Processing Load And Biopotentials: An Evaluation Of A Consumer Electroencephalogram (EEG)

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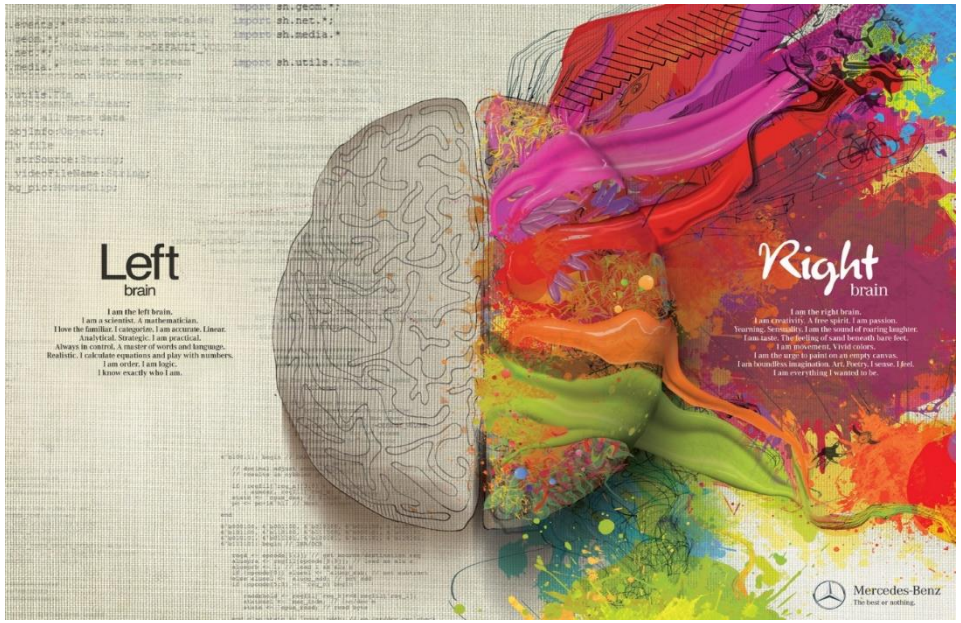
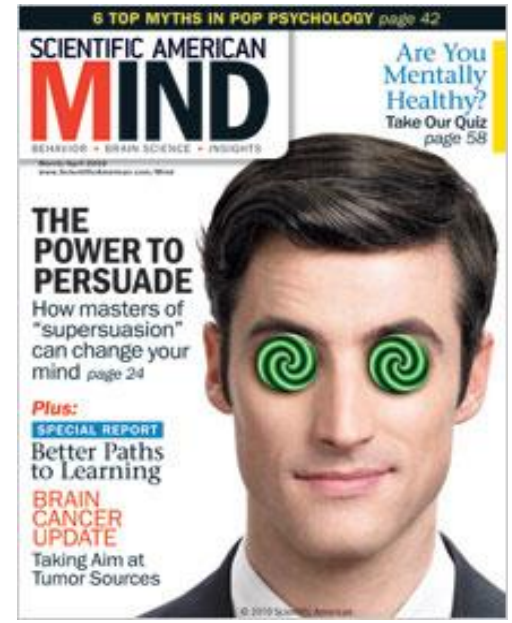
Introduction

- Popular Psychology
- Marketing for consumers
- Testing of Devices





NeuroSky

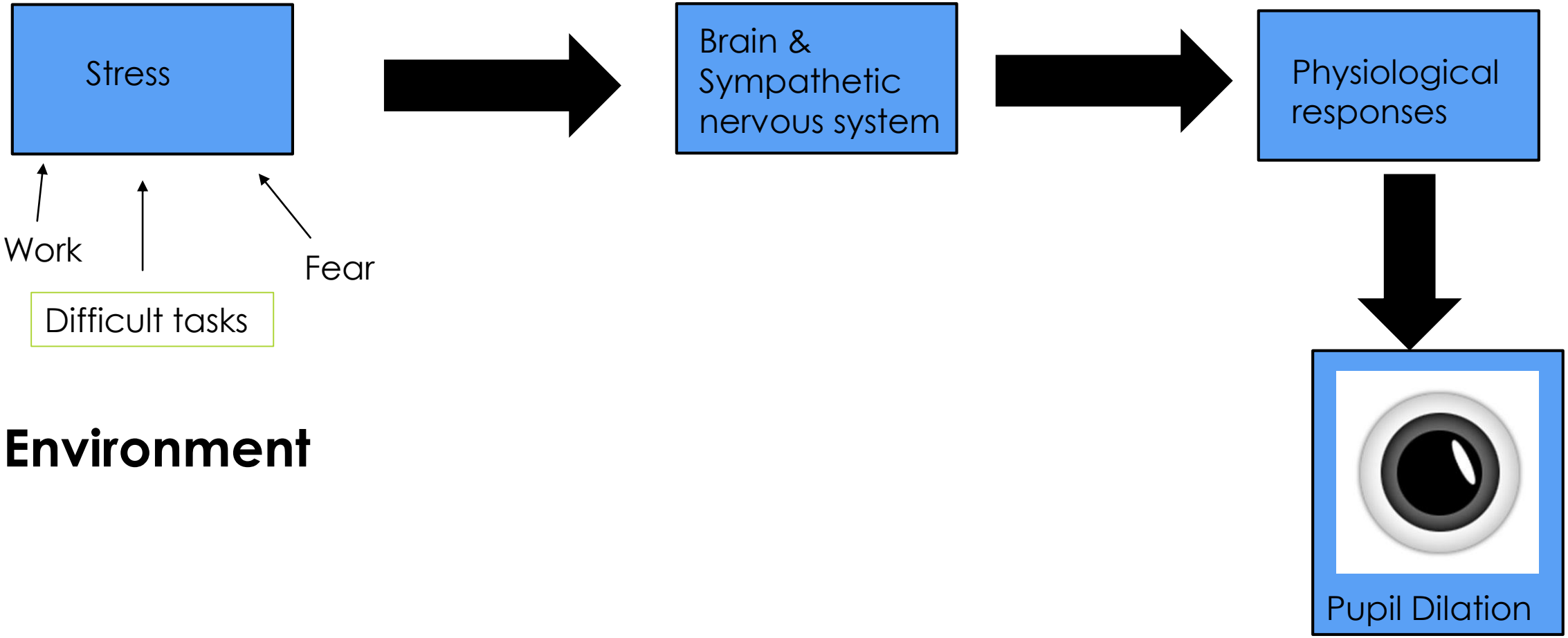
- A single channel Electroencephalogram device from NeuroSky
- Concentration & Meditation
- Claims of this device have not been tested
- The purpose of my study is to test this device, specifically NeuroSky claims of concentration.

