Imperial College London

# The Sixth Sense

## Electronically Augmented Perception

Julia Booth
julia.booth13@imperial.ac.uk

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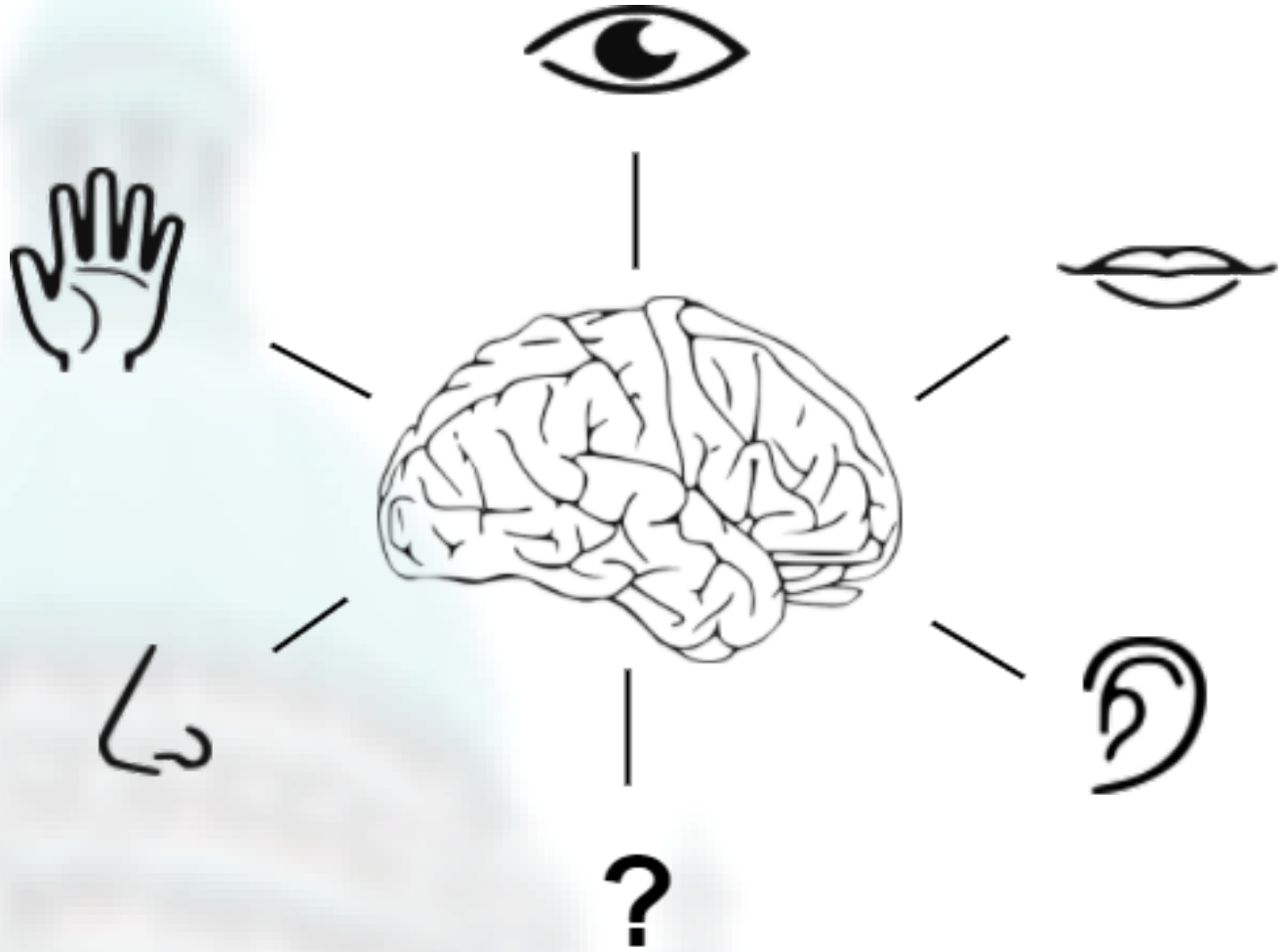
Imperial College London

