

Measuring stimulus latency in M/EEG using a universal low-cost open-source device

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INTRODUCTION

Stimulus timing is critical for MEG and EEG

- Time-locked averaging methods (ERP and ERF) rely on events being sampled accurately
- In typical EEG setups, the stimulus software sends markers or “triggers” that are meant to coincide with relevant events, that the amplifier will co-register with the electrophysiological data

Software and hardware introduce unknown & variable delays

- Stimulus software and Operating System
- Monitor refresh rate
- Graphics Cards
- Sound cards

Existing solutions are expensive, mostly proprietary and inflexible

- Existing dedicated “toolkits” retail around \$2000-3000
- EEG vendor specific single-modality sensor units \$300; require calibration and analysis
- Such hardware is closed source; making it less easy to replicate and compare between labs

CONCLUSION

Takeaway 1: Stimulus latency appears unexpectedly severe and varies across labs

- We observed latency that would affect the outcome
- Variation across labs, if uncorrected, would have affected replicability

Takeaway 2: Feasible to measure latency for every experiment with ElectroTime

- No elaborate changes to setup required
- Can be applied to existing experiments

Takeaway 3: Report latency and variance in the literature

- Improves replicability and comparison
- The open nature of the ElectroTime allows standardization

Takeaway 4: Adjust your analysis or setup

- Shift epoch onset by the average latency
- Reduce Type II error by modelling the latency variance into our inference
- If the latency variance is too severe; we must adapt the experimental setup or stimulation code.

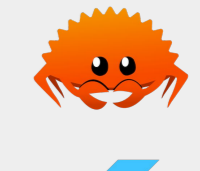

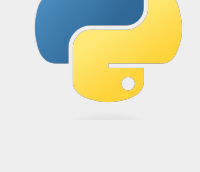
METHODS

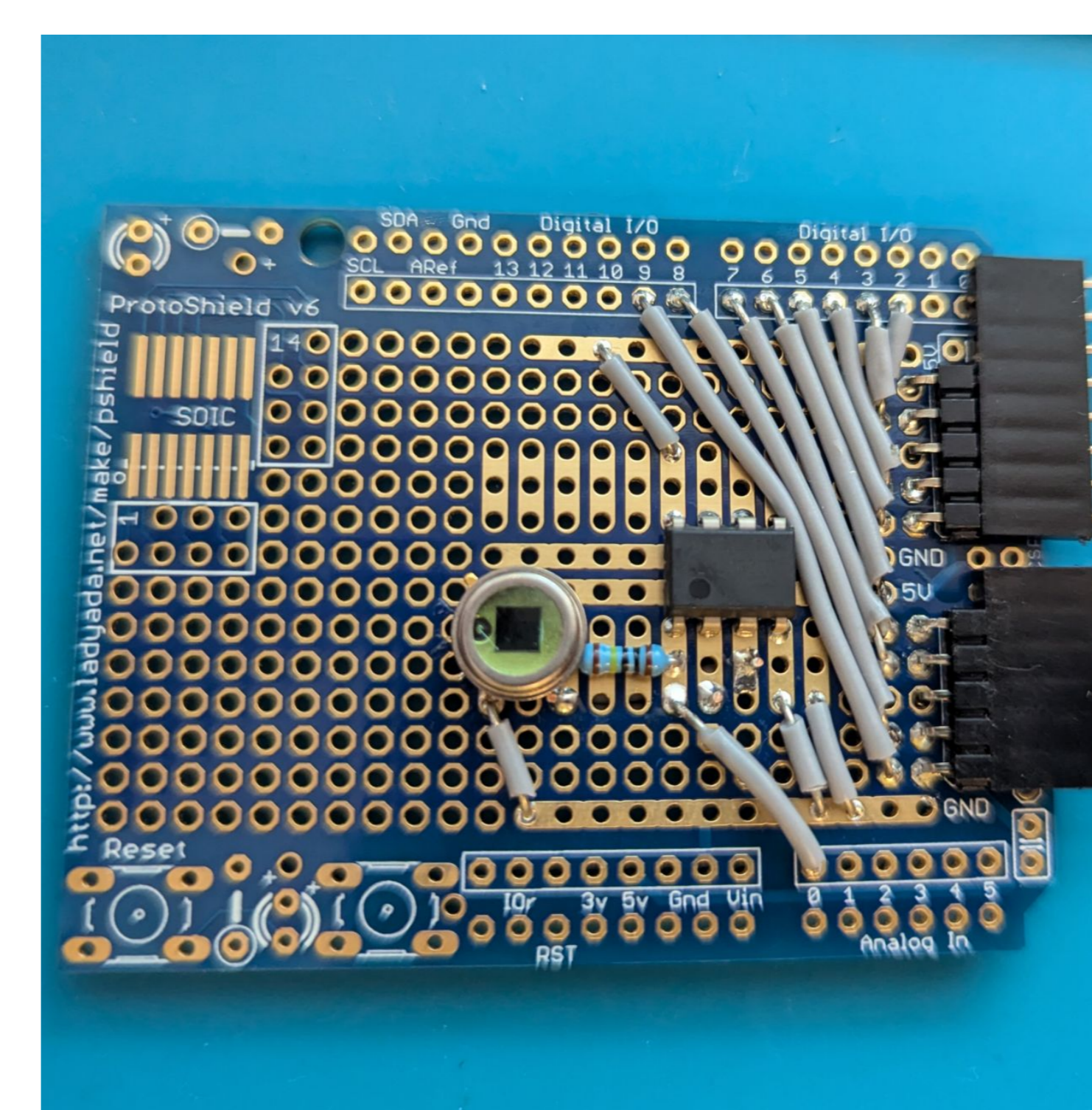
ElectroTime is open-source, easy to use, widely compatible and costs less than \$80