Literature Review

- Concentration can be measured by looking at alpha waves on an EEG readout (Klimesch, 1999).
- Concentration can also be measured using pupil dilation.
- Pupil dilation studies (Kahneman & colleagues, 1969; Bijleveld, Custards & Aarts).

Hypothesis: Pupil dilation does indeed measure concentration, and if the NeuroSky device measures concentration, the readout of the EEG output should correlate with the pupil dilation studies.

How the Pupil works

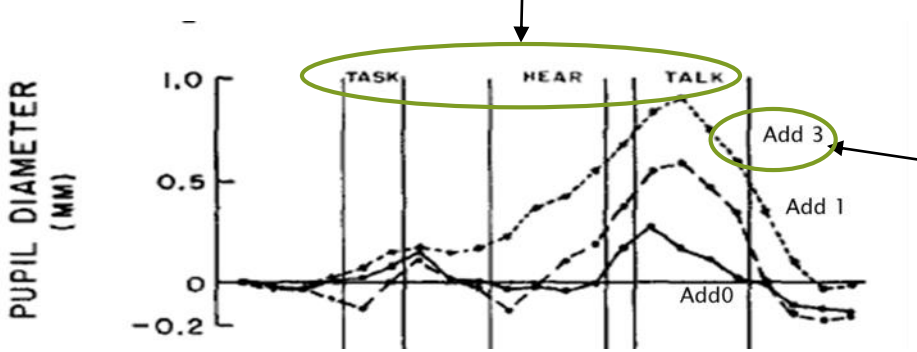


Environment

Experiment 1: Methodology

- Replicate Kahneman and colleagues 1969 study.

Experiment direction



X-axis: Size of pupil

Experimental conditions

Y-Axis: Time of the experiment

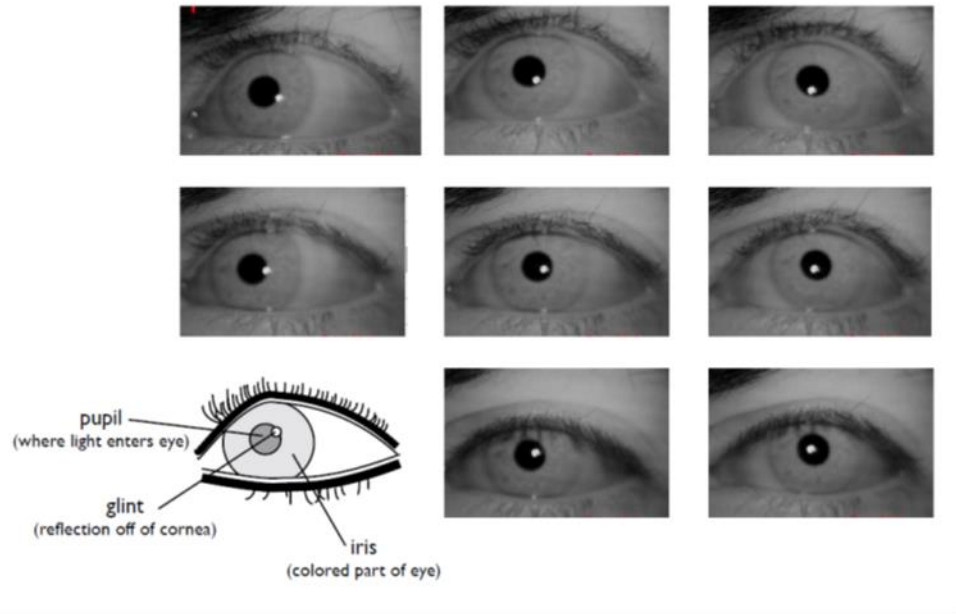
Experiment 1: Methodology

- Replicated Kahneman and colleges 1969 study
  - Task of the subject
  - Addition problems while on the eye tracker

