sharp-repo Documentation

Release 1.0

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Contents

Adaptive reasoning and problem solving represent crucial skills in increasingly information-rich working environments. The SHARP research project is a multi-institutional competitive and collaborative effort that seeks to understand the neurobiological substrates of fluid intelligence and its malleability in response to a wide variety of interventions. This research effort, across all involved institutions collected the largest dataset on the training of fluid intelligence and its possible neural correlates. To ultimately share this resources to all researchers, a repository has been created to hold this data: https://sharp.bidmc.harvard.edu. We have hosted this data using the XNAT data repository infrastructure. This infrastructure has been extended to fit the data elements of interest, including EEG, quantitative phenotypical information, cognitive assessment and MR imaging data. At present data includes over 500 research participants, and over 800 imaging sessions. Additional data access tools have been developed for easy researcher which are distributed alongside the data. This repository offers a valuable resource for studies investigating the flexibility of fluid intelligence.
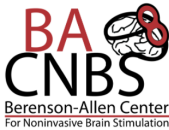
SHARP currently contains 6 projects, 1039 subjects, and 2373 imaging sessions.

Projects	Subjects	MR	PET	CT

ID:

Name:

Description:

Keywords:

Investigator:
(SELECT) ▼

Submit

Projects

RobotFactory_GameData

Project ID: GameData   PI: Alvaro Pascual-Leone
You are a **member** for this project.

INSIGHT

Project ID: INSIGHT   PI: Aron Keith Barbey
Strengthening Human Adaptive Reasoning and Problem-Solving.
You are a **collaborator** for this project.

FAST

Project ID: FAST   PI: Alvaro Pascual-Leone
To design, evaluate, and refine a set of interventions that are designed to enhance adaptive reasoning and problem-solving (ARP) skills among healthy adults …
You are an **owner** for this project.

EEG_DATA_1B

Project ID: EEG_SHARP   PI: Alvaro Pascual-Leone
Raw EEG data for Sharp for different sites.
You are a **collaborator** for this project.

Recent Data Activity

EEG_SHARP	EEG	PostTest_0132
EEG_SHARP	EEG	Training_0132
EEG_SHARP	EEG	PreTest_0132
EEG_SHARP	EEG	PostTest_0131
EEG_SHARP	EEG	Training_0131
EEG_SHARP	EEG	PreTest_0131
EEG_SHARP	EEG	PreTest_0130
EEG_SHARP	EEG	Training_0130
EEG_SHARP	EEG	PostTest_0130
EEG_SHARP	EEG	PostTest_0129
EEG_SHARP	EEG	Training_0129
EEG_SHARP	EEG	PreTest_0129
EEG_SHARP	EEG	PostTest_0128
EEG_SHARP	EEG	Training_0128
EEG_SHARP	EEG	PreTest_0128
EEG_SHARP	EEG	Training_0127
EEG_SHARP	EEG	PreTest_0127
EEG_SHARP	EEG	PostTest_0127

Working with XNAT using PyXNAT

1.1 Download PyXNAT Module

```
!pip install pyxnat
```

1.1.1 Connect to server: Enter user : password

```python
import pyxnat
import os

# connect to XNAT instance
from pyxnat import Interface
xnat = Interface(server='http://sharp.bidmc.harvard.edu:8080',  cachedir='/tmp')
xnat.select.projects().get()
```

1.2 Different types of datatypes supported by XNAT

```
xnat.inspect.datatypes()
```

1.3 Check number of Subject

```python
subjects = xnat.select('/projects/FAST/subjects')
subjects.get().__len__()
```

1.4 Loading the project

```
project = xnat.select.project('FAST')
print(project)
```

1.5 Working with Subject Data

```
contraints = [('xnat:subjectData/SUBJECT_ID','LIKE','%'),
                'AND', ('xnat:subjectData/PROJECT', '=', 'FAST')
             ]
table = xnat.select('xnat:subjectData', ['xnat:subjectData/SUBJECT_LABEL',
↪'xnat:subjectData/PROJECT','xnat:subjectData/SUBJECT_ID']).where(contraints)
table.__len__()
```

```
print(table)
```

1.6 Working with MRI Session Data

```
contraints = [('xnat:mrSessionData/ID','LIKE','%'),
                'AND', ('xnat:subjectData/PROJECT', '=', 'FAST')
             ]
table1 = xnat.select('xnat:mrSessionData', ['xnat:mrSessionData/SUBJECT_LABEL',
↪'xnat:mrSessionData/SESSION_ID']).where(contraints)
table1.__len__()
```

```
print(table1)
```

1.7 Filtering using Behavioral scores

```
contraints = [('xnat:subjectData/SUBJECT_ID','LIKE','%'),
                ('behavioral:scores/VocabScore', '>=', '36'),
                'AND', ('xnat:subjectData/PROJECT', '=', 'FAST')
             ]
table1 = xnat.select('xnat:subjectData').where(contraints)
table1.__len__()
```

1.8 Downloading the selective data

Lets start with download data for one subject

```
subject = xnat.select.project('FAST').subject('0001')
experiment = subject.experiment("SHARP_E00746")
allscans = experiment.scans()
allscans.download("/tmp", type='ALL', extract=False)
```

Now lets write a filer to download the selective data for all the subjects

```
# Filer can be developed based on the data parameters
contraints = [('xnat:mrSessionData/ID','LIKE','%'),
                'AND', ('xnat:subjectData/PROJECT', '=', 'FAST')

list_subjects = xnat.select.project('FAST').subjects().where(contraints)
for list_subject in list_subjects:
    list_experiments = list_subject.experiments().where(contraints)
    for list_experiment in list_experiments:
        print list_experiment
        scans = list_experiment.scans()
        try:
            # Number 2 is for Anatomical data. Similar types can be set for other
↪data types
            scans.download("/tmp", type='2', extract=False)
        except:
            print "There are no scans to download"
```

Working with EEG data

```python
import pyxnat
import os

# connect to XNAT instance
from pyxnat import Interface
xnat = Interface(server='http://sharp.bidmc.harvard.edu:8080',  cachedir='/tmp')
xnat.select.projects().get()
```

```python
project = xnat.select.project('EEG_SHARP')
```

```python
subject = project.subject('0001')
```

```python
experiments = subject.experiments()
```

```python
for list_experiment in experiments:
    files = list_experiment.resources().files()
    for fl in files:
        print (fl)
```

Definitions for Parameters Listed in the Generated Data for EEG and RobotFactory

All generated files are formatted as two dimensional tables. The rows correspond to a subject activity such as an IQ test or a Switch task problem, and the columns list data for the activity. This section describes the parameters that appear in the table columns.

