

# Threat or challenge? Measuring cognitive workload and physiological arousal to infer mental state

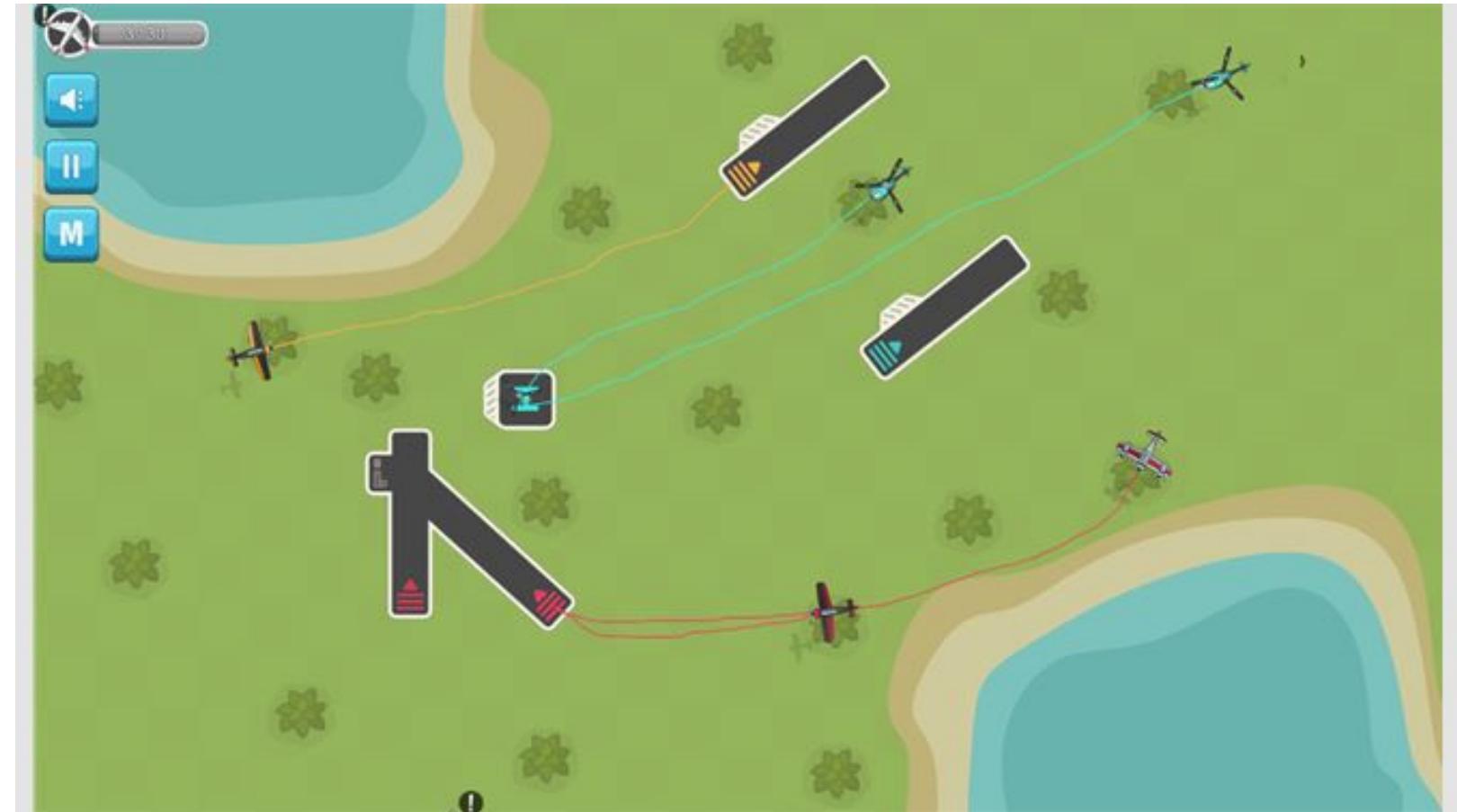
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# Air Traffic Controllers (ATC)

- Highly demanding
- Constant traffic
  - Heathrow – 1 plane every 45 seconds
  - Sydney – 20 every 15 minutes
- Very serious consequences
- So how do we train people for this?



# ATC-DIN Project



## THE PROBLEM:

RAAF Air Traffic Controllers are required monitor a range of complex data both in civil environments and on deployment. The decisions these operators make have a significant impact on the safety and security of personnel and equipment. The volume of information they are required to process to undertake this critical task can have a detrimental impact on an operator's ability to make effective decisions and lead to decreased situational awareness.

Improving the ability of combat air traffic controllers and related personnel to operate under difficult conditions is an important goal.

**Unanswered questions** subserving this goal include the efficacy of different training methods to improve situational awareness under high cognitive load and the relative value of various personnel selection procedures designed to identify the most capable individuals.

Potential projects leading towards answers for these questions could include analysis of the cognitive load on operators in current practices and the impacts of this on their decision-making.

