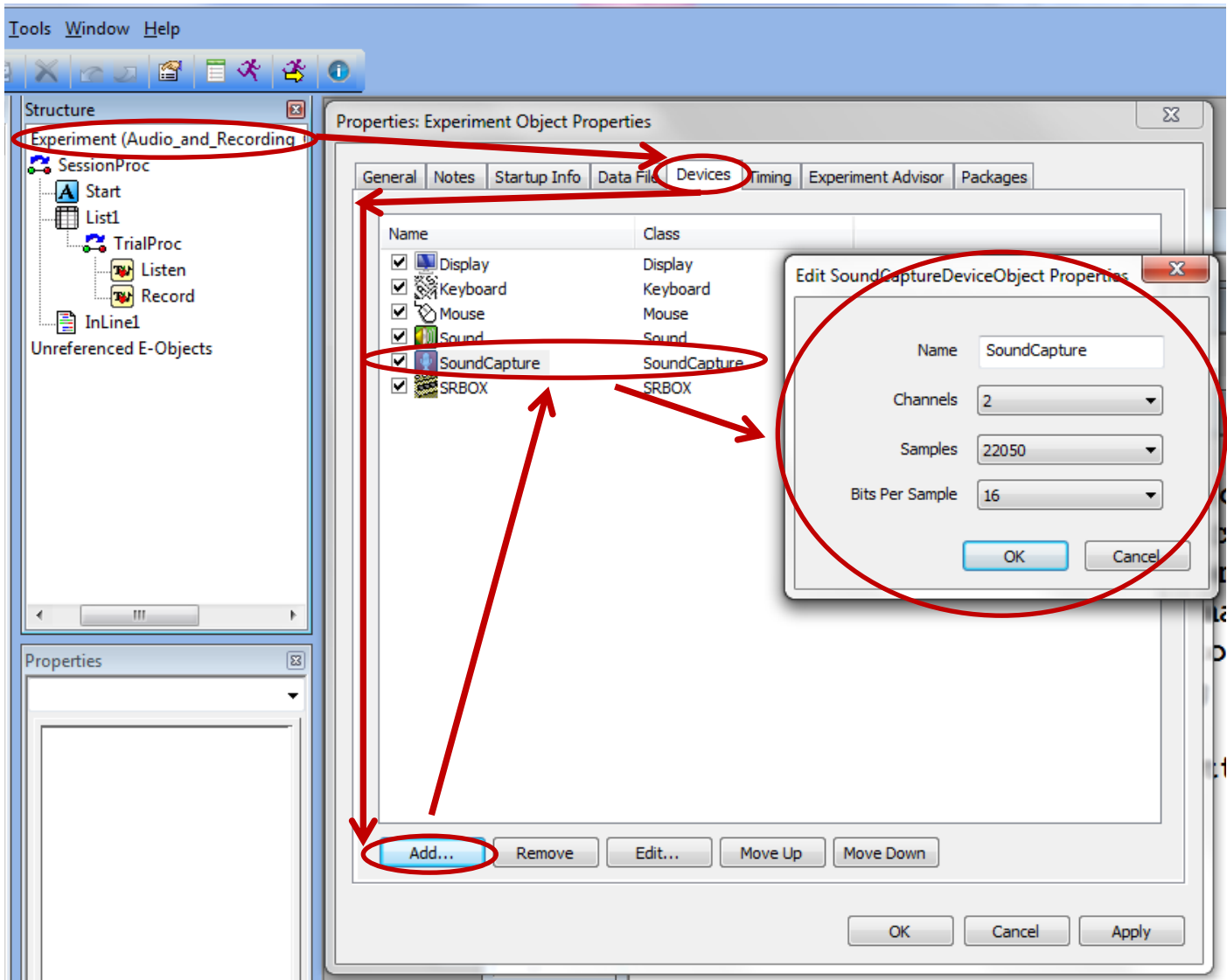
c. To setup audio recording on your slide, you will need to add a "SoundOut" object to the slide (by dragging), which is a red button with a microphone. Select it, then hit the green properties button with the pointer finger. Here you can specify where your audio recordings get saved (@Auto just means they will be saved in the same directory as your E-Prime file). Buffer size is the length of your recording. You can leave the rest the same.