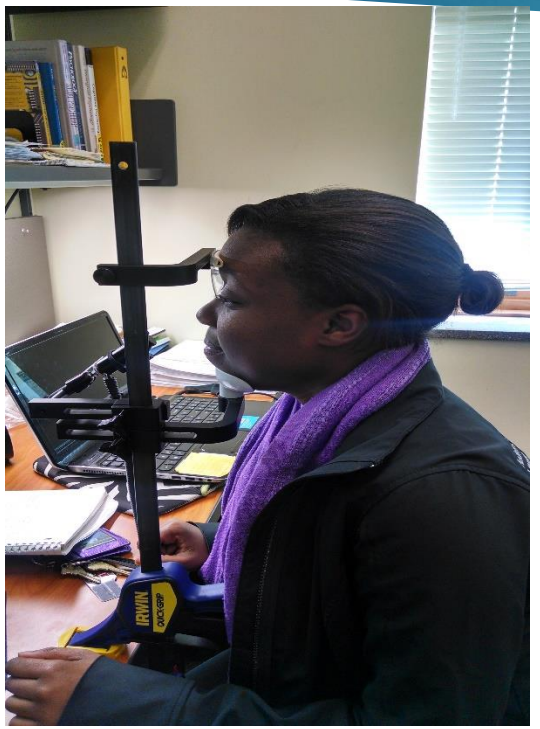
Methodology

Experiment 1: Methodology

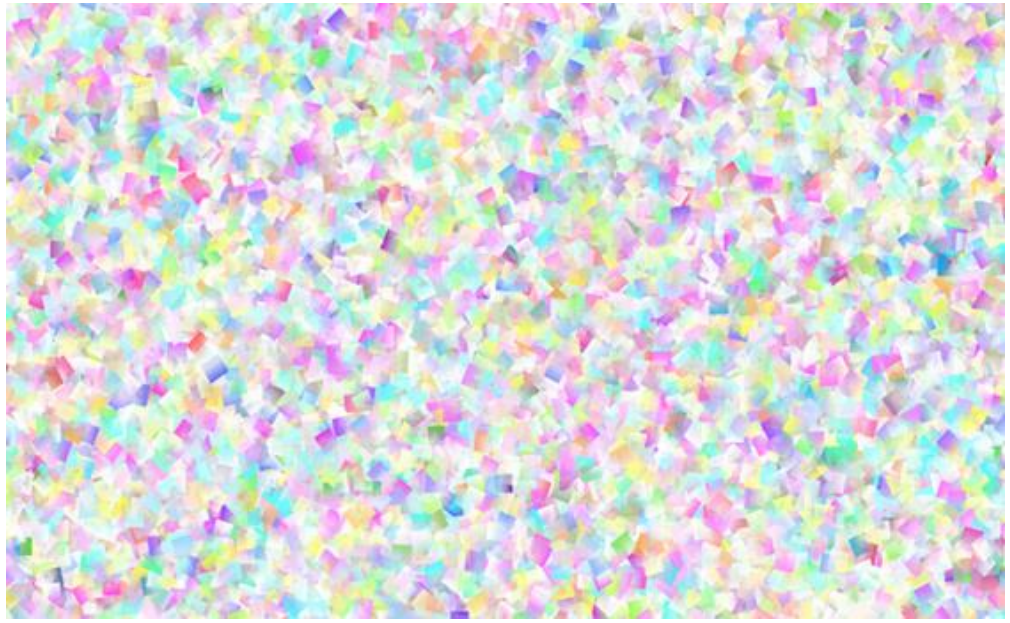
- Equipment
  - 60 Hz dark pupil infra-red eye tracker.



Experiment 1: Methodology



Set-up with Subject

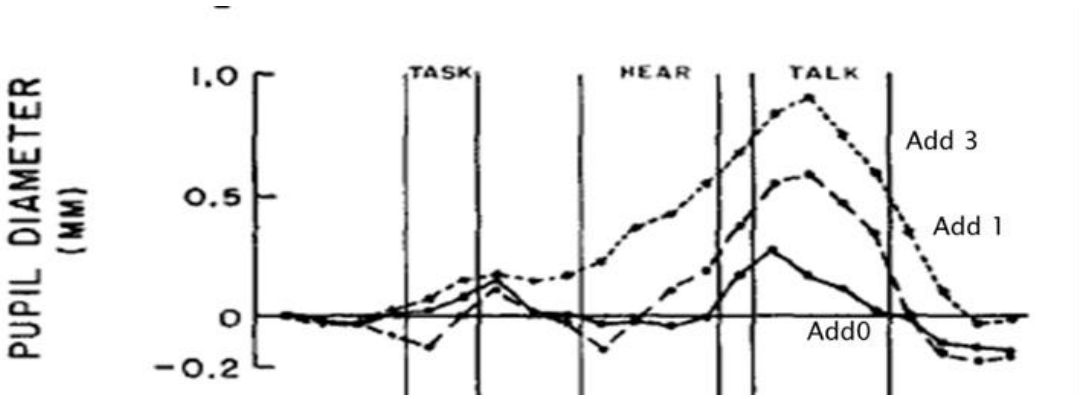


Screen subjects looked at.

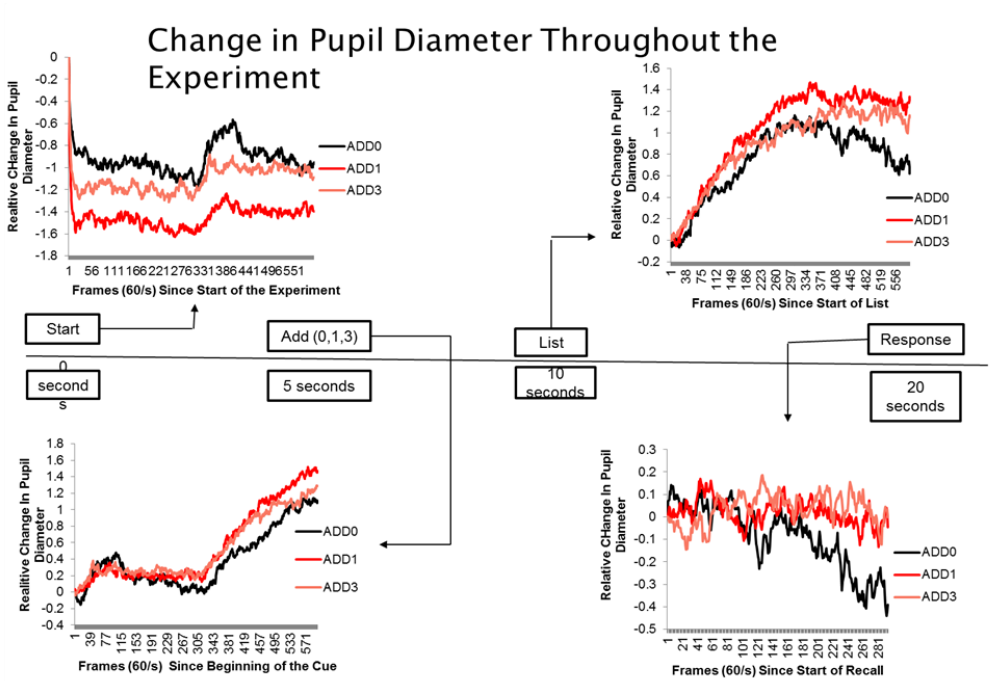
Experiment 1: Methodology

- Participants
  - 29 students
  - 4 males & 25 females
  - 3 removed from data analysis