The parameter definitions are described in the following subsections:

- Parameters that are defined for many (even all) generated files, and parameters that are specific to the following activities:

  - The BOMAT and Sandia IQ tests

  - The Inhibit and Switch EF tasks

  - The Silo Detection, Thumbprint Detection and Visual Search Active Control training

- Parameters that are specific to the Rotation Span EF task

- Parameters that are specific to RobotFactory training

- Parameters that are specific to the questionnaires

- Parameters that are specific to the EEG files: the blinded EEG data files and the generated *eeg-sum* file

Unless noted otherwise, the time units for values extracted from Presentation log files are expressed in units of $1/10^{th}$ of a millisecond (Presentation time).

3.1 Parameters That Apply to Many of the Generated Files

Parameter	Description
Accuracy	The proportion of attempted problems that were solved correctly. For the Switch task, only switch cases (the cue has changed from the previous problem) are tallied.

Table 3.1 – continued from previous page

Parameter	Description
Age	The subject's age expressed in years.
AgeBin	The subject's age expressed in one of these ranges: • <21 (less than 21 years old) • 21-25 • 26-30 • 31-35 • 36-40 • 41-45 • 46-50 • 51-55 • 56-60 • 61-65 • 66-70 • >70 (older than 70)
Animal	Used with the Inhibit task, set to TRUE when the stimulus represents an animal and FALSE if not.
Att10	Used with the IQ tests, the number of problems answered by the subject during the first 10 minutes of the test. For the Sandia test, this value includes cases when the subject did not provide an answer within the 60 second per problem deadline.
Att5	Used with the IQ tests, the number of problems answered by the subject in the first 5 minutes of the test. For the Sandia test, this value includes cases when the subject did not provide an answer within the 60 second per problem deadline.
Attempted	The number of problems attempted and answered by the subject. For the Sandia test, this value includes cases when the subject did not provide an answer within the 60 second per problem deadline.
Avg$i$	For an active control task (silo detection, thumbprint or visual search), the average difficulty level over the subject's i^{th} training session.
AvgRT	The subject's average response time for answering problems. For the Switch task, only switch cases (the cue has changed from the previous problem) are used in the computation.
Block	The EF and active control tasks are divided into sections that are identified by a block label, e.g., PRACTICE, PERFORMANCE, etc.

Table 3.1 – continued from previous page

Parameter	Description
Condition	The subject's intervention protocol, a combination of: • The type of training (RobotFactory or Active Control) • The type of tES Values are: • RF tDCS • RF tRNS • RF tDCS Sham • RF tRNS Sham • AC tDCS Sham • AC tRNS Sham
Corr10	The number of IQ test problems solved correctly during the test's first 10 minutes.
Corr5	The number of IQ test problems solved correctly during the test's first 5 minutes.
Correct	The number of problems solved correctly. For the Switch task, only switch cases (the cue has changed from the previous problem) are tallied.
CorrNoResp	An inhibit trial (inhibit case) was answered correctly by no keyboard response.
CorrResp	An inhibit trial (don't inhibit case) was answered correctly by the correct keyboard response.
Cue	The switch cue that was presented, either a heart or a cross.
CueTime	The Presentation time when the switch cue was presented.
CueUncert	The Presentation-computed uncertainty in the CueTime.
Date	The date when the data file was created. With the exception of the side-effects questionnaires, this is also the date the subject performed the activity.
Delay	For the Switch task, the duration between the presentation of the cue and the presentation of the stimulus, expressed in Presentation time units.
Duration	The elapsed time for subject to complete the active control task.
EduLevel	The level of education achieved by the subject expressed as one of: • no high school • some high school • high school graduate • some college • college graduate • some master's degree or higher • completed master's degree or higher
EduYears	The subject's educational level expressed in years. For example, undergrad completion is typically 16 years.
Expected	The correct response to an active control task problem (left or right shift key).

Table 3.1 – continued from previous page

Parameter	Description
Final*i*	For an active control task (silo detection, thumbprint or visual search), the subject's difficulty level and the end of the ith training session.
Gender	The subject's gender, male or female.
Ho/He	Used with the Visual Search task to distinguish between the easier homogenous problems (the same character used for all distracters) from the more difficult heterogeneous problems (many characters are used for the distracters).
IgnoredEvents	Ignored events occur when the subject presses a keyboard key during an EF or AC task when a subject response is not expected. Excessively high numbers during a task could suggest a problem with the keyboard or a subject's lack of cooperation doing the task. In summary files, this parameter expresses the number of ignored events that occurred during the task or test. In detailed files, it consists of a letter followed by a number. The letter indicates the key pressed (P => subject paused the scenario, R => subject resumed the scenario, X => all other keys). The number is the Presentation time for the event.
IncorrNoResp	An inhibit trial (inhibit case) was answered incorrectly by a keyboard response.
IncorrResp	An inhibit trial (don't inhibit case) was answered with the incorrect keyboard response.
Init*i*	For an active control task (silo detection, thumbprint or visual search), the difficulty level at the start of the subject's i^{th} training session.
InhCorr	This field captures information about the subject's response when an inhibit cue is presented. It takes one of these four values: • True – inhibit cue was presented and subject did not press a shift key • Before – inhibit cue was presented and subject had already pressed a shift key before the cue was presented • After – inhibit cue was presented and subject pressed a shift key after the cue was presented • Blank – an inhibit cue was not presented The parser does not account for human reaction time. For example, if a key press occurs one millisecond after the cue, the InCorr value will be set to "After" even though from the perspective of the human's response time, the "Before" value might be considered more appropriate.

