

Developing and Evaluating Emergency Response Training with Virtual Reality

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Human Interface Technology Lab NZ (HIT Lab NZ)



- At University of Canterbury
 - Christchurch, NZ
 - Faculty of Engineering
- Founded in 2002
 - VR/AR Pioneers Tom Furness & Mark Billinghurst
- Largest interaction lab in NZ
 - 45-60 Researchers at any given time
- Multidisciplinary
- Research and Teaching
 - Masters & PhD Programs



HIT Lab NZ Philosophy



- We Put People Before Technology
 - *Hangarau Tangata, Tangata Hangarau*
- Start with the **person**...
- ...look at the **tasks** they are trying to perform...
- ...look at the **environment** they are in...
- ...apply appropriate **technologies** to support them in their work, learning, etc.

HIT Lab NZ / Applied Immersive Gaming Initiative (AIGI) Academic Staff



Prof Rob Lindeman



Prof Stephan Lukosch



A/Prof Heide Lukosch



Prof Andy Phelps



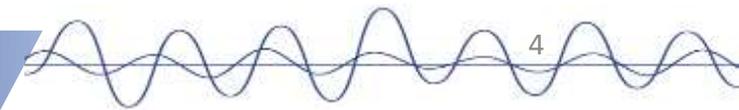
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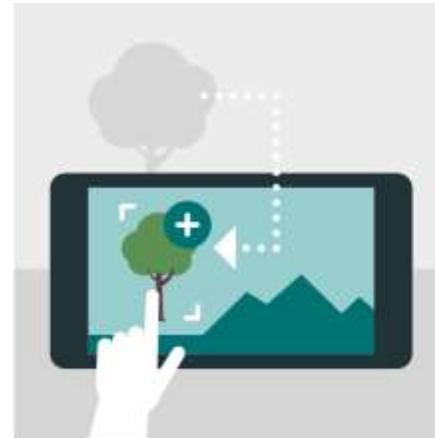
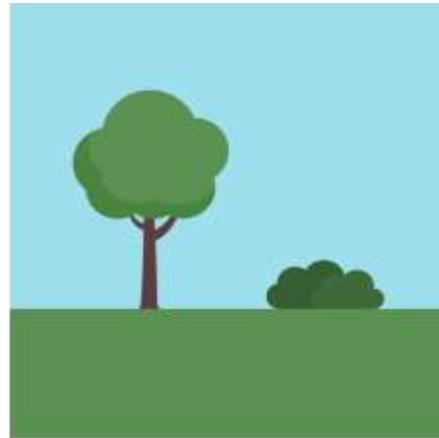
HIT Lab NZ Research Themes



- Applied Immersive Gaming
- Virtual Reality (VR)
- Augmented Reality (AR)



Our Work Spans the Entire Mixed Reality Continuum



MIXED REALITY / APPLIED IMMERSIVE GAMING

AR

AV

VR

**REAL
ENVIRONMENT**

**AUGMENTED
REALITY**

**AUGMENTED
VIRTUALITY**

**VIRTUAL
ENVIRONMENT**

How to develop and evaluate Human Interface Technology?

Technology:

Multisensory experience, use of actual hardware when possible

+

Context:

Realistic Environment and Interaction

+

Simulation:

Accurate Feedback & Progress

Current Training Challenges

- Increase in wildfire events
- Greater dependency on helicopters & airplanes
- High risk, high cost
- Limited training opportunities



Wildfire Firefighting



Wildfire Firefighting



Air Attack Supervisor (AAS)

The Air Attack Supervisor (AAS):

1. Must have a high level of **situation awareness**
2. Must have excellent **communication** and **radio operation** skills
3. Must have the ability to make high-quality **decisions** under stress



AAS Challenge

- Training Air Attack Supervisors is expensive, dangerous and unrealistic:
 - One field training can cost up to \$100,000 NZD
 - Field exercises do not fully recreate an actual fire event
 - It is hard to screen people for this role and provide accreditation
 - Training possibilities are very limited

Virtual Reality Training

- Economical
- Safe
- Has the potential to replicate real-life scenarios
- Intuitive
- Assessable and adaptable



Air Operations Platform



AAS Summary Video

Evaluating the Effects
of Realistic Communication
Disruptions in VR Training for
Aerial Firefighting

Experiments

1. Visually acquired **Situation Awareness**.
2. Disruptive **Communications**.
3. **Decision Making** under stress.



Experiment 1: Situation Awareness

Question: Do immersive displays afford better Situation Awareness?



Experiment 1: Situation Awareness: Method

Compared three display technologies with three environments in 3x3 latin square design. Tasked with conducting a Virtual “Aerial Observation”...

