Functions for comparing waveforms

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Citing use of these functions

- Please cite use of the pupil toolkit as:

Siegle, G. J. (2003) The Pupil Toolkit, University of Pittsburgh. Available directly from the author, as used in, e.g., Siegle GJ, Steinhauer SR, Carter CS, Ramel W, Thase ME (2003): Do the seconds turn into hours? Relationships between sustained pupil dilation in response to emotional information and self-reported rumination. Cognitive Therapy and Research 27:365-382.

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Comparing waveforms

- Comparing waveforms is not trivial
- We have implemented functions for computing tests at every sample along the waveform.
- Unless these comparisons are a-priori I recommend using these only in the context of a group x time or condition x time interaction done on a dimension-reduced dataset.
- Controlling type I error
  - Guthrie & Buchwald's (1991) technique
    - Guthrie D, Buchwald JS (1991): Significance testing of difference potentials. *Psychophysiology* 28:240-244.
  - Blair & Karniski's (1993) technique
    - Blair RC, Karniski W (1993): An alternative method for significance testing of waveform difference potentials. *Psychophysiology* 30:518-524

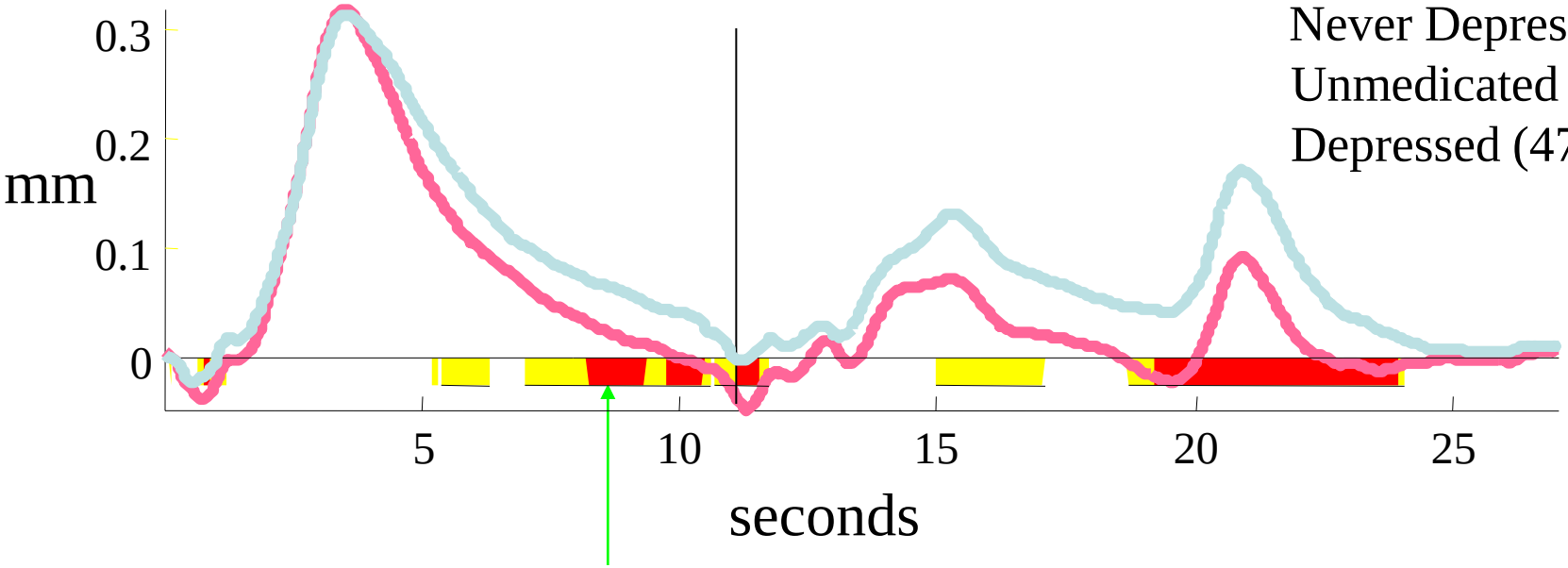
What you will need

- Pupil Toolkit code: 3 directories
  - Computing_autocorrelations
  - Simulations_for_patch_length
  - Testing_waveform_differences
  - aux_pupiltoolkit_files
- Matlab statistics toolbox
- If you want to use the Randauto function in gsgutsims (good for simulating waveforms with a given autocorrelation) you will need Richard Strauss's statistics library which you can download at:
  - http://www.faculty.biol.ttu.edu/strauss/matlab/matlab.htm
  - Otherwise it will replace calls to Randauto in gsgutsims with calls to gsrandauto2 or gsrandauto which are poorer versions

Example output: T-tests at every sample, marking intervals significantly long enough to care about via Guthrie & Buchwald (1991)

What's the emotion?
UGLY

Put the digits
in numerical order
7 4 3 1 5



Regions of significant differences. Yellow is p<threshold you pass as an argument (p<0.1 by default) and red is less than p<.05. The black line is intervals longer than the patch length you pass in.

Pupil toolkit functions to implement Guthrie & Buchwald's (1991) technique

- gutautocorr
  - gives the autocorrelation (acorr) of waveforms in matrix X (subjects x samples) after removing k principal components
