

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

By. Kristen Bishop

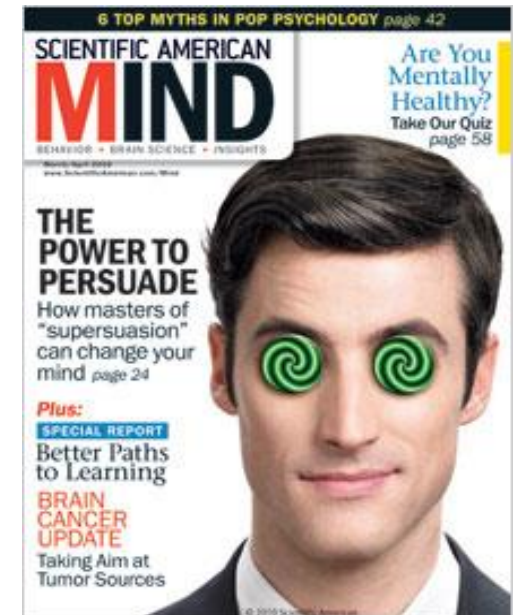
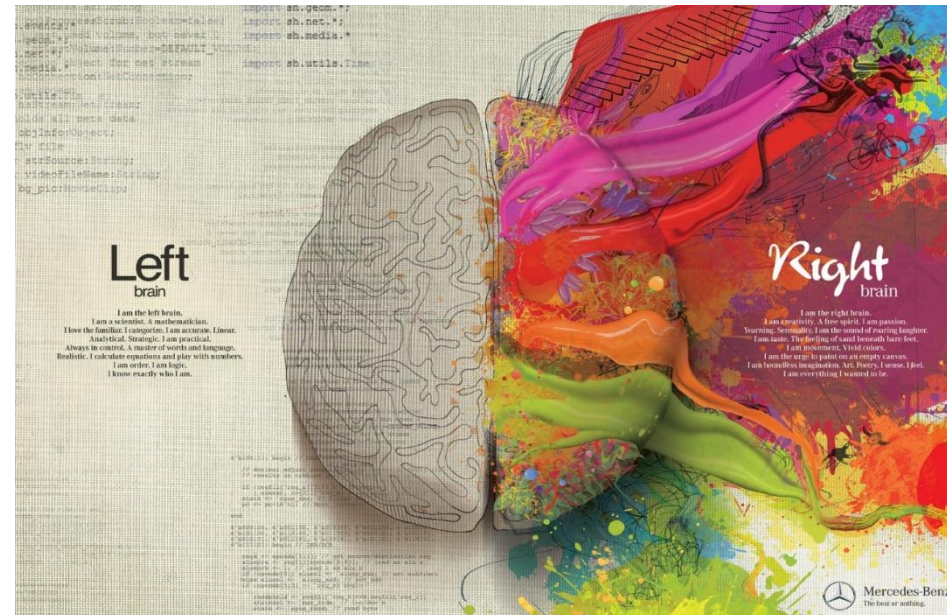
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J.N. Andrews Honors Program


# 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.



The screenshot displays the NeuroSky mobile application interface. At the top, there are two main sections: "Discover your brain in 5 minutes!" with a music note icon, and "Are you ready for SpeedMath?" with a math icon. Below these are two circular progress indicators: "Concentration" (yellow) and "Meditation" (blue). At the bottom, there are four feature cards: "FOCUS" (yellow), "RECHARGE" (blue), "LISTEN" (green), and "PLAY" (purple).

**Discover your brain in 5 minutes!**  
Experience how it feels to see your brainwaves change in real time on your computer. Discover how to control your ability to focus or meditate and learn about how your brain responds to your favorite music with the brainwave sensing MindWave Mobile brainwave headset.

**Are you ready for SpeedMath?**  
Train your arithmetic skills to be more precise and efficient. After you have completed a problem set, review your attention levels and hone in on your problem areas. Try building up your quick thinking math skills by answering problems both accurately and quickly.

**Concentration**

**Meditation**

**FOCUS**  
See your level of focus and learn how to raise or lower your level of attention.

**RECHARGE**  
View your level of calm and learn how to clear your mind of distracting thoughts.

**LISTEN**  
Listen to your favorite music and discover how it effects your brainwaves.

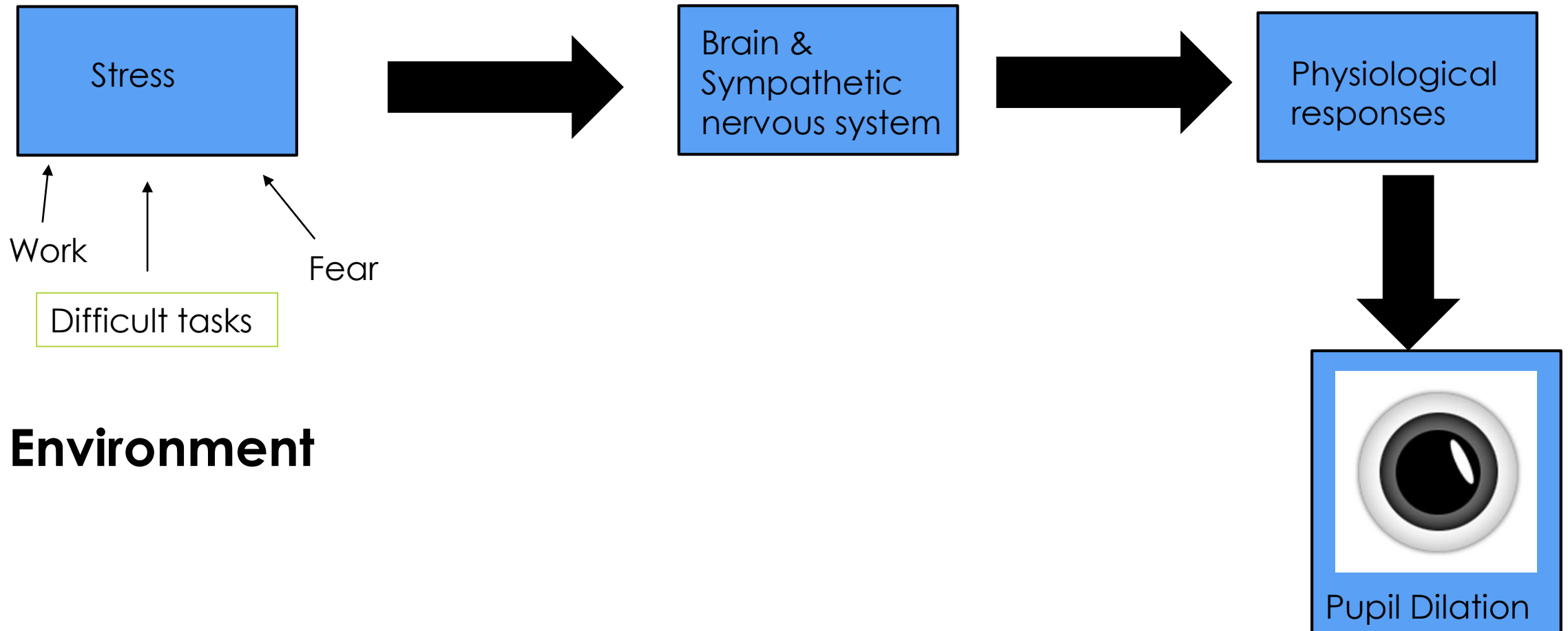
**PLAY**  
Test your level of control with mini games or download over 100 more apps from NeuroSky.com