# Cognitive Workload

Cognitive Workload = level of how hard you're working

Restricted by your capacity

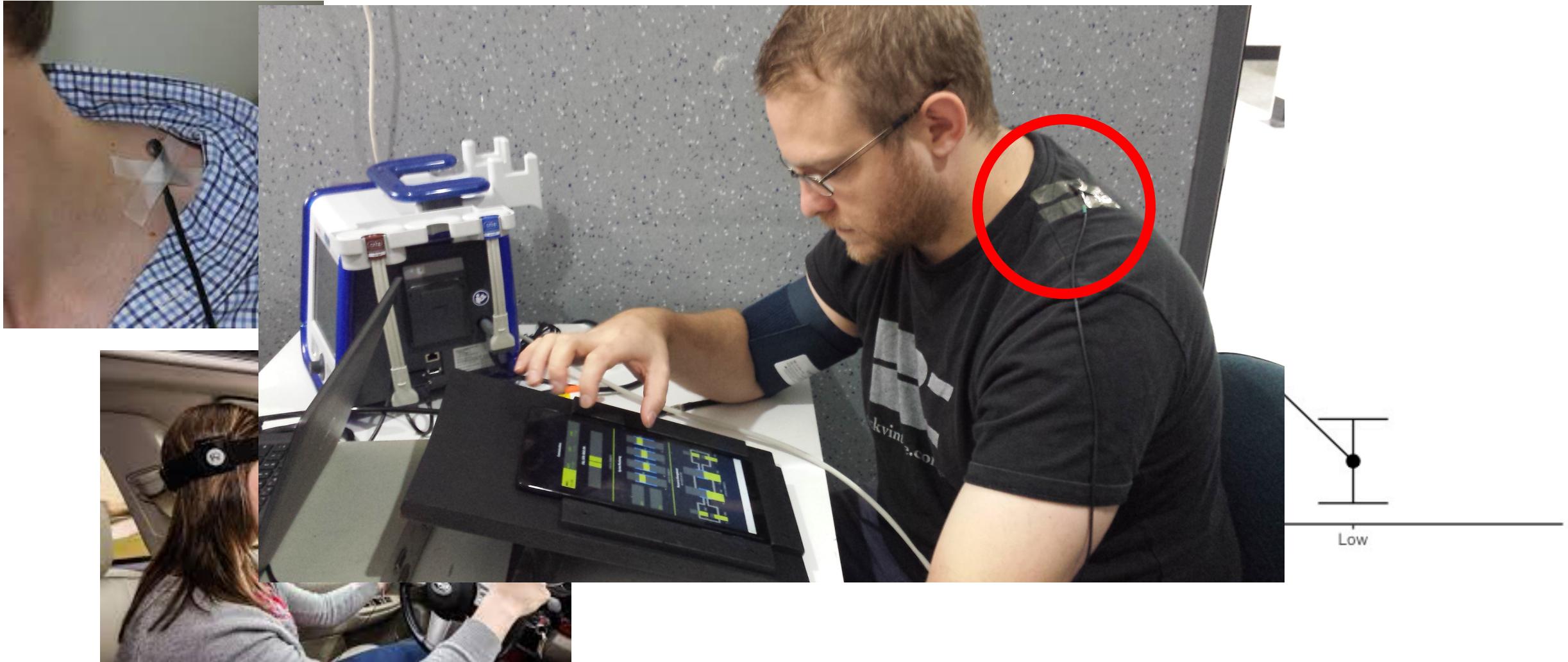
Amount of resources being used

Affects task performance

Higher workload >>> less resources available



# DRT and typical patterns



# Motivational State

- Different people react differently to pressure scenarios
- Could be **challenged**
  - Perceived sufficient (or nearly) resources to match demands
- Could be **threatened**
  - Perceived insufficient resources to match demands
- Biopsychosocial model of performance
  - Affect
  - Cognition
  - Physiological Response



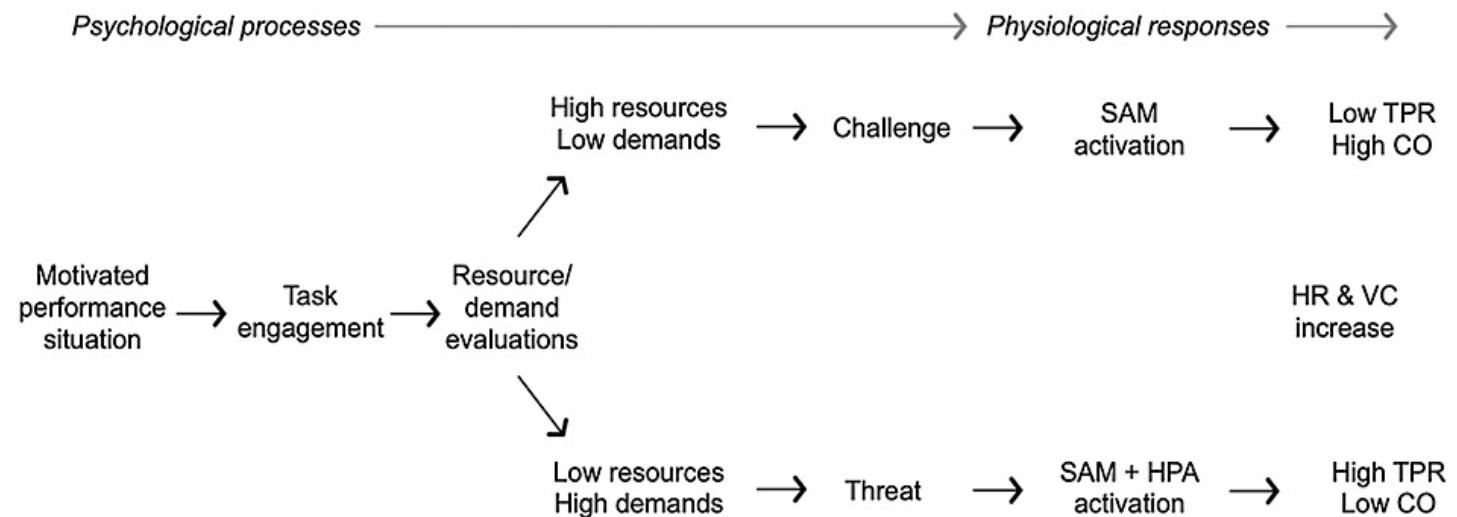
# Physiological Underpinning

# Challenge – Sympathetic Adreno Medullary axis

- Increased contractility, stroke volume, HR and cardiac output
  - Decline in vascular resistance
  - Unchanged blood pressure (TPR)