1. HDTV
2. VR Head Mounted
3. 270° Projection System



VS



VS

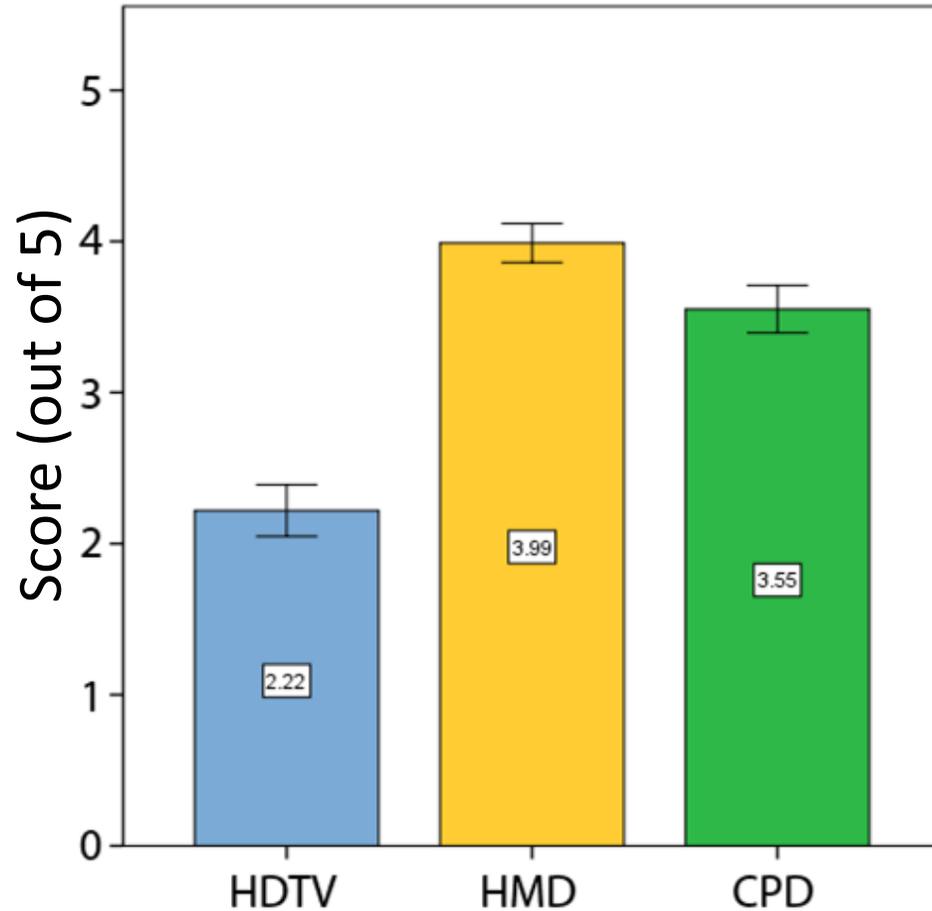


Measures

- iGroup Presence Questionnaire
- Simulator Sickness Questionnaire
- Situation Awareness Global Assessment Technique: L1 Perception, L2 Comprehension, L3 Prediction

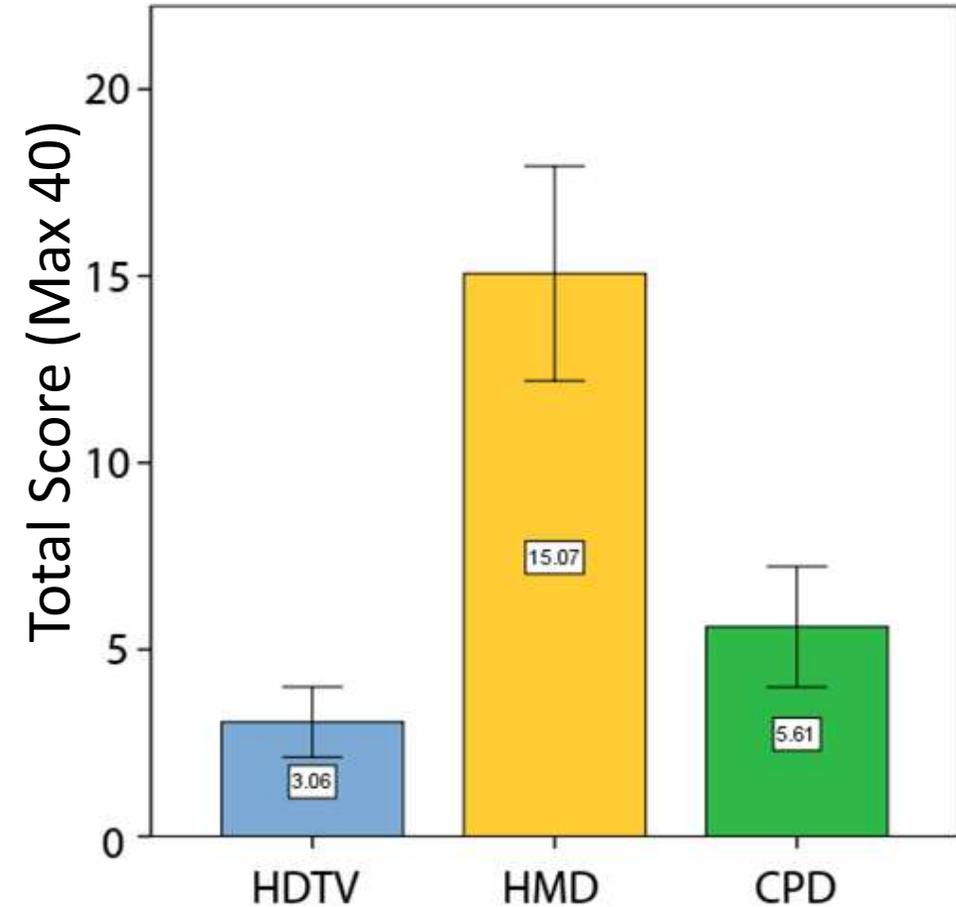
Exp 1: Presence & Simulator Sickness Results