Experiment 1: Results

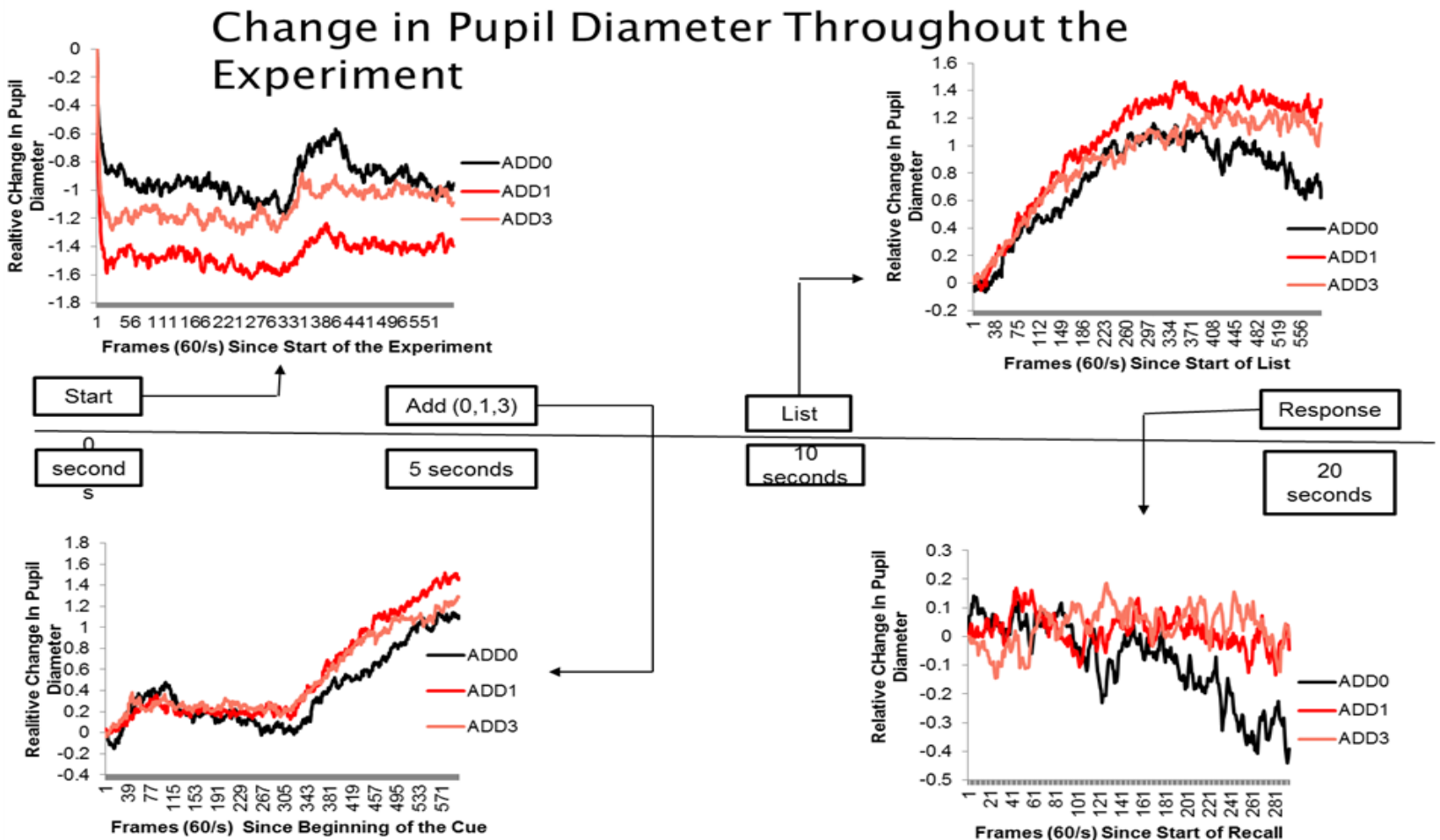


Original study



Experiment 1

Experiment 1: Results



Experiment 1: Statistics

- Eye tracking data was split into 4 groups
- R 3.0.2 using the *aov* function
- A one-way ANOVA was done on each group

Frames	F(2,50)	P
0-200	2.16	.13
200-400	2.92	.06
400-600	5.59	*.01
0-600	4.02	*.02

* Significant values

Experiment 1: Conclusions

Conclusion 1

1969 study is accurate in their finding and is replicable.

Conclusion 2

Task difficulty, or concentration, can be measured using an eye tracker.

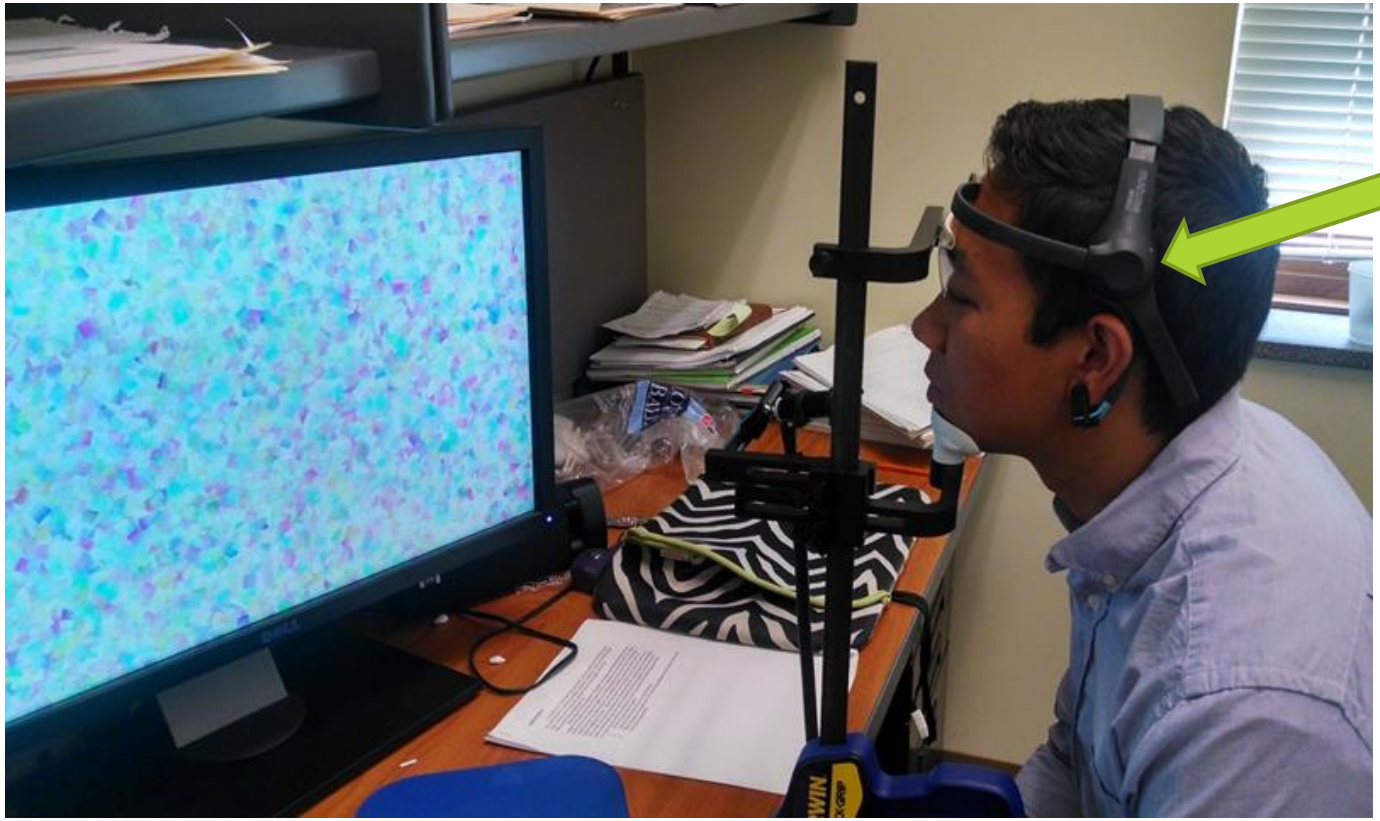
Conclusion 3

We found the biggest increase in pupil size in the add 1 condition instead of the add 3 condition