  - [acorr,kmin]=gutautocorr(X,k)
- gsgutsims
  - Runs simulations for Guthrie and Buchwald's (1991) technique to yield minimum # of consecutive tests necessary for a difference to be considered significant at p<.05
  - [minlen]=gsgutsims(N,T,sig,auto,numsims)
    - N=# subs, T= sampling interval, sig = target waveform-wise significance (usually 0.05), auto = autocorrelation in the data, numsims = # of simulations (default = 1000)
- gsgutsimsbetween(Ng1,Ng2,T,sig,ro,numsims)

Pupil toolkit functions to implement Blair & Karnitski's technique

- getblairkarniskitmax
  - [tmaxthresh,p05tmax] = getblairkarniskitmax(data,group,sigthresh)
  - generates all permutations of data to conditions and for each permutation does a t-test at each time-point.
  - We then select the tmax for which 95% (or other threshold) of the permutations are rejected, such that 95% of the permutations have NO significant t-tests
  - We then apply that threshold to the successive t-tests in our waveform of interest.

Functions to compare waveforms: Within Subjects

- diffwavgraph
  - Contrasts 2 conditions via t-tests at each sample
  - [s,h]=diffwavgraph(wavcond1,wavcond2,samprate,resamprate,alpha,outliers,patchlen,bw,pscale,wavcond3,pscalemag,xax,linewidth)
  - **NOTE: This is the only function in the set which is well documented… If you get this you'll get the rest…**
- condwavgraph
  - contrasts all conditions within subjects via anova at each sample
  - [s,h]=condwavgraph(condwavs,samprate,resamprate,alpha,outliers,patchlen,bw,pscale,xax)

diffwavgraph help file

graphs cond1 v. cond2
expects 2 matrices, each with subjects in rows and wavs in columns
and significance of difference for each time point
usage: s=diffwavgraph(wavcond1,wavcond2,samprate,resamprate,alpha,outliers,patchlen,bw,pscale,wavcond3,pscalemag,xax,linewidth)

wavecond1: this is the matrix of N rows for condition 1
wavecond2: this is the matrix of N rows for condition 2
samprate: the sampling rate, in Hz
resamprate: The rate at which to resample the data - usually the same as samprate

You can leave the samprate and resamprate the same and the routine will run fastest, and in the most principled way. The reason to consider resampling is to decrease the autocorrelation in the data. The more you resample, the "rougher" the data will be, and thus the less points you'll need in a row to get significance. So, in case you play with resampling in getting the autocorrelation, I let you throw that in as a parameter...