igroup Presence Questionnaire



HMD vs HDTV ($p < 0.001$), HDTV vs CPD ($p < 0.001$)
HMD vs CPD ($p = 0.008$)

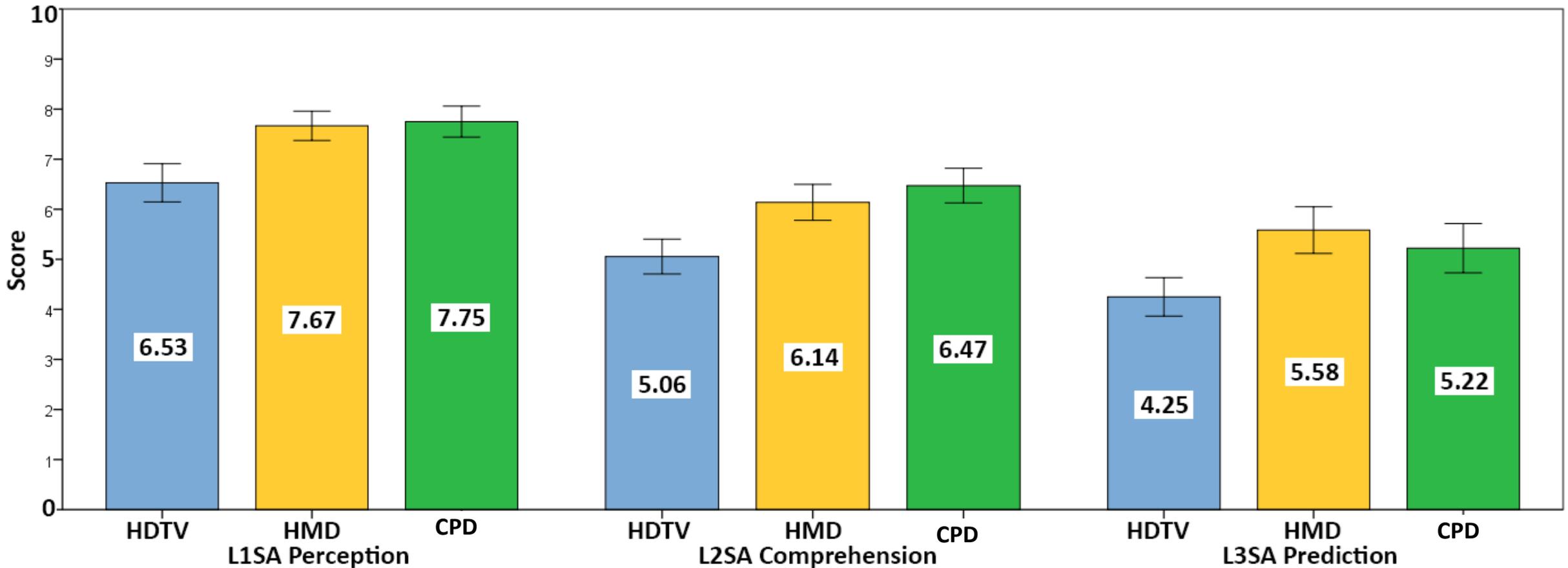
Simulation Sickness Questionnaire



HDTV vs HMD ($p = 0.012$), HMD vs CPD ($p = 0.002$)

N=36

Exp 1: Situation Awareness Results



HDTV vs HMD ($p=0.012$)
HDTV vs CPD ($p=0.031$)
HMD vs CPD (no significance)

HDTV vs HMD ($p=0.025$)
HDTV vs CPD ($p=0.001$)
HMD vs CPD (no significance)

HDTV vs HMD ($p=0.012$)
HDTV vs CPD ($p=0.031$)
HMD vs CPD (no significance)

Experiment 2: Communications

Question: What effect do disruptive communications have on stress in a virtual aerial firefighting scenario?