# 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.

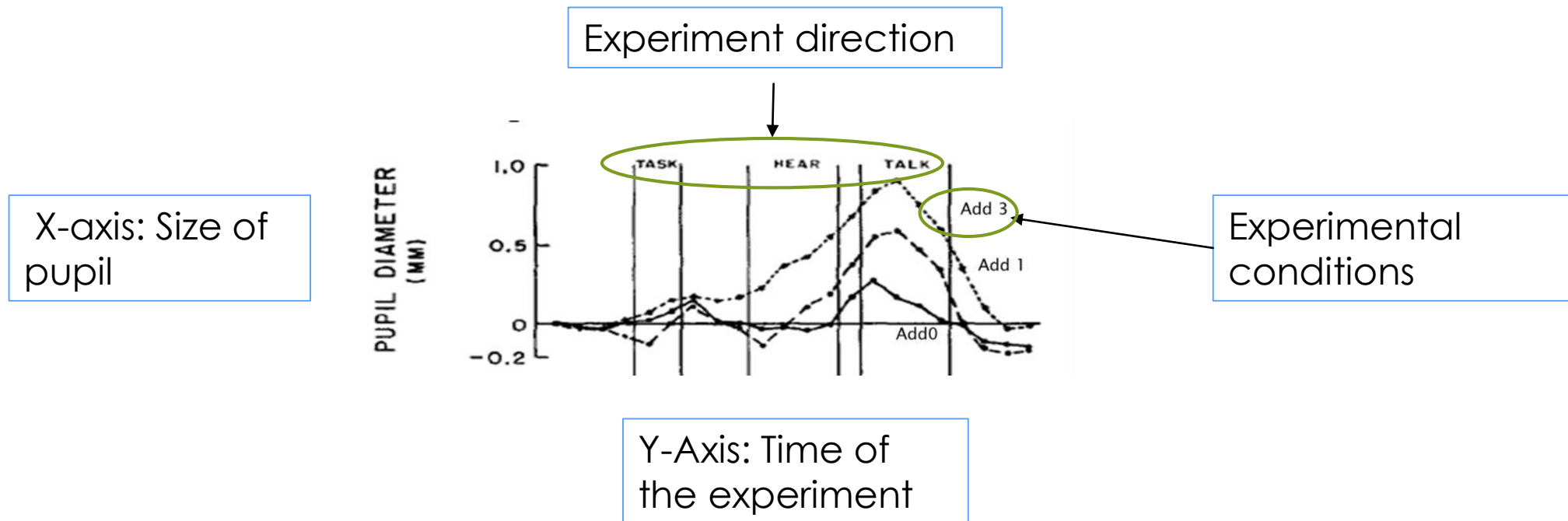
# How the Pupil works





# Experiment 1: Methodology

- ▶ Replicate Kahneman and colleagues 1969 study.



# Experiment 1: Methodology

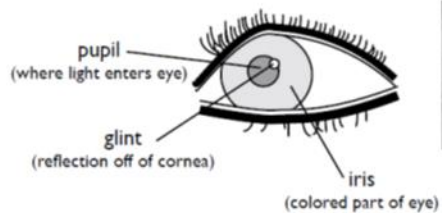
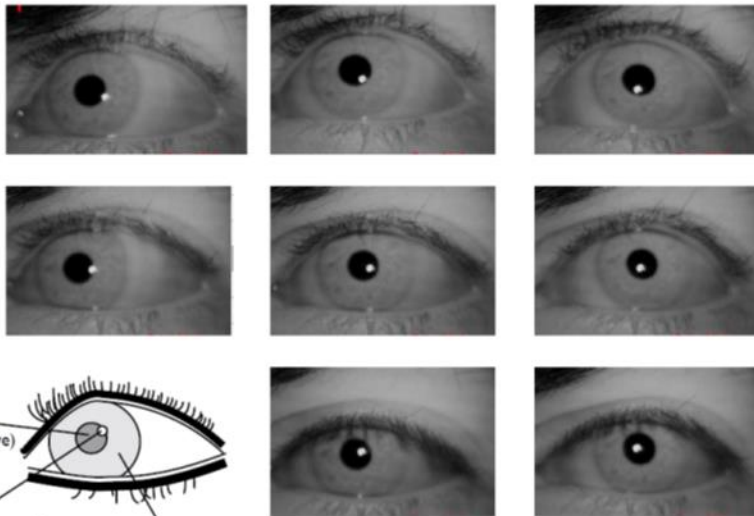
- ▶ Replicated Kahneman and colleagues 1969 study
  - ▶ Task of the subject
  - ▶ Addition problems while on the eye tracker