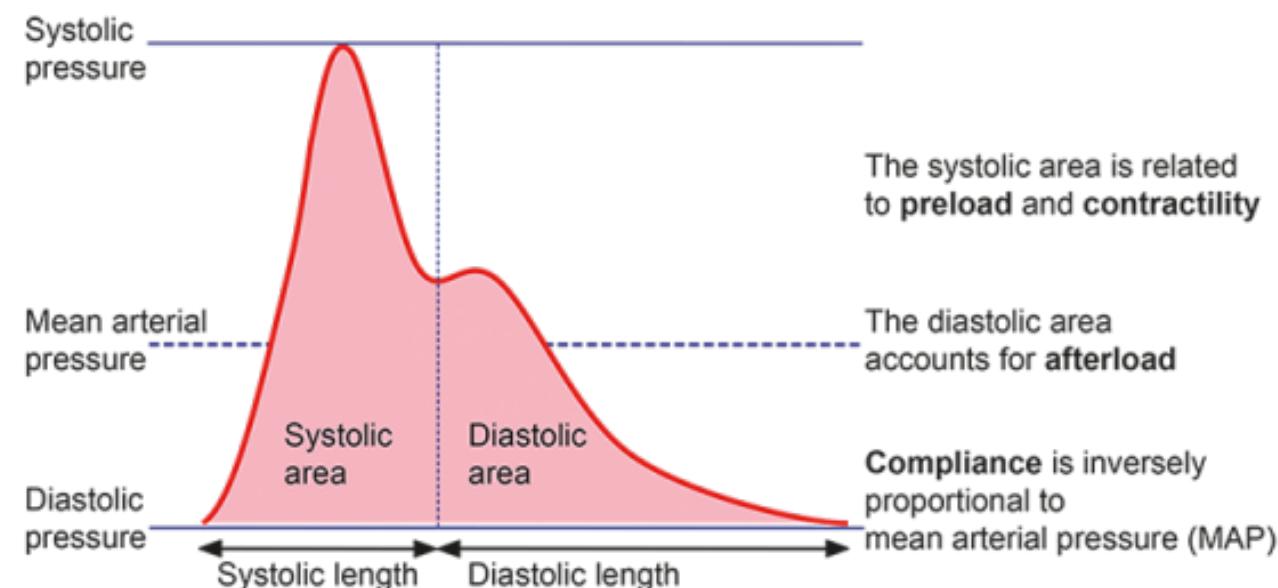
**Threat** – Pituitary Adrenal Cortical axis

- Increased contractility, stroke volume, HR and cardiac output
  - Unchanged vascular resistance (sometimes increase)
  - Increase in blood pressure (TPR)

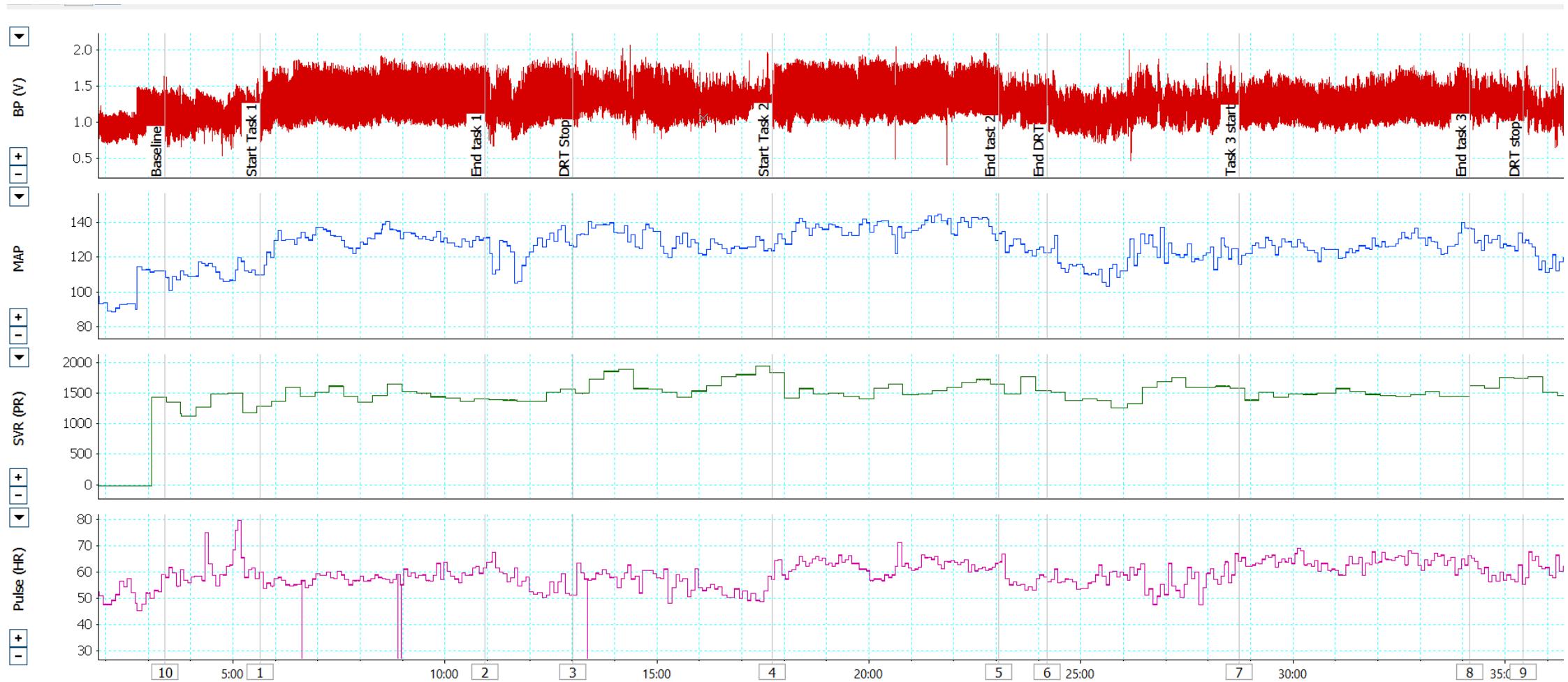


# The Glove

- Measure state using CNAP
  - Continuous Non-invasive Arterial Pressure
  - “gold standard”
- Measures:
  - Blood pressure
  - Hemodynamics (i.e. changes)
  - Rhythms
  - Pulse waves
    - Stroke volume & pulse pressure
- Uses pulse contour analysis



## Screenshot of biometric recording during Collision Detection Task



BP: blood Pressure

MAP: mean arterial pressure

SVR: Systemic vascular resistance (**SVR**)

Pulse: Heart rate

# Our study

Workload

+

Physiological State

What happens?

Can it be manipulated?

Reliable measures?