KEY HARDWARE

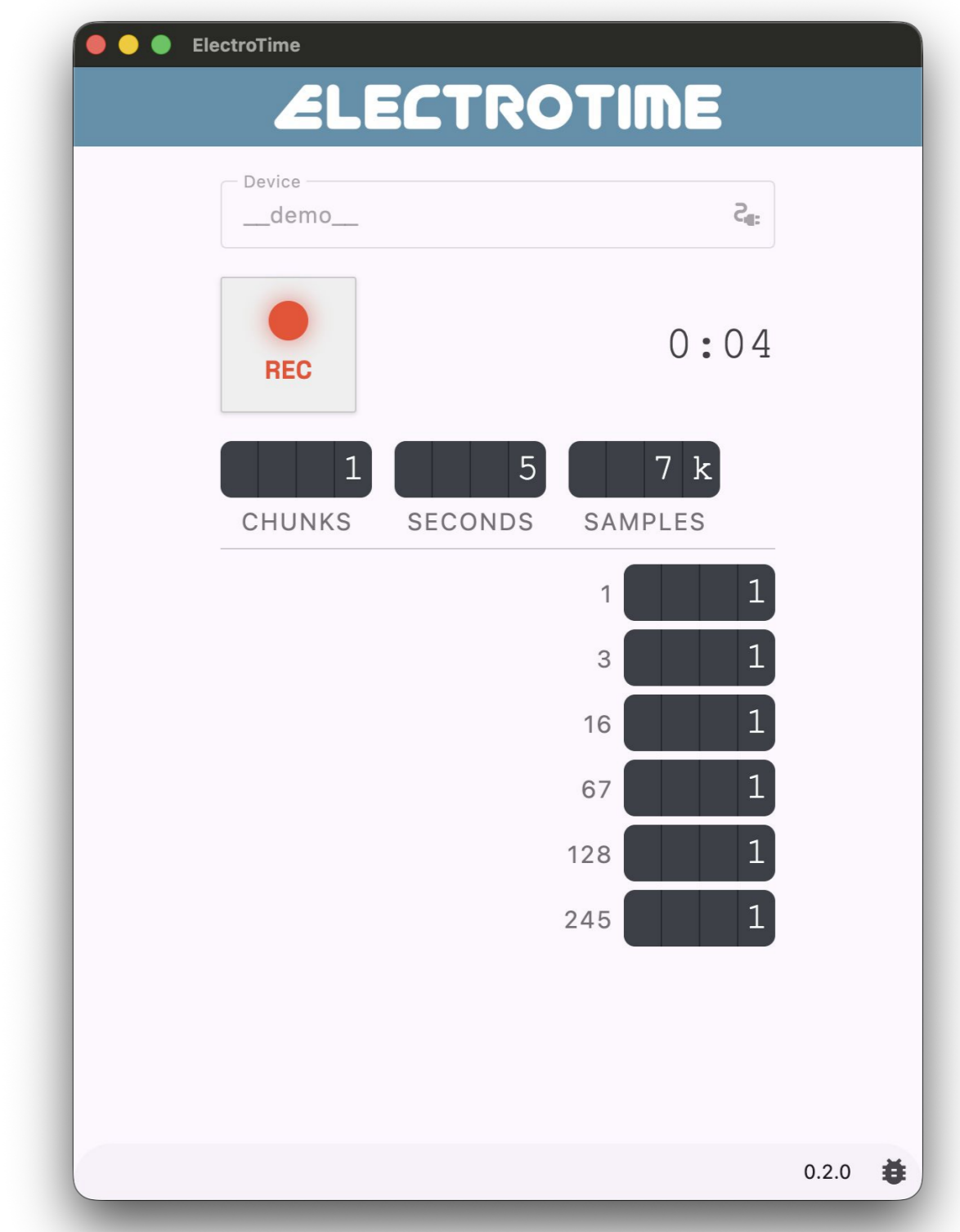
- Arduino Uno
- Photodiode
- 3.5” audio input
- 3D printed enclosure
- DB37 trigger interface