## Methodology



# Experiment 1: Methodology

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

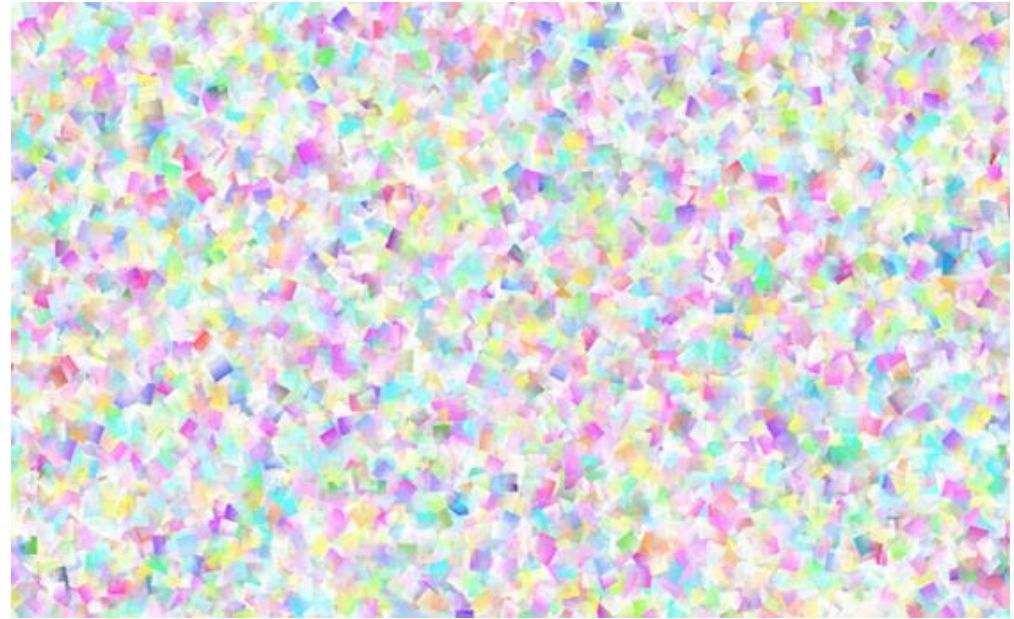




# Experiment 1: Methodology



Set-up with Subject

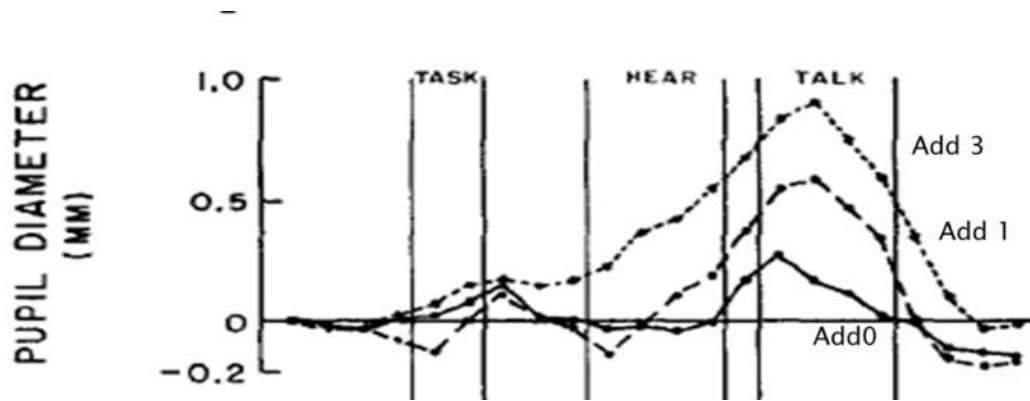


Screen subjects looked at.