# Our study

Setup

At least 2  
experimenters



# Our study

## Setup

- Covid safe



# Our study

## Setup

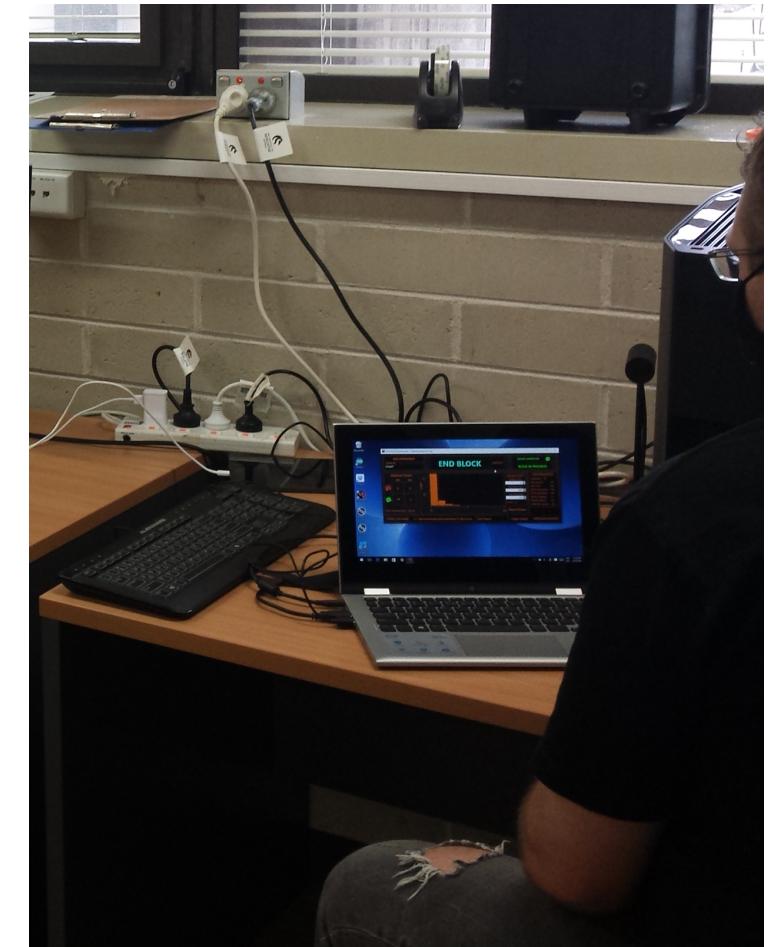
- The glove goes on the non-dominant hand
- Blood pressure monitor on as well



# Our study

## Setup

- DRT runs as per normal
- Press a foot pedal (dominant foot)



# Our study

## Setup

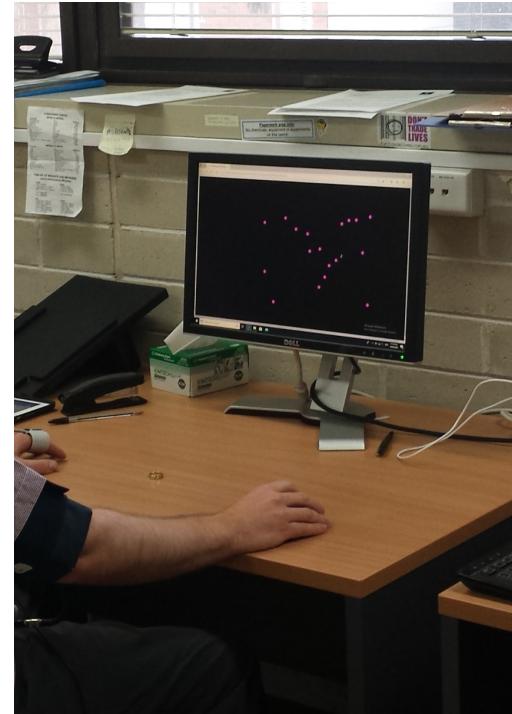
- Fancy head wear
- Related to another experiment
  - fNIRS



# Our study

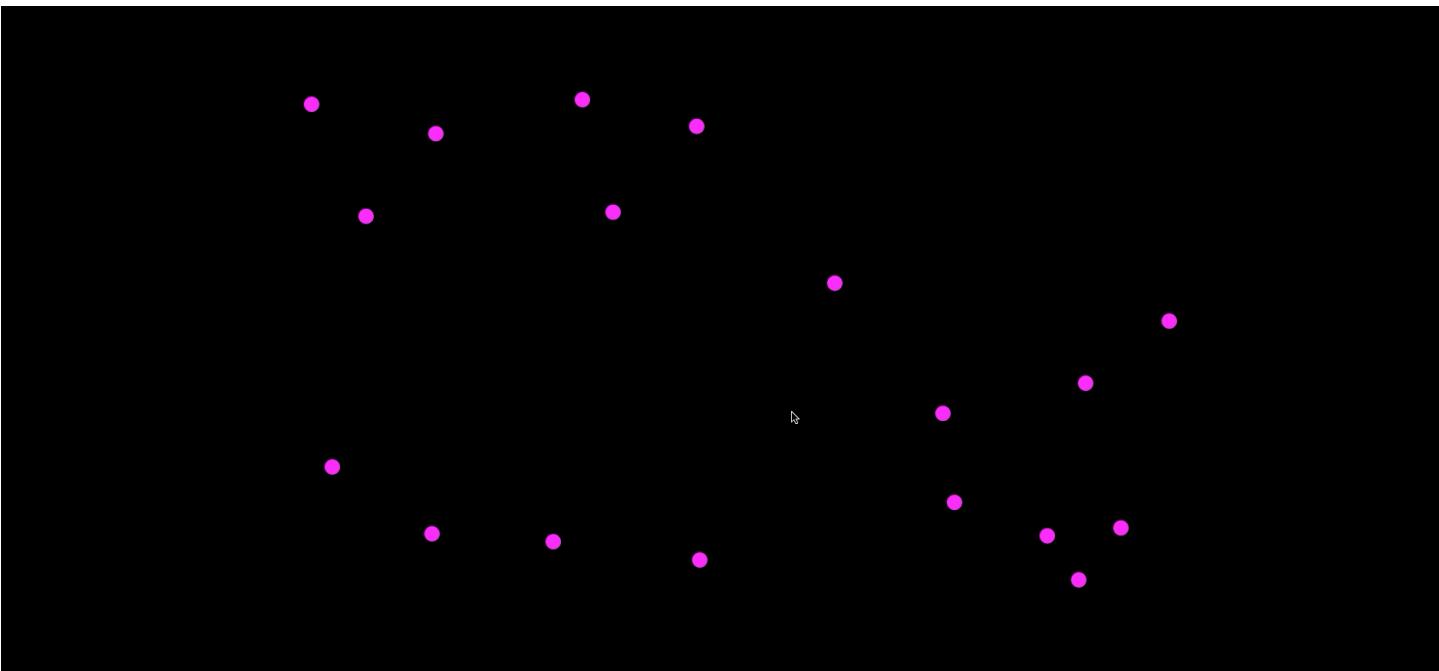
Main tasks:

- Collision Detection
- Cedar OWAT



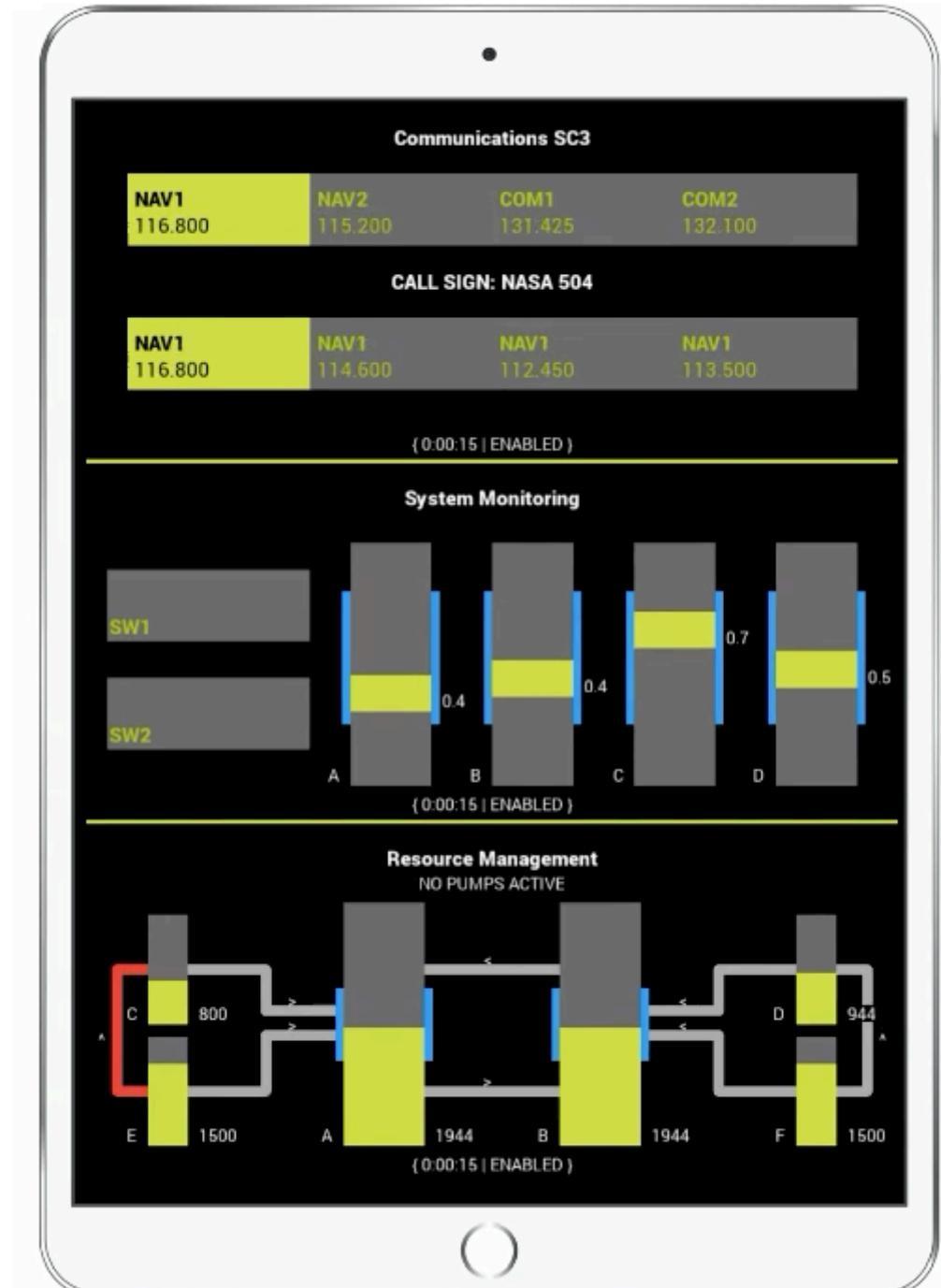
# Collision Detection

- Must detect which objects will collide
- 15 second trials
- Several difficulty levels
- Performance = Detections and RT