KEY SOFTWARE

- Firmware 
- Desktop App 
- Analysis code 
- Website
- Documentation
- Software Updates



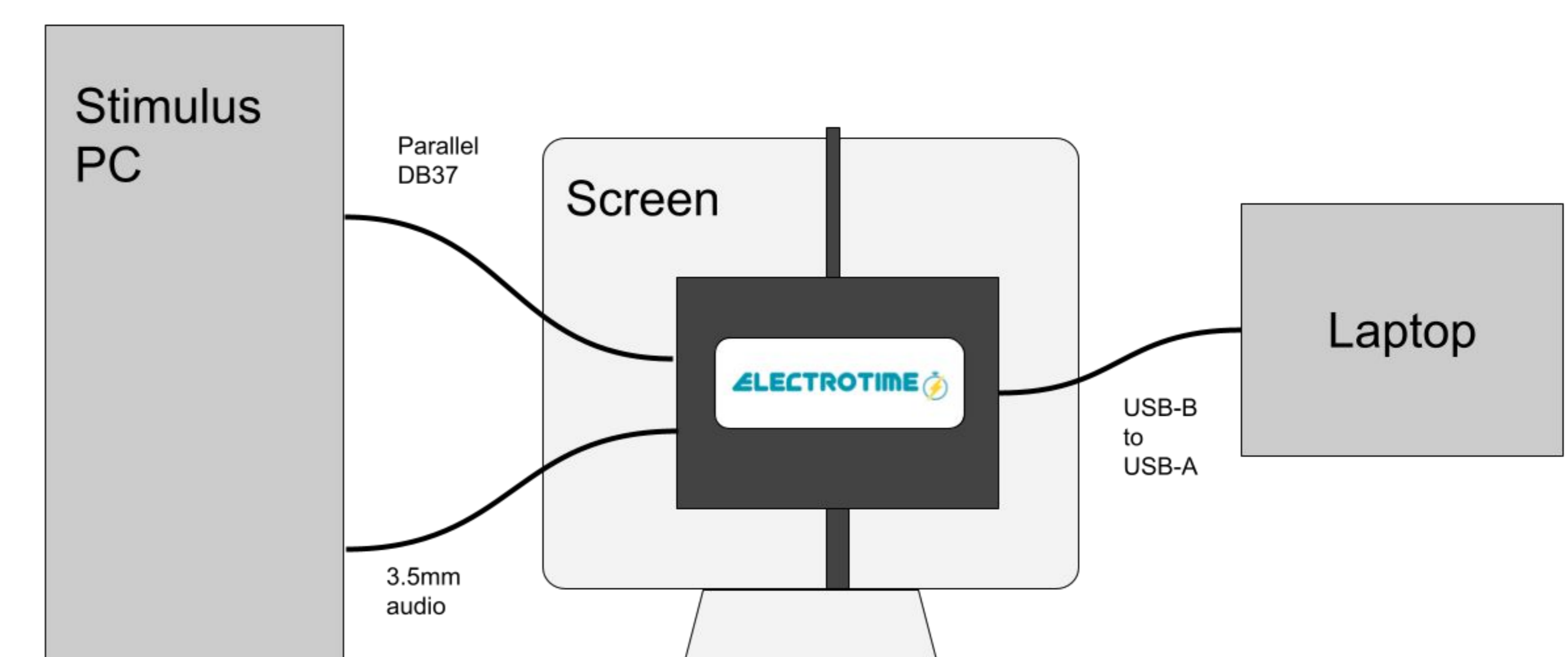
circuit



application



device



lab setup

RESULTS

We measured latency across four #EEGManyLabs sites