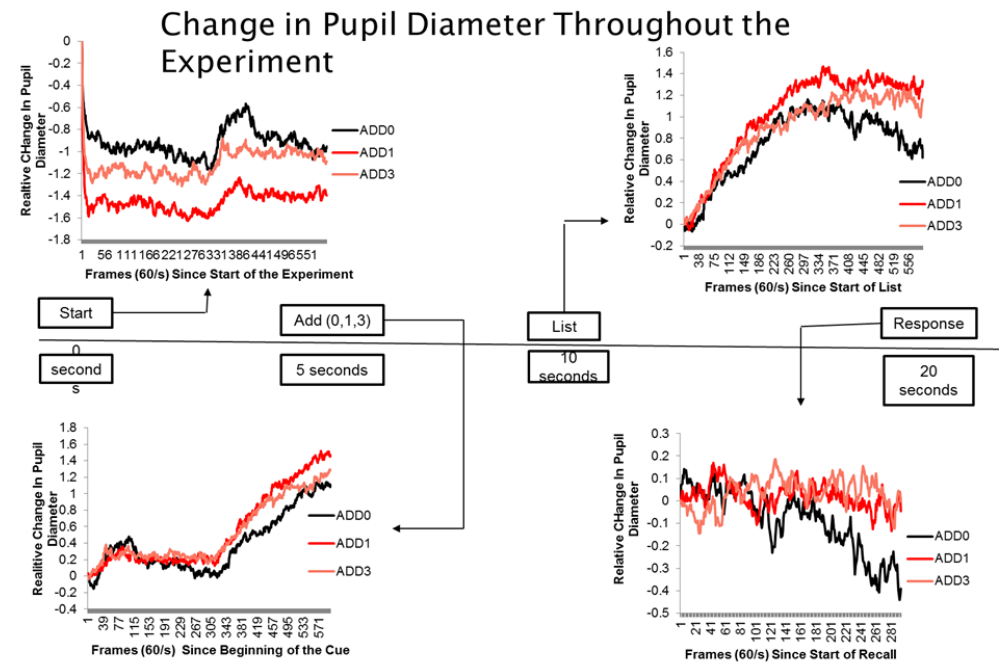
# Experiment 1: Methodology

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

# Experiment 1: Results



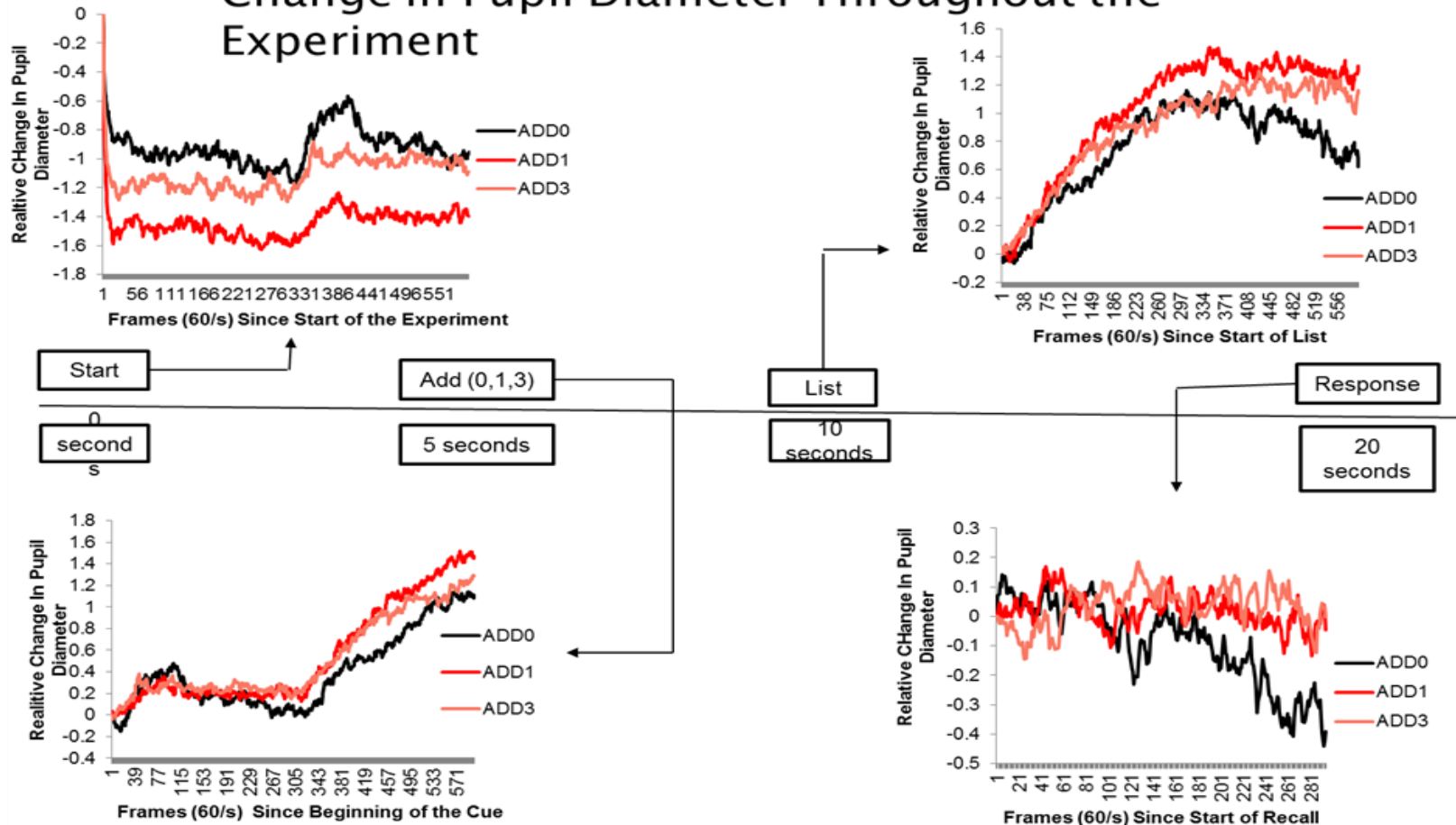
Original study



Experiment 1

# Experiment 1: Results

## Change in Pupil Diameter Throughout the Experiment



# 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

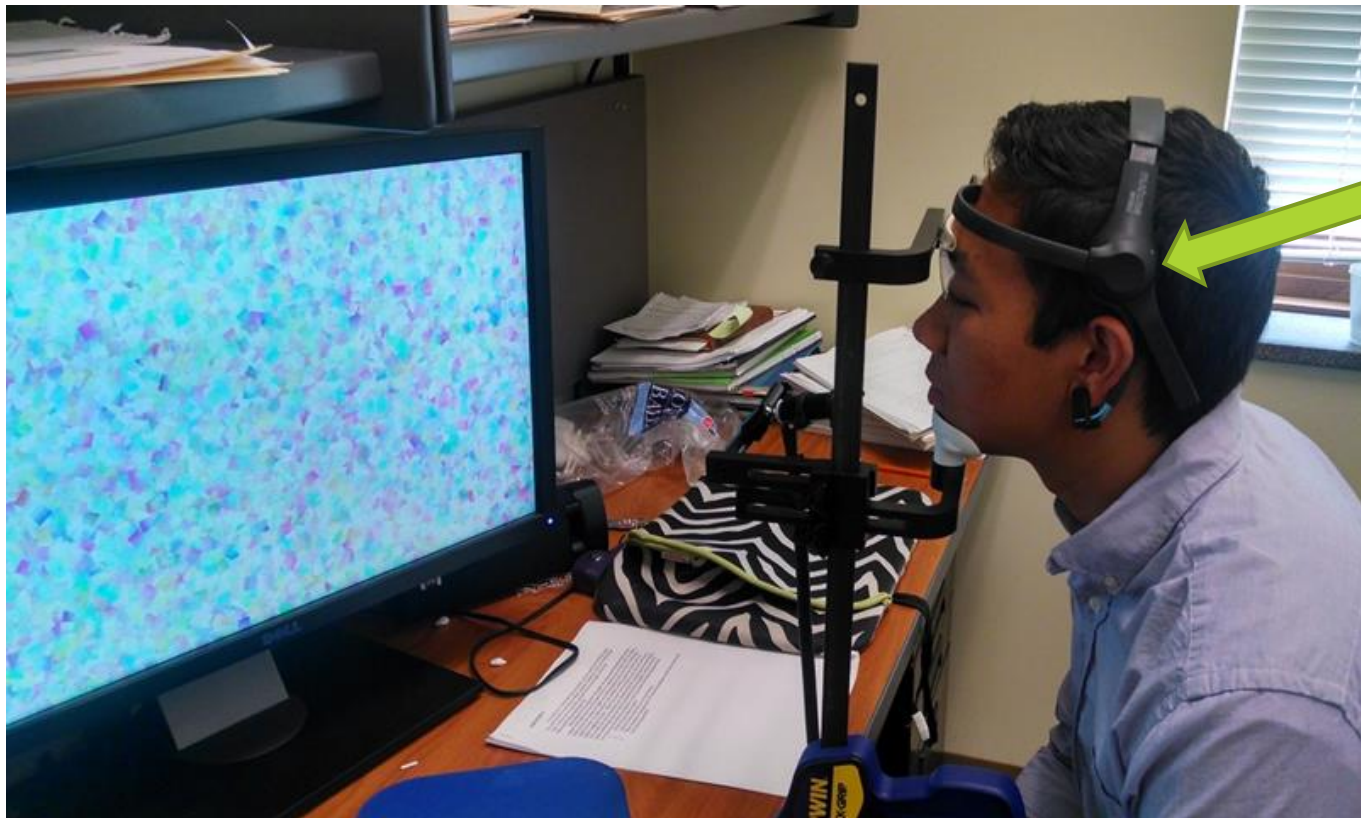
We found the biggest increase in pupil size in the add 1 condition instead of the add 3 condition



