



a place of mind

THE UNIVERSITY OF BRITISH COLUMBIA

REDUCING COMPENSATORY MOVEMENTS IN STROKE THERAPY THROUGH THE USE OF ROBOTIC DEVICES AND AUGMENTED FEEDBACK

BULMARO VALDÉS
PHD CANDIDATE, BIOMEDICAL ENGINEERING
SUPERVISOR: DR. MACHIEL VAN DER LOOS



Collaborative **A**dvanced **R**obotics
and **I**ntelligent **S**ystems Laboratory

WHO ARE WE?



Collaborate

Engineers

Therapists

Stroke survivors

Kinesiologists

Neuroscientists

STROKE



Major cause of disability in developed countries [1]

- Direct and indirect costs in Canada: \$3.6 billion [2]
- Most stroke survivors return home

Hemiparesis (80% stroke survivors [3])

- Movement impairment on one side of the body
- Complete functional recovery in only 5-20% of survivors [4]

[1] I. L. Katzan, 2013.

[2] Public Health Agency of Canada, 2009.

[3] National Stroke Association, 2015.

[4] G. Kwakkel et al., 2003.

COMPENSATORY MOVEMENTS



Negative effects:

- Difficult to unlearn and could lead to pain
- Maladaptive and could reduce range of motion
- Distorted joint positions

Trunk Displacement:

- Common when reaching and grasping
- One important movement to reduce in therapy [1-3]

Compensation might be the only option for certain stroke survivors

[1] S. M. Michaelsen et al., 2001.

[2] E. Brokaw et al., 2013.

[3] M. L. Woodbury et al., 2009.

TRUNK RESTRAINT



- Common strategy to reduce trunk displacement
- Capable of increasing range of motion of elbow and shoulder joints [1-3]

However:

- Only passively prevents trunk displacement
- Continuous physical guidance
- Not ideal for unsupervised therapy

[1] S. M. Michaelsen et al., 2001.

[2] S. M. Michaelsen et al., 2004.

[3] S. Jeyaraman et al., 2010.

NEED



- **Provide feedback**
- **Promote correct movement patterns**

SOLUTION



Repetitions

=

Robots

Track movement

=

Motion tracking cameras

RESEARCH QUESTIONS



PHASE 1

How is trunk compensation affected by distance and height?
[1]

PHASE 2

- a) Could trunk compensation be decreased by force or visual feedback?
 - b) Could one of these feedback modalities be more effective than the other one?
- [2]

PHASE 3

- a) Could trunk compensation be decreased by visual+force+scores or visual+force feedback?
 - b) Could one of these feedback modalities be more effective than the other one?
- [3]

[1] B.A. Valdes, S.M.N. Glegg, H.F.M. Van der Loos, *J. Mot. Behav.*, 2016.

[2] B.A. Valdés, A.N. Schneider, H.F.M. Van der Loos, submitted Sep. 2016.

[3] B.A. Valdes, H.F.M. Van der Loos, submitted Apr. 2017.

PHASE 1



How do people reach forward and use their trunk?