Experiment 2: Methodology

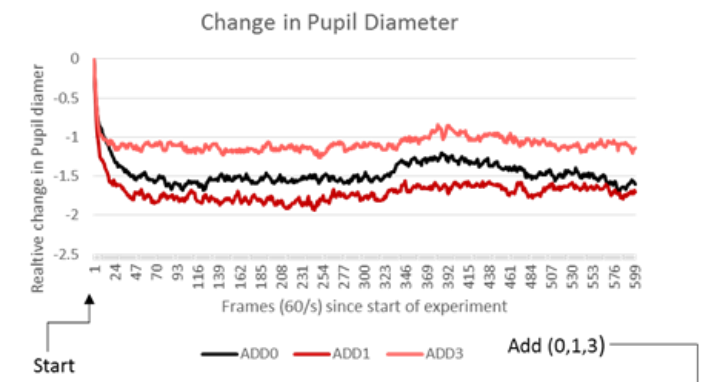
- Same methodology as experiment 1, but with the NeuroSky device.
- 31 subjects
  - 8 males 24 females
  - 5 removed from data analysis (for track loss and recording failure)

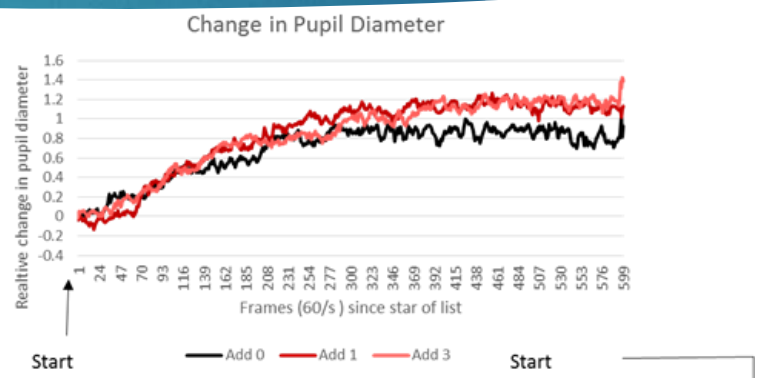
Experiment 2: Methodology



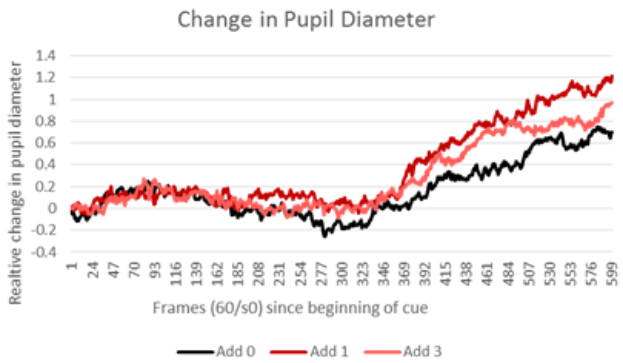
NeuroSky Headband

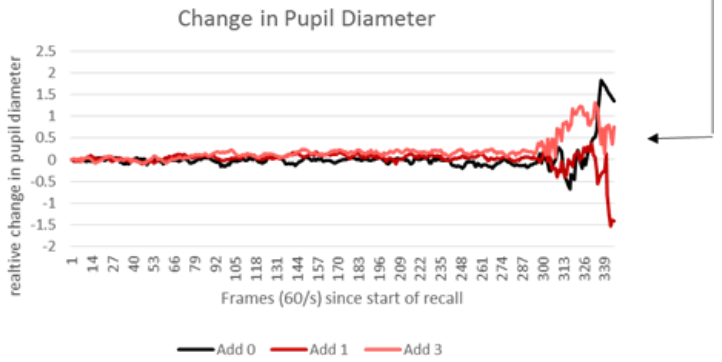
Experiment 2: Conclusions





Add (0,1,3)

