PD Percept Pipeline

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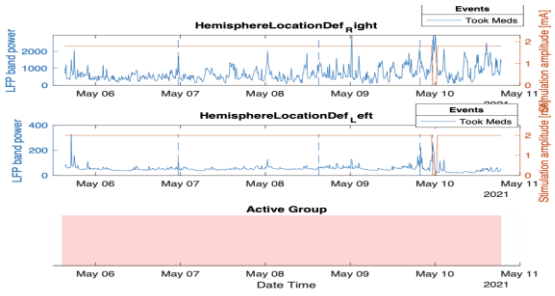
Version1 (Published): https://github.com/C-ACT/Percept-LFP-Toolbox/
Version2: Percept Extract Code

Scripts: Working Upload	Version of Matlab Used: 2021a - 2022b
loadJSONs	Prompts a single BrainSense Medtronic JSON file from up to 60 days prior to office visit. Extracts, saves and plots indefinite streaming and timeline data and stimulation group settings in folder of choice as "LFPTrendlogs.mat" structure and figure. As adapted by Yohann Thenaisie 02.09.2020 - Lausanne University Hospital (CHUV)
combine_Groups	Synthesises a cumulative dataset (as a .mat file) of stimulation settings from "LFPTrendlogs.mat<ActiveGroup." : Prompts user to select LFPTrendLogs of JSONs extracted from a single patient, loads and create a queue of the **ActiveGroup** Variable into singular table, and saves as "PD_AG.mat." Repetitive data is overwritten.
structureData	Generates a cumulative dataset (as a .mat file) of stimulation amplitudes and raw LFP band power from "LFPTrendlogs.mat<LFPTrendLogs" Prompts user to select **LFPTrendLogs** of JSONs extracted from a single patient. Time constraint is specified in "HH:MM:ss"" format, via **c1** and **c2** variables as lower and upper time bounds, respectively. The dataset reflects data sourced from times **c1 to c2.** Variables **T** and **S** are tables generated as a result of data extraction from the LFPTrendLogs struct format, sorted chronologically, with ommission of duplicate data. **T** and **S** variables are contrained to **c1 and c2 ranges** and saved as "structureData.mat" (default set to c1 = "09:00:00", c2 = "21:00:00"). A row is added to each table to fill in missing "dates", but assigned to NaN (unknown value)
visData	Calculates the daily IQR, daily standard deviation and FS using a non-overlapping window of **k**, indicated range of days (default is k=5). Prompts user to select "structureData.mat," or cumulative JSON data according to timetables **T** and **S**. @iqr matlab function is applied for each unique date of data, across each hemisphere LFP band power row within the T timetable, then is @std. Fluctuation score is calculated after filling each null value iqr row (date/day) with the *previous* known value. **k** consecutively summed values of IQR, are reported as day 1 out of k FS. Process is repeated until the last group of k days has its value recorded. These statistics are saved to folder. Standard deviation and fluctuation scores are plotted
saveCSV	Timetables are saved as csv
PD_Timeline_Extended (pd_01)	Prompts for table that includes the date of first programming. Reorganizes and rereferences data according to provided first programming date and subsequent visits or "sessions". Puts all measurements sequentially in a single column for JMP compatibility/ analysis.
Session_Category	
StackTablesVariables	
Resampling and Checking Groups	
loadJSONs2/ExtractGroups	Re-extracts stimulation settings to accommodate found inconsistencies (missing samples, sample hemisphere allocation) and inclusions of more precise setting changes (pulse width, rate, band of interest, contact)
combineAllGroups	

Script: LoadJSONs



Import	Name	Size	Bytes	Class
☑	ActiveGroup	1x4	14115	table
☑	LFPTrendLogs	1x1	91649	struct

Resulting LFPTrendLogs.mat Files.

ActiveGroup

1x4 table

	1 DateTime	2 OldGroupId	3 NewGroupId	4 NewProgramSettings
	15-Sep-2021 13:...	'GROUP_A'	'GROUP_A'	1x1 struct

Contents of the Active Group Variable contains a table of the Stimulation settings and "Groups" Streamed by user.

1x1 struct with 5 fields

Field	Value
LFP	1x1 struct
stimAmp	1x1 struct
json	_Json_Session_Report_20211001T170705.json'
recordingMode	'LFPTrendLogs'
events	9x6 table

LFPTrendLogs.LFP

Field	Value
data	2334x1 double
time	1x2334 datetime
nChannels	1
channel_names	1x1 cell
xlabel	'Date Time'
ylabel	'LFP band power'

LFPTrendLogs.stimAmp

Field	Value
data	2334x1 double
time	1x2334 datetime
nChannels	1
channel_names	1x1 cell
xlabel	'Date Time'
ylabel	'Stimulation amplitude [mA]'

Contents of the LFPTrendLogs Variable contains a struct of stimulation amplitude data and LFP Band Power averaged sampled per 10 minutes (REF). Additional contents unused include user-recorded events.

Script: Combine_Groups

PD_AG = 2x4 table

	DateTime	OldGroupId	NewGroupId	NewProgramSettings
1	03-Nov-2022 20:45:50	'GROUP_A'	'GROUP_A'	1×1 struct
2	19-Oct-2022 19:23:23	'GROUP_A'	'GROUP_A'	1×1 struct

PD_AG = 2x4 table

	DateTime	OldGroupId	NewGroupId	NewProgramSettings
1	19-Oct-2022 19:23:23	'GROUP_A'	'GROUP_A'	1×1 struct
2	19-Oct-2022 19:23:23	'GROUP_A'	'GROUP_A'	1×1 struct

PD_AG = 2x4 table

	DateTime	OldGroupId	NewGroupId	NewProgramSettings
1	19-Oct-2022 19:23:23	'GROUP_A'	'GROUP_A'	1×1 struct
2	19-Oct-2022 19:23:23	'GROUP_A'	'GROUP_A'	1×1 struct

PD_AG = 2x4 table

	DateTime	OldGroupId	NewGroupId	NewProgramSettings
1	19-Oct-2022 19:23:23	'GROUP_A'	'GROUP_A'	1×1 struct
2	13-Jan-2023 15:31:49	'GROUP_A'	'GROUP_A'	1×1 struct

PD_AG = 2x3 timetable

	DateTime	OldGroupId	NewGroupId	NewProgramSettings
1	19-Oct-2022 19:23:23	'GROUP_A'	'GROUP_A'	1×1 struct
2	13-Jan-2023 15:31:49	'GROUP_A'	'GROUP_A'	1×1 struct

Script: structureData

Each Table contains an array of data values, specified by time corresponding to each date column.