PHASE 1: RECRUITMENT



10 No Stroke

10 Stroke

PHASE 1: EXPERIMENTAL SETUP

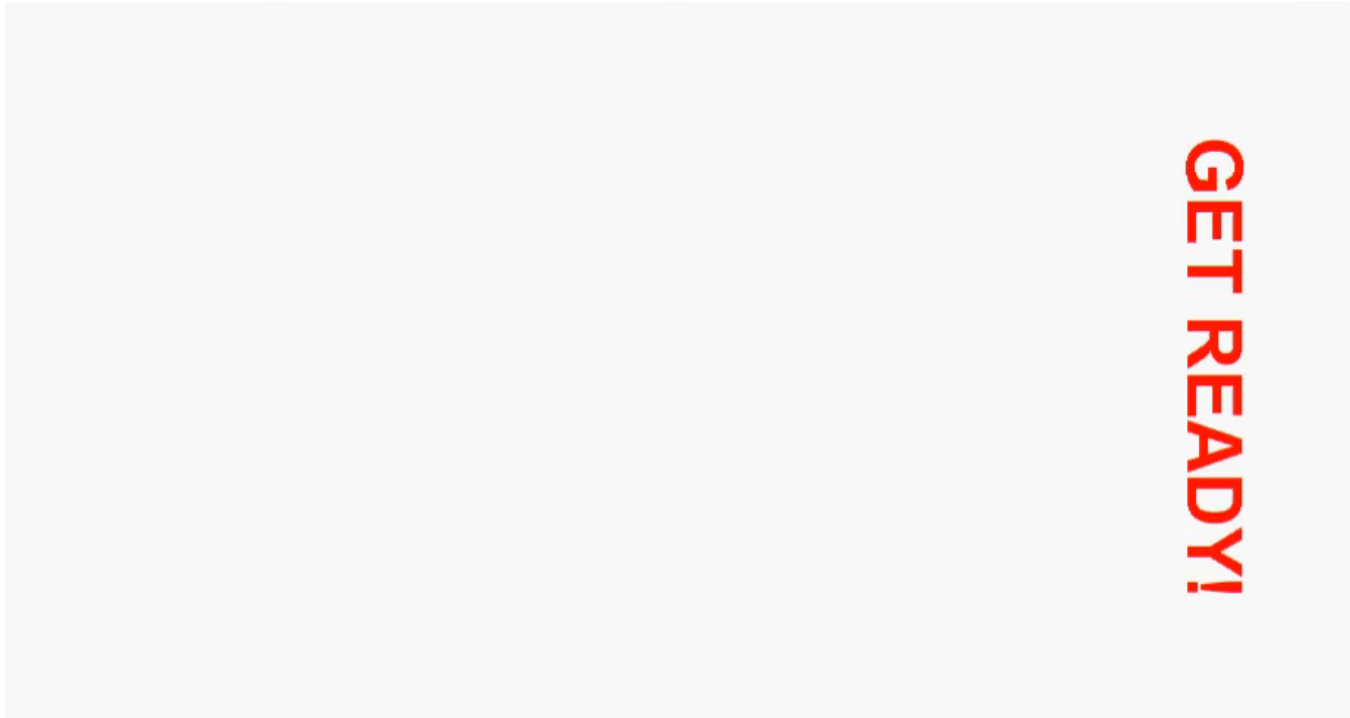


Motion Tracking Camera

Computer Screen

Robotic Devices

PHASE 1: TASK



PHASE 1: RESULTS



- Stroke = more trunk movement
- More trunk movement = knee height
- Harder to move up

PHASE 2



Can we reduce trunk compensation using visual or force feedback?