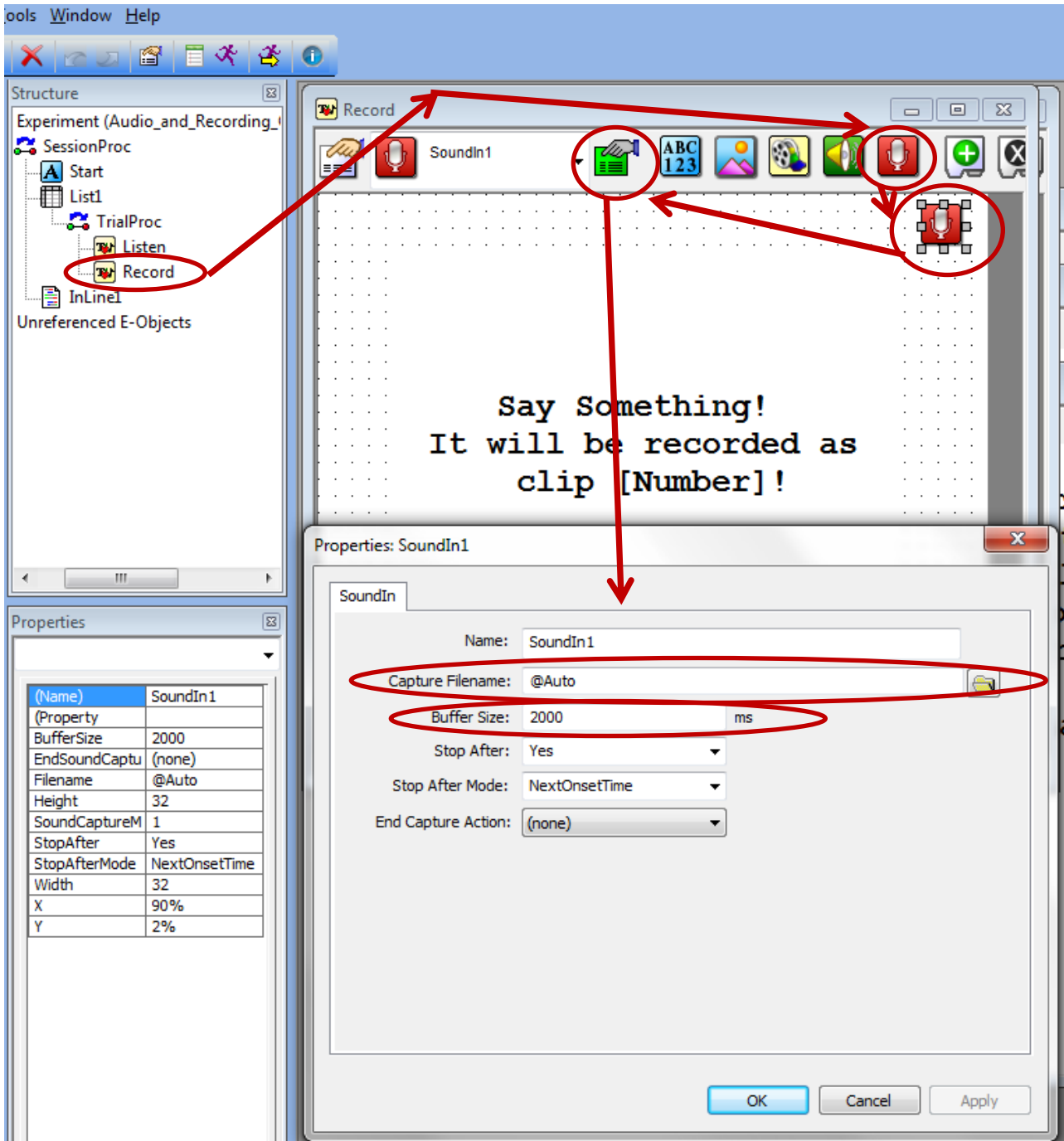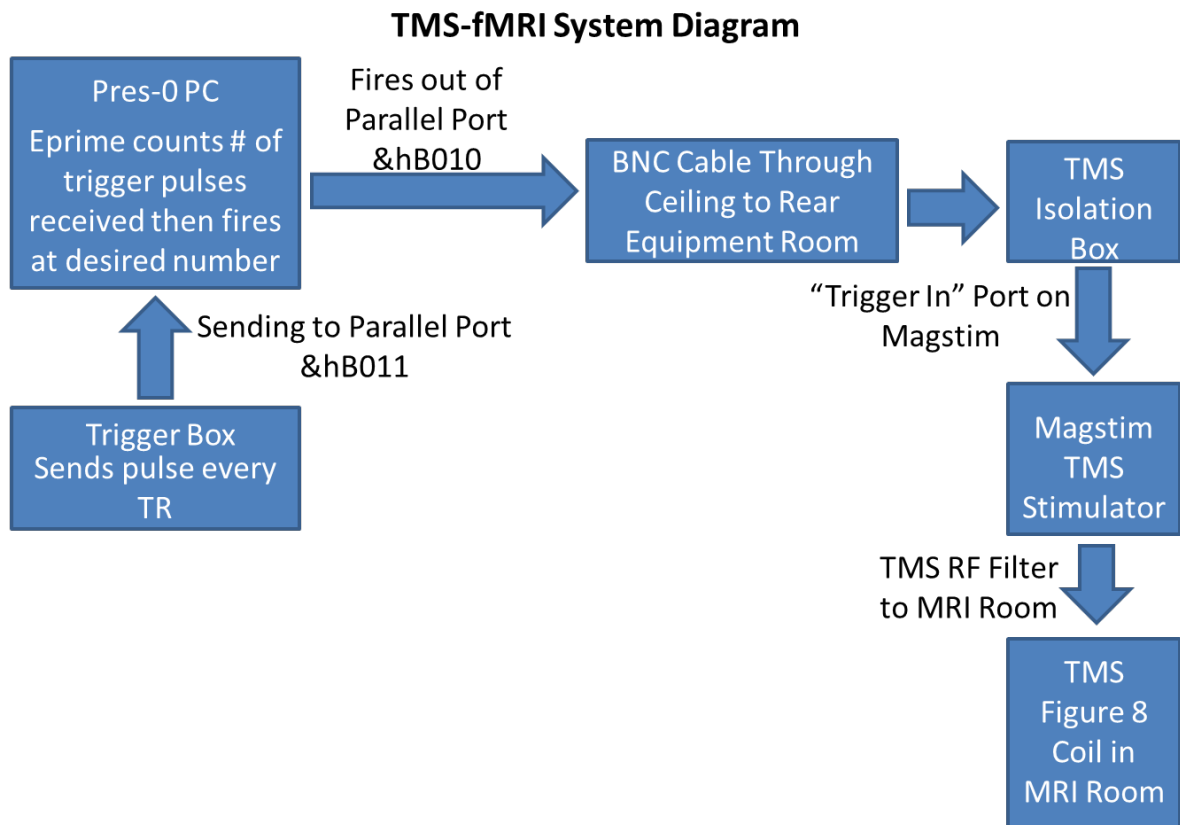
d. Finally, you will need to make sure that your sound recording buffer size, and the duration of your slide are agreeable. For example, a buffer size of 2000 ms with a slide duration of 1000 ms will cause an error. Make sure your prerelease is NOT set to "same as duration"; otherwise you will have problems. Just set it to 100 ms, which should be fine.