S	270x7	721703	timetable
T	270x6	1286353	timetable

Workspace

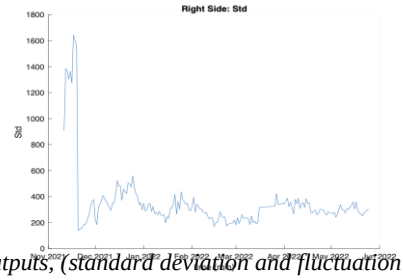
Date	1 Raw Date Time (HH	2 Raw LFP Band Powe	3 Duration (HH:mm:s	4 LFP Band Power – R/CH1	5 LFP Band Powe	6 Date Time (HH:mm:ss
05-May-2021	1x53 datetime	53x2 double	1x35 duration	35x1 double	[]	1x35 datetime
06-May-2021	1x144 datetime	144x2 double	1x72 duration	72x1 double	[]	1x72 datetime
07-May-2021	1x144 datetime	144x2 double	1x72 duration	72x1 double	[]	1x72 datetime
08-May-2021	1x144 datetime	144x2 double	1x72 duration	72x1 double	[]	1x72 datetime
09-May-2021	1x141 datetime	141x2 double	1x72 duration	72x1 double	[]	1x72 datetime
10-May-2021	1x112 datetime	112x2 double	1x59 duration	59x1 double	[]	1x59 datetime
11-May-2021	144x1 datetime	144x2 double	72x1 duration	72x1 double	[]	72x1 datetime
12-May-2021	144x1 datetime	144x2 double	72x1 duration	72x1 double	[]	72x1 datetime
13-May-2021	144x1 datetime	144x2 double	72x1 duration	72x1 double	[]	72x1 datetime

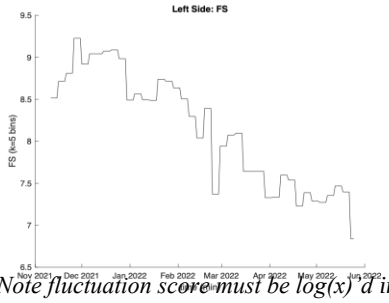
Table T. Note Fluctuation score provided is not yet log'd.

Date	1 Duration (HH:mm:ss)	2 Stim Amp – R/CH1 (mA)	3 Stim Amp – L	4 Channel Names	5 Band of Intere	6 Pulsew	7 Date Time (HH:m
05-May-2021	1x107 duration	107x1 double	[]	"ONE_AND_THREE"	15.6300	60	1x107 datetime
06-May-2021	1x144 duration	144x1 double	[]	"ONE_AND_THREE"	15.6300	60	1x144 datetime
07-May-2021	1x216 duration	216x1 double	[]	"ONE_AND_THREE"	15.6300	60	1x216 datetime
08-May-2021	1x216 duration	216x1 double	[]	"ONE_AND_THREE"	15.6300	60	1x216 datetime
09-May-2021	1x216 duration	216x1 double	[]	"ONE_AND_THREE"	15.6300	60	1x216 datetime
10-May-2021	1x203 duration	203x1 double	[]	"ONE_AND_THREE"	15.6300	60	1x203 datetime
11-May-2021	72x1 duration	72x1 double	[]	"ONE_AND_THREE"	17.5800	60	72x1 datetime
12-May-2021	72x1 duration	72x1 double	[]	"ONE_AND_THREE"	17.5800	60	72x1 datetime
13-May-2021	72x1 duration	72x1 double	[]	"ONE_AND_THREE"	17.5800	60	72x1 datetime

Table S

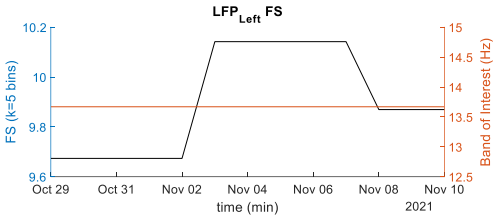
Script: visData

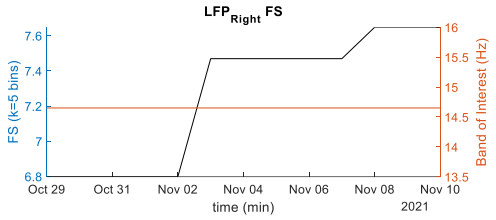


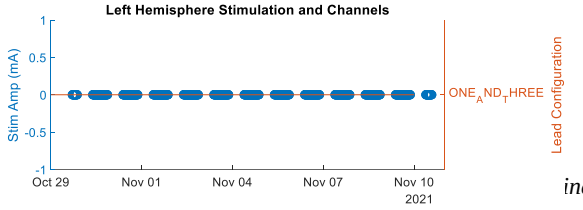


*Calculated outputs, (standard deviation and fluctuation score). *Note fluctuation score must be log(x) d in data tables/raw tables, but depiction is a log-x-axis scale.*

Old version of this script (Github) provides the following image sequences:







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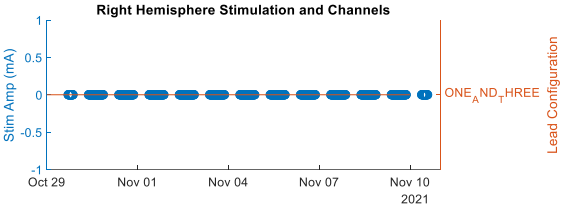
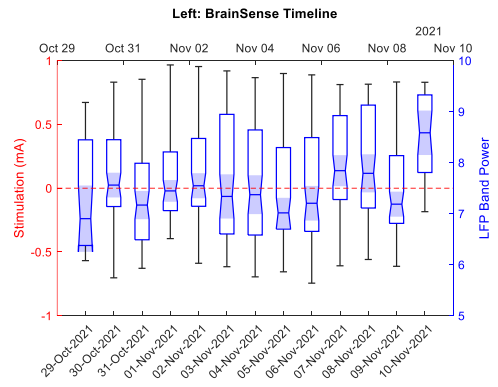
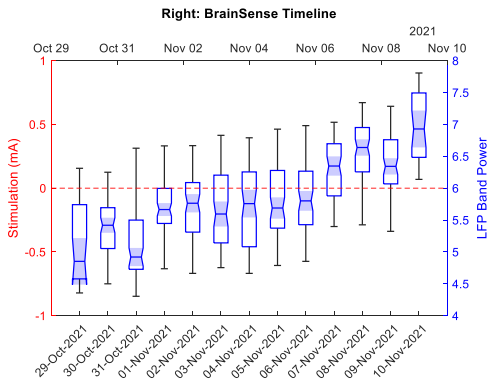
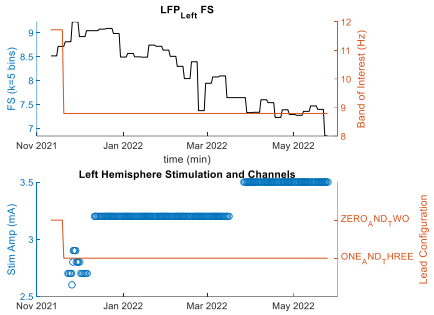
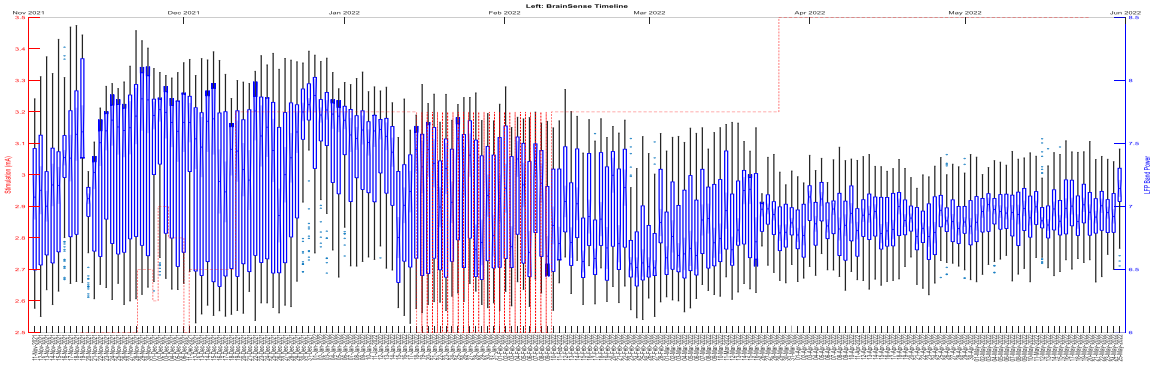






Additional Examples





Script: PD_Timeline_Extended (pd_01)

PD_Timeline_Extended

Days Since First Programming	Data	Group	Patient	Data_Type	Session Number
-22	NaN	GROUP_B	[redacted]	IQR (uVp) - Left	1
-22	NaN	GROUP_B		IQR (uVp) - Right	1
-21.6206481481481	0	GROUP_B		Stimulation Amplitude (mA) - Left	1
-21.6206481481481	0	GROUP_B		Stimulation Amplitude (mA) - Right	1
-21.6137037037037	0	GROUP_B		Stimulation Amplitude (mA) - Left	1
-21.6137037037037	0	GROUP_B		Stimulation Amplitude (mA) - Right	1
46.7057523148148	0	GROUP_B		Stimulation Amplitude (mA) - Left	2
46.7057523148148	0	GROUP_B		Stimulation Amplitude (mA) - Right	2
46.7057523148148	0	GROUP_B		Stimulation Amplitude (mA) - Right	2
46.7093634259259	1.7	GROUP_B		Stimulation Amplitude (mA) - Left	2
46.7093634259259	1.9	GROUP_B		Stimulation Amplitude (mA) - Right	2
46.7093634259259	83	GROUP_B		LFP Band Power - Left	2
46.7093634259259	286	GROUP_B		LFP Band Power - Right	2
46.7126967592593	0	GROUP_B		Stimulation Amplitude (mA) - Left	2

Limitations/Improvements from first Version (Github)

- In PD_AG Generation the following needs to be automated
- Rename groups if the, BOI, and channel is different only
- A Question if we group the left and right as different classified “groups” even if one hemisphere remains the same? Maybe this explains variation later so for now - separate left and right hemisphere groups
- Case of Different Group, Same Settings
- Normalize LFP to reduce outliers before FS calculated

Data Statistics Steps in JMP (V.2022-23)

Recording and re-referencing according to program dates (JSON file)

Each JSON file corresponds to an office visit, which is notated below. Data used to separate data acquired between office visits by assigning data the *session number* category variable.

RedCap									
Subject	Record ID	1st programming	2nd	3rd	4th	5th	6th		
1	[redacted]	11/25/22	12/9/22	1/11/23	2/8/23	3/8/23			
2	[redacted]	6/8/22	7/13/22	8/10/22	10/12/22	12/14/22			
3	[redacted]	7/6/22	8/3/22	10/12/22	11/9/22	2/8/23			
4	[redacted]	5/11/22	5/11/22	6/15/22	7/1/22	8/3/22	8/24/22	9/21/22	
5	[redacted]	6/8/22	7/8/22	9/7/22	10/5/22	12/7/22	3/10/23		