# Experiment 2: Methodology

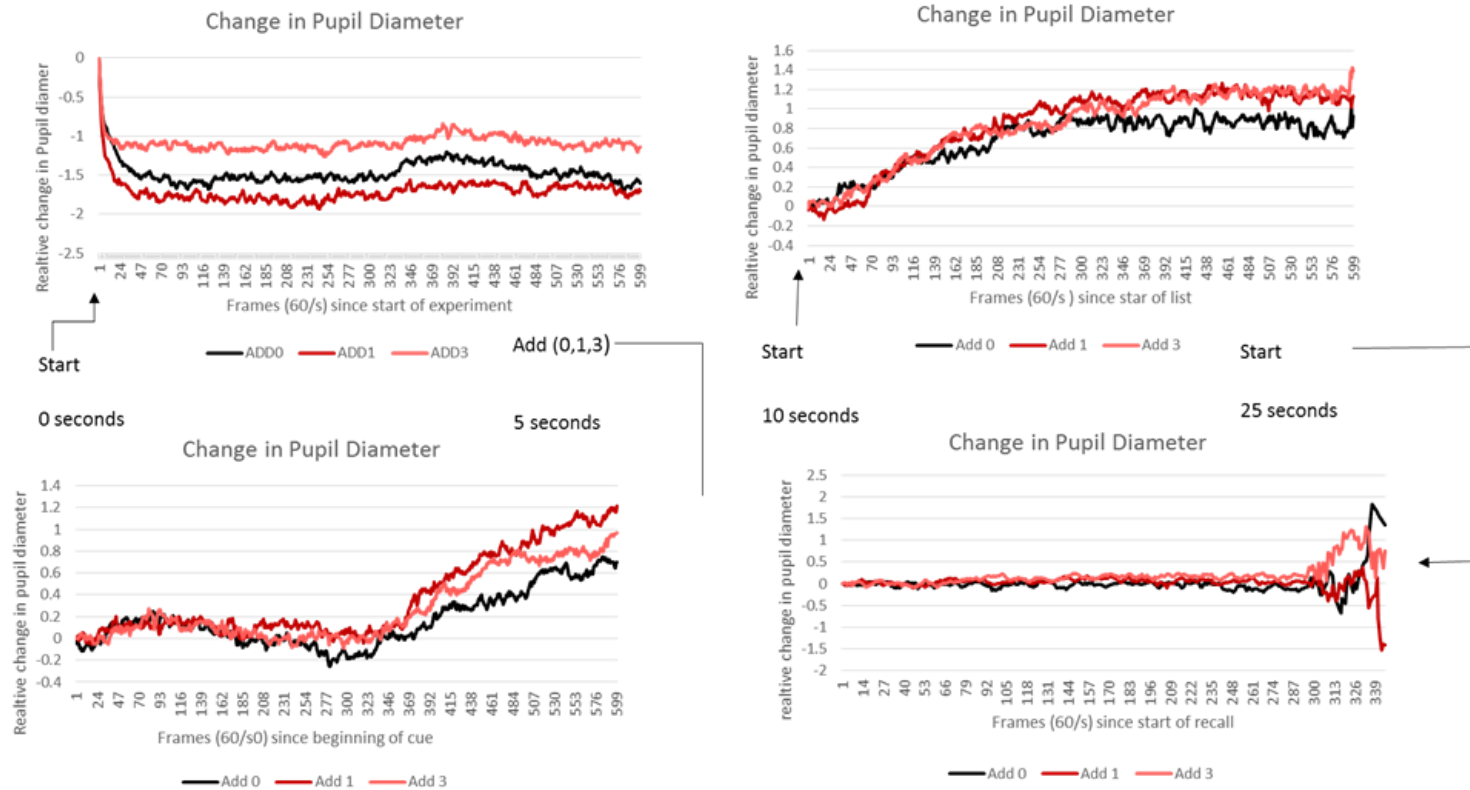
- ▶ Same methodology as experiment 1, but with the NeuroSky device.
- ▶ 31 subjects
  - ▶ 8 males 24 females
  - ▶ 5 removed from data analysis ( for track loss and recording failure)

