tDCS MATLAB Stimuli Instructions/Help

(These stimuli were written by Ethan Duwell, PhD in 2022

while he was a postdoc in Adam Greenberg’s Lab at MCW)

Latest Update: 12/28/22

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1. Open MATLAB
2. Navigate to the “tDCS\_stim\_MATLAB” directory
3. There should be 3 subdirectories titled matlab, images, and data\_master.

Enter the “matlab” subdirectory (this is where the matlab code lives..).

Your MATLAB window should look something like this:

(absolute path will vary machine based on where the tDCS\_stim\_MATLAB directory installed.. this is what it looks like on my machine..)

Graphical user interface, text, application, email

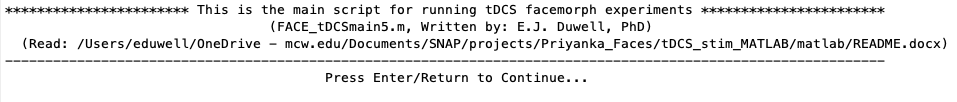
Description automatically generated

1. To run any of the 3 task versions, you begin by typing “FACE\_tDCSmain5” in the command window:Graphical user interface, application, Word

   Description automatically generated

Then, press enter to begin. (To keep things simple, I made it such that is the only command you should need to enter. Everything else from here on out will simply be responding to the prompts on the command line..)

1. You will then be greeted by a welcome screen that should look something like this:



Press Enter/Return to continue as prompted in the command window.

**NOTE:** the file path after “Read:” should be the location of this instructions file (README.docx) on your computer. This was included such that you can readily locate these instructions if needed..

1. You will then be prompted to select which of the 3 stimulus versions you would like to run (QUEST, Training, or Assessment):

Text

Description automatically generated

Enter the number corresponding to the task version you wish to run as prompted (1 for QUEST, 2 for training, or 3 for assessment). Then hit enter/return.

**NOTE:** the ‘training’ and ‘assessment’ versions of the task require that you run QUEST first..

1. As noted above, you will need to run QUEST on each subject prior to running the ‘training’ and ‘assessment’ versions as these use the output from the initial QUEST session to set parameters various parameters according to subject specific accuracy thresholds measured in that session.

That said, as steps 1-6 are the same for all three tasks, I will now list the instructions for running each below:

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Version-Specific Stimulus Instructions

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**QUEST Version:**

… (after completing 1-7 above)

1. After typing “1” and pressing enter in step 6 (above), you should receive a confirmation message saying “… Running the QUEST version.” Followed by a prompt saying:

“Press Enter/Return to Continue”

Press enter/return as prompted to continue.

1. After pressing Enter/Return, the command line will prompt you to enter the subject’s 3-letter ID/initials:

Graphical user interface, text

Description automatically generated

These can be the subject’s actual initials if you wish or any other 3-digit ID code. However, *make sure that they are unique for each subject/do not repeat the same digits on different subjects!* Also, *make sure you continue using this same 3-digit ID for subsequent “Training” and “Assessment” versions!*

Type the subject’s unique 3-digit ID and then press return/enter.

1. The command prompt will then ask you whether you want to run “practice trials” prior to the real session:

Graphical user interface

Description automatically generated with medium confidence

If you type “y”, the stimulus will provide the subject with instructions and a few practice trials before the real QUEST session begins. (You will probably always want to say yes, as this is the first task each subject does.. However, I provided the ability to choose y/n just in case..)

If you type “n”, the instructions and practice trials will not be included.

(let’s assume you pressed “y”…)

1. After making the selection above and hitting return/enter the command prompt will announce how many blocks/repetitions of the QUEST procedure will be run:

Text

Description automatically generated

The default is currently set to 1 block. As pictured above, it will ask you if this is OK. If so, press ‘y’ and then enter/return. (This is probably what you will want to run..)

However, if you want to run more than 1, repetition of the initial QUEST, you can type ‘n’. It will then ask how many reps you want to run, at which point you can type the number of reps you want to run. (You probably won’t want to do this).

**NOTE:** If you do run multiple initial QUEST blocks as described above, the subsequent training and assessment versions of the task will use an average psychometric curve fit from across the separate reps/blocks to compute the relevant thresholds.

