

**PSY 308**  
**Cognition Of Motor Movements**  
Monsoon 2024

Assignment 2

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## **Introduction**

Pupillometry has emerged as an important area of study as it offers a non-invasive, objective window into cognitive and emotional processes. This way of measuring human cognitive processes, has numerous advantages over other cognitive measures, in response to various mental states, such as attention, arousal, and emotional intensity (Franzen et al., 2022). This information can be invaluable for understanding human behaviour, improving user experience design, and even diagnosing neurological disorders (Hsu & Kuo, 2023).

The primary aim of this assignment is to perform an analysis to investigate the relationship between pupil dilation and reaction time in response to different emotional stimuli (Happy, Angry, Neutral) and experimental conditions (Main vs Control). By comparing these measures, we seek to understand how emotional cues and experimental manipulations influence cognitive processes and attention allocation.

## **Methodology**

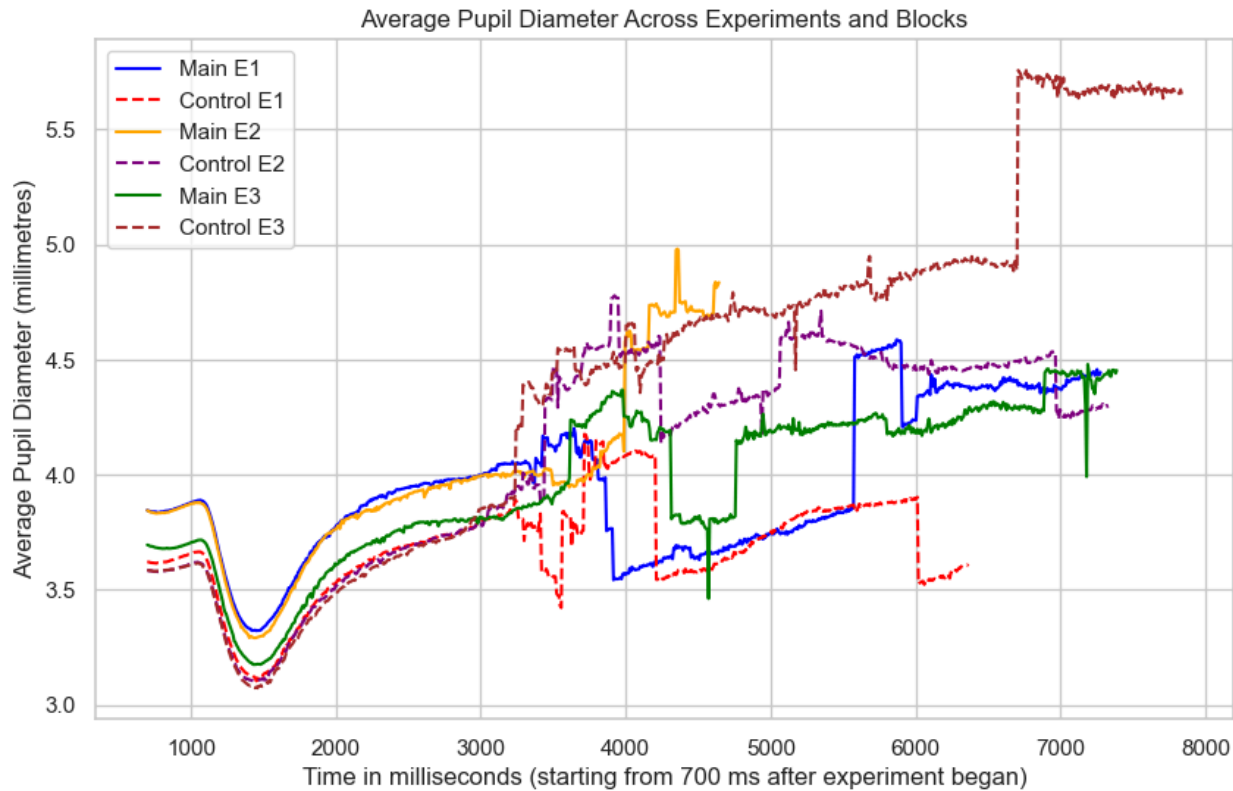
The dataset used was collected from participants who were tasked with responding to facial expressions of Happy, Angry, and Neutral emotions. The participants completed two conditions: the Main Experiment, where they identified emotions, and the Control Experiment, where they identified the position of a red dot on the faces. The data consists of trials organised into three blocks (E1, E2, E3), corresponding to Happy, Angry, and Neutral expressions.