Experiment 2: Communications: Method

Three conditions in order (30 minutes total)

1. No disruption (clean comm's) (10 min)
2. Background radio chatter (10 min)
3. BRC + Broken Signal/Signal Failure (10min)

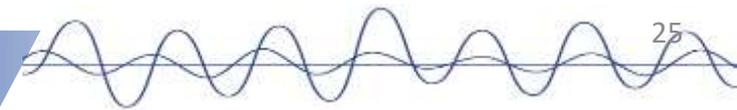
Measurements

- Zephyr Bioharness Heart Rate Monitor (HRV)
- Dundee Stress State Questionnaire (DSSQ)

Experimental Constants

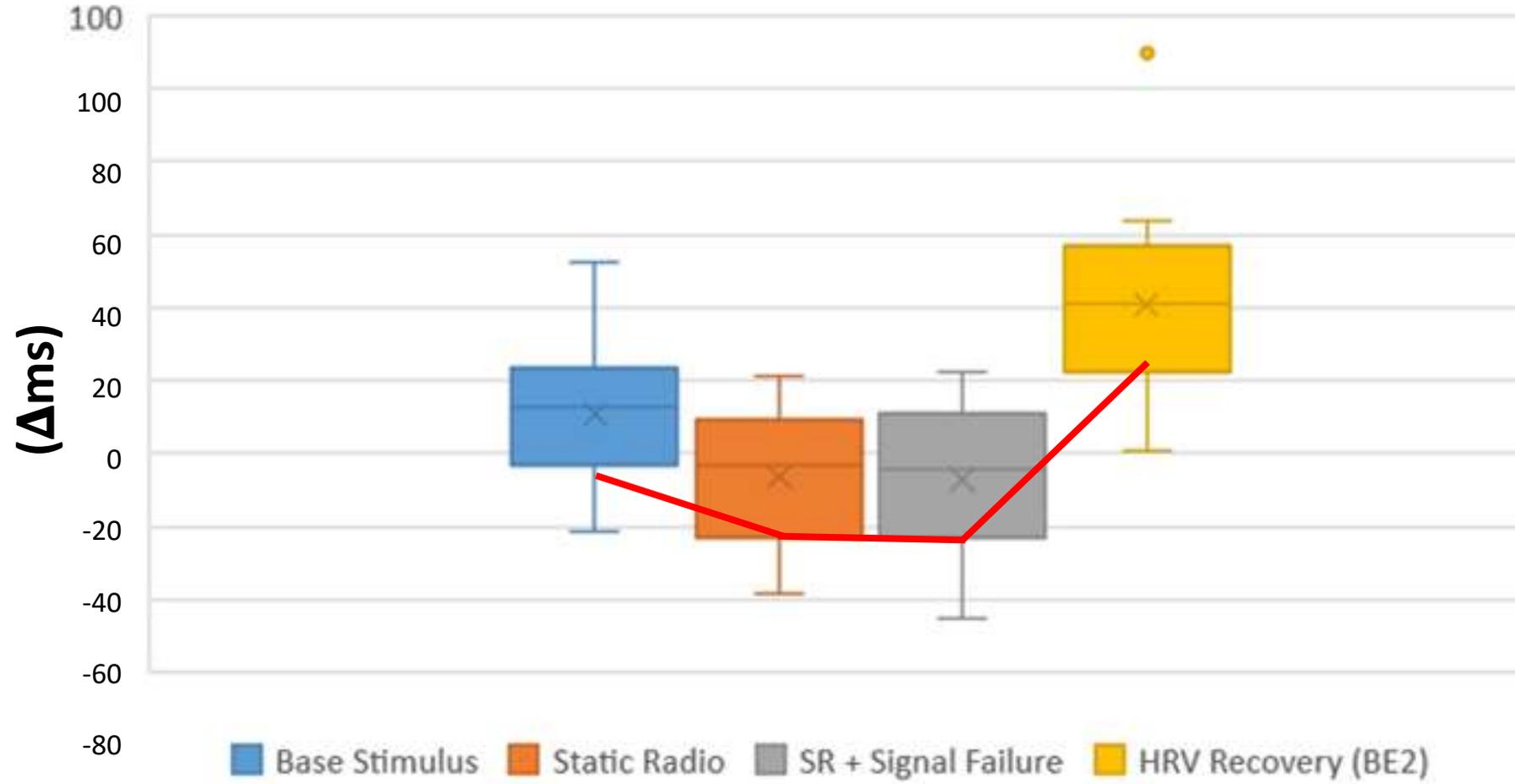
- Multi-actor system
- AI aircraft pilots (with comms)
- Communication system
- Multi-sensory feedback system - Visual, Audio, Vibro-tactile