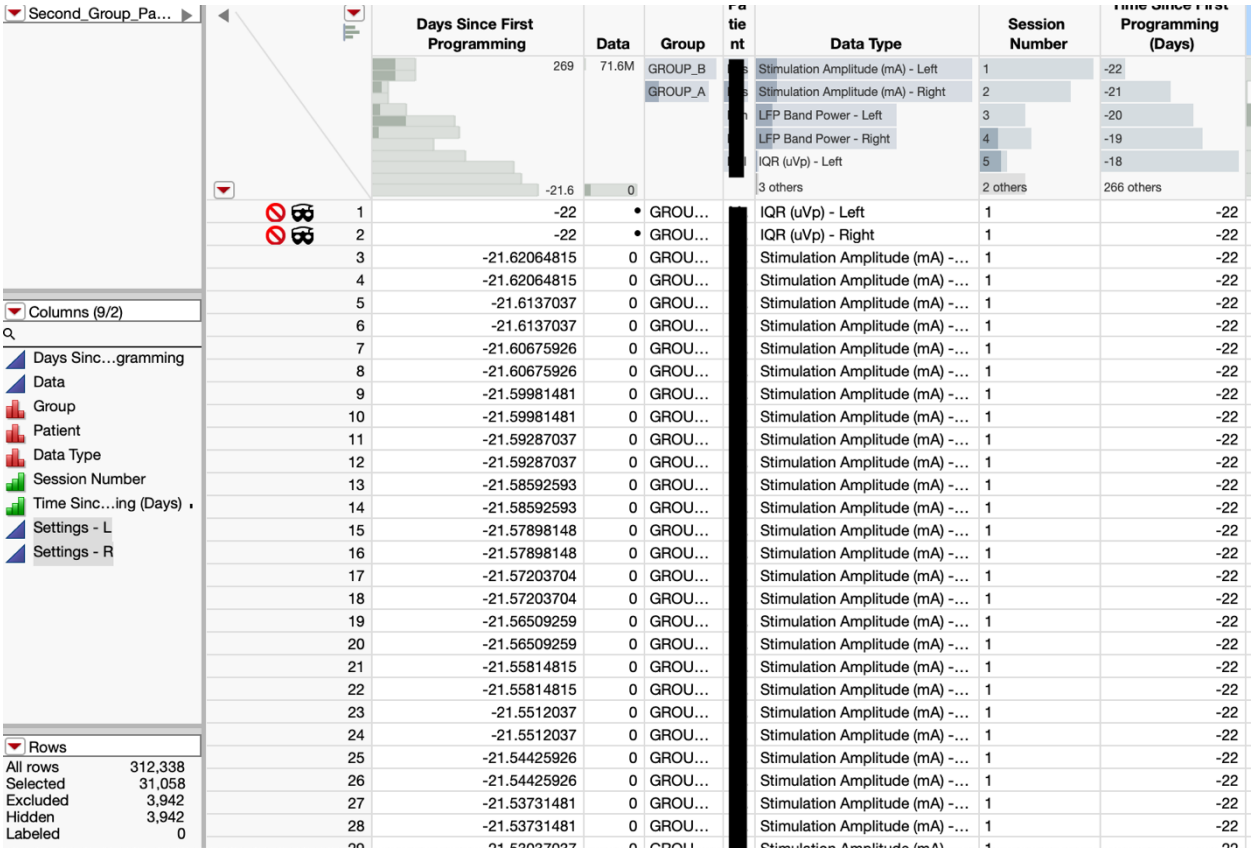
Pasting in Table

Outcome of last Matlab script

PD_Timeline_Extended

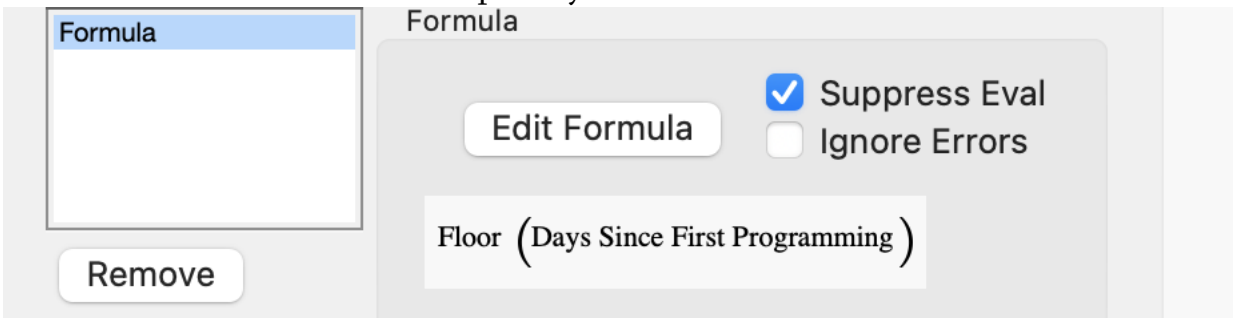
Days Since First Programming	Data	Group	Patient	Data_Type	Session Number
-19	10.5	GROUP_A	[redacted]	IQR (uVp) - Right	1
-19	90.5	GROUP_A		Fluctuation Score (uVp) - Right	1
-19	1216.5	GROUP_A		IQR (uVp) - Left	1
-19	6647	GROUP_A		Fluctuation Score (uVp) - Left	1
-18.205787037037	0	GROUP_A		Stimulation Amplitude (mA) - Left	1
-18.205787037037	0	GROUP_A		Stimulation Amplitude (mA) - Right	1
-18.205787037037	89	GROUP_A		LFP Band Power - Right	1
-18.205787037037	2180	GROUP_A		LFP Band Power - Left	1
-18.1988425925926	0	GROUP_A		Stimulation Amplitude (mA) - Left	1
-18.1988425925926	0	GROUP_A		Stimulation Amplitude (mA) - Right	1
-18.1988425925926	86	GROUP_A		LFP Band Power - Right	1
-18.1988425925926	2420	GROUP_A		LFP Band Power - Left	1
-18.1918981481481	0	GROUP_A		Stimulation Amplitude (mA) - Left	1
-18.1918981481481	0	GROUP_A		Stimulation Amplitude (mA) - Right	1
-18.1918981481481	88	GROUP_A		LFP Band Power - Right	1
-18.1918981481481	2098	GROUP_A		LFP Band Power - Left	1
-18.1849537037037	0	GROUP_A		Stimulation Amplitude (mA) - Left	1
-18.1849537037037	0	GROUP_A		Stimulation Amplitude (mA) - Right	1