Data preprocessing was performed before performing any form of analysis. Firstly, We defined dictionaries to store pupil data and reaction times for each block (E1, E2, E3) and experiment type (Main and Control). Then from the CSV files containing pupil data, we extract pupil diameter measurements from columns 87 onward (after the stimulus presentation). These measurements are converted to numeric values and averaged across time points for each trial. Reaction times are also extracted, converted to numeric values, and stored for each block. The data is then organised by experiment type and block. Finally, we calculate the averages of pupil diameter data across participants for each block, as well as the median reaction times for each condition. This aggregation allows for a comprehensive analysis of the pupil and reaction time responses across the experimental conditions.

We used line plots to illustrate average pupil diameter changes over time for each emotional block (Happy, Angry, Neutral) in both Main and Control conditions. Bar

plots are used to display average reaction times across these blocks, comparing Main and Control conditions. Additionally, we used scatter plots to depict experiment duration variations across blocks and plot relationships between reaction time and pupil diameter. We also used violin plots to visualise the distribution of reaction times by stimulus type and condition among other things.

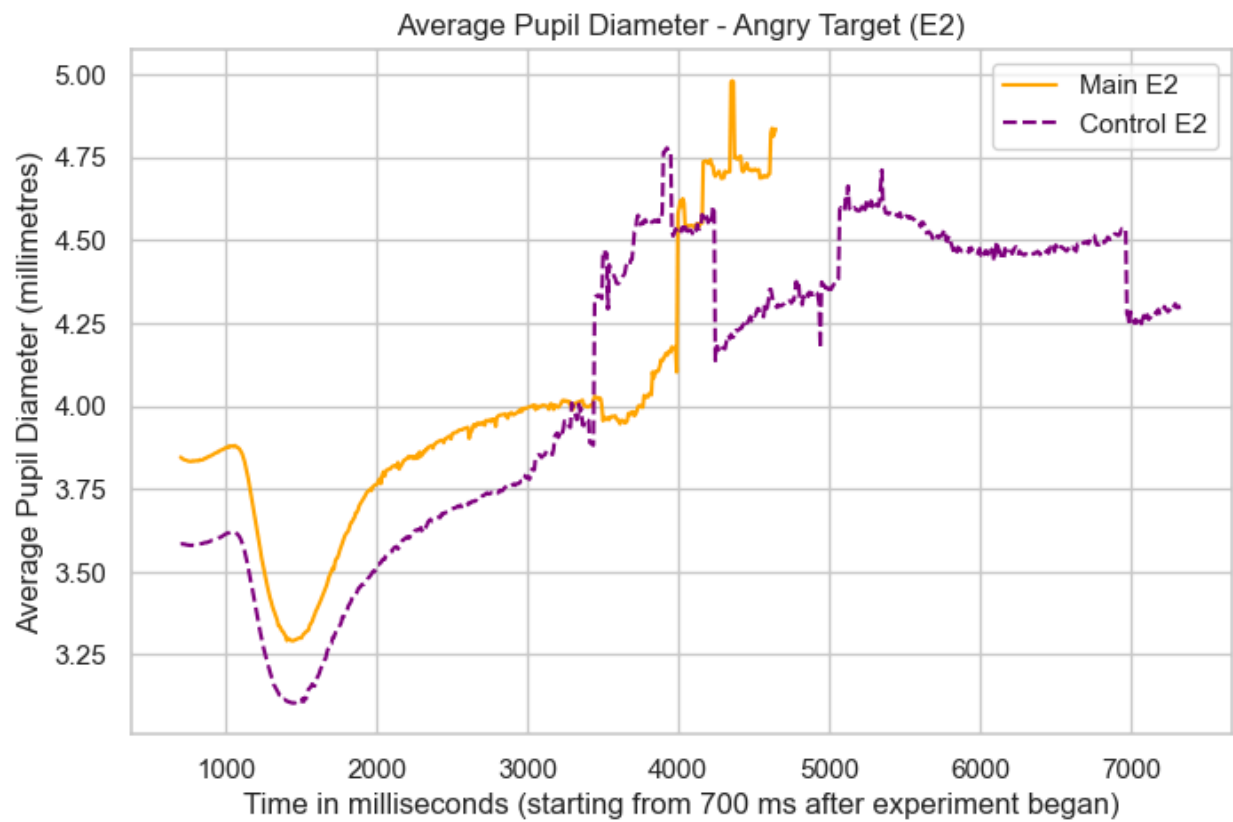
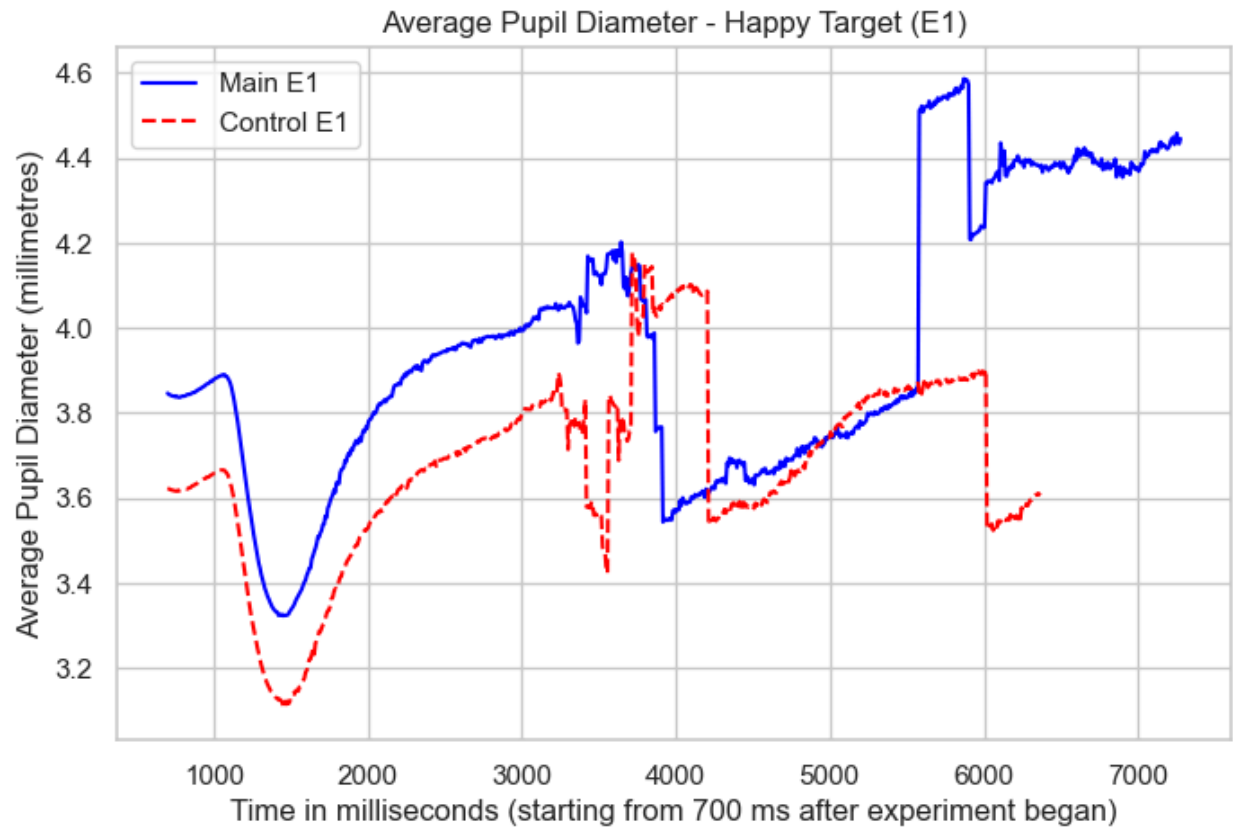
## Results, Analysis & Inferences