Table 3.1 – continued from previous page

Parameter	Description
Inhibit	The duration before the sounding of the inhibit cue: • S50 – the inhibit cue was presented 50 ms after presenting the noun • NNN – the inhibit cue was presented NNN ms after presenting the noun, where NNN is computed by a staircase algorithm that considers the response times of the subject's previous keyboard presses • Blank – an inhibit cue was not presented
InhTime	The Presentation time when the inhibit cue was presented; blank when inhibit cue is not presented.
InhUncert	Presentation computed uncertainty associated with InhTime.
Institution	The institution that performed the trial, Harvard, Honeywell, Northeastern (NEU) or Oxford.
IsLogical	Used with the Sandia test to denote a "logical" problem. The Sandia test consists of logical and relational problems.
IsSwitch	Set to TRUE for switch problems where the cue has changed since the previous problem. This condition will be true for approximately half of all switch problems.
Large	True if the stimulus noun represents something bigger than a soccer ball, and false otherwise.
LevelMax	The most difficult level for the task attempted by the subject over the course of an active control training session.
LevelMin	The easiest level for the task attempted by the subject over the course of an active control training session.
Living	True if the stimulus noun represents a living entity, and false otherwise.
LogAtt	The number of Sandia test logical problems attempted by the subject.
LogAtt10	The number of Sandia logical problems attempted by the subject during the first 10 minutes of the test.
LogAtt5	The number of Sandia logical problems attempted by the subject during the first 5 minutes of the test.
LogCorr	The number of Sandia test logical problems solved correctly by the subject.
LogCorr10	The number of Sandia logical problems solved correctly by the subject during the first 10 minutes of the test.
LogCorr5	The number of Sandia logical problems solved correctly by the subject during the first 5 minutes of the test.
LogTO	The number of times the subject reached the 60-second Sandia problem time limit while solving a logical test problem.
LogTO10	During the first 10 minutes of a Sandia test, the number of times the subject reached the 60-second problem time limit while solving a logical test problem.

Table 3.1 – continued from previous page

Parameter	Description
LogTO5	During the first 5minutes of a Sandia test, the number of times the subject reached the 60-second problem time limit while solving a logical test problem.
Max$i$	For an active control task (silo detection, thumbprint or visual search), the maximum difficulty level for the subject's i^{th} training session.
Min$i$	For an active control task (silo detection, thumbprint or visual search), the minimum difficulty level for the subject's i^{th} training session.
NAccuracy	Subject's accuracy solving non-switch problems (switch cue is unchanged from the previous problem).
NAvgRT	Used for the Switch task, the subject's average response time solving non-switch problems (switch cue is unchanged from the previous problem).
NCorrect	The number of non-switch problems (switch cue is unchanged from the previous problem) that the subject solved correctly.
NonSwitch	Count of non-switch problems attempted by the subject (the switch cue is unchanged from the previous problem).
NTimeout	The number of timeouts that occurred when the subject was solving a non-switch problem (switch cue is unchanged from the previous problem).
Period	The trial phase period: • Pre-test • Training • Post-test
Problem	The problem number.
RelAtt	The number of Sandia test relational problems attempted by the subject.
RelAtt10	During the first 10 minutes of the test, the number of Sandia relational problems attempted by the subject.
RelAtt5	During the first 5 minutes of the test, the number of Sandia relational problems attempted by the subject during the first 5 minutes of the test.
RelCorr	The number of Sandia test relational problems solved correctly by the subject.
RelCorr10	During the first 10 minutes of the test, the number of Sandia relational problems solved correctly by the subject.
RelCorr5	During the first 5 minutes of the test, the number of Sandia relational problems solved correctly by the subject.
RelTO	The number of times the subject reached the 60 second Sandia problem time limit while solving a relational test problem.
RelTO10	During the first 10 minutes of the test, the number of times the subject reached the 60 second Sandia problem time limit while solving a relational test problem.

Table 3.1 – continued from previous page

Parameter	*Description*
RelTO5	During the first 5 minutes of the test, the number of times the subject reached the 60 second Sandia problem time limit while solving a relational test problem.
Response	The subject's response. For the IQ tests it is a number (1..6 for BOMAT and Ravens and 1..8 for Sandia). For the Inhibit, Switch and active control tasks, the response is a either the left-shift key or the right-shift key.
RespTime	The Presentation time when the subject entered a response.
RespUncert	The Presentation-computed uncertainty in the subject's response time.
Score	The subject's score for the problem, true if correct, false if incorrect, or timeout.
Silos	In the Silo Detection task, the number of silos in the image presented to subject.
Status	The subject's completion status, Active (not completed), Finished, Excluded, Quit or Dropped. Subjects marked as Finished completed the intervention. Subjects marked as Excluded completed the intervention but were excluded from the analysis, generally because they showed less than a minimum threshold of participation during the intervention. The Quit and Dropped status indicate that the subject did not complete the intervention, either because the subject quit or because the experimenters had to drop the subject due to missed appointments, was later found to have an exclusionary condition, etc.
StimTime	Time when the stimulus was presented to the subject
Stimulus	The stimulus presented to the subject.
StimUncert	The Presentation-computed uncertainty in the stimulation time.
Subject SubjNum	A unique subject identifier. Either the (unblinded to experimenters) MITRE participant ID number without the "HON" prefix, or a blinded subject id. Blinded subject ids are randomly assigned from the range @0001-@0999.
SubjWord	The subject's unblinded unique mnemonic id.
Timeout	For the Sandia test, the number of times the 60 second per problem timer expired without a subject response. For the Switch task, the number of times the subject did not respond to a switch problem (the cue has changed from the previous problem).
TO10	During the first 10 minutes of a Sandia test, the number of times the 60 second per problem timer expired without a subject response.
TO5	During the first 5 minutes of a Sandia test, the number of times the 60 second per problem timer expired without a subject response.

Table 3.1 – continued from previous page

Parameter	Description
Upload	The week during which the data was added to the parser's database. The upload date is typically a Monday but the actual upload may have been a few days before or after. Most often the data was recorded during the previous week.

3.2 Parameters That Are Specific to the Rotation Span Executive Function Task

Parameter	Description
Arrow$i$	The ith arrow presented to the subject. Arrows are represented by a two character compass direction. The short arrows are expressed in lower case, the long arrows in upper case. For example, "nn" is the north (up) pointing short arrow and "NE" is the northeast pointing long arrow.
ArrAns$i$	The subject's answer for the ith arrow.
ArrScore$i$	The subject's score for answering the *i:sup:'th'* arrow.
ArrPresentTime$i$	The Presentation time when the *i:sup:'th'* arrow was presented.
ArrAnsTime$i$	The Presentation time when the subject answered the *i:sup:'th'* arrow.
ArrowsAcc	Overall accuracy of subject's arrow recall.
ArrowsBlank	Number of arrows marked as "blank" during the arrow recall phase.
ArrowsCleared	Number of arrows that were cleared during the arrow recall phase.
ArrowsClearedCmds	Number of times arrows were cleared during the arrow recall phase.
ArrowsCorr	The number of arrows that were recalled correctly during the arrow recall phase.
ArrowsExtra	Number of extra arrows provided during arrow recall phase (e.g., four arrows were presented and the subject's recall contains more than four arrows).
ArrowsMissing	Number of arrows that were not provided during arrow recall phase (e.g., four arrows were presented and the subject's recall contains fewer than four arrows).
ClearedArrows	Lists of recalled arrow sequences that were cleared (if any) before the subject submitted his response. Each sequence begins with a timestamp for the start of the recall which is followed by the list of arrows being cleared and then terminated by the time when the sequence was cleared.