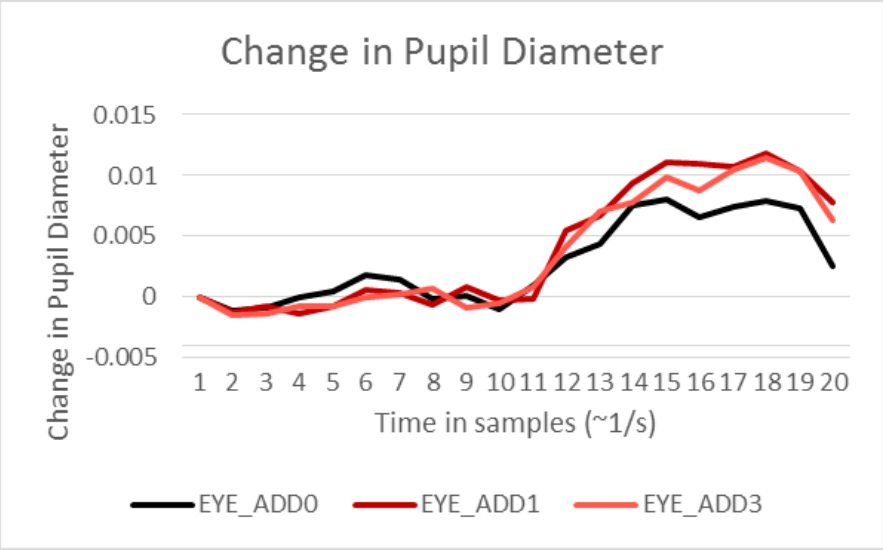




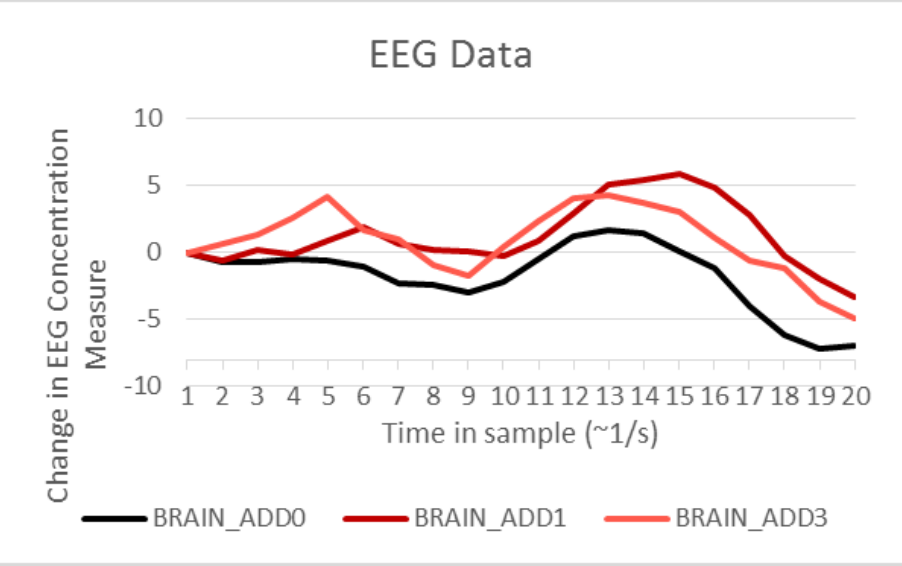
Similar waves as found in the 1969 study and in experiment 1