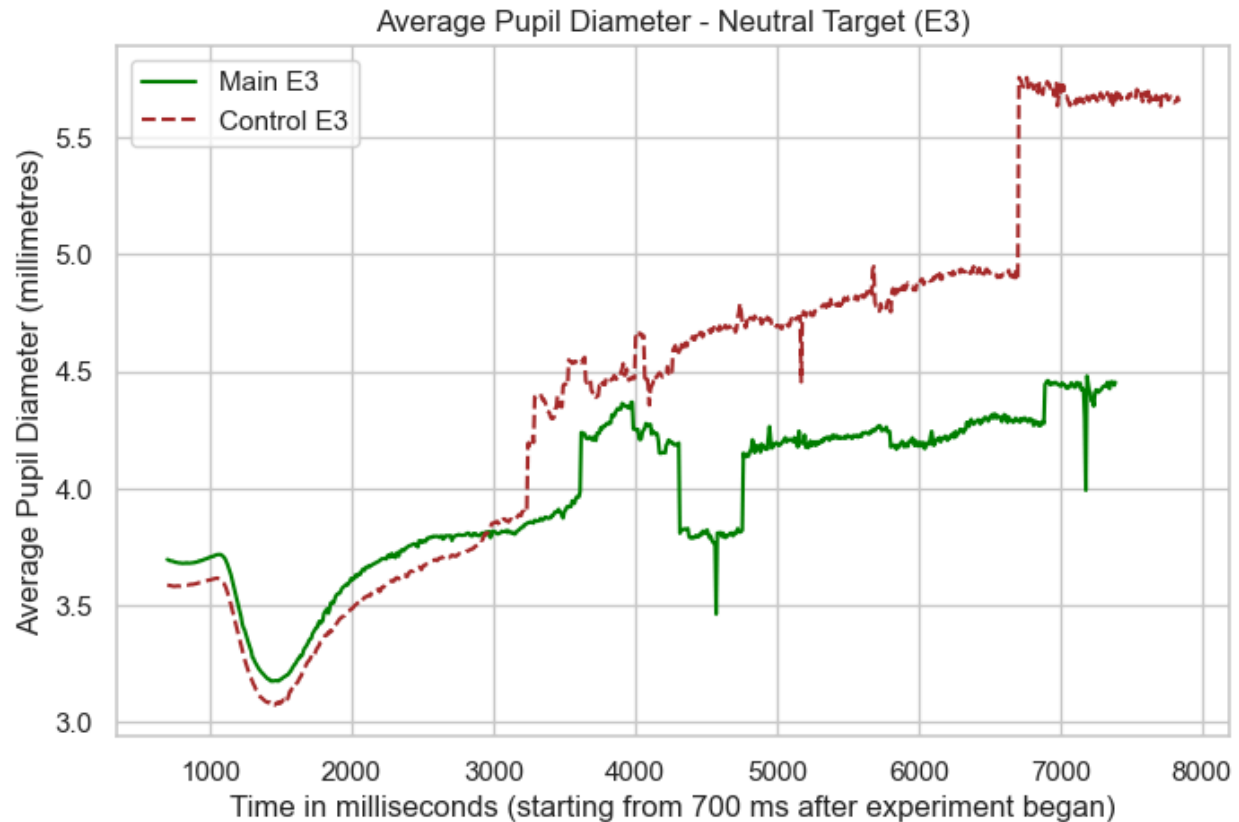


A single plot showing how average pupil diameter varies over time for different experimental conditions and emotional stimuli. The x-axis represents time in milliseconds, and the y-axis represents pupil diameter in millimetres. Different coloured lines are used to represent different conditions and blocks.