Table 3.2 – continued from previous page

Parameter	Description
ClearedEndTime	If subject cleared arrows during arrow recall, the Presentation time of the last clearance (hence the starting time for recalling the arrows that were not cleared).
DistractorDwellTimeLimit (ms)	The maximum time allowed for the subject to respond to the letter query ("was the letter normal or inverted?"). The number is computed when the subject performs the pretest version of the task as: *average response time + 3 * stdev response time* for the letters answered correctly during a letter practice session. The value computed during pretest is reused during posttest.
ExtraArrows	The list of extra arrows for cases when the subject's arrow response contains more arrows than were presented to the subject. Two values are provided for each response, the time the entry was made and the identity of the extra arrow.
Letter$i$	The ith letter presented to the subject. Letters are described in these three parts: • The letter displayed ('F', 'G', 'J', or 'R') • A rotation from the unrotated position (one of eight compass points expressed by two character mnemonic – NN, NE, EE, SE, SS, SW, WW, NW) where NN is considered to be the unrotated position • The symbol '|>' if presented in normal orientation and '<|' if presented inverted. So for example 'G EE <|' indicates that the letter G was presented rotated 90 degrees clockwise and then inverted.
LetScore$i$	The subject's response to the ith letter (inverted or not).
LetPresentTime$i$	The Presentation time when the ith letter was presented.
LetDismissTime$i$	The Presentation time when the subject dismissed the ith letter.
LetQueryTime$i$	The Presentation time when the subject was prompted for a response to the ith letter.
LetAnsTime$i$	The Presentation time when the subject responded to the ith letter.
LettersAcc	Accuracy of the letter responses (is letter inverted or not?).
LettersCorr	The number of letters answered correctly.
LettersTO	The number of letter presentations that ended without a subject response.
NumArrBlank	Number of arrows that were set to "blank" instead of being recalled.
NumArrCleared	The number of arrows that were cleared by arrow clear commands.
NumArrCorr	Number of arrows that were recalled correctly.
NumArrExtra	Number of extra arrows in the arrow recalls.

Continued on next page

Table 3.2 – continued from previous page

Parameter	*Description*
NumArrMissing	Number of arrows that were missing from the arrow recalls.
NumLetCorrect	The number of letters answered correctly (normal or inverted?)
NumLetTimeoutPresent	Number of times the subject failed to dismiss the letter within the permitted letter presentation interval.
NumLetTimeoutResp	Number of times the subject failed to answer the letter query (normal or inverted) within the query presentation period.
NumTimesArrCleared	Number of times that the subject restarted the arrow recall by erasing the currently recalled arrows.
RecallBeginTime	The time when the subject began the arrow recall sequence.
SeqBeginTime	The time when the subject started the letter/arrow sequence.
SeqEndTime	The time when the subject completed the recall sequence.
SeqLength	The number of letter arrow pairs in the Rotation Span sequence (3, 4 or 5).
Trials	The number of trials performed by the subject. The full rotation span task contains 70 trials. Note: A bug in the Rotation Span scenario that was not resolved until midway through phase 1B testing caused the log file for a single Rotation Span sequence (3, 4 or 5 letter/arrow pairs) to be incomplete. The parser does not attempt to score these incomplete sequences. This error occurred 13 times, and for those instances the "rotation-sum" file will show 65, 66, or 67 in the "Trials" column instead of the expected 70.

3.3 Parameters That Are Specific to RobotFactory

[TBD: need inputs from RobotFactory developers.]

Parameter	*Description*
ActualN	
Automaton	
AvgRespTimeEst	
BaseStopSignalDelay	
Cluster	The RF cluster associated with the shift.
CurrentAccuracy	
ClusterComplete	
CurrentLevel	
CurrentStopSignalDelay	
CurrentTask	

Table 3.3 – continued from previous page

Parameter	Description
DisplayedInhSignal	
EstRespTime	
ExpResp	
GivenResp	
InhibitDelayUsed	
InhibitProb	
isLastDay	When set to TRUE, indicates that the subject received the special experience provided for the last trai
JumpBack	
LastMedianResponseTime	
Level	The game's level of difficulty.
LogFileId	
MatchProb	
N	
n-Back	
n-BackProb	
NextInhibitDelay	
NextState	
PassCount	
PreInhExpResp	
PreInhNextState	
PreInhSigmaP	
PreInhSigmaPRight	
ProgressionDataFile	
ReportedRespTime	
RespTime	
Shift	The name of the RobotFactory game being played during a two minute shift.
ShiftNum	A count of the two-minute RobotFactory shifts played by the subject.
ShortSsdChance	
ShortStopSignalDelay	
ShortStopSignalDelayChance	
SrtEstimateConstAlpha	
StopSignalDelayStepValue	
SigmaP	
SigmaPRight	
SigmaS	
SigmaS_Color	
SigmaS_Grid	
SigmaS_Number	
SigmaS_Picture	
SigmaS_Shape	
SigmaS_Word	
SigmaSR_Color	
SigmaSR_Grid	
SigmaSR_Number	
SigmaSR_Picture	
SigmaSR_Shape	
SigmaSR_Word	
SigmaSRight	
StimShowTime	

Table 3.3 – continued from previous page

Parameter	Description
SubjLastMedianRT	
SubjSSRT	
SwitchProb	
UpdatedInhDelay	
TrialId	A cross-reference into the rf-triggers file used by EEG analysis tools.
TrialTime	
UsedShortDelay	

3.4 Parameters That Are Specific to the Questionnaires

Parameters specific to each questionnaire are listed in the following tables in the order they appear in the log files.