# Experiment 2: Methodology



NeuroSky Headband

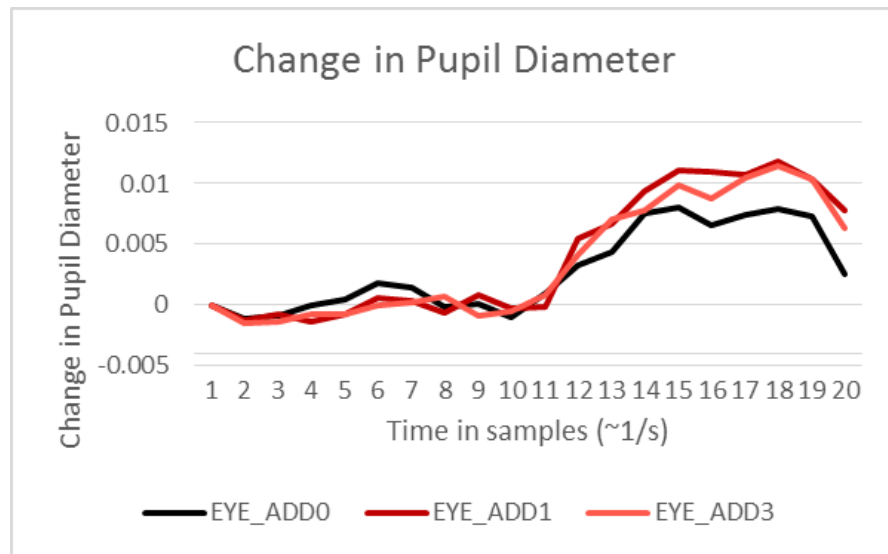
# Experiment 2: Conclusions



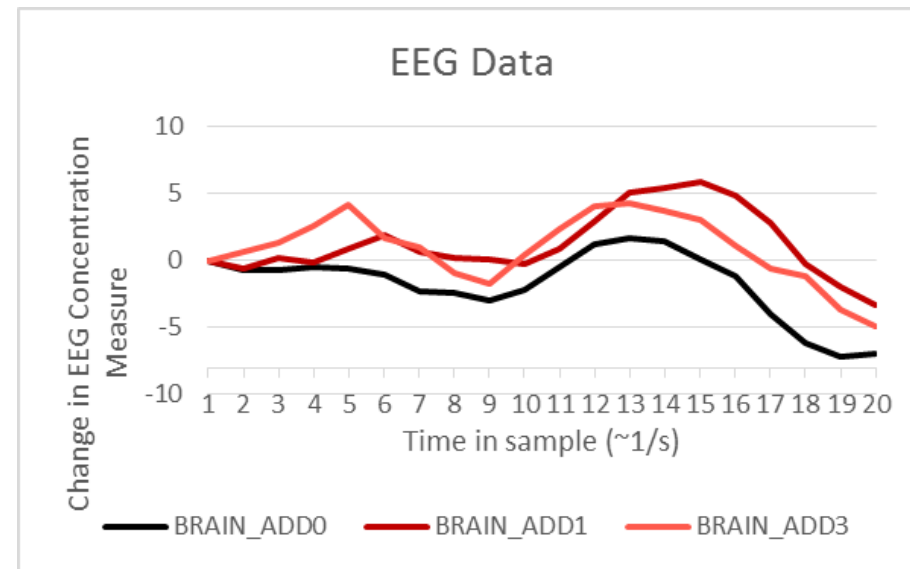
Similar waves as found in the 1969 study and in experiment 1

# Experiment 2: Conclusions

## Eye study



## EEG Study



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

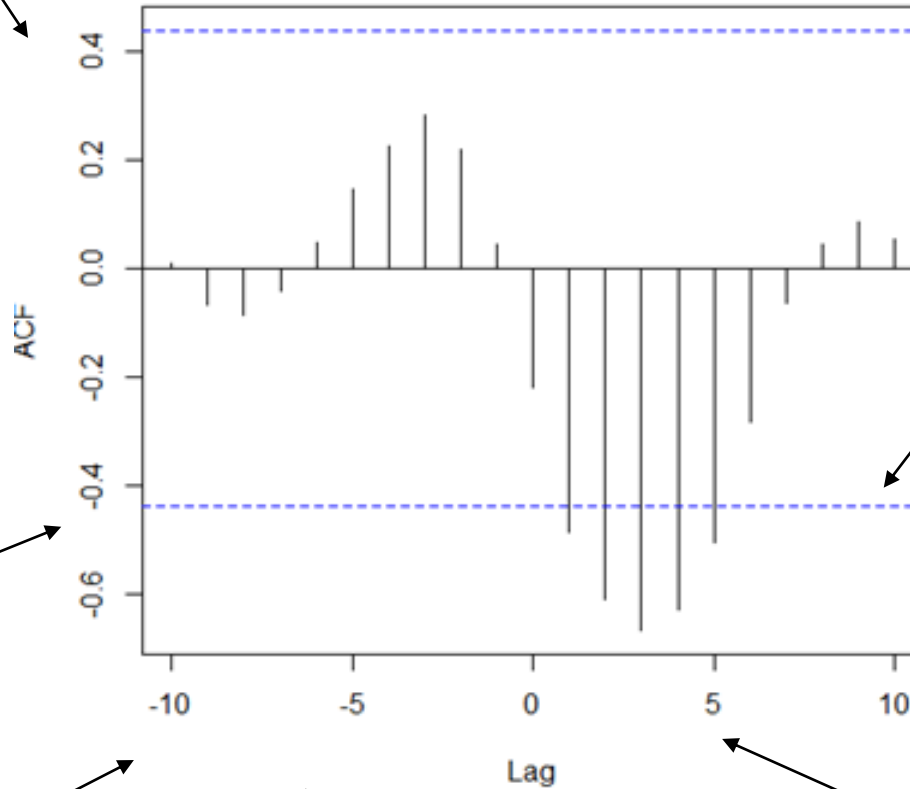
Positive correlation: the lines are moving together