N = 25, 8 AAS (Experts), 6 Firefighters, 11 Novices

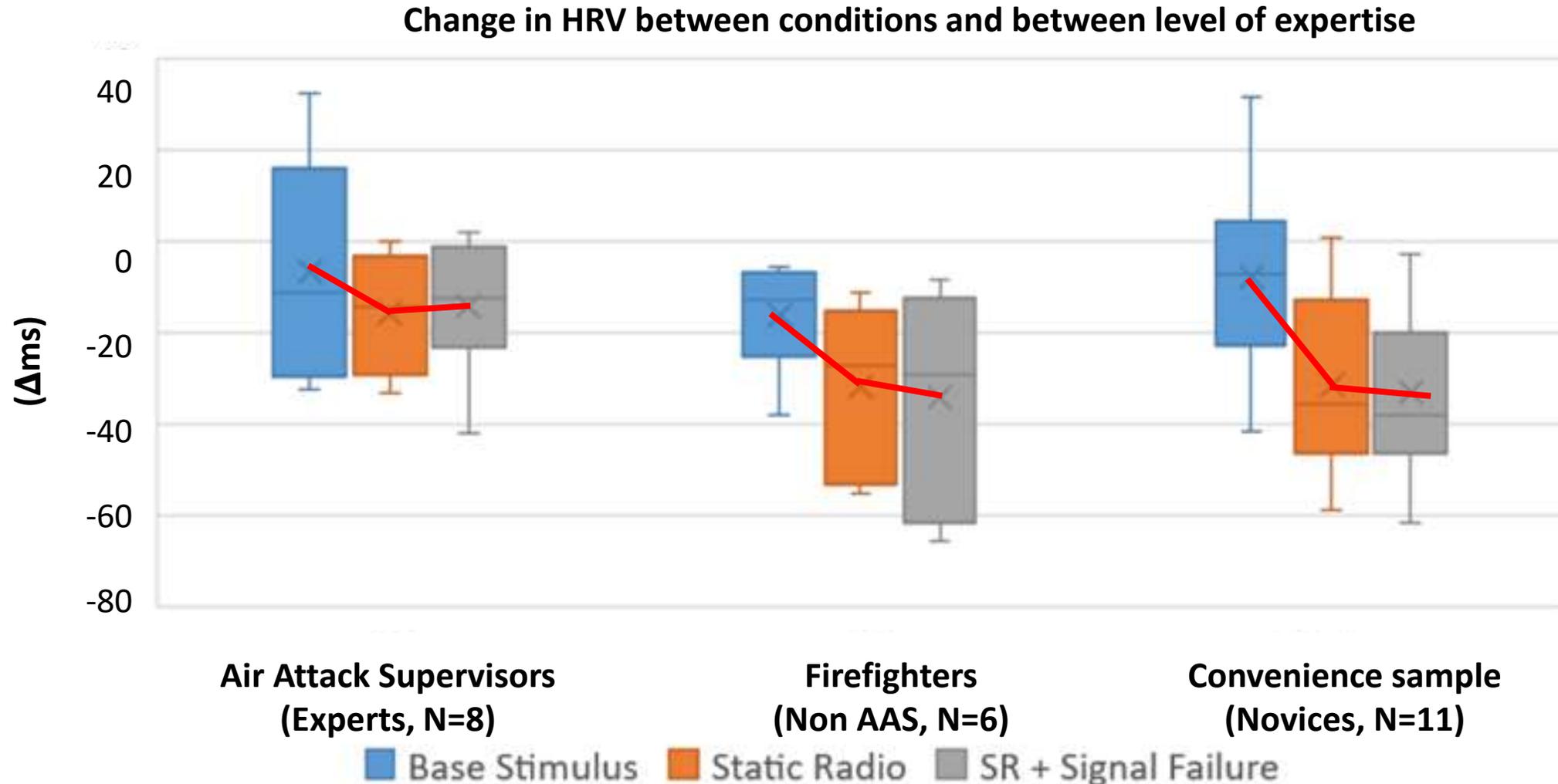


Experiment 2: Results: Heart Rate Variability

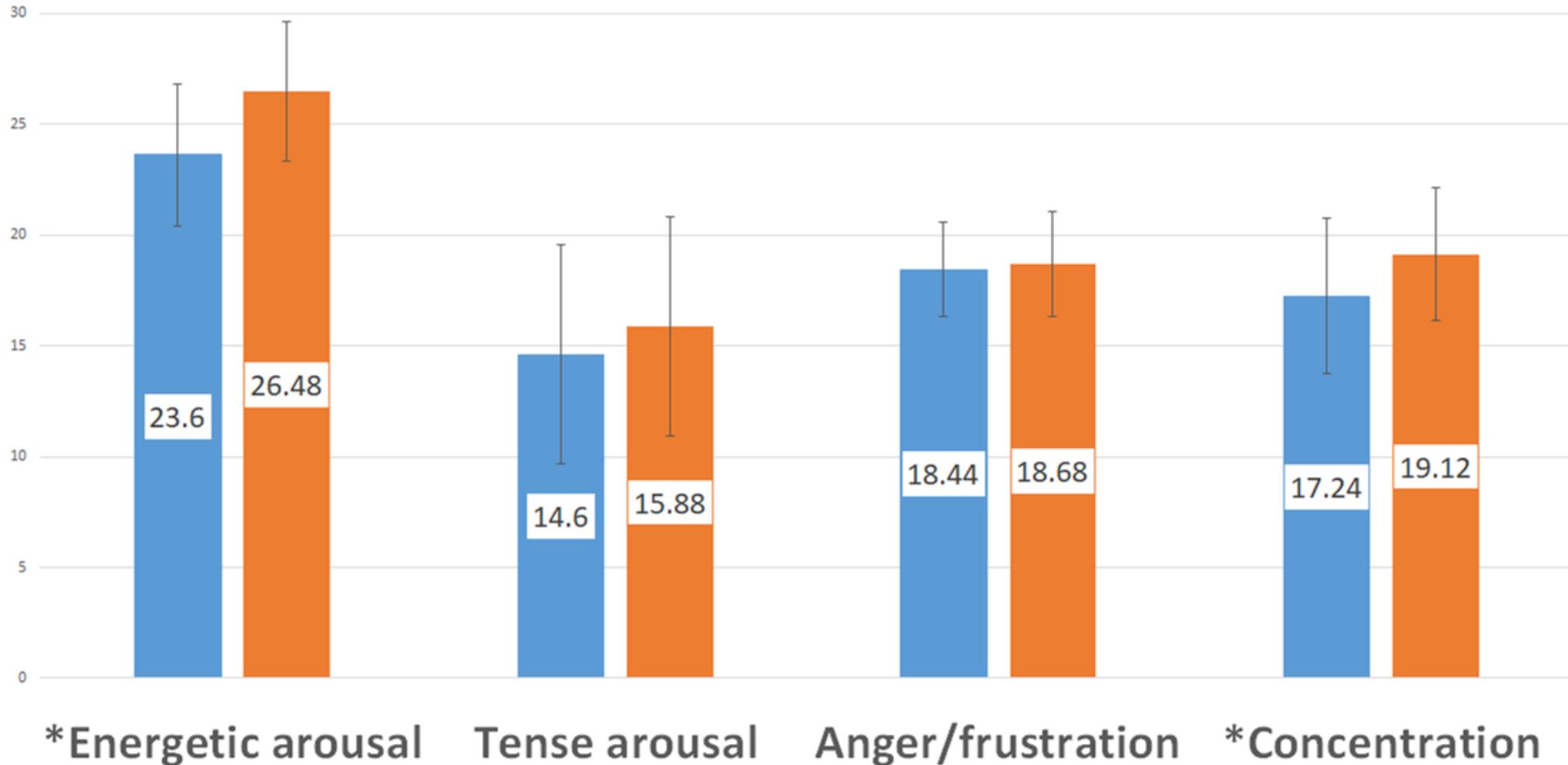
Change in HRV between conditions for all participants



Experiment 2: Results: Heart Rate Variability



Experiment 2: Communications: Results: DSSQ



■ Before ■ After

* p<0.001

Experiment 3: Decision Making

Question: Can a VR/MR based training simulator provide greater post training confidence than existing training methods?