Paste all patients into single JMP table



	Days Since First Programming	Data	Group	Patient	Data Type	Session Number	Time Since First Programming (Days)
1	-22	•	GROU...		IQR (uVp) - Left	1	-22
2	-22	•	GROU...		IQR (uVp) - Right	1	-22
3	-21.62064815	0	GROU...		Stimulation Amplitude (mA) -...	1	-22
4	-21.62064815	0	GROU...		Stimulation Amplitude (mA) -...	1	-22
5	-21.6137037	0	GROU...		Stimulation Amplitude (mA) -...	1	-22
6	-21.6137037	0	GROU...		Stimulation Amplitude (mA) -...	1	-22
7	-21.60675926	0	GROU...		Stimulation Amplitude (mA) -...	1	-22
8	-21.60675926	0	GROU...		Stimulation Amplitude (mA) -...	1	-22
9	-21.59981481	0	GROU...		Stimulation Amplitude (mA) -...	1	-22
10	-21.59981481	0	GROU...		Stimulation Amplitude (mA) -...	1	-22
11	-21.59287037	0	GROU...		Stimulation Amplitude (mA) -...	1	-22
12	-21.59287037	0	GROU...		Stimulation Amplitude (mA) -...	1	-22
13	-21.58592593	0	GROU...		Stimulation Amplitude (mA) -...	1	-22
14	-21.58592593	0	GROU...		Stimulation Amplitude (mA) -...	1	-22
15	-21.57898148	0	GROU...		Stimulation Amplitude (mA) -...	1	-22
16	-21.57898148	0	GROU...		Stimulation Amplitude (mA) -...	1	-22
17	-21.57203704	0	GROU...		Stimulation Amplitude (mA) -...	1	-22
18	-21.57203704	0	GROU...		Stimulation Amplitude (mA) -...	1	-22
19	-21.56509259	0	GROU...		Stimulation Amplitude (mA) -...	1	-22
20	-21.56509259	0	GROU...		Stimulation Amplitude (mA) -...	1	-22
21	-21.55814815	0	GROU...		Stimulation Amplitude (mA) -...	1	-22
22	-21.55814815	0	GROU...		Stimulation Amplitude (mA) -...	1	-22
23	-21.5512037	0	GROU...		Stimulation Amplitude (mA) -...	1	-22
24	-21.5512037	0	GROU...		Stimulation Amplitude (mA) -...	1	-22
25	-21.54425926	0	GROU...		Stimulation Amplitude (mA) -...	1	-22
26	-21.54425926	0	GROU...		Stimulation Amplitude (mA) -...	1	-22
27	-21.53731481	0	GROU...		Stimulation Amplitude (mA) -...	1	-22
28	-21.53731481	0	GROU...		Stimulation Amplitude (mA) -...	1	-22

***Note:** Additional Variable and data type changes. *Session number* was set to numeric ordinal variable. *Days Since first programming* was copied to a new column and set to numeric ordinal; formula applied was as follows to categorize data into days and visualize the distribution of data per day.