3.4.1 Demographic Questionnaire

Parameter	Question
Sex	Sex (Female or Male)
AgeQ	Age
Weight	Weight expressed in pounds
Height	Height expressed in inches
Race/Ethnicity	Race/Ethnicity (select all that apply): White, African American, Hispanic or Latino, Asian, American Indian/Alaskan Native, Native Hawaiian/Pacific Islander, Unknown, Other [specify]
Cigarettes	Do you smoke cigarettes? (No or Yes)
NumCigs	If Yes, how many cigarettes do you typically smoke per day?
TBI	Have you ever had a diagnosed concussion or mild traumatic brain injury? (No or Yes)
TbiAge	If yes, at what age?
Unconscious	If yes, did you lose consciousness? (Yes or No)
UnconTime	If yes, for how long did you lose consciousness (minutes)?
EngLangAge	At what age did you begin learning English? If English is your native language that you were exposed to from birth, respond with 0.
Languages	Please specify which language(s), other than English, you speak (if any) (separate each language with a comma).
LangAges	Ages Learned (enter as number & separate each language with a comma).
Major	Major area of study in college. Leave blank if you did not attend college.
EduLevelQ	Highest level of education (self) (no high school, some high school, high school graduate, some college, college graduate, some master's degree or higher, completed master's degree or higher).
EduYearsQ	Total years of education - enter as numeral (example, undergrad completion is typically 16 years).
EduLevelMother	Highest level of education (mother).
EduLevelFather	Highest level of education (father).
Occupation	Occupation (self).
OccMother	Occupation (mother).
OccFather	Occupation (father).
VideoTime	On average, how many hours a week do you play video/computer games?
VideoGames	How many different video/computer games do you typically play in a year?

3.4.2 Physical Activity Questionnaire #1 (Godin)

Parameter	Question
Level	Choose ONE activity category that best describes your usual pattern of daily physical activities, including activities related to house and family care, transportation, occupation, exercise and wellness, and leisure or recreational purposes. • Level 1: Inactive or little activity other than usual daily activities. • Level 2: Regularly (5 days/wk) participate in physical activities requiring low levels of exertion that result in slight increases in breathing and heart rate for at least 10 MINUTES at a time. • Level 3: Participate in aerobic exercises such as brisk walking, jogging or running, cycling, swimming or vigorous sports at a comfortable pace or other activities requiring similar levels of exertion for 20 to 60 MINUTES per week. • Level 4: Participate in aerobic exercises such as brisk walking, jogging or running at a comfortable pace, or other activities requiring similar levels of exertion for 1 to 3 HOURS per week. • Level 5: Participate in aerobic exercises such as brisk walking, jogging, or running at a comfortable pace, or other activities requiring similar levels of exertion for OVER 3 HOURS per week.
Strenuous	During a typical 7-day period (a week), how many times on average do you do the following kinds of exercise for more than 15 minutes during your free time? 1. STRENUOUS EXERCISE (heart beats rapidly) e.g., running, jogging, hockey, football, soccer, squash, basketball, cross country skiing, judo, roller skating, vigorous swimming, vigorous long distance bicycling
Moderate	1. MODERATE EXERCISE (not exhausting) e.g., fast walking, baseball, tennis, easy bicycling, volleyball, badminton, easy swimming, alpine skiing, popular and folk dancing
Mild	1. MILD EXERCISE (minimal effort) e.g., yoga, archery, fishing from river bank, bowling, horseshoes, golf, snow-mobiling, easy walking
Sweat	During a typical 7-day period (a week), in your leisure time, how often do you engage in any regular activity long enough to work up a sweat (heart beats rapidly)? (Often, Sometimes, Never/Rarely)

3.4.3 Physical Activity Questionnaire #2 (MAQ)

Parameter	*Question*
Activities	Please check the box next to all activities listed below that you have done more than 10 times in the past year: • Jogging (outdoor, treadmill) • Swimming (laps, snorkeling) • Bicycling (indoor, outdoor) • Softball/Baseball • Volleyball • Bowling • Basketball • Skating (roller, ice, blading) • Martial Arts (karate, judo) • Tai Chi • Calisthenics/Toning exercises • Wood Chopping • Water/coal hauling • Football/Soccer • Racquetball/Handball/Squash • Horseback riding • Hunting • Fishing • Aerobic Dance/Step Aerobic • Water Aerobics • Dancing (Square, Line, Ballroom) • Gardening or Yardwork • Badminton • Strength/Weight training • Rock climbing • Scuba diving • Stair Master • Fencing • Hiking • Tennis • Golf • Canoeing/Rowing/Kayaking • Water skiing • Jumping rope • Snow skiing (X-country/Nordic track) • Snow skiing (downhill) • Snow shoeing • Yoga • Walking for exercise (out/indoor, treadmill) • Other
Jogging	For each activity that you checked above, check the button underneath the months you did each activity over the past year (12 months) and then estimate the average amount of time spent in that activity.
JoggingTimes	Avg # of times per month

JoggingMins
pattern shown above for Jogging:
  • Jogging
  • JoggingTimes
  • JoggingMins
is repeated for each of the items listed on right.
	Average # of minutes each time
	
	• Swimming
	• Dancing
	• Bicycling
	• Gardening
	• Baseball
	• Badminton
	• Volleyball

3.4.4 Acute Side Effects Questionnaire

Parameter	Question
DateRecorded	The date when the information was originally recorded (the date of the subject's visit). This parameter is needed for the side-effects questionnaires which are initially recorded on paper and then subsequently transcribed electronically. For these questionnaires, the "Date" parameter corresponds to when the information was entered electronically, and the "DateRecorded" value corresponds to when the subject received the tES.
Stimulation	Type of stimulation (tDCS, tRNS or Sham tDCS, Sham tRNS). This question was removed from the questionnaire in late April 2015 because this subject information is already known through our subject condition assignment process (see the "Condition" parameter). It also required that the person administering the questionnaire be unblinded.
Experimenter	Experimenter/Co-investigator who administered the questionnaire.
PainPreSeverity	Are you experiencing any pain (headache, scalp pain, discomfort)? • Question asked *before* stimulation (Absent, Mild, Moderate, Severe).
PainPostSeverity	• Question asked *after* stimulation (Absent, Mild, Moderate, Severe).
PainPostRelationship	• Relationship between subject's pre and post pain severity, as assessed by senior staff (None, remote, Possible, Probable, Definite).
PainComments	(text field)
IrritationPostSeverity IrritationPostRelationship IrritationComments ConcentrationPostSeverity ConcentrationPostRelationship ConcentrationComments	*Repeat Pain Pre/Post/PostRelationship/Comments pattern with these two questions:* Is your scalp irritated (burning)? [Experimenter assess scalp redness] Are you having trouble concentrating?
SensationsSeverity	Since the beginning of today's session, have you felt sensations under the electrode locations (tingling, itching, burning, pain)?
SensationsRelationship	Assessed by senior staff (None, remote, Possible, Probable, Definite).
SensationsComments	
NervousnessRelationship NervousnessComments NauseaRelationship NauseaComments OtherRelationship OtherComments OtherEffect	*Repeat Sensations Severity/Relationship/Comments pattern with these three questions:* Since the beginning of today's session, have you felt nervous? Since the beginning of today's session, have you felt nauseous? Is there anything else that you would like to tell me? Did the subject have any other adverse effect during or