**Observation:** All conditions exhibit an initial dip in pupil diameter shortly after the experiment begins and the stimuli are presented.

**Inference & references:** This dip likely represents a phenomenon known as the "pupillary light reflex", where pupils constrict in response to visual stimuli or a sudden increase in brightness (Barrionuevo et al., 2023; Binda et al., 2013). Even though the stimulus here is likely emotional rather than simply visual, this reflex can still occur as an involuntary response to attention-grabbing stimuli (Barbur et al., 1992).

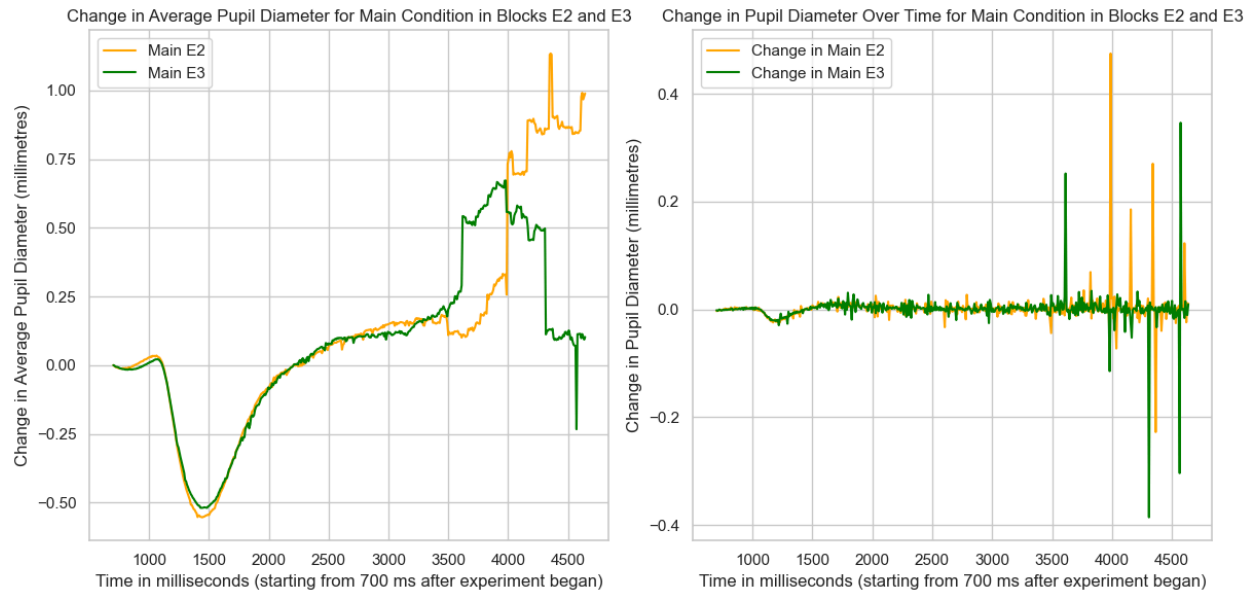




The three graphs above illustrate changes in average pupil diameter over time for different emotional stimuli (Happy, Angry, Neutral) and experimental conditions (Main, Control). Each graph shows the time course of pupil dilation, with the x-axis representing time in milliseconds and the y-axis representing pupil diameter. Different coloured lines represent the Main and Control conditions for each emotional stimulus.

**Observation:** Across all three emotional conditions, the Main experiment consistently shows a higher initial pupil diameter than the Control experiment, following the initial dip.