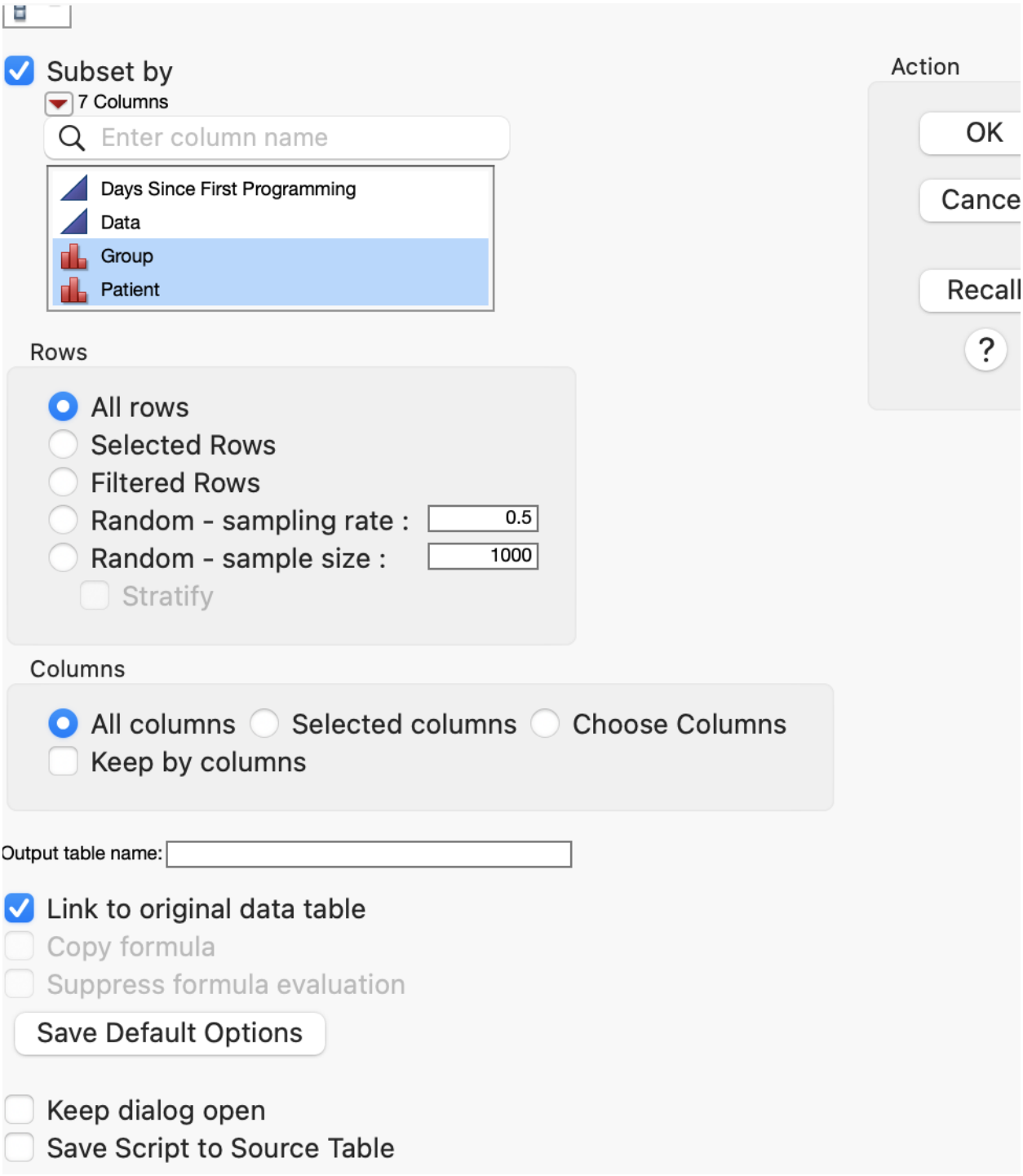


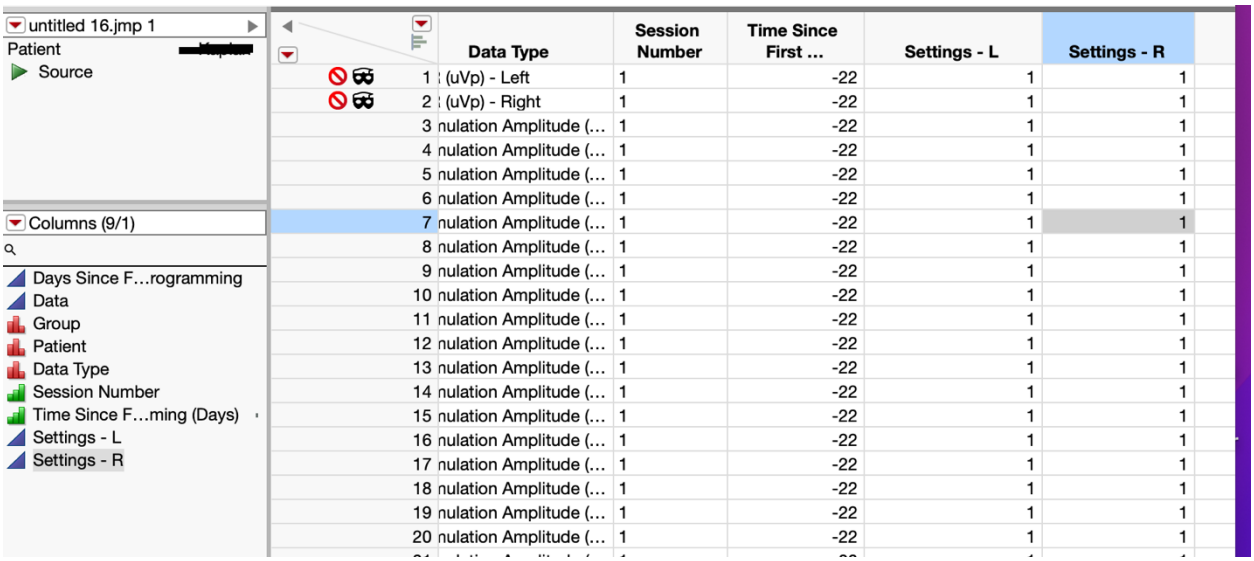
1. Data Table of all patients, Rows>DataFilter>: greater than -0.0001 and less than 180.0001: Image basics. Will Need to scale images individually/ view at 1-2 levels at a time.
2. Manually Filter Table to reflect stimulation settings, including listing all stimulation changes from each json, re-referencing setting start dates, re-grouping settings in categories that reflect unique band power sensing bands and sensing channel/contact, as well as pulse width. Table reordered and referenced to group dataset in JMP by recording setting specifications.

EX:

Days Elaps	Reassigned Group - L	Reassigned Group - R	GroupNam	Dates	BP - Left	BP - Right	Channel - L	Channel - R	PW-L	PW-R
-36.1920949	1	1	A	'19-Oct-2022 19:23:23'	15.63	17.58	ZERO_AND_T	ZERO_AND_TWO		
-21.134838	2	2	A	'03-Nov-2022 20:45:50'	12.7	9.77	ZERO_AND_T	ZERO_AND_TWO		
49.64709491	3	3	A	'13-Jan-2023 15:31:49'	14.65	19.53	ZERO_AND_T	ONE_AND_THREE		
-67.157419	1	1	A	'01-Apr-2022 20:13:19'	14.65	13.67	ZERO_AND_T	ZERO_AND_THREE		
0.570162037	1	1	A	'08-Jun-2022 13:41:02'	14.65	13.67	ZERO_AND_T	ZERO_AND_THREE		
0.574421296	2	2	B	'08-Jun-2022 13:47:10'	22.46	62.5	ZERO_AND_T	ZERO_AND_TWO		
63.58305556	2	3	B	'10-Aug-2022 13:59:36'	22.46	21.48	ZERO_AND_T	ZERO_AND_TWO		
-8.42806713	1	1	A	'27-Jun-2022 13:43:35'	21.48	21.48	ZERO_AND_T	ZERO_AND_TWO		
28.57388889	2	2	A	'03-Aug-2022 13:46:24'	16.6	23.44	ONE_AND_TH	ONE_AND_THREE		
98.58853009	3	3	A	'12-Oct-2022 14:07:29'	22.46	20.51	ONE_AND_TH	ONE_AND_THREE		
-221.095694	4	2	A	'01-Oct-2021 21:42:12'	83.98	28.32	ZERO_AND_T	ZERO_AND_TWO		
-18.2193171	5	4	A	'22-Apr-2022 18:44:11'	18.55	11.72	ZERO_AND_T	ZERO_AND_THREE		
0.598171296	5	4	A	'11-May-2022 14:21:22'	18.55	11.72	ZERO_AND_T	ZERO_AND_THREE		
0.60287037	6	1	B	'11-May-2022 14:28:08'	24.41	24.41	ZERO_AND_T	ONE_AND_THREE		
35.63908565					(Delete)					