PHASE 2: RECRUITMENT



15 Stroke

PHASE 2: EXPERIMENTAL SETUP

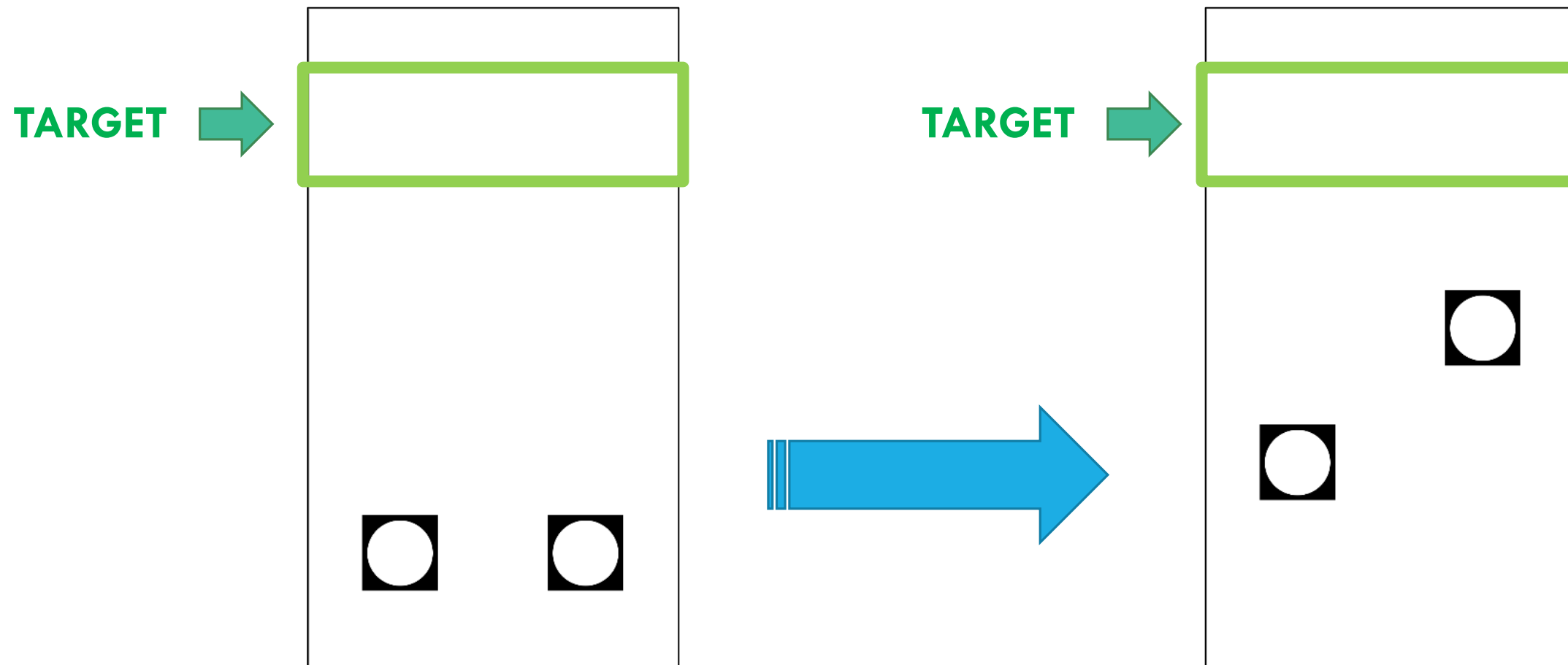


Robotic Device

Computer Screen

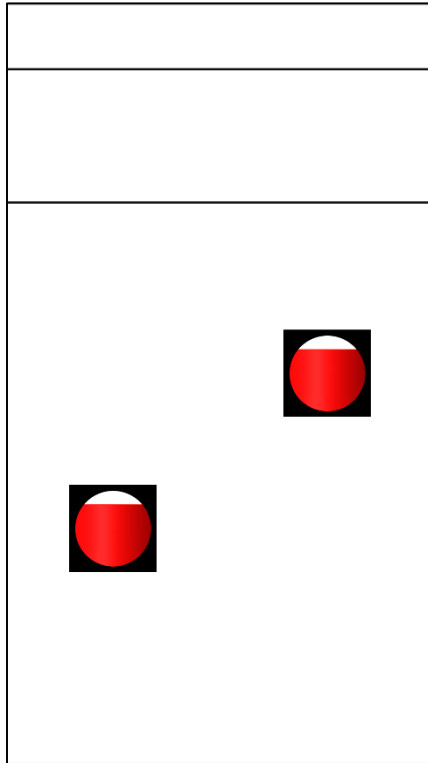
Motion Tracking Camera

PHASE 2: TASK