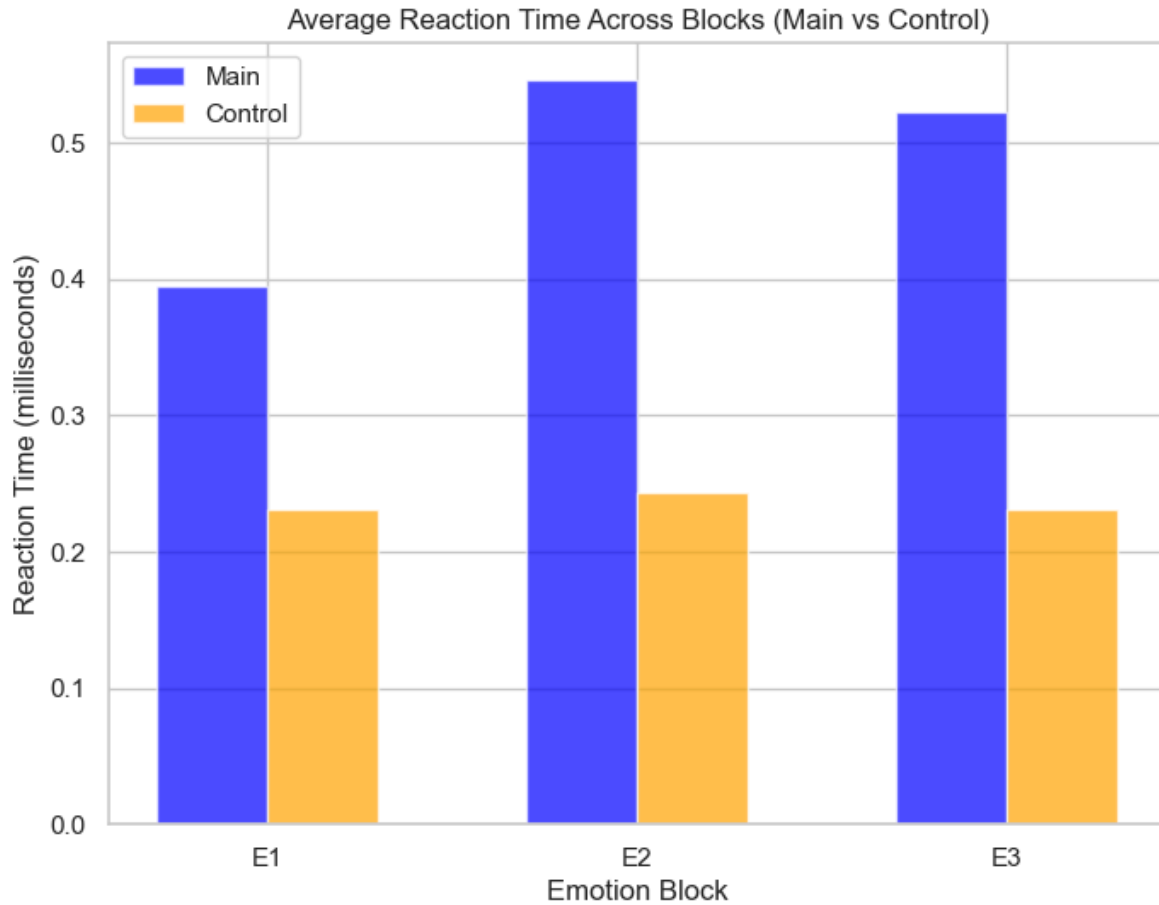
**Inference & references:** This higher initial pupil dilation in the Main experiment could reflect an increased cognitive effort and attentional engagement associated with processing the emotional stimuli and making a judgment, as compared to the simpler task of detecting a red dot in the control experiment as was also observed by Bradley et al. (2008) in a similar experiment.



The graphs show changes in pupil diameter over time for two conditions (E2 and E3). The left graph shows average change, while the right graph shows individual changes in average pupil diameter over time for Angry and Neutral emotions, only for the main experimental condition. The x-axis represents time in milliseconds, and the y-axis represents pupil diameter.

**Observation:** The average change in pupil diameter spike more in the positive direction and average pupil diameter subsequently higher for the Angry condition than the Neutral condition.