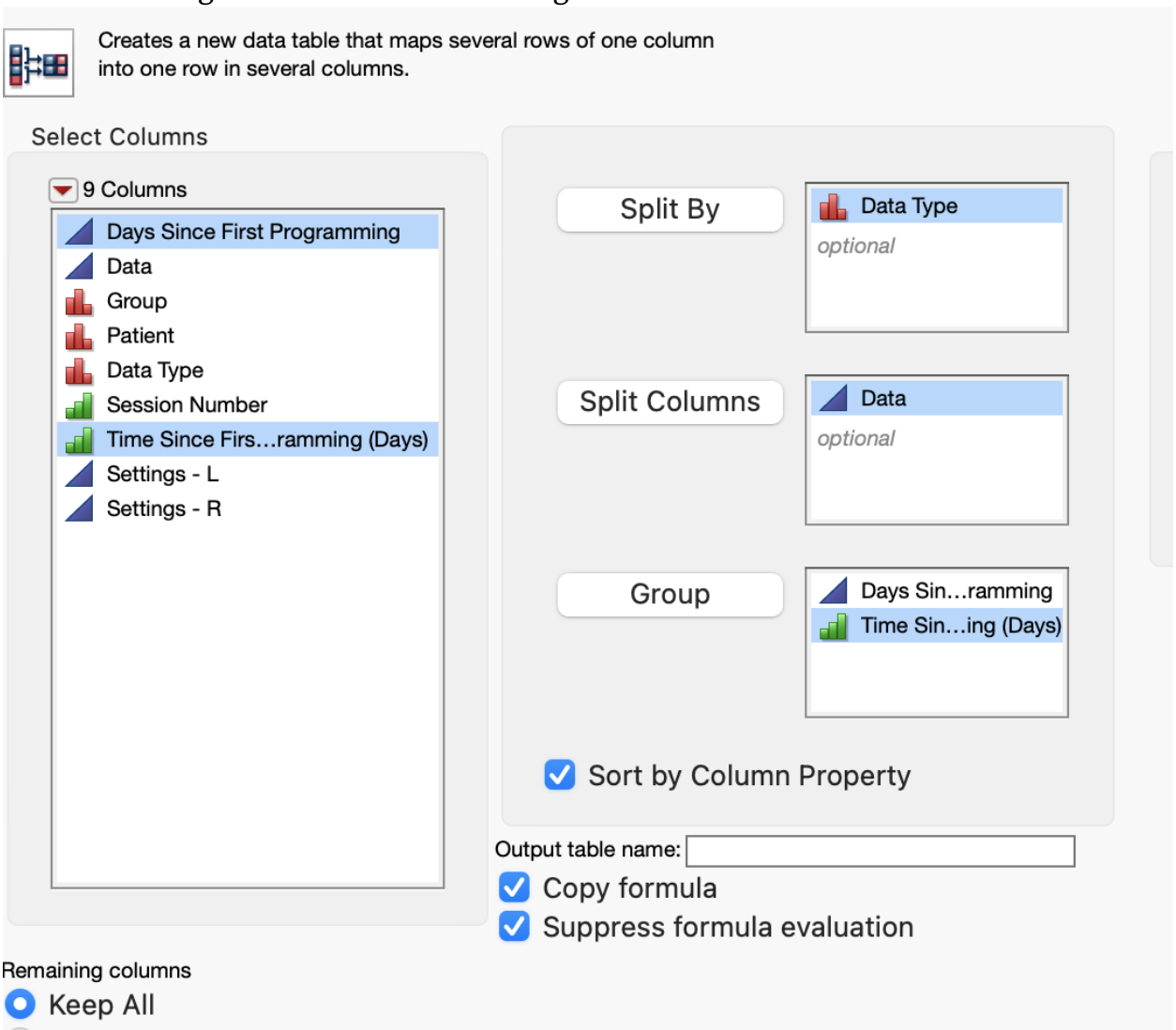
1. Subset: (By Patient, for each patient)


Subset by
7 Columns
Enter column name
Days Since First Programming
Data
Group
Patient
Action
OK
Cance
Recall
?
Rows
All rows
Selected Rows
Filtered Rows
Random - sampling rate :
0.5
Random - sample size :
1000
Stratify
Columns
All columns
Selected columns
Choose Columns
Keep by columns
Output table name:
Link to original data table
Copy formula
Suppress formula evaluation
Save Default Options
Keep dialog open
Save Script to Source Table



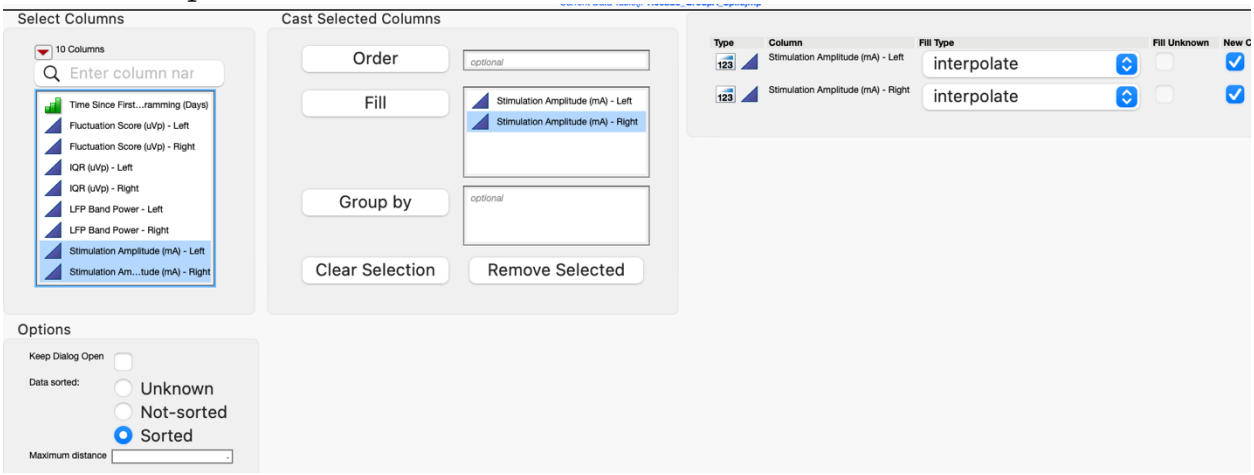
1. **Split: and Rename by Group Patient Type**