3.4.5 Multidimensional Mood State Questionnaire

All responses are answers to the statement "Right now I feel…" completed by the word specified in the table below. Responses are selected from:

- Definitely not

- Not

- Not really

- A little

- Very much

- Extremely

Parameter	*"Right now I feel…"*
Content	Content
Rested	Rested
Restless	Restless
Bad	Bad
WornOut	Worn-out
Composed	Composed
Tired	Tired
Great	Great
Uneasy	Uneasy
Energetic	Energetic
Uncomfortable	Uncomfortable
Relaxed	Relaxed
Activated	Highly activated
Superb	Superb
Calm	Absolutely calm
Sleepy	Sleepy
Good	Good
AtEase	At ease
Unhappy	Unhappy
Alert	Alert
Discontent	Discontent
Tense	Tense
Fresh	Fresh
Happy	Happy
Nervous	Nervous
Exhausted	Exhausted
Calm	Calm
Awake	Wide awake
Wonderful	Wonderful
Relaxed	Deeply relaxed

3.4.6 Engagement Questionnaire

Except where noted, subjects were asked to answer questions on a 1 (*Not At All*) to 7 (*A Lot*) scale. In some questions, *Not At All* was replaced by *Very Poor*. In some questions, *A Lot* was replaced by *Very Much So, Very Aware, Very Difficult, Very Well or Definitely Yes*.

Parameter	Question
Attention	To what extent did the game hold your attention?
Focus	To what extent did you feel you were focused on the game?
Effort	How much effort did you put into playing the game?
Trying	Did you feel that you were trying your best?
LoseTrackOfTime	To what extent did you lose track of time, e.g. did the game absorb your attention so that you were
WorldAwareness	To what extent did you feel consciously aware of being in the real world whilst playing?
EverydayConcerns	To what extent did you forget about your everyday concerns?
Surroundings	To what extent were you aware of yourself in your surroundings?
NoticeEvents	To what extent did you notice events taking place around you?
UrgeToStop	Did you feel the urge at any point to stop playing and see what was happening around you?
InteractingWithGame	To what extent did you feel that you were interacting with the game environment?
SeparatedFromWorld	To what extent did you feel as though you were separated from your real-world environment?
Fun	To what extent did you feel that the game was something fun you were experiencing, rather than a
GameStrongerThanWorld	To what extent was your sense of being in the game environment stronger than your sense of being
Involvement	At any point did you find yourself become so involved that you were unaware you were even usin
OwnWill	To what extent did you feel as though you were moving through the game according to your own
Challenging	To what extent did you find the game challenging?
GiveUp	Were there any times during the game in which you just wanted to give up?
Motivated	To what extent did you feel motivated while playing?
Easy	To what extent did you find the game easy?
MakingProgress	To what extent did you feel like you were making progress towards the end of the game?
Performance	How well do you think you performed in the game?
EmotionalAttachment	To what extent did you feel emotionally attached to the game?
InterestGameProgress	To what extent were you interested in seeing how the game's events would progress?
WantToWin	How much did you want to "win" the game?
Suspense	Were you in suspense about whether or not you would do well in the game?
SpeakToGame	At any point did you find yourself become so involved that you wanted to speak to the game direc
EnjoyGraphics	To what extent did you enjoy the graphics and the imagery?
EnjoyGame	How much would you say you enjoyed playing the game?
DisappointedGameEnded	When it ended, were you disappointed that the game was over?
PlayGameAgain	Would you like to play the game again?
HowImmersed	How immersed did you feel? (1 – Very immersed to 7 – Not At All Immersed)
ReadInstructions	Did you read all instructions completely before starting each task? (Yes or No)
CommentReadInstructions	If No, please describe the reasons (250 char).
UnderstandInstructions	Did you understand the task instructions? (1 – Not at all to 7 – Completely)
CommentUnderstandInstructions	If there are tasks for which you did not completely understand the instructions, please specify how
EffortInstructions	How much mental effort did it take for you to follow the instructions? (1 – Very Little to 7 – A lo

3.4.7 Sleepiness Questionnaire #1 (Pre)

Parameter	Question
Sleepiness	This is a quick way to assess how alert you are feeling. If it is during the day when you go about your business, ideally you would want a rating of a one. Take into account that most people have two peak times of alertness daily, at about 9 a.m. and 9 p.m. Alertness wanes to its lowest point at around 3 p.m.; after that it begins to build again. Rate your alertness at different times during the day. If you go below a three when you should be feeling alert, this is an indication that you have a serious sleep debt and you need more sleep. Degree of sleepiness: 1. Feeling active, vital, alert, or wide awake 2. Functioning at high levels, but not at peak; able to concentrate 3. Awake, but relaxed; responsive but not fully alert 4. Somewhat foggy, let down 5. Foggy; losing interest in remaining awake; slowed down 6. Sleepy, woozy, fighting sleep; prefer to lie down 7. No longer fighting sleep, sleep onset soon; having dream-like thoughts 8. Asleep
Sleep	How many hours of sleep did you get last night?

3.4.8 Sleepiness Questionnaire #2 (Post)

Parameter	Question
Sleepiness	This is a quick way to assess how alert you are feeling. If it is during the day when you go about your business, ideally you would want a rating of a one. Take into account that most people have two peak times of alertness daily, at about 9 a.m. and 9 p.m. Alertness wanes to its lowest point at around 3 p.m.; after that it begins to build again. Rate your alertness at different times during the day. If you go below a three when you should be feeling alert, this is an indication that you have a serious sleep debt and you need more sleep. Degree of sleepiness: 1. Feeling active, vital, alert, or wide awake 2. Functioning at high levels, but not at peak; able to concentrate 3. Awake, but relaxed; responsive but not fully alert 4. Somewhat foggy, let down 5. Foggy; losing interest in remaining awake; slowed down 6. Sleepy, woozy, fighting sleep; prefer to lie down 7. No longer fighting sleep, sleep onset soon; having dream-like thoughts 8. Asleep

3.4.9 Alcohol & Caffeine Questionnaire

Parameter	Question
Alcohol	How many drinks containing alcohol have you consumed in the past 24 hours? One standard drink is defined as: 1. 12 ounces of beer (5% alcohol content) 2. 8 ounces of malt liquor (7% alcohol content) 3. 5 ounces of wine (12% alcohol content) 4. 1.5 ounces or a "shot" of 80-proof (40% alcohol content) distilled spirits or liquor (e.g., gin, rum, vodka, whiskey)
Caffeine	How many drinks containing caffeine have you consumed within an hour prior to your visit? One standard drink is defined as: 1. 6 ounces of tea 2. 12 ounces of soda 3. 8.5 ounces of Red Bull 4. 3.5 ounces of coffee (Note: Starbucks "tall" coffee is 12 ounces)

3.4.10 Handedness Questionnaire

The subject was asked to respond to this instruction:

Please indicate your preferences in the use of hands in the following activities by selecting the appropriate button. Where the preference is so strong that you would never try to use the other hand unless absolutely forced to, select left/right hand "strongly preferred." If in any case you are really indifferent select "No preference."