1. After selecting ‘y’ and pressing enter/return, the instructions/practice session should begin. The display monitor will be taken over by psychtoolbox, and after a minute or two the following instruction screen should appear:

Graphical user interface, text, application

Description automatically generated

After reading, the subject must press enter/return to continue, as prompted.

1. Next, a screen displaying examples of human/ape face-morphs should appear:

A picture containing diagram

Description automatically generated

After viewing, the subject can press enter/return to continue as prompted.

1. Finally, an instruction page will appear explaining the button presses/how to do the task:

Text, letter

Description automatically generated

After the subject reads the instructions/understands the task, they can press enter/return to continue as prompted.

1. After the subject presses enter/return, the practice trials should begin. After completing the practice trials, the following screen should appear:

Graphical user interface, text, application, email

Description automatically generated

The subject must press enter/return to proceed to the real QUEST session.

1. Before the real QUEST session begins, the following screen will appear:

Text

Description automatically generated with medium confidence

Here, the subject must press enter/return again, and then the session should begin.

1. When the session is complete, the following screen will appear:

Text

Description automatically generated

After the subject presses enter/return. The windows should close, and the data will be saved in the subject’s directory in the “data\_master” folder. (The directory name will be the subject’s 3-digit initial/ID code.)

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**Training Version:**

… (after running the initial QUEST session and completing 1-7 above)

1. After typing “2” and pressing enter in step 6 (above), you should receive a confirmation message saying “… Running the Training version.” Followed by a prompt saying:

“Press Enter/Return to Continue”

Press enter/return as prompted to continue.

1. After pressing Enter/Return, the command line will prompt you to enter the subject’s 3-letter ID/initials:

Graphical user interface, text

Description automatically generated

**Again:** *Make sure you are using the same 3-digit ID used in the subject’s initial QUEST session!*

Type the subject’s unique 3-digit ID and then press return/enter.

1. The command prompt will then ask you whether you want to run “practice trials” prior to the real session:

Graphical user interface

Description automatically generated with medium confidence

If you type “y”, the stimulus will provide the subject with instructions and a few practice trials before the real Training session begins. (You will probably always want to say yes.. However, I provided the ability to choose y/n just in case..)

If you type “n”, the instructions and practice trials will not be included.

(let’s assume you pressed “y”…)

1. After making the selection above and hitting return/enter the Training stimulus program will search for the output directory containing the data from the initial QUEST session. It will then load that data and compute the subject’s specific thresholds based on the psychometric curve estimated from the initial QUEST. Those thresholds should be reported on the command line as pictured below:

**Graphical user interface, text, application, email

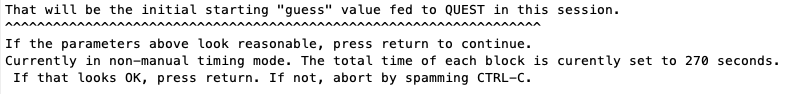
Description automatically generated**

Without getting too far into the weeds, here’s what the “Quest” vs. “Non-quest” trials stuff means:

* In the ‘training’ version of the stimulus, there is a QUEST procedure running online during the task homing in on the subject’s 80% accuracy threshold.
* However, the stimulus will only “take QUEST’s suggestion” of what the next trial should be on a certain proportion of trials (“quest trials”). On the other trials (“non-quest trials”), the stimulus will either be the “canonical ape” or selected randomly from a separate range. The range of possible facemorph parameters is different on “quest” vs. “non-quest” trials. On quest trials, parameters can range between 1 and the subject’s 85% accuracy threshold. On quest trials, parameters can range between 1 and the subject’s 75% accuracy threshold. A greater range is allowed for quest trials to allow for the possibility of subjects’ response thresholds changing.

At this point you should examine the thresholds and facemorph parameters reported and make sure they look reasonable/correct. If they do, you press return/enter to continue.

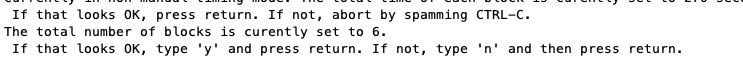
1. Your command prompt should then report the length of the blocks in seconds:



Block length is currently set to 270 seconds (4.5 minutes). It is possible to change this parameter if necessary, but that option is not currently built into the command line interface. If you know what you’re doing, you can adjust it in the parameters section of the training version of the program (the current version file is FACE\_TRNmain5.m … the parameter is called “tim\_expmt”). Otherwise, email Ethan and he can either adjust it in the parameters section or build in a command line option.