1. Filter Again - Rows>DataFilter>: greater than -0.0001 and less than 180.0001:

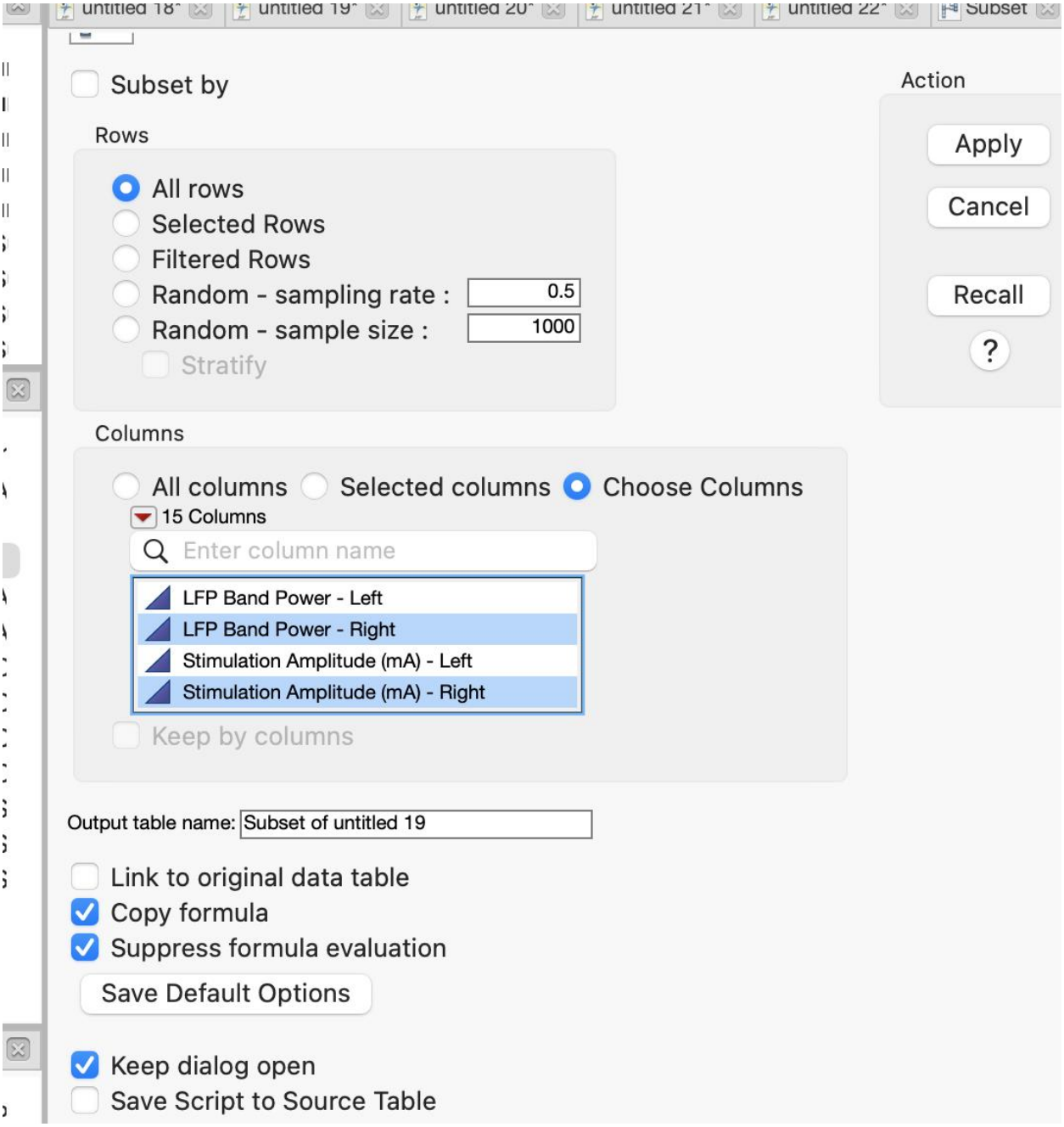


1. Exclude data again for statistical testing: Rows>DataFilter>: greater than -0.0001 and less than 180.0001

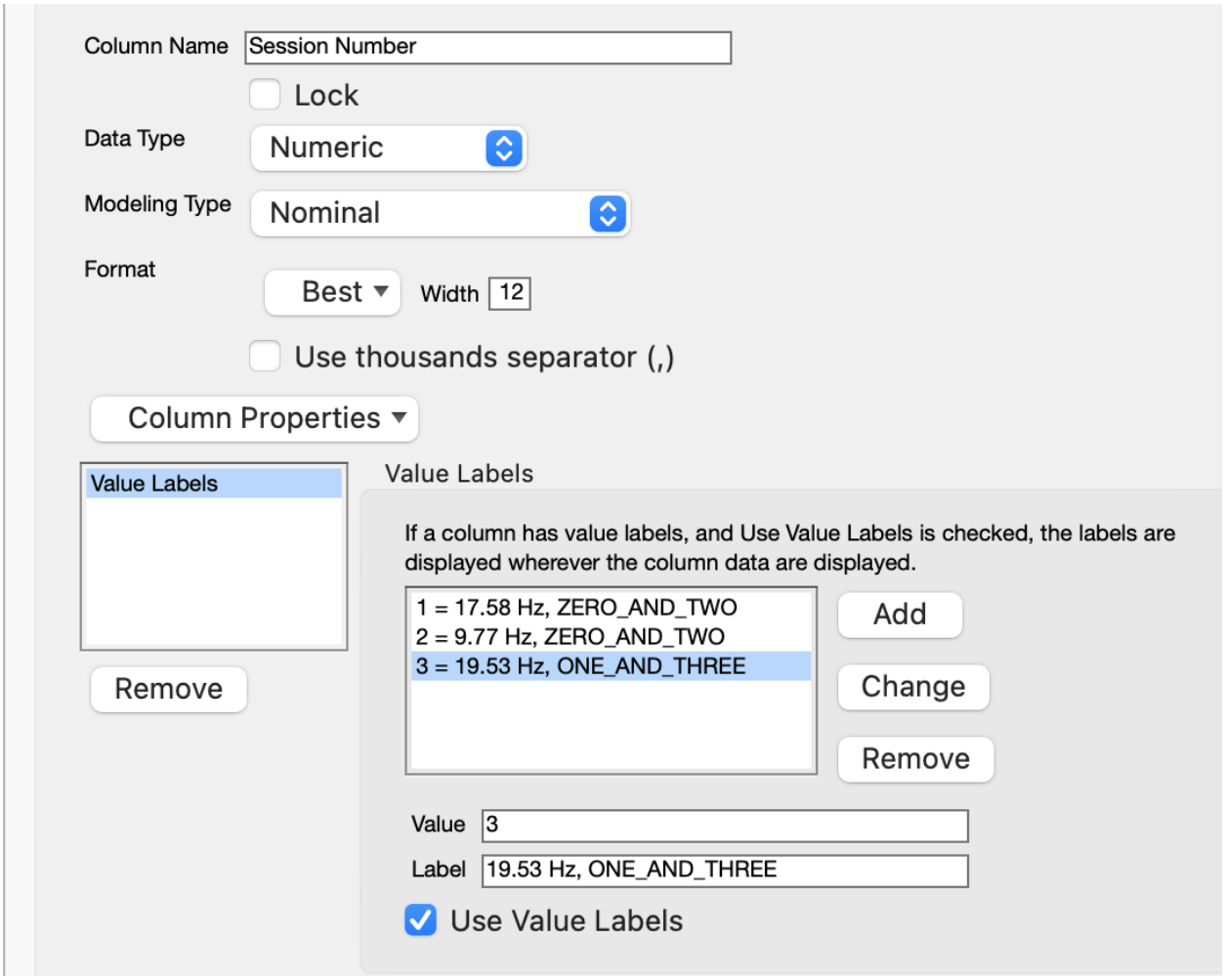
2. Interpolating the stimulation amplitudes for missing values; Fill missing Values, interpolate



4. Split Tables into “Left and Right Hemispheres” via Tables>Subset



5. Program Settings Encoded to **Settings-R** or **Settings-L**



Filter out beta bands <12.5 >30 Hz

6. Scatterplot Matrix via Analysis>Multivariate