alpha: threshold for significance, usually set to .05 or .1

And like Guthrie and Buchwald, I like the .1 threshold. That said, if regions I like are not coming out, I often like to see what the actual significance of patches "would be" so that I can know whether it's a power issue. Towards that end, I'll often play, in the privacy of my darkened office with the door locked, with thresholds of .3 or .5...

outliers:

This is an easy way to recompute patches with specific people taken out, just to see if things change. By default it should be a vector with N rows and one column of all zeros. If you put ones on any row, those people are not counted in computing mean waveforms or significance tests.

patchlen: the length of consecutive data points required for sig

note: patchlen does NOT account for resamprate. So, even if you downsample to 1hz, a patchlen of 17 refers to 17 points in a row in the original sampled space. Thus you must change it yourself in the calling routine...

bw: whether or not graphs should be in black and white

For display on the screen, set bw=0 and graphs will appear in color. For publications in which color is costly, set bw=1 and it will make your graphs in black and white, with dotted lines as necessary.

pscale:

This should be zero for most applications. That will set the significance bars to a uniform height. If pscalemag is not zero, the significance bars are of the height of the p-value, scaled by pscale.

wavcond3:

This is an optional 3rd condition, which is plotted but not included in tests. Set it to zero if there is no third condition.

pscalemag:

This is how large the bars for significance should appear under the x axis (if pscale =0). So if the y axis goes from -10 to 10, you might make pscale = 1. But if the y axis goes from -.1 to .1 you might make pscale = 0.02. making pscalemag negative puts the significance bars below the x axis

xax:

This is the units you want on the x-axis. By default it puts the x-axis in seconds. But if you want it in ticks, pass a vector which counts from 1:wavelen.

linewidth:

This is how wide the lines are on the plots. 0.5 by default. If you want to thicken then up, e.g., for a poster, pass in values > 0.5

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Functions to compare waveforms: Between Subjects

- grpdiffwavgraph
  - Contrasts groups
- grpsrdiffwavgraph
  - Contrasts groups after covarying stuff out
  - s=grpsrdiffwavgraph(wavs,group,covariates,samprate,resamprate,alpha,outliers,patchlen,bw)
- grpdiffblairwavgraph
  - Contrasts groups using Blair & Karnitzky's method of controlling type I error
  - s=grpdiffblairwavgraph(wavs,group,alpha,outliers,bw,xax,pscalemag,samprate)
- ngrpdiffwavgraph
  - Contrasts >2 groups

Functions to compare waveforms: Between subjects on a contrast between conditions

- grpwdiffwavgraph.m
  - Compares groups on a within-subjects contrast
- grpwdifftwavgraph4lines.m
  - Compares groups on a within-subjects contrast via t-tests graphing lines for each condition and group
- grpwdiffwavgraph4lines.m
  - Compares groups on a within-subjects contrast via hierarchical regression graphing lines for each condition and group

Functions to compare waveforms: Correlations

- corr1persubwavgraph
  - graphs correlation of a 1-per-subject self-report measure with a waveform from each subject
  - [s,h,rcorr]=corr1persubwavgraph(selfrepmeas,wavvals,samprate,resamprate,alpha,outliers,patchlen,bw,covar,pscale,xax,pscalemag)
- corrwavgraph
  - graphs mean correlation from each subject's correlations
  - s=corrwavgraph(corrsraw,samprate,resamprate,alpha,outliers,patchlen,bw,covar,pscale,xax,pscalemag)
- reg1persubwavgraph.m
  - graphs regression R^2 of a 1-per-subject self-report measure with a waveform from each subject. NOTE: INCLUDES interaction of measure with waveform
  - [s,h]=reg1persubwavgraph(selfrepindepmeas,wavvals,selfreptopred,samprate,resamprate,alpha,outliers,patchlen,bw,covar,pscale,xax,pscalemag)