In any event, you should not need to regularly change anything regarding the total trial length. At this point, you should simply check the block length and confirm it is what you think it should be. If it looks ok, press return. If it doesn’t, you can abort by holding down control and spamming the “c” button (this should kill any Matlab programs running.. a good general Matlab trick to know..). You can then edit the parameters and re-run. But again, this shouldn’t be an issue and would only occur if the script somehow got edited/altered...

1. The command prompt should then report the number of blocks that will be run:



The default option is currently set to 6 as pictured above. If that is the number of blocks you want to run (it’s what we’d initially planned/decided to do..), at this point you simply type ‘y’ and hit enter to continue.

If for some reason you need to run a different number of trials, you can type ‘n’ and hit enter. You will then be prompted to enter your desired number of trials.

1. After you specify the number of trials and hit enter (in 13 above), the stimulus should start/ the display screen should be taken over by psychtoolbox.
2. After a few moments, the first/only page of the instructions should appear. It provides instructions on how to perform the task and looks like this:

Text, letter

Description automatically generated

After the subject reads/understands the instructions, they can press return/enter as prompted to begin the practice trials.

1. When the practice trials are done, they will see a screen that looks like this:

Text

Description automatically generated

The subject must press return/enter to proceed.

1. They should then see the following screen:

Graphical user interface, text, application, email

Description automatically generated

The subject must now press return/enter to start the real session.

1. A few moments after they press return the following screen should appear:

Text

Description automatically generated with medium confidence

After they press return/enter this final time, the trials will begin.

1. After each block the following screen will appear:

Text

Description automatically generated

At this point the subject can take a break or press enter/return to proceed to the next block.

After they press enter/return, the screen pictured in 18 above will appear again. At which point they press enter/return again to complete the next block. This repeats until all blocks are completed.

1. When they hit enter/return after the final block, it may take a few minutes but things should wrap up and the screens will close out.

Data will again, be saved in the “data\_master” directory under the subdirectory corresponding to the subject’s ID.

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**Assessment Version:**

… (after running the initial QUEST session and completing 1-7 above)

1. After typing “3” and pressing enter in step 6 (above), you should receive a confirmation message saying “… Running the Assessment version.” Followed by a prompt saying:

“Press Enter/Return to Continue”

Press enter/return as prompted to continue.

1. After pressing Enter/Return, the command line will prompt you to enter the subject’s 3-letter ID/initials:

Graphical user interface, text

Description automatically generated

**Again:** *Make sure you are using the same 3-digit ID used in the subject’s initial QUEST session!*

Type the subject’s unique 3-digit ID and then press return/enter.

1. The command prompt will then ask you whether you want to run “practice trials” prior to the real session:

Graphical user interface

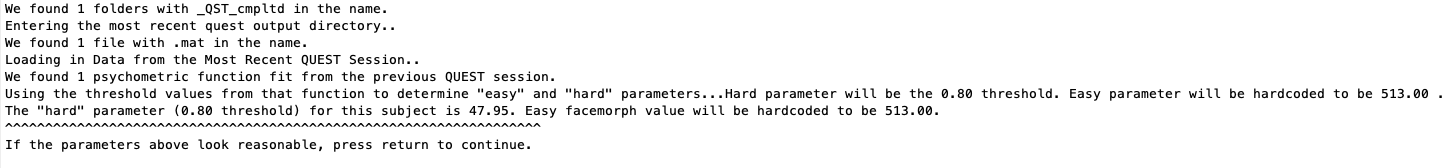
Description automatically generated with medium confidence

If you type “y”, the stimulus will provide the subject with instructions and a few practice trials before the real Training session begins. (You will probably always want to say yes.. However, I provided the ability to choose y/n just in case..)

If you type “n”, the instructions and practice trials will not be included.