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

Negative correlation: the lines are moving apart

Negative lag: EEG wave preceding the eye wave

Add 0 condition

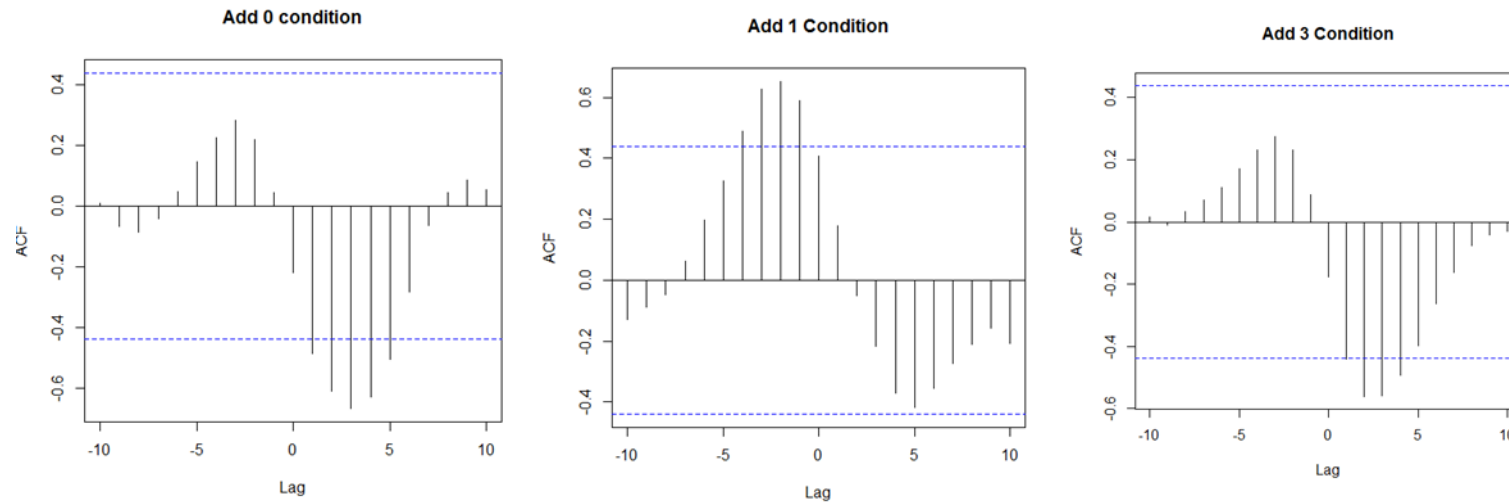


Significant level of  $p = .05$

Positive lag: Eye wave preceding EEG wave

# Experiment 2: Statistics

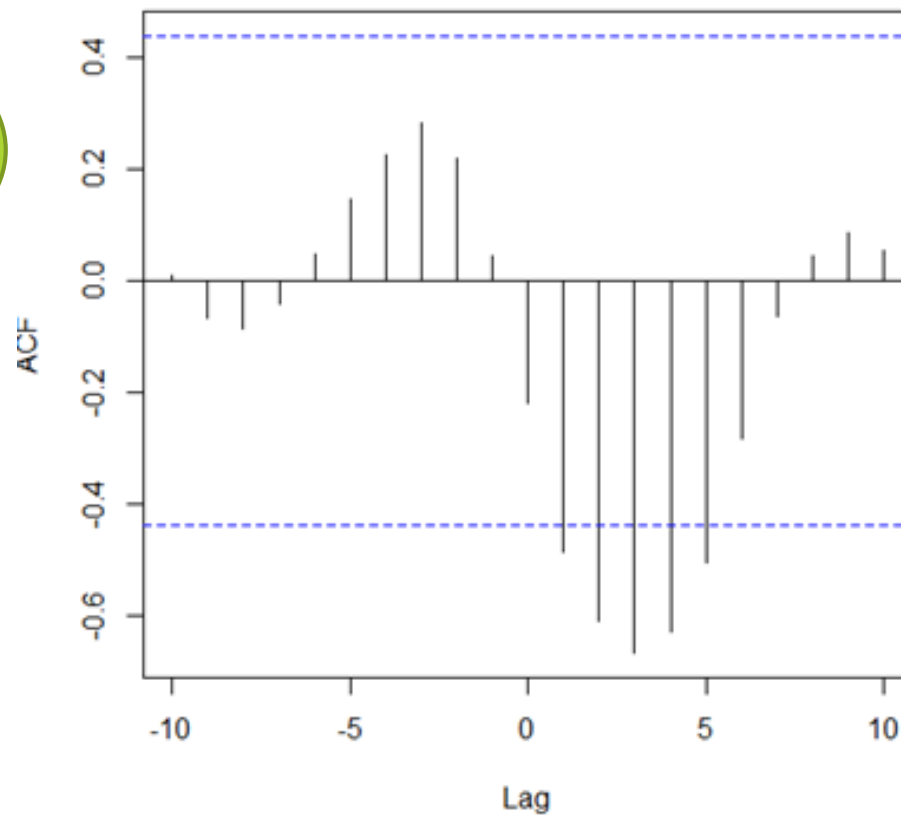
- ▶ A cross-correlation was done to see how similar the lines were.