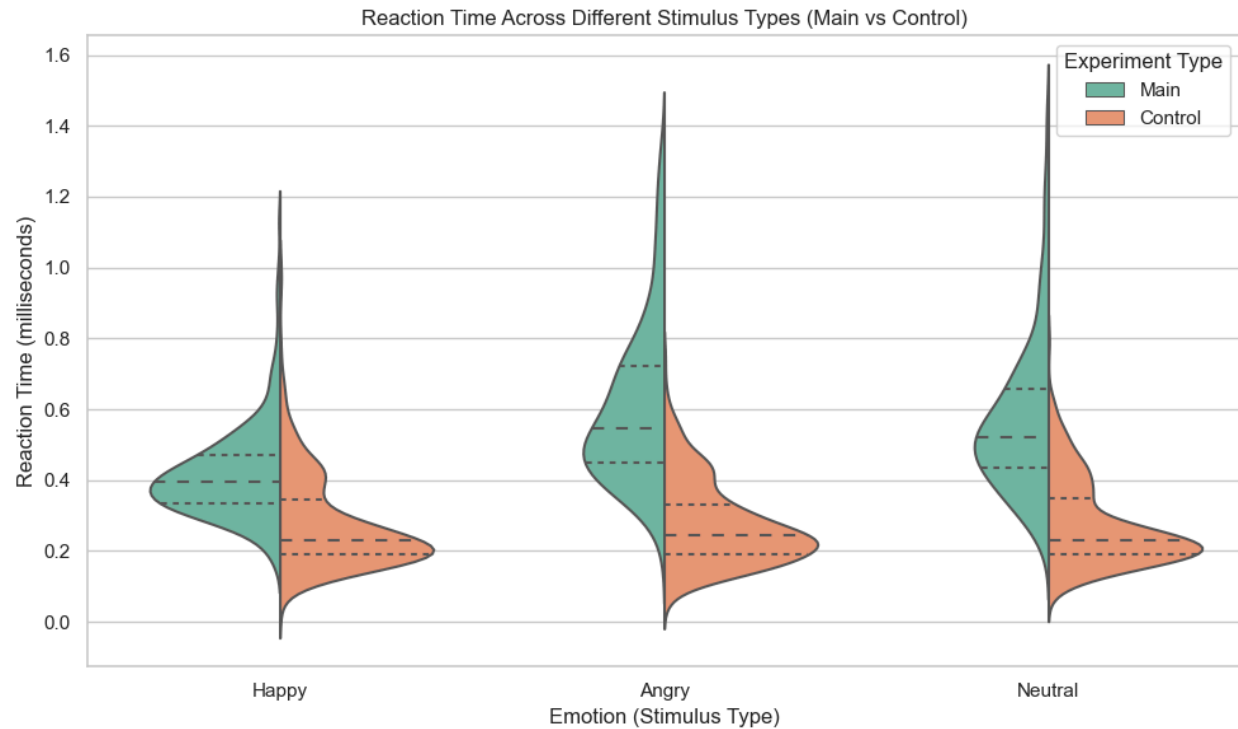
**Inference & references:** This increased pupil diameter for the Angry condition suggests heightened arousal and attentional engagement. Negative emotions, such as anger, increase arousal and attentional engagement, leading to larger pupil size as was also observed by Kinner et al. (2017). Heightened pupil dilation observed for angry stimuli also reflects an evolutionary response, where increased attention is directed towards potential threats (Sørensen & Barratt, 2014). Pupils dilate more when greater attention is allocated to a phenomenon (Kang et al., 2014). These studies, therefore validate our inference.



The Bar Plot displays the average reaction times for the Main and Control conditions across three different emotional blocks (E1, E2, E3). It compares the time participants take to respond to the stimuli in each condition.

**Observation:** The Main condition consistently exhibits higher reaction times than the Control condition across all three emotional blocks.

**Inference and references:** This suggests that the task of identifying the target emotion in the Main condition was more cognitively demanding than the task of detecting the red dot in the Control condition. This could be due to increased decision-making processes, attentional demands, and emotional processing required for the Main task.



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