(let’s assume you pressed “y”…)

1. After making the selection above and hitting return/enter, the Assessment stimulus program will search for the output directory containing the data from the initial QUEST session. It will then load that data and compute the subject’s specific parameters based on the psychometric curve/thresholds estimated from the initial QUEST. Those values should be reported on the command line as pictured below:

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On “hard” trials, the facemorph parameter should either correspond to the subject’s 80% accuracy threshold (0.80 threshold) or be the “canonical ape.” On “easy” trials, the facemorph parameter is hardcoded to be set at 513 for all subjects.

**Note:** Neither of these are currently editable via the command line interface. If you know what you’re doing, you can adjust them in the parameters section of the assessment version of the program (the current version file is FACE\_ASMTmain5.m … the parameter controlling the “hard” threshold is called “hPar\_thr”, the parameter controlling the hardcoded “easy” value is called “ePar\_thrHC“). Otherwise, email Ethan and he can either adjust the relevant values in parameters section or build in a command line option.

At this point, you should simply check and confirm the easy/hard parameters are set properly (see above). If it looks ok, press return.

1. The command prompt should now display the total number of blocks the assessment version is set to run, the approximate amount of time per block, and the number of trials which will be run to fit in that approximate time window (computed using the maximum possible trial length):

Text

Description automatically generated

As pictured above, if those parameters look ok, you can simply type “y” to accept the parameters and hit enter. However, if you would like to set a different block length or number of blocks, type “n” instead (this option was selected in the above example). You will then be prompted to enter the number of blocks and the length of blocks as shown above.

**\*NOTE:** in the assessment version, the actual number of trials included may not be *exactly* the number reported on the command line. It will end up being the number closest to that number that it can include while maintaining the required balance/proportion of various trial types…

After hitting enter, the session should then begin and psychtoolbox should take over the stimulus monitor, etc.

1. If running the instructions/practice trials, after a few moments, the following screen should appear with the subject’s instructions:

Text, letter

Description automatically generated

After the subject reads/understands the instructions, they can press return/enter to proceed to the practice trials.

1. When the practice trials are done, the following screen will appear:

Text

Description automatically generated

To continue, the subject must press enter/return.

1. Then the following screen should appear:

Text, letter, email

Description automatically generated

The subject, again, must press enter/return to proceed to the actual session, as prompted.

1. After completing each assessment block, the screen pictured in 14 will appear. The subject will then, again, need to press return/enter to proceed. On the final block, things should wrap/close up. Be patient. This sometimes takes a bit..

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GENERAL COMMENTS / NOTES:

**Psychtoolbox Warnings:**

Psychtoolbox has not been updated to run seamlessly with new Macbooks and has issues getting the uber-precise timing it can achieve on other platforms. It will issue warnings to this effect on the command line. It will also display a screen with an exclamation point and a purple warning page with frog at the beginning of sessions. These are also due to that timing issue. I had to turn on a setting to ignore these timing warnings to allow the stimuli to run. In exchange, I get the before-mentioned warning messages/screens. As far as I can tell, I am still able to achieve acceptable timing (within 10-s of msec accuracy). However, if you are concerned, I save detailed timing data for each trial in tdfs (trial descriptor files) saved the .mat output files for each session (see Data Output Files below..). Please check these.

**Data Output Directories:**

As mentioned above, when you run a subject, an output directory/folder will be automatically created in the “data\_master” directory located under the main “tDCS\_stim\_MATLAB” directory. The folder names correspond to subjects’ 3-digit IDs. Inside each of these there will be another subdirectory with a really long, obnoxious, scary-looking name.. something like:

“bins1000\_binTh4\_nqint3\_ntrls52\_thrs65-75-85\_grn01\_tgst01\_rng1000\_sdG20\_tprob70\_c50u500\_c50l0\_c50st100\_binwtd\_bwExp1\_maxmin800\_1\_mmSeg”

Don’t be scared of the folder name length.. all you really need to know is that the output folders from the Quest, Training, and Assessment sessions are saved inside. I’m a big fan of descriptive naming.. The pieces-parts of the obnoxiously long folder name indicate specific aspects of how the initial QUEST session/psychometric model fittings were run. I’d be happy to share the details if you like (just email me.. see email at top of file). Otherwise, it probably suffices for most users to say that the output directories from the individual sessions are saved inside the directory with the big, obnoxious name.. There should only be one of those per subject.