Experiment 3: Decision Making



Low Fidelity (radio only)



High Fidelity (VR)



Perfect Fidelity (RW)

Experiment Constants

Radio chatter
AAS trainer
Operations manager



Measurements

Zephyr Bioharness - Heart Rate Variability (HRV)
Dundee Short Stress State Questionnaire (SSSQ)

Experiment 3: Decision Making



Low Fidelity (radio only)



High Fidelity (VR)



Perfect Fidelity (RW)

N=11
(Between)

N=11
(Within)

SSSQ

HRV

Experiment Constants

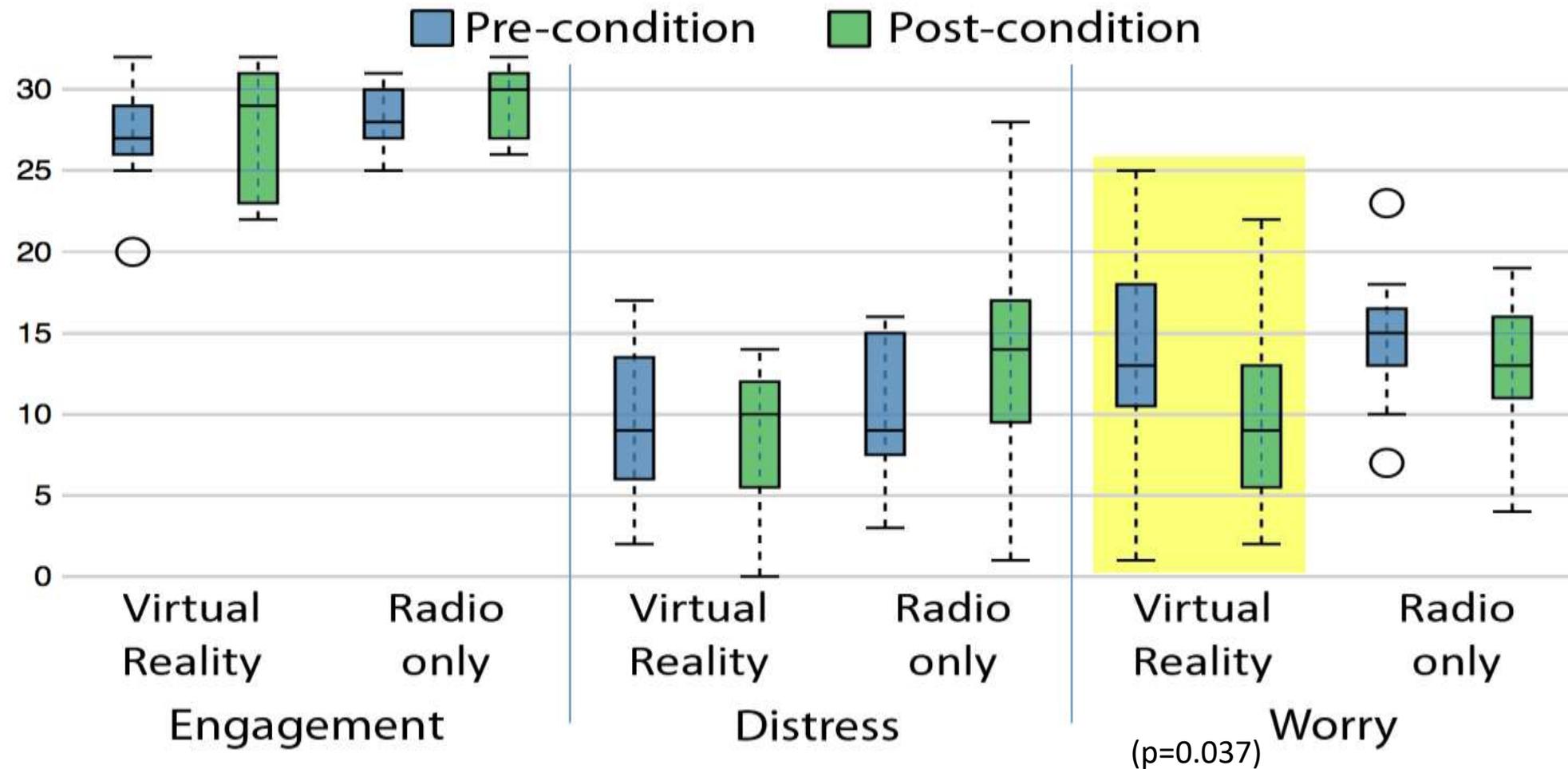
- Radio chatter
- AAS trainer
- Operations manager