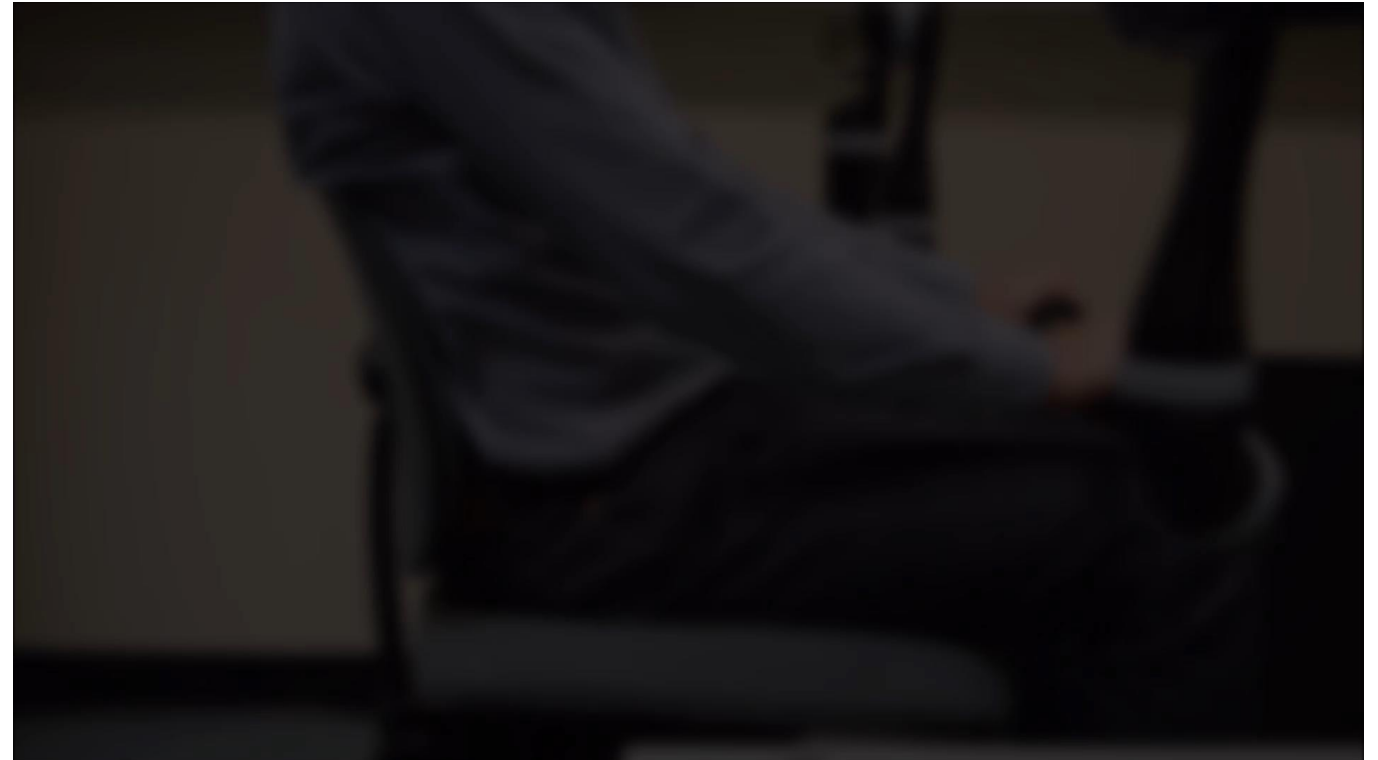


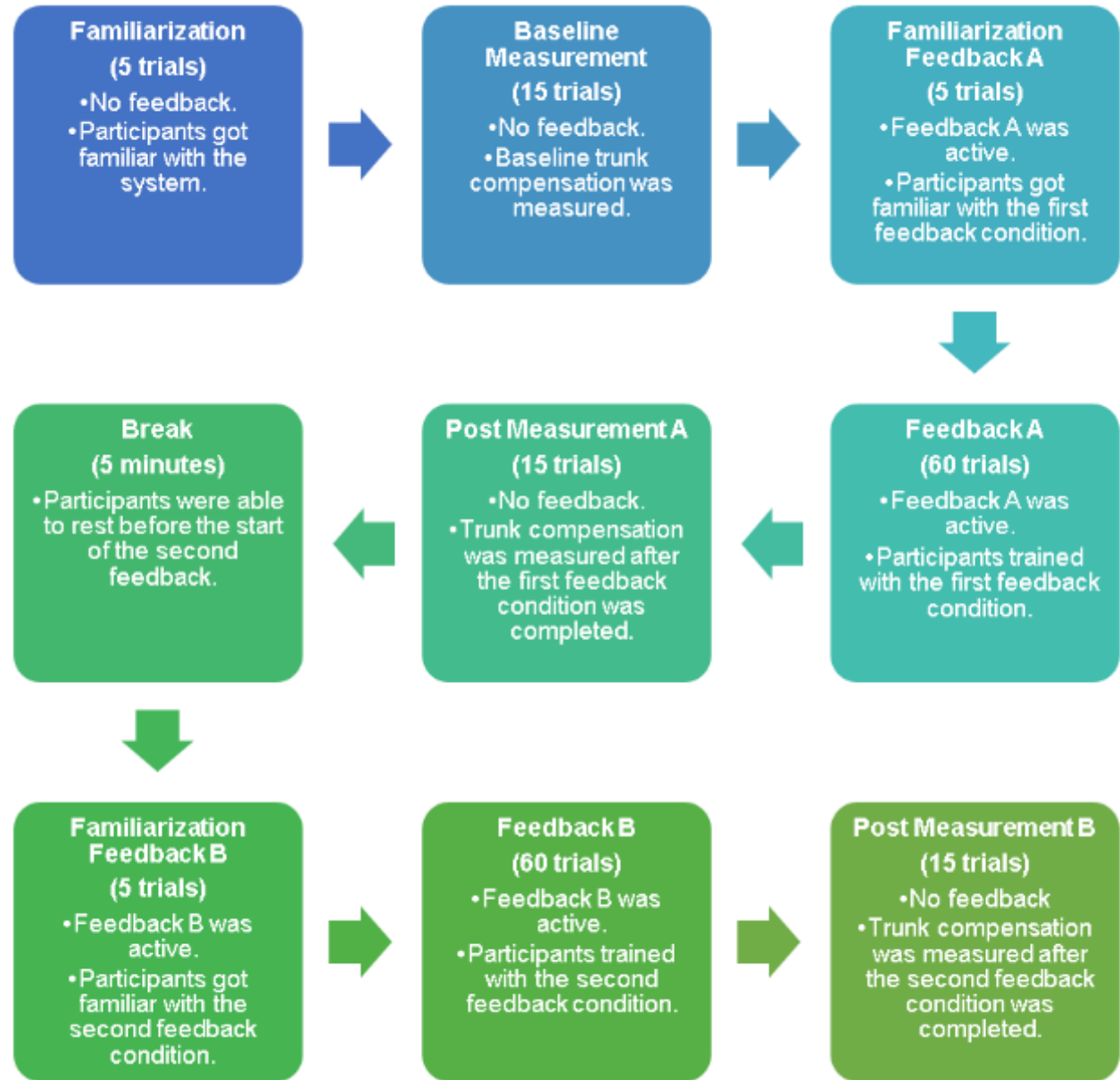
PHASE 2: FEEDBACK

VISUAL

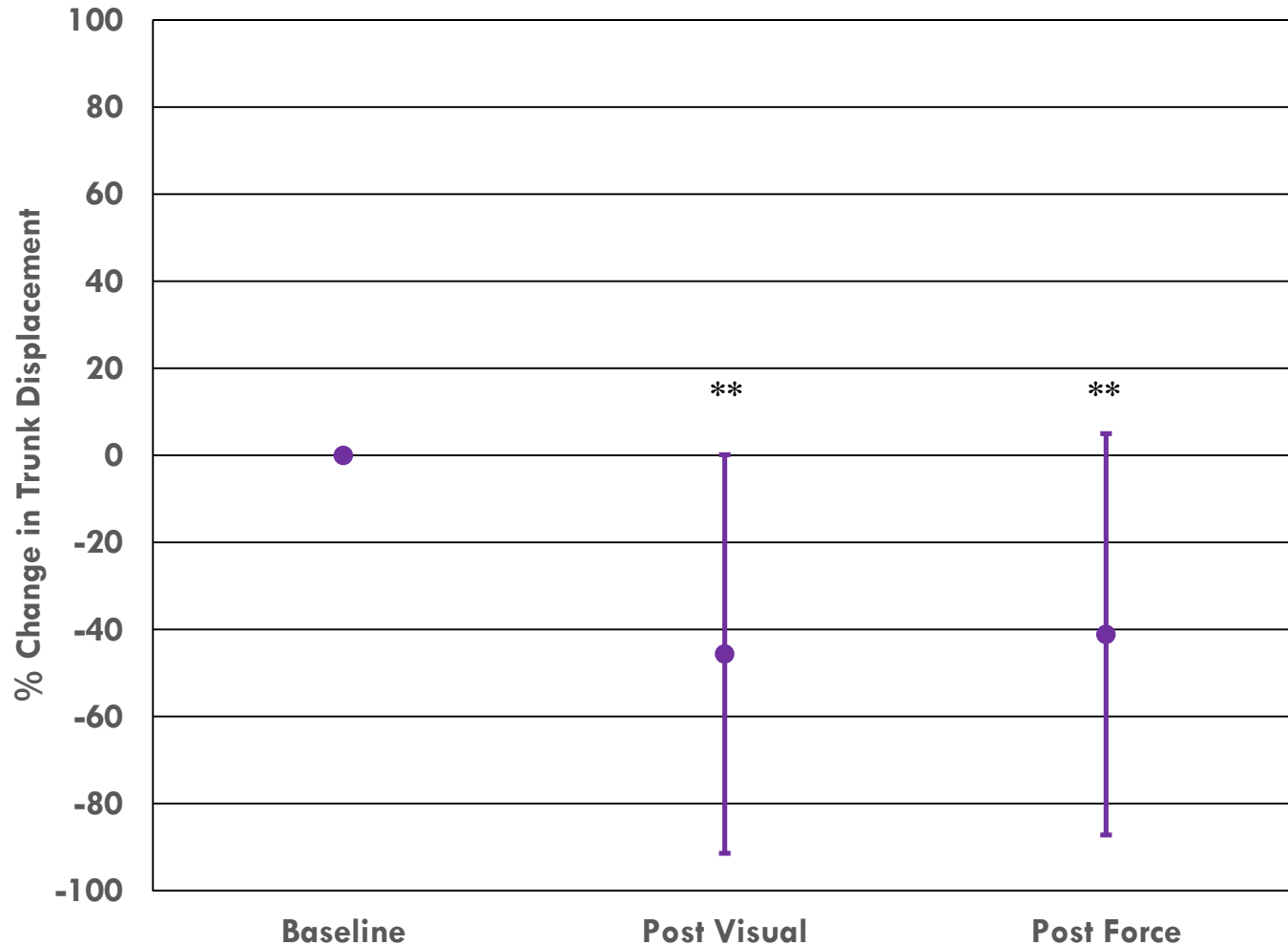


FORCE





PHASE 2: RESULTS



Visual Feedback:

- $\bar{X} = -45.6\%$ SD:(45.8)
- **p=.004****
- Effect size=0.99
- 95% Interval: -70.9,-20.2

Force Feedback:

- $\bar{X} = -41.1\%$ SD:(46.1)
- **p=.004****
- Effect size=0.89
- 95% Interval: -66.7,-15.6

PHASE 2: RESULTS



- No feedback was superior to the other one
- Some participants might find some feedback easier to use
- A large proportion of people (47%) preferred to receive both feedback conditions together

PHASE 3



Do we get better results when giving game scores?