If, in the very unlikely event, there are multiple directories with long obnoxious names within a subject’s folder, this means that the initial QUEST was run multiple times with different parameters. (the directory name autogenerates based on the parameters selected). I say this is highly unlikely to occur because the QUEST parameters are fixed/set the program’s (FACE\_QSTmain5.m) parameter section, and are not adjustable from the command line. (i.e. someone would have to tinker with/edit the parameters section in FACE\_QSTmain5.m) Nonetheless, even if this occurs, I have explicitly programmed in the ability to deal with it. If, for whatever reason, there are two long-obnoxious subdirectories, the subsequent programs (assessment and training versions..) should detect it and will ask you which one you want to use at the command line. However, if this occurs, I suggest you look into who’s been handling the matlab files and double-check to make sure everything is OK.

In any event, the data from each individual session are saved in sub-directories inside the directory with the long, obnoxious, descriptive name. The directory structure is created when the initial QUEST is run, and the assessment/training session data/any subsequent session run with that subject’s 3-digit ID is saved inside thereafter. You’ll notice that folder names will follow the following convention:

XXX\_########T######\_TAG

Here’s what they mean:

XXX : the subject’s 3-digit ID

########T###### : the precise date (first string of numbers, before the “T”) and time (military, accurate to the sec, second string of numbers after the “T”) that the session was run. This was included to prevent accidental overwriting of data from previous sessions. Each session creates a new output directory with a unique timestamp, thereby hopefully preventing users from accidentally overwriting folders/files from previous sessions. Also allows you to distinguish between separate sessions.

TAG : designates the type of session run where “QST”= Quest, “TRN”=Training, and “ASMT”=Assessment.

Finally, you’ll also probably notice that many/most of the Quest data directories will end in “\_cmpltd.” This, as you might gather, indicates that the Quest session was successfully completed. Because all of the subsequent sessions ride/rely on the initial Quest, I realized that this was a potentially problematic single-point-of-failure. This feature was one of my low-tech ways of addressing this issue. *The “\_cmpltd” tag is only added when the session is successfully completed, and the subsequent training/assessment sessions should only load the data from Quest output directories with this tag*. Consequently, if you end/abort a Quest session, for whatever reason, before its completed: don’t worry! Just re-run it. Only data from successfully completed Quest sessions (i.e directories tagged with “\_cmpltd”) should be detected/used in the later sessions.

Also, its generally good practice to archive data immediately after collection. I **highly suggest** copying/pasting a copy of the data collected in each session in an “archive” folder elsewhere on the computer (outside the tDCS\_stim\_MATLAB directory) or on another machine/drive immediately after every subject’s session. Don’t get burned..

**Data Output Files:**

The data from each session are saved in .mat files (matlab data files) located in the session-specific folders discussed above named with the “XXX\_########T######\_TAG” convention. These files are simply named XXX.mat, where “XXX” is the subject’s 3-digit ID.

The quick and stupid way to open/view these is to:

1. Have Matlab already open/running on your machine
2. Be sure to clear your workspace by typing “clear” in the command window.
3. Then navigate in your file browser to the location of the .mat file
4. Double click on it.
5. An “import wizard” GUI window should open. Click the “Finish” button.
6. The contents should now be in your Matlab workspace.

There are a fair number of things saved in thse files. However, there is probably only one output that you care about: what I call “tdfs” or “Trial Descriptor Files.” These essentially save all the relevant data/parameters/info from every trial in a given session in one place. The tdf outputs in the .mat files from the respective quest, training and assessment versions are all named slightly differently. Why, you ask? Because I’m bad, that’s why.

In the .mat files from the Quest version, the tdfs are saved in a variable called: tdfs

In the .mat files from the Training version, the tdfs are saved in a variable called: tdf\_out\_out

In the .mat files from the Assessment version, the tdfs are saved in a variable called: tdf\_out

I will probably write a more detailed description in the future. But for now, I hope these graphics/descriptions suffice to describe the contents of the tdf outputs:

All of the tdf outputs (whether from the quest, training, or assessment version) are structured the same way:

If you click on any of the tdf outputs listed above (in the matlab workspace), you’ll find that they are “arrays of arrays” which look something like this:

Graphical user interface, application, table, Excel

Description automatically generated

The above are from a dummy assessment session I ran on myself, but the other sessions’ tdf outputs are structured the same. The output array from *each block is saved in a separate cell*, in the order in which they were run. (In this case there were two blocks.. therefore two cells..)