# Experiment 2: Results

Add 0 condition

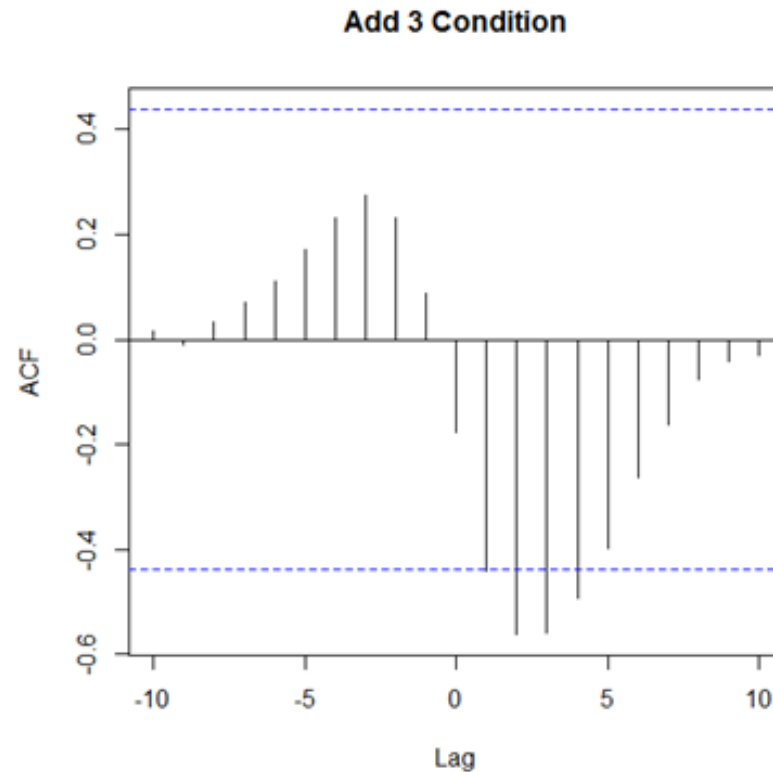


Positive correlation with a negative lag

Significant negative correlation with a positive lag

# Experiment 2: Results

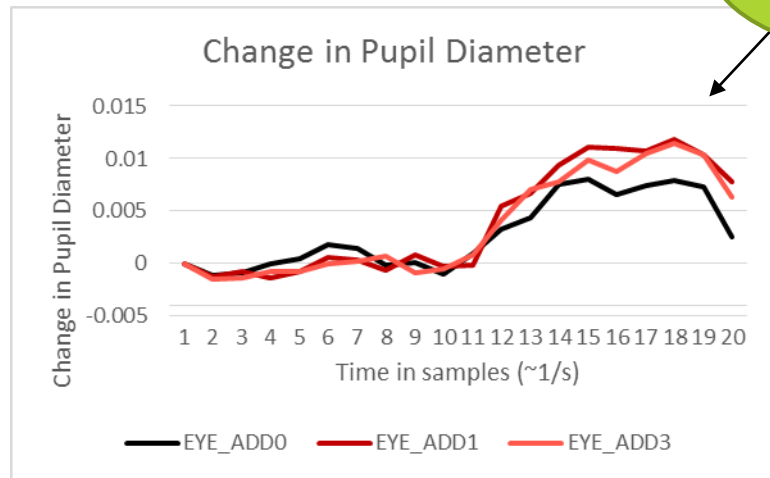
A positive correlation with a negative lag



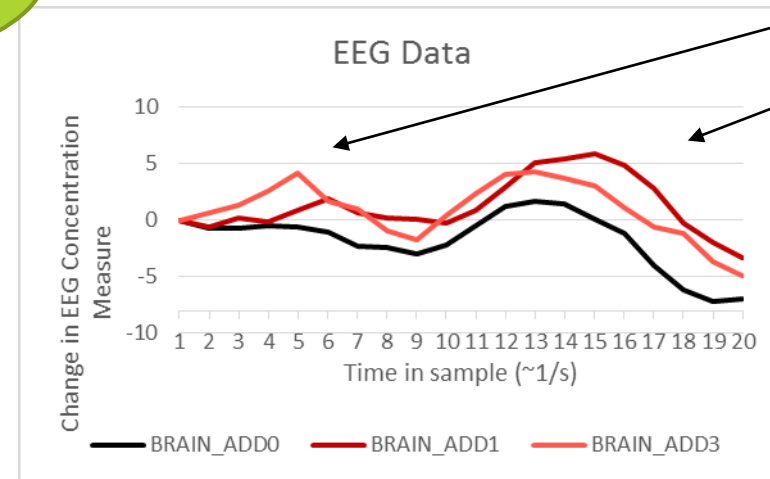
A significant negative correlation with a positive lag

# Experiment 2: Results

One Peaks

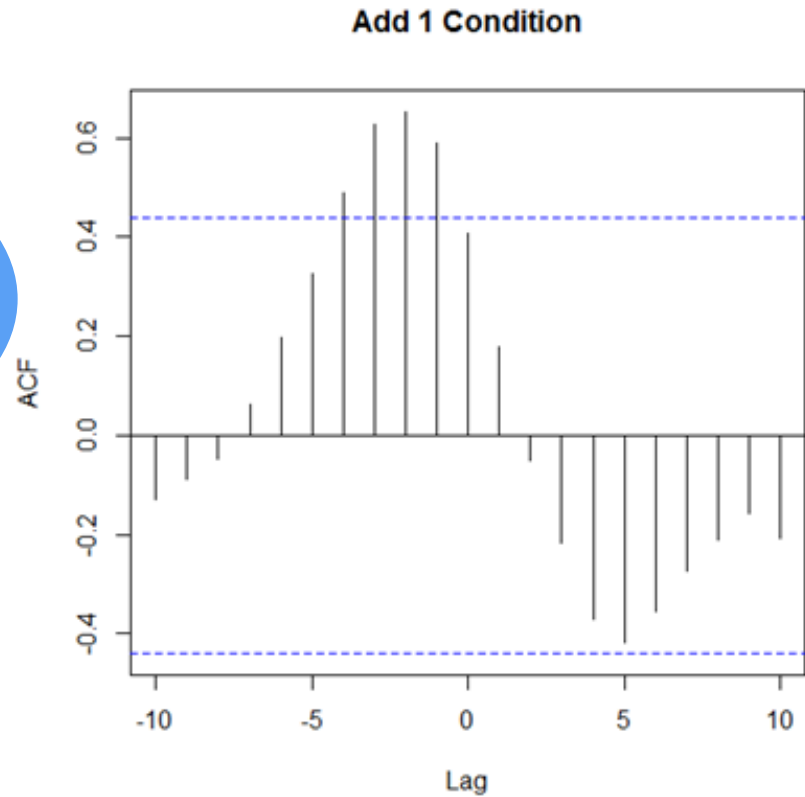


Two Peaks



# 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

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Questions.