Experiment 2: Conclusions

Eye study



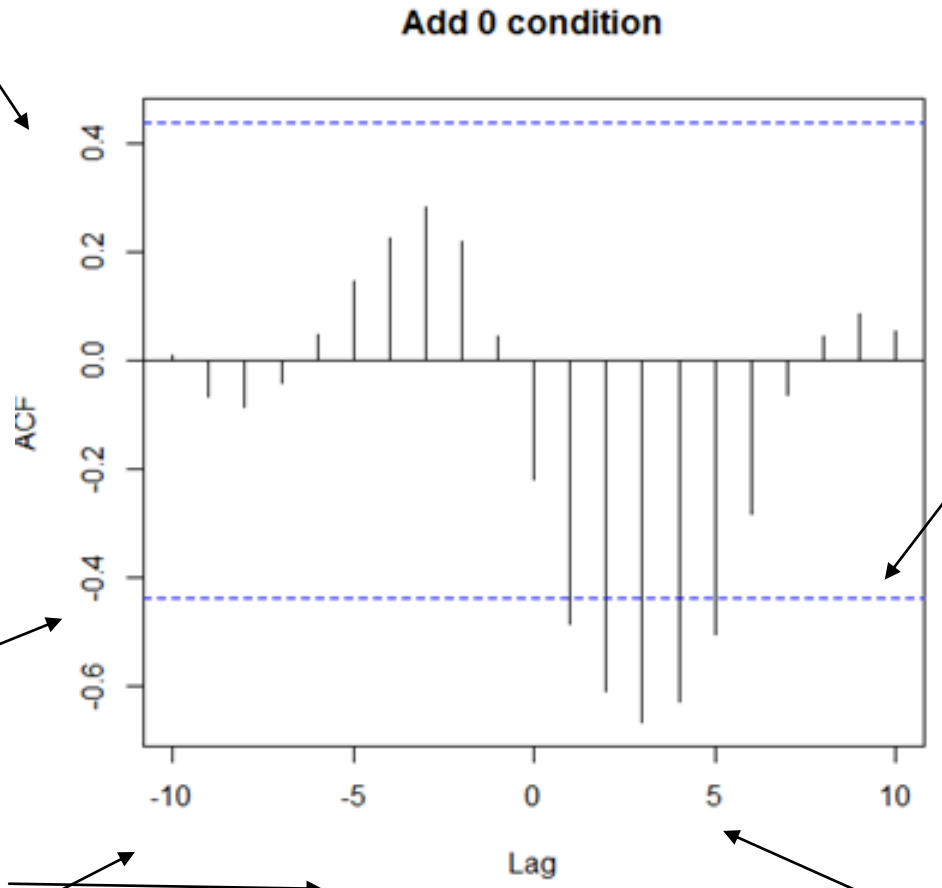
EEG Study



The curves of the lines for both the eye data and EEG data are very similar

Positive correlation: the lines are moving together

X-axis: ACF = Auto correlation function, correlation(r) number



Significant level of p = .05

Negative correlation: the lines are moving apart

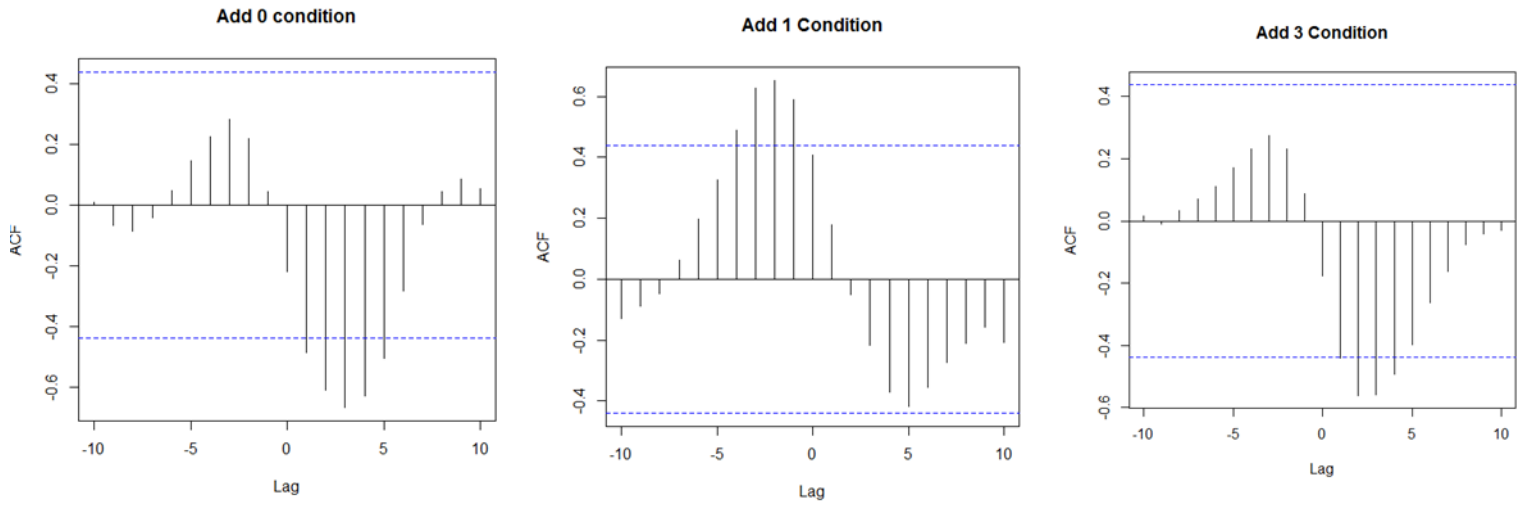
Y-axis: Time

Negative lag: EEG wave preceding the eye wave

Positive lag: Eye wave preceding EEG wave

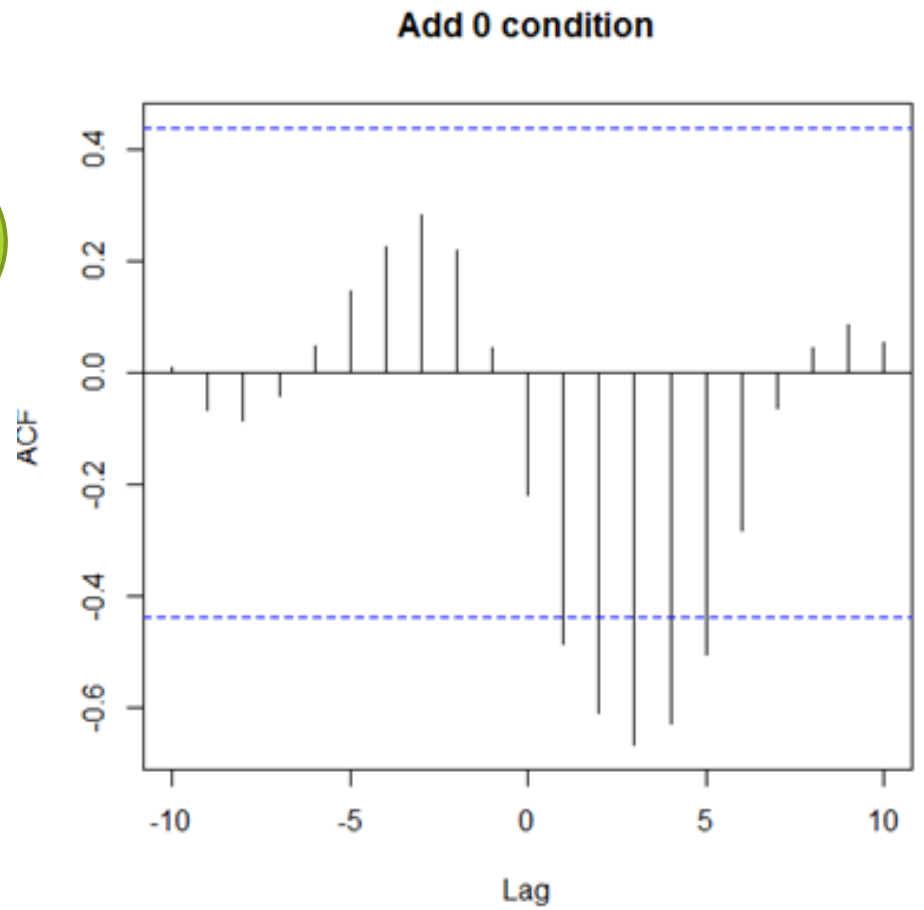
Experiment 2: Statistics

- A cross-correlation was done to see how similar the lines were.



Experiment 2: Results

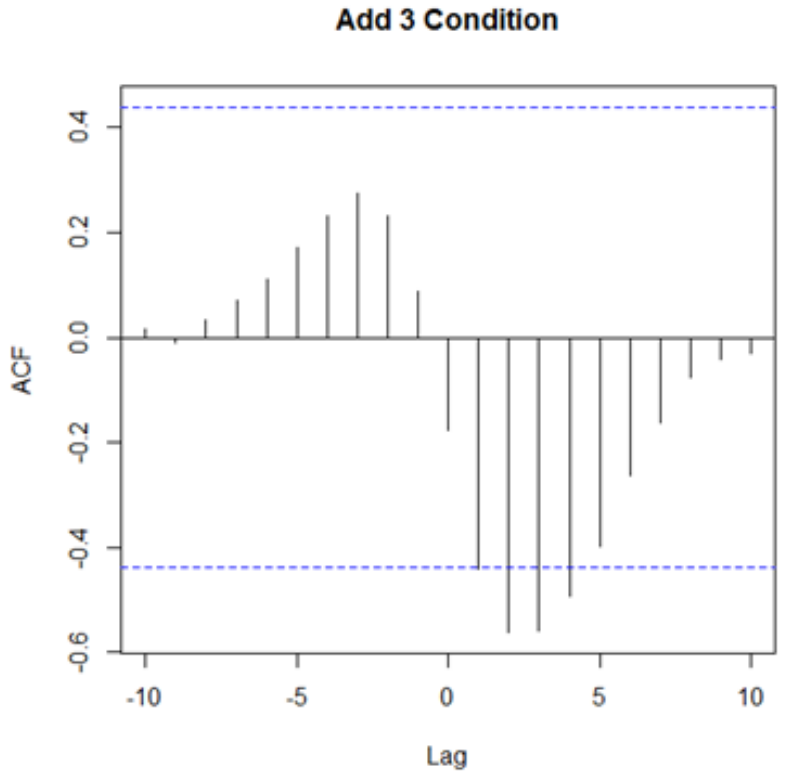
Positive correlation with a negative lag