If you click on one of these, it will open up the tdf output from that block. These should look like a spreadsheet like this:

Graphical user interface, application, table, Excel

Description automatically generated

The top row contains the column titles. However, each subsequent row contains the data from a single trial in the block.

Every tdf, regardless of the version run, should have 17 columns. Below are the column titles, and a description of the data they contain:

1. "ImgFile\_Path": the full path and file name of the image displayed on the trial

1. "FaceMorph\_Con": the facemorph condition for the trial. This column serves slightly different roles in each respective version:

-QST version: specifies whether it was a canonical ape trial (‘cApe’) or a mixed/morphed face trial (‘Mix’). For “Mix” trials, it also specifies which of the three interleaved Quests suggested the parameters used as “Mix\_Quest1”, “Mix\_Quest2”, or “Mix\_Quest3” respectively.

-TRN version: Also specifies whether it was a canonical ape trial (‘cApe’) or a mixed/morphed face trial (‘Mix’). However, for “Mix” trials, it specifies whether it was a “quest” trial (“Mix\_Quest”) or a non-quest/randomly selected trial (“Mix\_Rand”)

-ASMT version: specifies “Easy” vs. “Hard” trials. Also, for “Hard” trials, it specifies whether it was a canonical ape or a “mixed”/morphed face (“Hard\_cApe” and “Hard\_Mixed” respectively)

1. "Sal\_Con" : specifies the “salience” condition for the distracters. This column will be empty for the Quest version output as there are no distracters. However, in the training/assessment versions it will contain the distracter salience value (low, medium, or high).
2. "Config\_Con": specifies the configuration condition of the distracters. This one will also be empty for Quest version outputs as there are no distracters. However, in the training/assessment versions it will contain the distracter configuration code (number between 1-8).
3. "Image": contains a copy of the actual image matrix for the image displayed on the trial. Should be a 2D color image with matrix with 3 color channels (RGB) coded in uint8.
4. "Randomization\_Col" : This one will be empty in the Quest and Training version outputs. However, in the Assessment version it will be full of random numbers. These were used to randomize the column order during the creation of the input TDF. (The assessment version is the only one where all trials are pre-generated/randomized in this way prior to the session.. the other two have QUEST running and must adaptively select parameters on the spot within session)
5. "Correct\_RespKey": contains what the correct response/button press was for that trial (either a ‘z’ or an ‘m’).
6. "T\_Resp": Contains the response time for the trial expressed in seconds relative to the appearance of the stimulus image.
7. "T\_Trial": Contains the total time of the trial starting from the trial start time (currently 0.6 sec prior to when images appear) up to the time the subject responds/pushes a button.
8. "T\_Trial\_wITI": Contains the total time of the trial starting from the trial start time (currently 0.6 sec prior to when images appear) up to the end of the ITI (so it includes feedback and the ITI).
9. "Subj\_RespKey": Contains the key actually pressed by the subject on the trial.
10. "Correctness" : Indicates in binary fashion whether their response was correct (0=incorrect, 1=correct)

\*13-16 contain additional timing data which I included as a paranoid precaution. These all contain raw/absolute timepoints (*these are points in time*.. NOT lengths of time between various relative points in the trial sequence like 8-10). These were included in an effort to enable cross-checking the accuracy/consistency of the stimulus timing:

1. "tStart\_Raw": raw/absolute time the trial started
2. "tEnd\_Raw": raw/absolute time response was recorded
3. "tITIstart\_Raw": raw/absolute time the ITI started
4. "tITIend\_Raw" : raw/absolute time the ITI ended
5. "MorphPar": Contains the facemorph parameter value for the trial.

**Practical Tips:**

If you need to abort a session at any point, you can always hold down control and spam the “c” key repeatedly.. This should kill any of the programs. If it’s in the middle of a session and psychtoolbox is still holding the screen/mouse/keyboard hostage, type “sca” immediately after you kill the program by spamming control-c and hit enter. This means “screen close all” and should kill/close all the remaining screens and will give you back control of your peripherals.