# Cedar OWAT

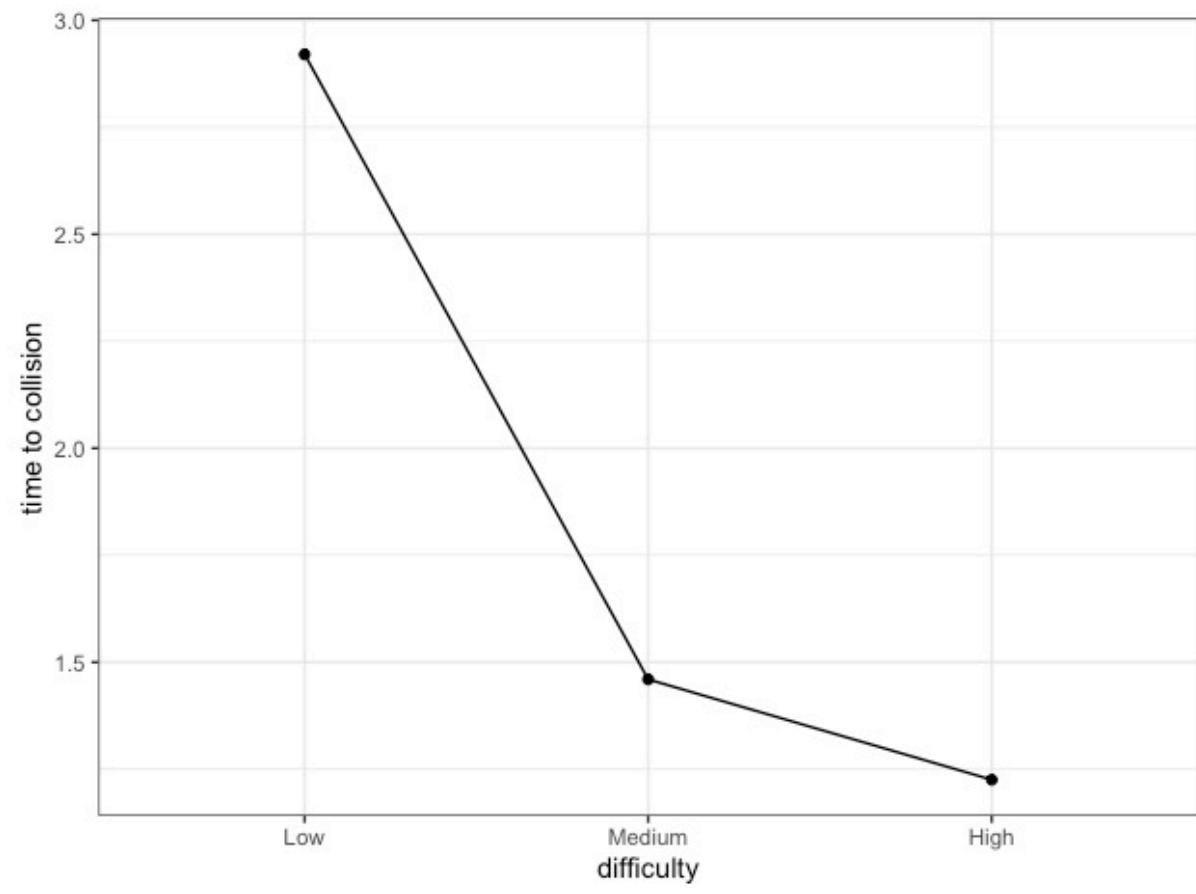
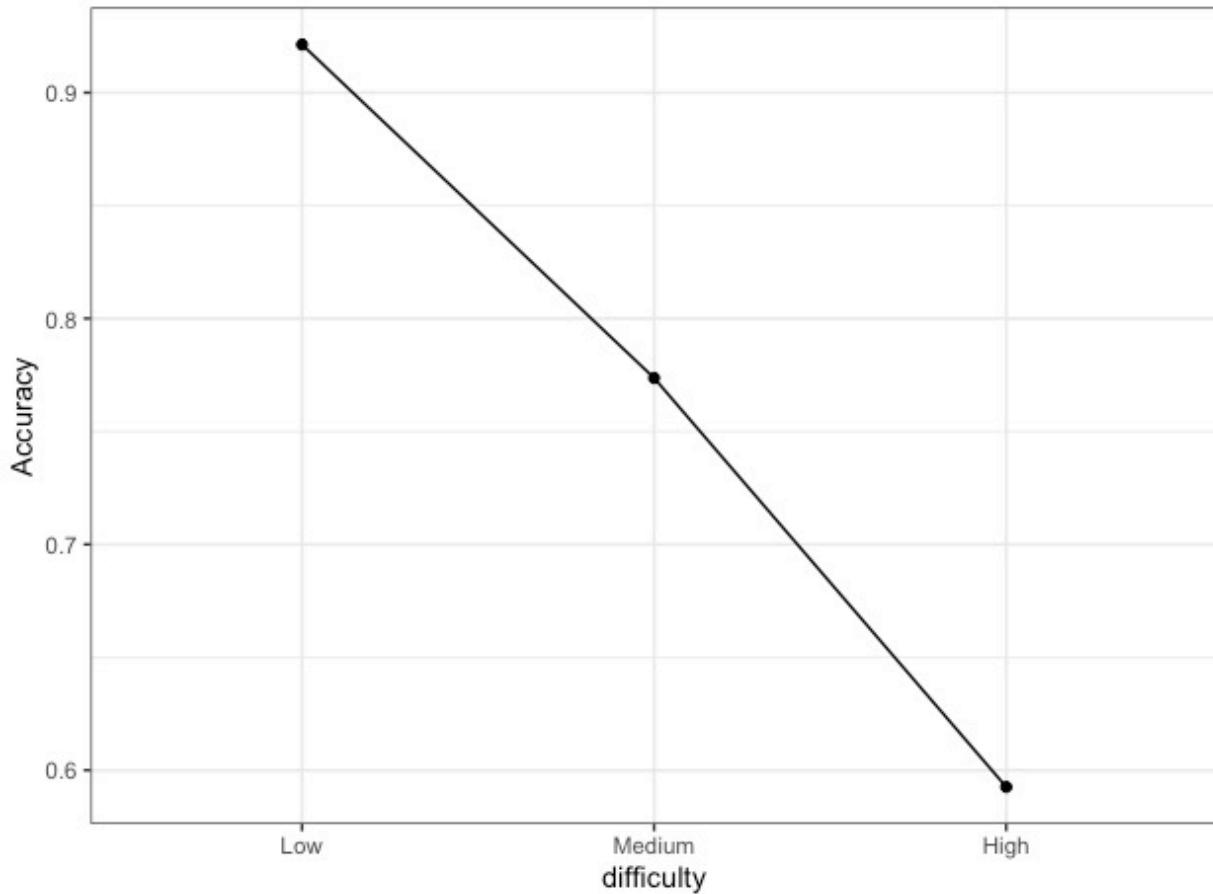
- Must react to situations and instructions
- Audio and Visual
- Several difficulty levels
- Performance = number of actions