Significant negative correlation with a positive lag

Experiment 2: Results

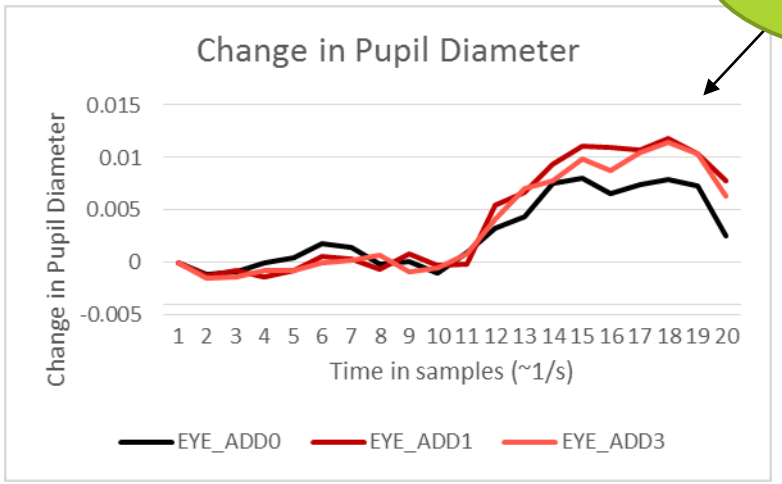
A positive correlation with a negative lag



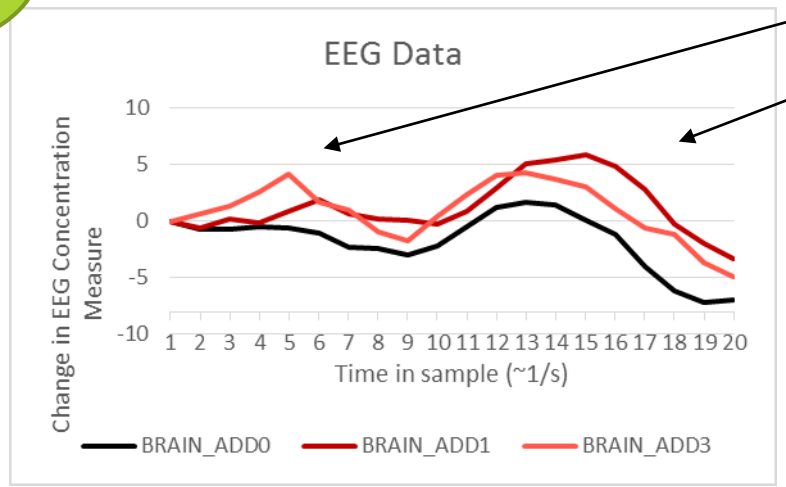
A significant negative correlation with a positive lag

Experiment 2: Results

One Peaks

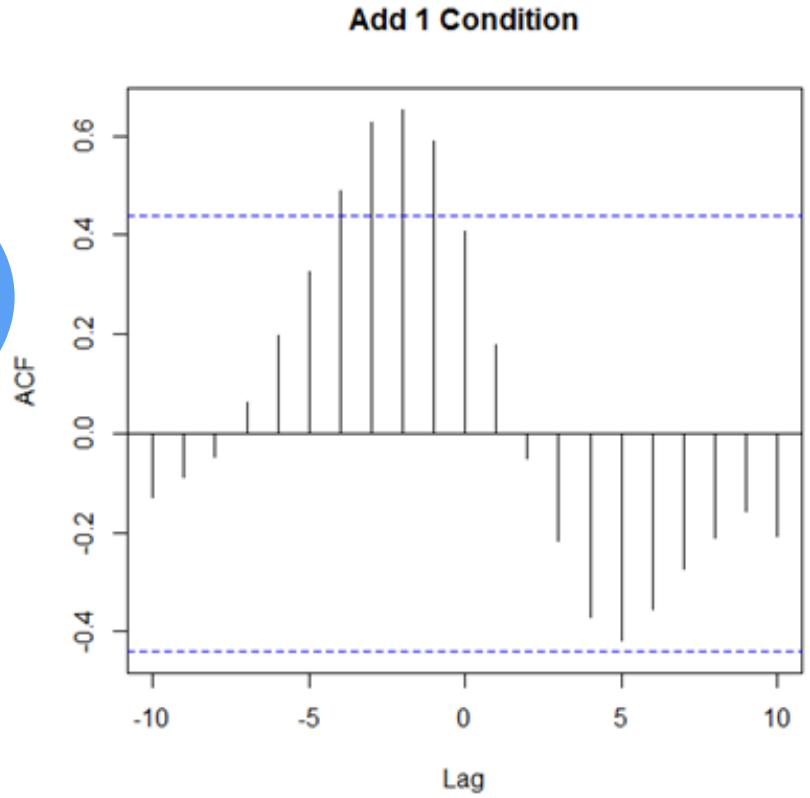


Two Peaks



Experiment 2: Results

Significant positive correlation with a negative lag



Negative correlation with a positive lag

Experiment 2: Results

What this means

- Only one condition fit the Brain/pupil model
- The baseline and add 3 condition are almost identical
- The NeuroSky device, actually measures concentration.
- More sensitive than pupil dilation measurements

Implications & Limitations

Implications

- Can be used for simple studies.
- Classroom use
- Layperson use
- Low cost

Limitations

- Single channel
- Sampling rate

Concluding Thoughts

- The claims of the NeuroSky device are true regarding concentration.
- Laypeople are really getting what they believe they are buying.
- This equipment has been validated for use in teaching and simple research projects.
  - Example: teaching EEG in physiological psychology class

Selected Bibliography

- Bijleveld, E., Custers, R., & Aarts, H. (2009). The unconscious eye opener: Pupil dilation reveals strategic recruitment of resources upon presentation of subliminal reward cues. Psychological Sciences, 20(11), 1313-1351. doi 10.1111/j.1467-9280.2009.02443.x
- Kahneman, D., Tursky, B., Shapiro, D., & Crider, A. (1969). Pupillary, heart rate, and skin resistance changes during a mental task. Journal of Experimental Psychology, 79(1), 614-167.
- Klimesch, W. (1999). EEG alpha and theta oscillations reflect cognitive and memory performance: a review and analysis. Brain Research Review, 29, 169-195.
- Racine, E., Bar-Ilan, O., & Illes, J. (2006). Brain imaging: A decade of coverage in print media. Science Communications, 28(1), 122-143. doi: 10.1177/1075547006291990
- Racine, E., Bar-Ilan, O., & Illes, J. (2005). FMRI in the public eye. Nature Reviews Neuroscience, 6, 159-164. doi: 10.1038/nrn1609

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Questions.