Some of the activities require both hands. In these cases the part of the task, or object, for which hand preference is wanted is indicated in parentheses.

Please try to answer all the questions, and only leave a blank if you have no experience at all of the object or task.

Responses to questions use this key:

1 – Left hand strongly preferred

2 – Left hand preferred

3 – No preference

4 – Right hand preferred

5 – Right hand strongly preferred

Parameter	Activity
Writing	Writing
Drawing	Drawing
Throwing	Throwing
Scissors	Scissors
Toothbrush	Toothbrush
Knife	Knife (without fork)
Spoon	Spoon
Broom	Broom (upper hand)
Match	Striking Match (match)
OpenBox	Opening box (lid)

3.4.11 Debriefing Questionnaire

Parameter	Question
ReceivingStimulation?	Do you think you were actually receiving electrical stimulation during training? (Yes or No)
CommentStimulation	Comment (250 char).
RotationStrategy?	While performing the Rotation Task that had you remember letters and arrows, did you employ a particular strategy? (Yes or No)
CommentStrategy	If yes, please explain (500 char).

3.5 Parameters That Are Specific to the EEG Files

There are three types of files with EEG content exported by the parser:

- EEG data files, they have a .easy suffix

- Stimulation files, they have a .stim suffix

- The parser generated eeg-info.csv file

The EEG data files and the stimulation files are generated by the Neuroelectrics NIC application. The EEG data is recorded at 500 Hz and the stimulation data is recorded at 1000 Hz. The stimulation file is only generated for cases when a subject is being stimulated with tES, including the sham conditions. The EEG data files and stimulation files are posted as parser output although they are really created by the NIC.

For each EEG file, the NIC also generates an information file (.info file suffix) which the parser uses for populating parameters in the generated eeg-info file.

The NIC does not reliably generate .stim and .info files. We have instances where one or the other file is missing.

3.5.1 EEG Data Files

The parser modifies the .easy file generated by the parser in these two ways:

1. Normalizes and blinds the file name

2. Adds a column heading row to the EEG data file

The .easy file name generated by the NIC should have this format:

<timestamp><subject-id><qualifier>.easy

The NIC generates the timestamp but the <subject-id> and <qualifier> parts are entered by the experimenter and mistakes (including typos) occur about 5% of the time. The <qualifier> provides an indication of what the subject was doing during the recording (pretest, training, eyes-open, eyes-closed, etc.).

After correcting errors in the <subject-id> and <qualifier>, the parser generates this normalized file name for the EEG data file:

<subject-id><timestamp><qualifier>.easy

Because EEG analysis started when many of the analysts were blinded, we actually write the EEG data with blinded file names having this format:

<blinded-id><seq-number><qualifier>.easy

The <blinded-id> is a randomly selected integer that uniquely identifies the subject, and the <seq-number> replaces the timestamp in a manner that preserves numerical ordering. That is, if

$$timestamp_{sub'1'} < timestamp_{sub'2'}$$

Then the corresponding sequence numbers will also follow this relation:

$$seqnumber_{sub'1'} < seqnumber_{sub'2'}$$

The EEG-sum file shows all three names for each EEG file, the original name provided by the NIC, the normalized file name (which we don't use), and the blinded file name which we use for naming the exported EEG data files.

When there is a stimulation file corresponding to an EEG data file, we write that file with the same name as the EEG data file but with a .stim file extension:

<blinded-id><seq-number><qualifier>.stim

These are the file qualifiers used for naming the blinded files:

Qualifier	Description
pretest-eo	Prior to the subject's pretest, the 5 minute eyes-open recording.
pretest-ec	Prior to the subject's pretest, the 5 minute eyes-closed recording.
pretest-test	The subject's pretest.
training$i$-pretec	Prior to the subject's i^{th} training, the 5 minute eyes-closed recording. Expected on training sessions 3 and 8 for subjects trained by Honeywell, Northeastern and Oxford.
training$i$-train	EEG recorded during the subject's i^{th} training. If the subject received tES, this file will contain just the portion of the training when tES was being applied. Otherwise it will contain EEG for the entire training session.
training$i$-posteeg	EEG recorded during the subject's i^{th} training, after the completion of tES. This file will not exist if the subject did not receive tES during the session.
training$i$-postec	After the subject's i^{th} training, the 5 minute eyes-closed recording. Expected on training sessions 3 and 8 for subjects trained by Honeywell, Northeastern and Oxford.
training$i$-train	Prior to the subject's pretest, the 5 minute eyes-open recording.

The only change we make to the contents of the EEG data file is to add a row with column headings for the EEG data.

We make no changes to the contents of the stimulation files.

These are the columns in the EEG data files, ordered from first to last:

Parameter	Description
<channel>	The first eight columns (StarStim), or first 20 columns (Enobio 20), or 32 columns (Enobio 32) contain EEG data. If the parser found a .info file corresponding to the EEG data file, these column headers are populated from the montage described in the .info file. Otherwise, the generic names *Chan1, Chan2, …* are used.
1 Accel2 Accel3	Accelerometer sensor values.
Trigger	A trigger value injected by the pretest, posttest or training application being used by the subject.
NeTime	A timestamp associated for the EEG data values. The value is provided by a StarStim or Enobio headset, and expresses milliseconds since the start of the UNIX-defined epoch.

3.5.2 The Generated eeg-sum File

The following table describes the contents of the generated eeg-sum file. Unless otherwise noted, values are extracted from the information file (.info) expected for each EEG data file. Values are left blank when this file is missing.