6. **Setting up TMS Firing**
   a. TMS firing is controlled via E-Prime from the presentation computers. Currently Presentation-0 is the computer used to fire the TMS (Presentation-1 was used in the past, but has been phased out for TMS).
   b. A typical TMS-fMRI experiment will have the subject receive TMS at a specific TR interval, and sometimes at a specific frequency. The fastest frequency used to date is 7Hz stimulation. E-Prime will count the # of TRs that have elapsed in the experiment (via parallel port &hB011), and when this matches your predefined # of TRs interval, it will send a trigger pulse through parallel port &hB010 to fire the TMS. Most TMS experiments want to fire the TMS 100 ms prior to the next TR, so here is a typical example:
      i. I want to fire the TMS every 4 TRs, and my sequence has a TR of 2200 ms. In this case, E-Prime would count the 4 TRs, and wait for 2100 ms (100 ms prior to next TR), then fire the pulse. This is to minimize image artifacts and also ensure correct observation of the TMS effect in the MRI data.
   c. Once E-Prime fires through the parallel port, the signal is passed along a BNC cable through the ceiling to the rear equipment room where the Magstim Rapid Stimulator sits.
   d. This signal is fed into a custom "TMS Isolation Box" that prevents back propagation of signal along the BNC cable. This allows for use of % outputs up to 100%. However, in practice, the **MAXIMUM % output that should be used is 95%.** Anything higher than that puts a lot of stress on the TMS coil. **Make sure the isolation box is turned ON (GREEN LED ON)!**
   e. The isolation box passes the firing pulse to the Magstim TMS stimulator through a BNC port on the back. The Magstim fires, sending the pulse through a RF filter into the figure 8 coil inside the MRI room. See a system diagram below:

TMS-fMRI System Diagram

Pres-0 PC
Eprime counts # of trigger pulses received then fires at desired number

Fires out of Parallel Port &hB010

Sending to Parallel Port &hB011

Trigger Box
Sends pulse every TR

BNC Cable Through Ceiling to Rear Equipment Room

TMS Isolation Box

"Trigger In" Port on Magstim

Magstim TMS Stimulator

TMS RF Filter to MRI Room

TMS Figure 8 Coil in MRI Room

f. For practical purposes, most users only need to modify the timing of the TMS firing. To do this, obtain a working copy of the TMS firing program from CBI's biomedical engineer. There is a part of the experiment called "TriggerList" – the 2 parameters that you want to change are:

    i. **"Time_from_TROnset_to_TMS_Trigger_millisec"** – much like the name says, this specifies the delay from the time of the desired TR, to when the pulse is actually fired. Generally this number is your sequence's TR – 100ms.

    ii. **"TR_number"** – the desired TR during which you want to fire the TMS. Some people use equal spacing (every 3 TRs) and others vary it (as shown below).

ID	Weight	Nested	Procedure	Time_from_TROnset_to_TMS_Trigger_millisec	TR_number
1	1		TrialProc	2400	5
2	1		TrialProc	2400	10
3	1		TrialProc	2400	14
4	1		TrialProc	2400	20
5	1		TrialProc	2400	24
6	1		TrialProc	2400	29
7	1		TrialProc	2400	34
8	1		TrialProc	2400	39
9	1		TrialProc	2400	43
10	1		TrialProc	2400	49
11	1		TrialProc	2400	55
12	1		TrialProc	2400	59
13	1		TrialProc	2400	65
14	1		TrialProc	2400	69
15	1		TrialProc	2400	74
16	1		TrialProc	2400	78
17	1		TrialProc	2400	83
18	1		TrialProc	2400	89
19	1		TrialProc	2400	95
20	1		TrialProc	2400	100

    iii. You can run TMS at higher frequencies by having the same TR_number in multiple list entries, with different "Time_from_TROnsets." So, for instance, if you want a train of 5 TMS pulses at 10 Hz that occurs 2 seconds after the onset of image acquisition (or TR), your times would be: 2000, 2010, 2020, 2030, and 2040 ms (all with the same TR_number entry). 20 Hz would of course be 2000, 2005, 2010, 2015, 2020 ms.

g. **Known Issues and Solutions for TMS-fMRI System (ask CBI's biomedical engineer for full documentation of each):**

    i. At one time, when the TMS fired about 8 or 9 times and the scanner was running, we'd get a "Table Stop Error" from the scanner, which would stop the sequence. This would happen whether the TMS coil was inside or outside the room. We discovered the problem was back-propagation along the BNC trigger cable from the E-Prime computer. We added an isolation box (which is just a circuit with an opto-isolation chip in it) to fix this problem.

    ii. The TMS unit used to disarm itself when the scanner was shimming (and sometimes it would disarm randomly). This is due to back-propagation of signals through the TMS coil and cable to the stimulator, causing it to shut off. We discovered that by providing an extra path to ground on the cable going from the TMS stimulator to the RF filter, we could effectively stop this disarming behavior. To implement this, we created an aluminum foil shield, grounded to the RF filter around that cable.

    iii. There are known image artifacts that appear when performing TMS in the scanner. Right now everyone just lives with these.