PHASE 3: RECRUITMENT



14 Stroke

PHASE 3: EXPERIMENTAL SETUP

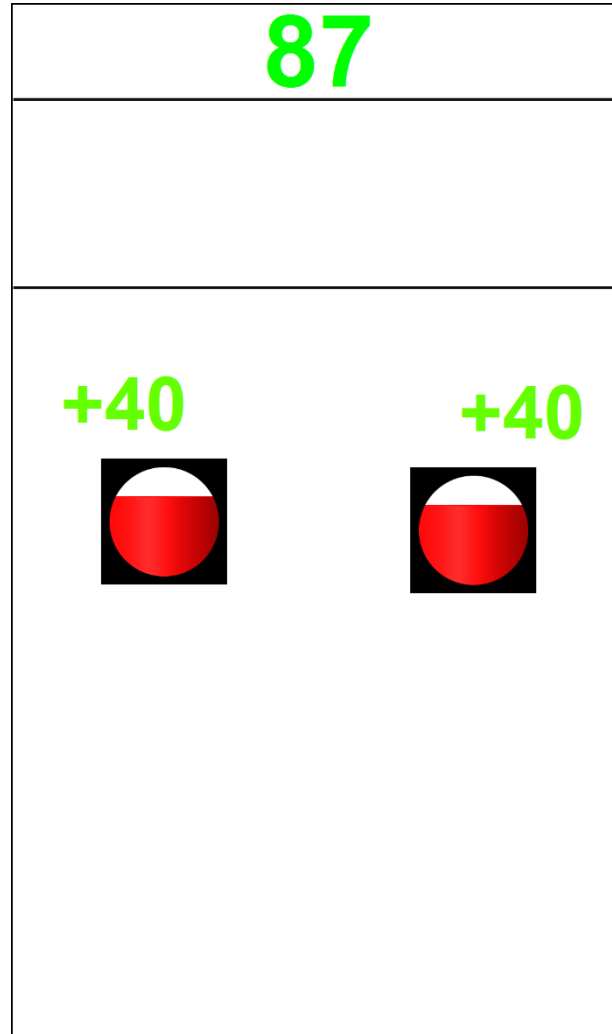


Robotic Device

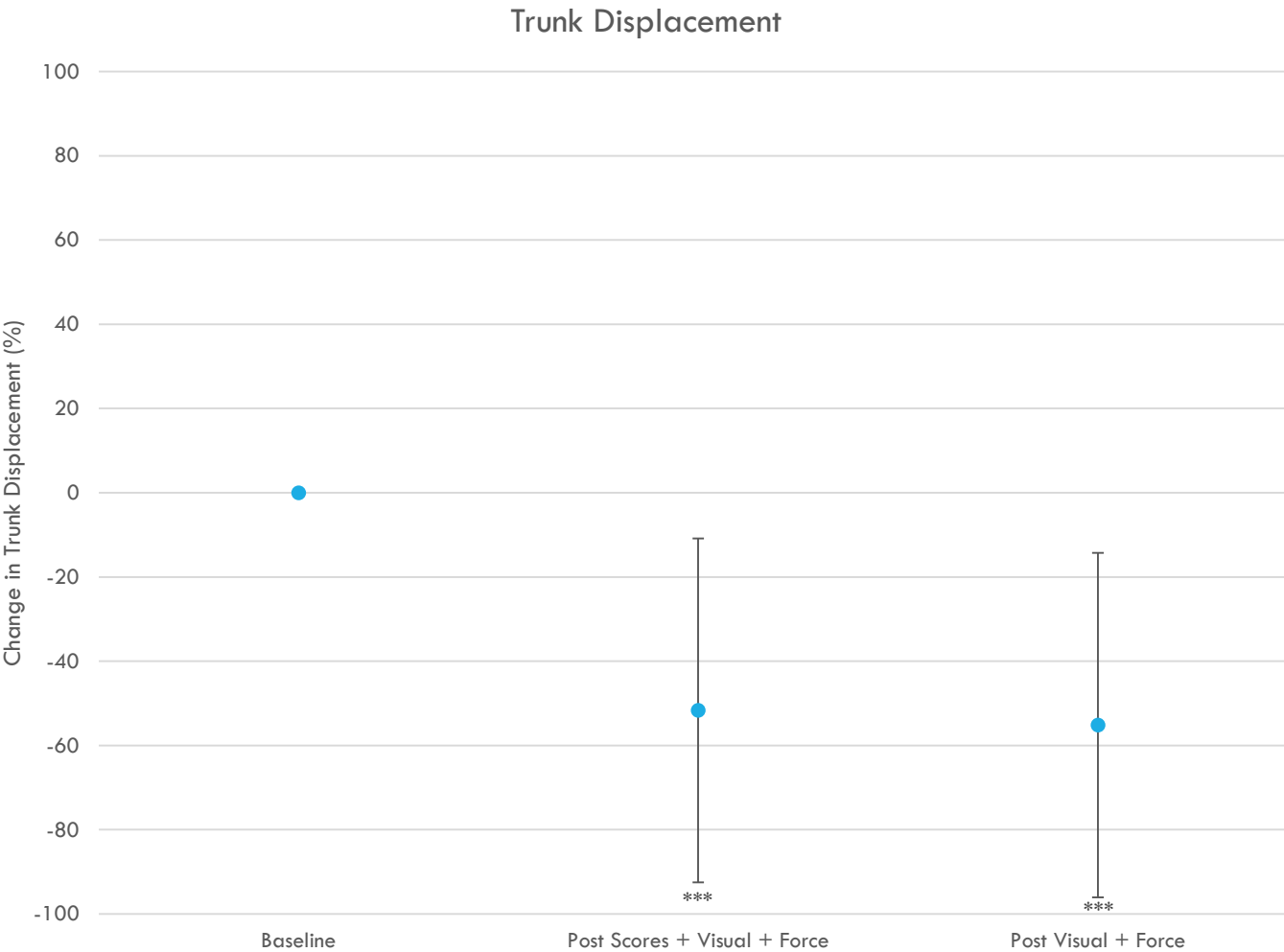
Computer Screen

Motion Tracking Camera

SCORES



PHASE 3: RESULTS



Phase 3:

	Scores + Visual + Force	Visual + Force
Average (SD)	-51.7 (40.8)	-55.2 (40.9)
T-Test	t(13)=-4.73 p=.000***	t(13)=-5.05 p=.000***
Effect	d=1.27	d=1.35

PHASE 3: RESULTS



- No information was better than the other one
- People (93%) prefer to receive scores

LIMITATIONS



- Small number of participants
- We only had 1 session
- We need larger groups + weeks of rehabilitation

SUMMARY



Background:

- Stroke is a major cause of disability
- Stroke survivors compensate

Need:

- Need to correct movements

Solution:

- Robots + motion tracking cameras

SUMMARY



- Giving information about trunk movement can reduce compensation
- Technology can be used to provide this information
- Participants prefer to receive scores
- It is really important that people participate in research studies