The parser can generate a blinded version of the eeg-sum file which omits these four columns:

- FileDate

- Notes

- OriginalFile

- NormalizedFile

Parameter	Description
AccelChans	Number of accelerometer channels, either zero or three. (From EEG information file.)
AddChan	Presence of an "Additional Channel". (From EEG information file.)
BlindedFile	The blinded name for the generated EEG data file.
Device	The device type, either *StarStim*, *StarStim (EEG only mode)*, *Enobio20*, or *Enobio32*. (From EEG information file.)
Duration	Duration of the EEG file, expressed in hh:mm:ss format.
EegChans	Number of EEG recording channels. (From EEG information file.)
EegRecs	Number of EEG records in the file. (From EEG information file.)
EogCorr	Status of the EOG correction filter. (From EEG information file.)
FileDate	Date when EEG data was recorded expressed in local time.
FW	The version of the firmware in the NECBOX.
InfoFile	Set to TRUE when the parser was able to find the information (.info) file corresponding to the EEG data (.easy).
LineFilter	Status of the line filter.
LostSamples	Number of missing EEG data records from the file.
MAC	The NECBOX's MAC address (uniquely identifies the specific unit).
Montage	The EEG montage used for connecting EEG sensors to the headcap. (From EEG information file.)
NIC	The NIC software version. (From EEG information file.)
NormalizedFile	The normalized name for the generated EEG data file (not used since we name the generated EEG data files with the BlindedFile name).
Notes	Manually entered notes about the EEG data file.
OriginalFile	The file name of the original EEG data file.
PacketsLost	The number of packets (and percent of total) sent via Bluetooth by the NECBOX that were not received by the NIC. (From EEG information file.)
Qualifier	The second part of the EEG file qualifier (the first part can be inferred from the "Period" parameter.

Table 3.6 – continued from previous page

Parameter	*Description*
Rating	A subjective evaluation that rates the file against three metrics. The metrics are: • Duration – the EEG recording is longer "D+" or shorter "D-" than expected • Triggers – the file contains more "T+" or fewer "T-" triggers than expected • Trigger rate – relative to the file's duration, the file contains more "R+" or fewer "R-" triggers than expected. A blank rating means that the file's duration and triggers conform to expectations.
ShamRampDown	The sham ramp down time, expressed in seconds. (From EEG information file.)
ShamScore	The likelihood that the subject was receiving sham stimulation. A score of less than -1 suggests that the subject is very likely to have received sham stimulation while a score greater than 1 suggests that the subject is very unlikely to have received sham stimulation. Values in the range -1 .. 1 cannot be used to infer the sham condition. File duration may accurately determine sham condition however. A blank value is used for files that show no evidence of stimulation, sham or otherwise. Note: this column may not be generally useful since the result is factored into the StimError column: incorrect sham conditions are reported as sham_yes and sham_no, and cases where the sham condition could not be determined are reported as sham_unverified.
StimChans	The number of StarStim channels used for stimulation. (From EEG information file.)
StimDuration	The duration of the stimulation protocol, expressed in seconds. (From EEG information file.)
StimError	Deviations from the expected tES for this file type and for this subject. No stimulation is expected for all file types except training i-train when i is greater than 2 (training without tES). Values are composed from these clauses: • no_stim: tES was expected but not detected • tDCS: tDCS stimulation was detected when tRNS or no stimulation was expected • tRNS: tRNS stimulation was detected when tDCS or no stimulation was expected • sham_no: sham tES was expected but subject received either tDCS or tRNS stimulation • sham_yes: tDCS or tRNS stimulation was expected but subject received sham stimulation instead • sham_unverified: we are unable to determine with confidence if subject received tES or sham tES.

Continued on next page

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Parameter	*Description*
StimFile	Set to TRUE when the parser found a stimulation file (.stim suffix) corresponding to the EEG data file.
StimProtocol	The name of the stimulation template used for controlling stimulation. (From EEG information file.)
StimRampDown	The stimulation ramp down time, expressed in seconds. (From EEG information file.)
StimRampUp	The stimulation ramp up time, expressed in seconds. (From EEG information file.)
StimRecs	The number of stimulation records. (From EEG information file.)
StimType	The type of stimulation (tDCS or tRNS). (From EEG information file.)
Triggers	The number of triggers (non-zero trigger values) found in the EEG data file.

Parser File "rf-triggers"

The generated "rf-triggers" file provides linkage for a RobotFactory trigger value found in an EEG data file back to the game play information in a parser generated "robotfactory" file. The "rf-triggers" file is intended to be used with a specific Matlab utility and is not likely to be useful outside the context of that utility.

For a training session, RobotFactory creates an "output_log" file and an "LSL_Testing" file while also sending trigger values for the NIC to merge into the EEG stream. The "output_log" file contains much of the information provided in the parser generated "robotfactory" files. The "LSL_Testing" file contains the trigger values sent to the NIC along with timestamps and other information relating to the trigger. The generated "rf-triggers" file contains much of the information in the "LSL_Testing" file.

The TrialID column was added to the generated "robotfactory" file to support this capability. It simply numbers the lines in the file.

4.1 Contents of the "rf-triggers" File

The parser builds a line in the "rf-triggers" file for each "LSL_Testing" file. Consequently a line spans an entire training session (and so can be very long – remember that this file is intended to be used by another tool).

The line begins with an approximation for the blinded EEG file name for the training session. The name is approximate because typically there is more than one EEG file and because, given the timestamp in the RobtFactory output_log file, the parser can at best infer an approximate time for the EEG data file. To emphasize that the file name is approximate, it is prefixed by '$'.

So the intent is to have another (and yet to be implemented) semi-automated utility that, given the approximate file name could scan the generated "eeg-sum" file and generate a list of likely EEG data files for the training session. It seems prudent for someone to check the generated list.

Following the approximate EEG file name, the line contains a 4-tuple for each trigger sent to the NIC. The 4-tuple contains these values:

- A label that describes the purpose of the trigger (e.g., begin_shift, begin_trial, begin_stimulus, stimulus_begins_exiting)

- The trigger value, a 32 bit value where the high order bit is always set (to distinguish from triggers not generated by RobotFactory which never have the high order bit set)

- A trial id that identifies the row in the "robotfactory" collection of files that corresponds to the trial that contains this trigger, or a negative number which denotes the following cases:

    - -1: the trigger is outside the bounds of a trial (before first trial, after last trial, between trials)

    - -2: there is a corresponding output_log file, but it does not contain any shifts

    - -3: the output_log file does not contain this shift

    - -4: the output_log does not contain this trial

- A timestamp for the trigger

CHAPTER 5

Publications

CHAPTER 6

Indices and tables

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