Measurements

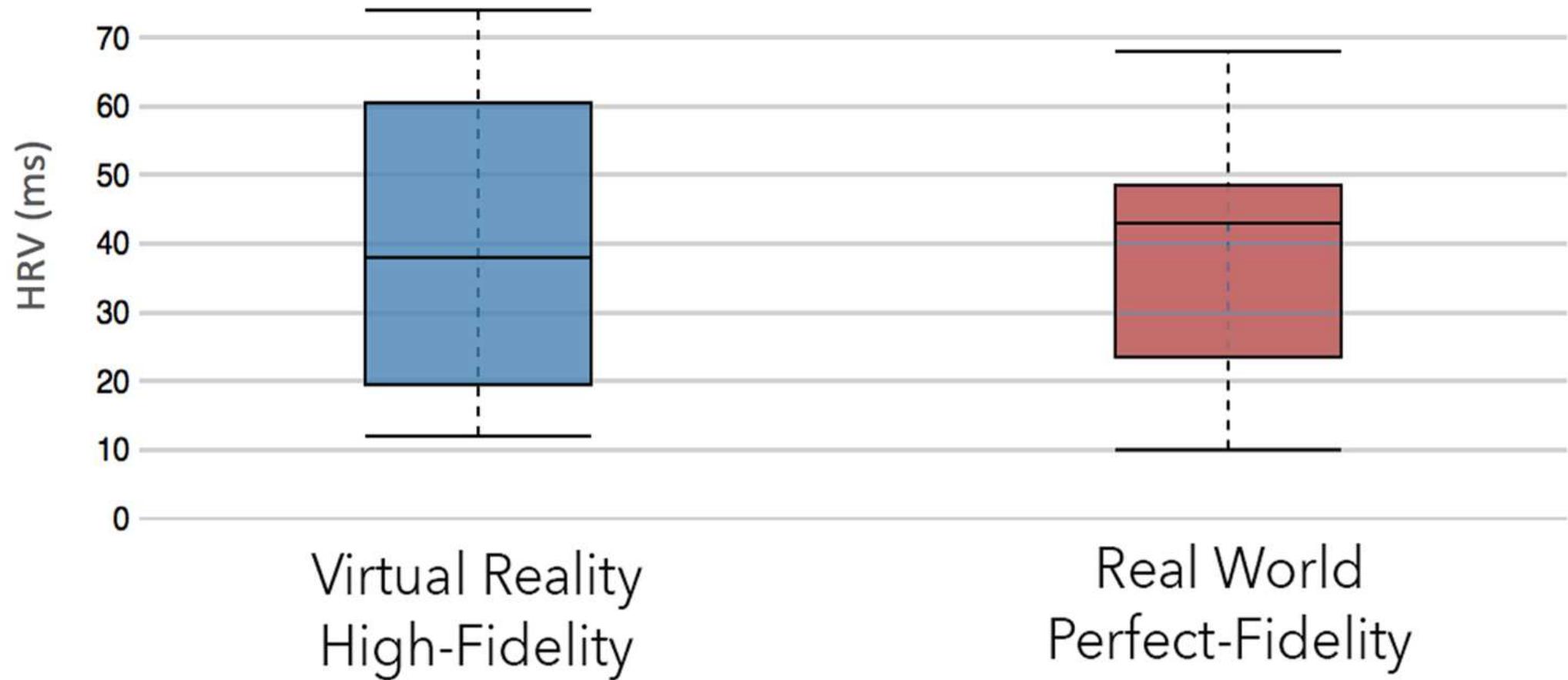
- Zephyr Bioharness - Heart Rate Variability (HRV)
- Dundee Short Stress State Questionnaire (SSSQ)



Experiment 3: Stress Questionnaire (VR vs. low-fi)



Experiment 3: HRV



Final Results

Experiment 1: **Situation Awareness**

A more immersive simulator gives better Situation Awareness training

Experiment 2: **Communications**

Immersive simulators expose expert behaviours for training communication

Experiment 3: **Decision Making**

A more immersive simulator provides less post-training worry indicating trainees feel more confident going into a live exercise

Conclusion

VR/MR is a highly effective tool to augment training and conduct evaluations with end-user in a realistic environment:

- VR simulation can provide a close to real-life experience
- Context and difficulty can be easily adapted for different levels of training and evaluations
- With a 270° projection system face-to-face communication and interaction with real equipment is possible
- Potentially less demanding on cognitive workload, trainees can focus on the task i.e., (radio) communication

Interested in collaborating?

HIT Lab NZ

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Websites: www.hitlabnz.org

Facebook:

www.facebook.com/HITLabNZ

Questions?

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How to Engage with Us: We are **Open for Business!**



- Masters Students
- PhD Students
- Interns
- Exchanges
- Visiting Researchers (e.g., sabbatical)
- Corporate projects / sponsorship (e.g. for prototype evaluation)
- Consultancy (buy some staff time)

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