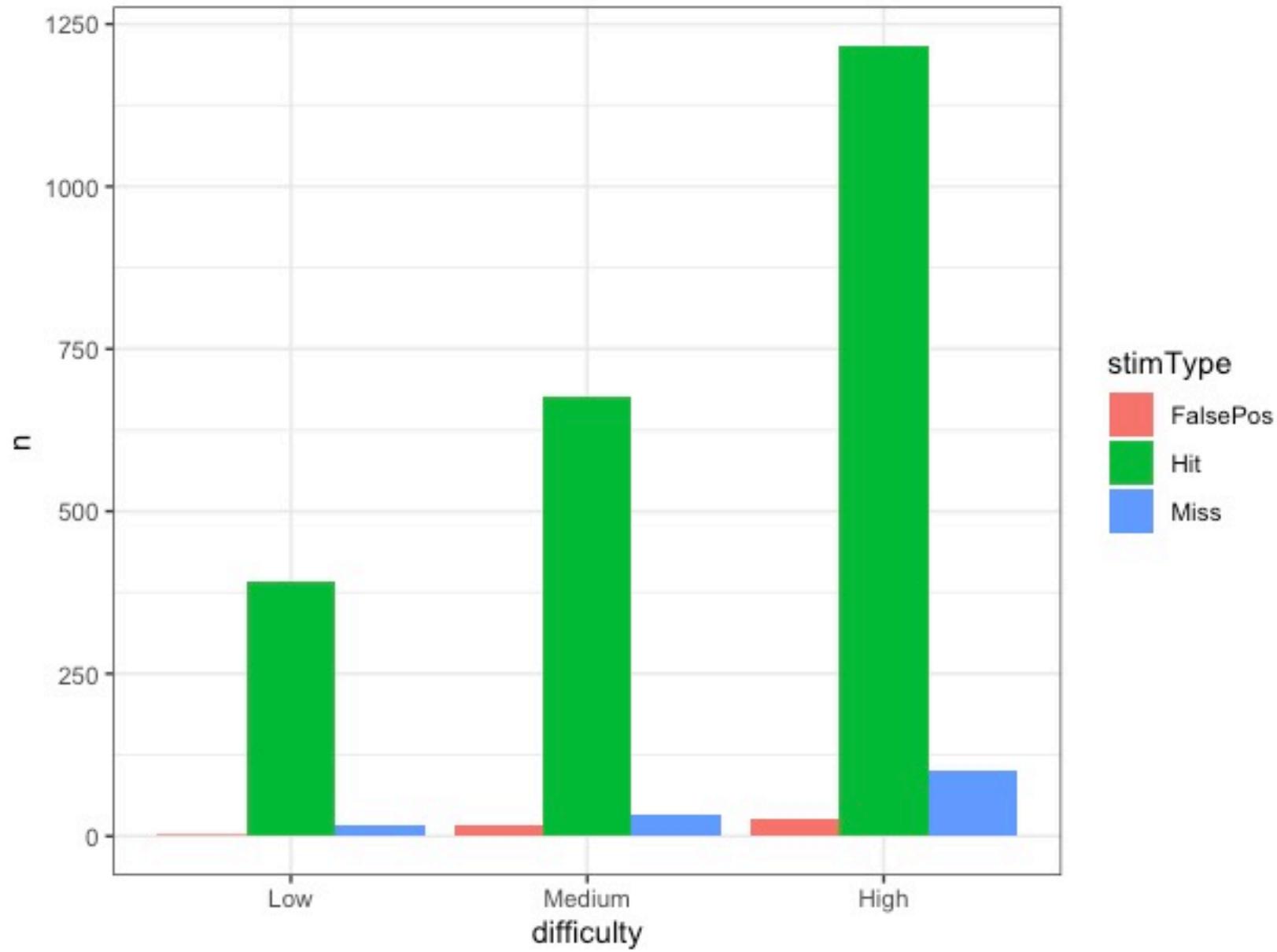
# Preliminary Results

- OWAT & Collision
- DRT
- Glove

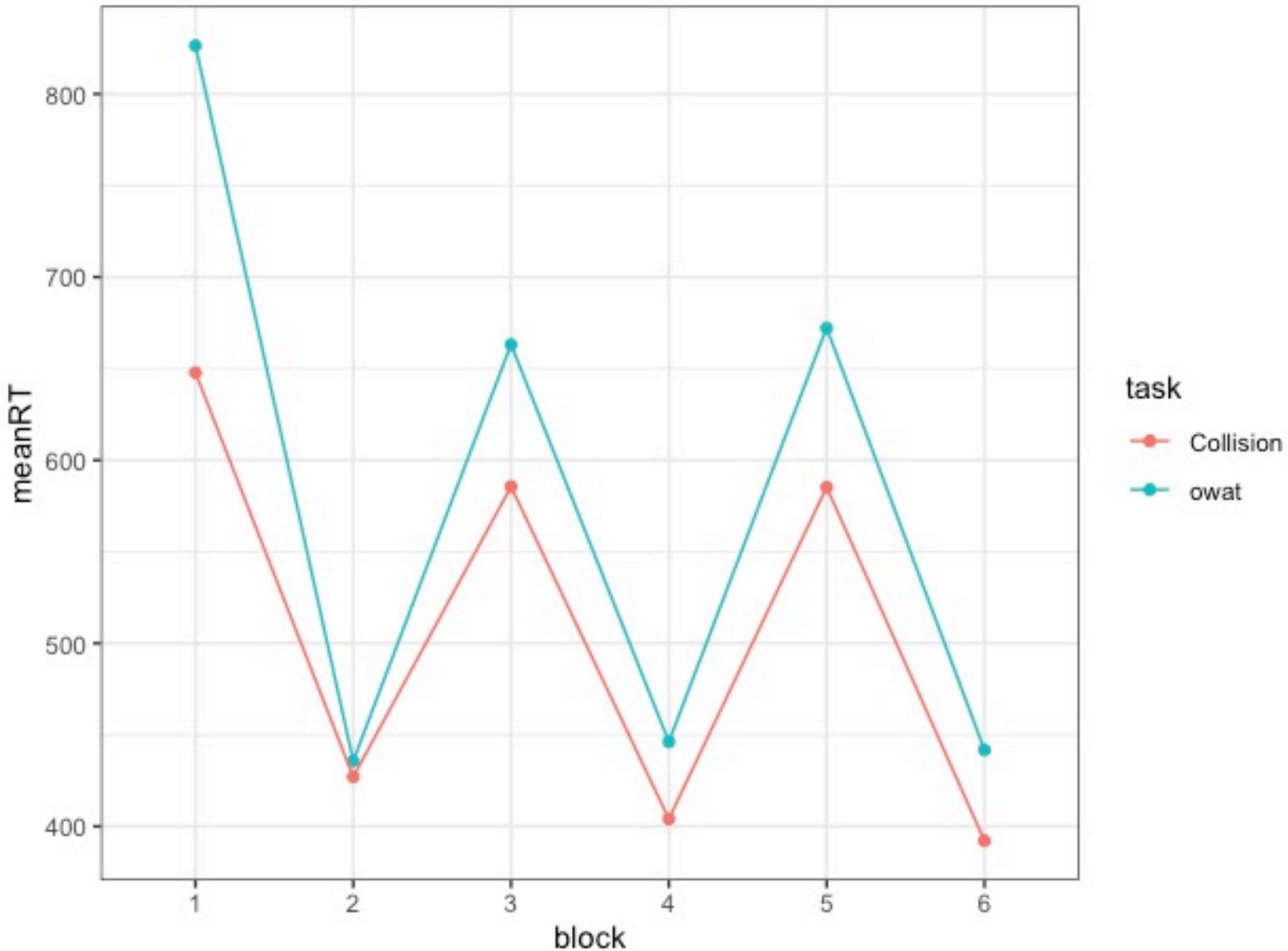
# Collision Detection



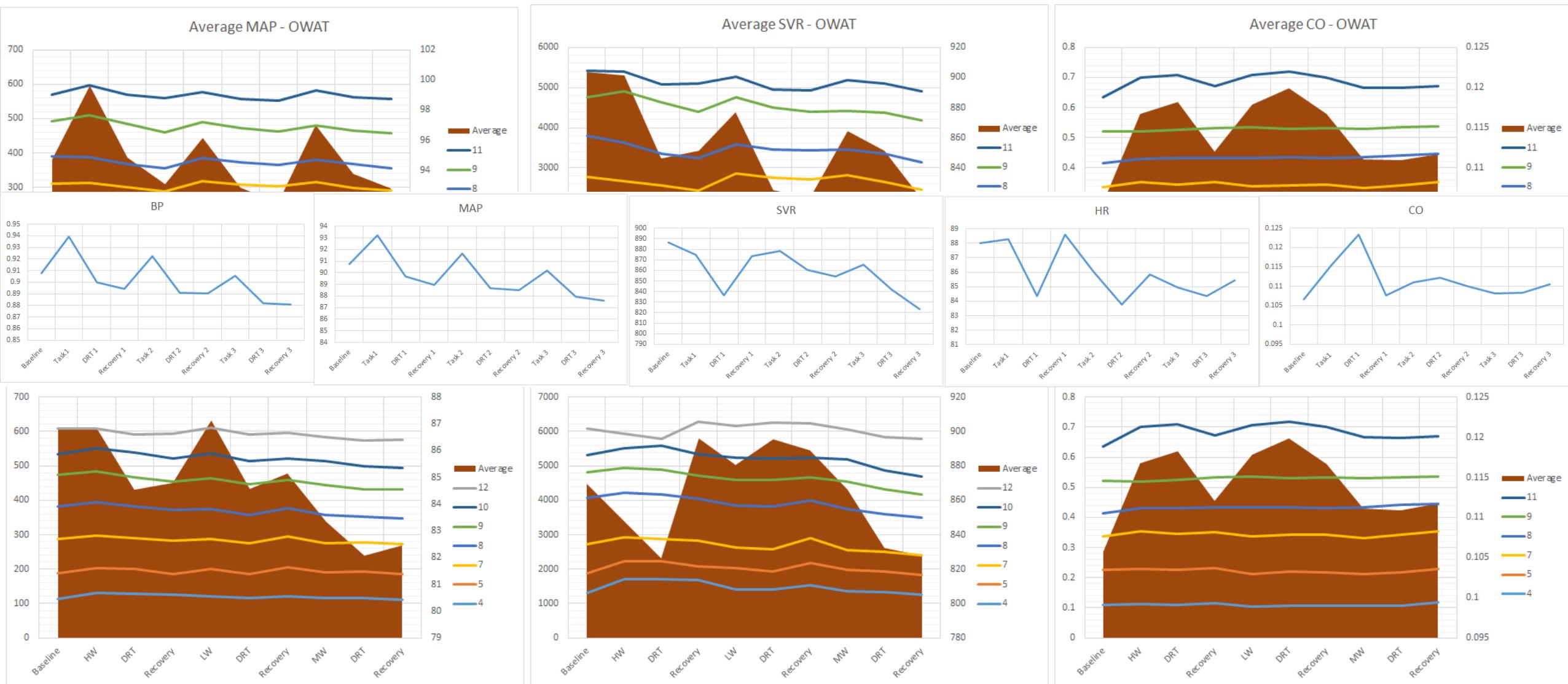
# OWAT



# DRT



# Glove Results



# Conclusions

- Tasks moderate workload
  - DRT captures workload change
  - Glove captures workload change
  - Observe challenge patterns
  - Observe threat patterns
- 
- In lab workload-state manipulation



# What's Next?

- Is DRT affected by state?
  - Online study
- Include “consequences” to illicit threat
- Extend to personnel selection
  - Already some work done with RAAF
- Extend this to training
  - i.e. train challenge states
- Extend to real world
  - Working with ATCs

# Cheers

## Project Leads:

- **Eugene Nalivaiko** – Biomedical Sciences UoN
- **Rohan Walker** – Biomedical Sciences UoN
- **Ami Eidels** – Newcastle Cog Lab
- **Scott Brown** – Newcastle Cog Lab

## Researchers:

- **Alireza Mazloumi Gavgani** - Biomedical Sciences UoN
- **Alexander Todd**: data collection and writing
- **Murray Bennett**: data collection and coding
- **Timothy Whelan**: data collection
- **Ebon Baxter**: data collection

## Collaborators

- **CT Lin, Avinash Singh, Alka John** – UTS
- **Anselm Fatiaki** – Defence



# Online study

- Multiple Object Tracking
- NO glove >>> Only DRT
- Between Subjects
- Threat/Challenge Framing

## Results

- No difference (individual differences?)
- BUT – Poor MOT performance = More threatened.