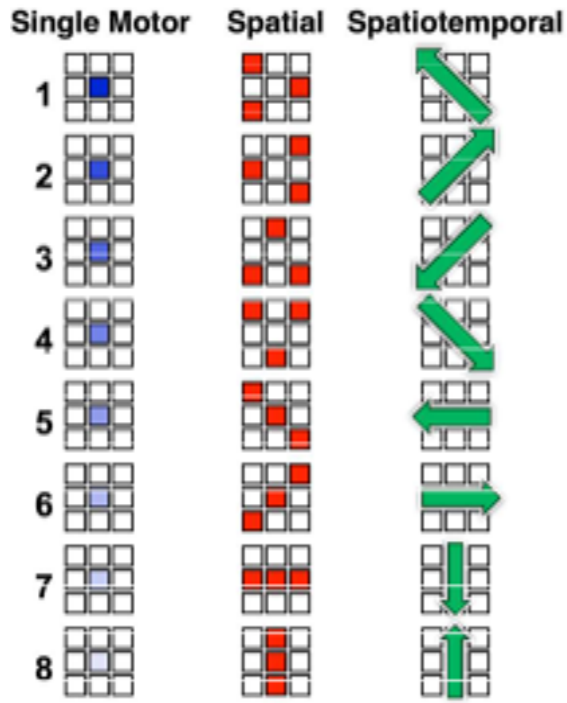
# Presentation outline

# Introduction



# Background

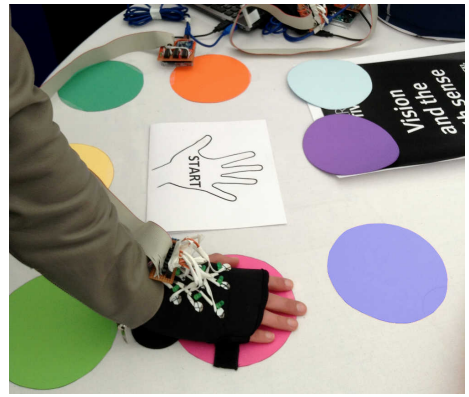
- In 1969 Bach-y-Rita attempted to replace the sense of sight using electrotactile grids [2]
- More recently Nagel et al. used vibrations to give the user a "sense" of their orientation [3]
- In 2015 Novich and Eagleman investigated how vibrations could be used as an interface to the brain [1]




Novich and Eagleman [1]

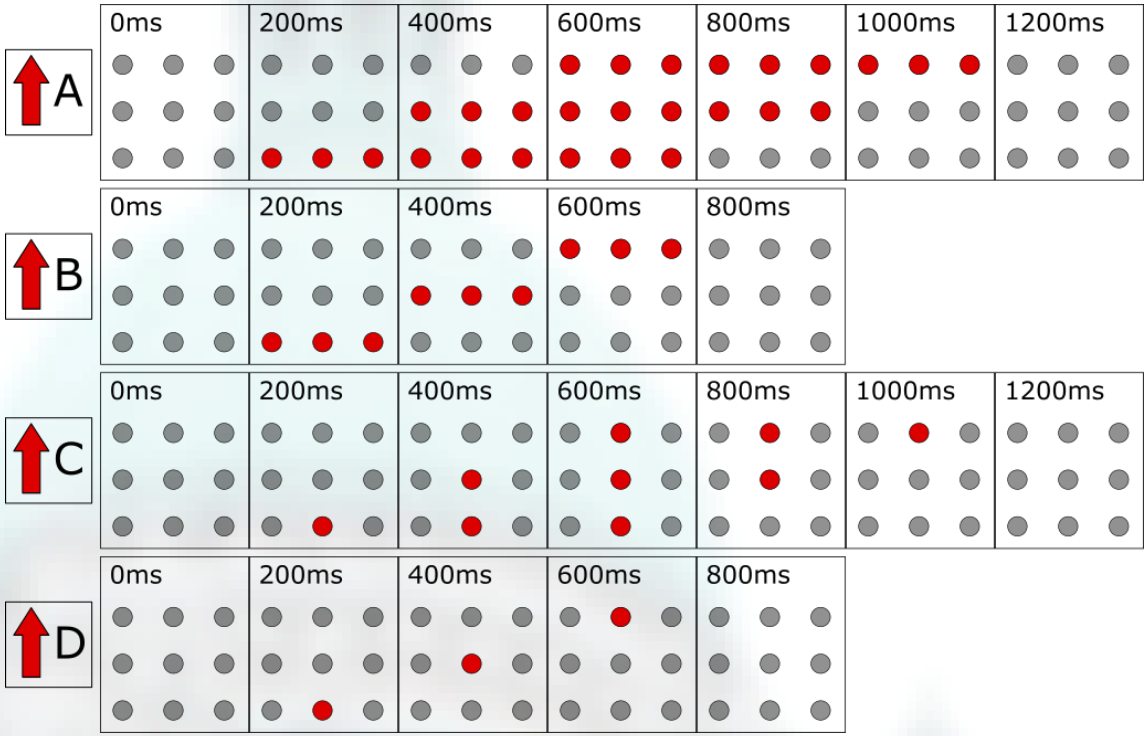
# Investigation of Vibrotactile Communication

- Investigate whether patterns of vibrations can be used to communicate directions
- Gloves embedded with a 3x3 array of vibratory motors controlled by a smart phone application
- Test subjects were asked to identify which direction the vibration pattern was indicating



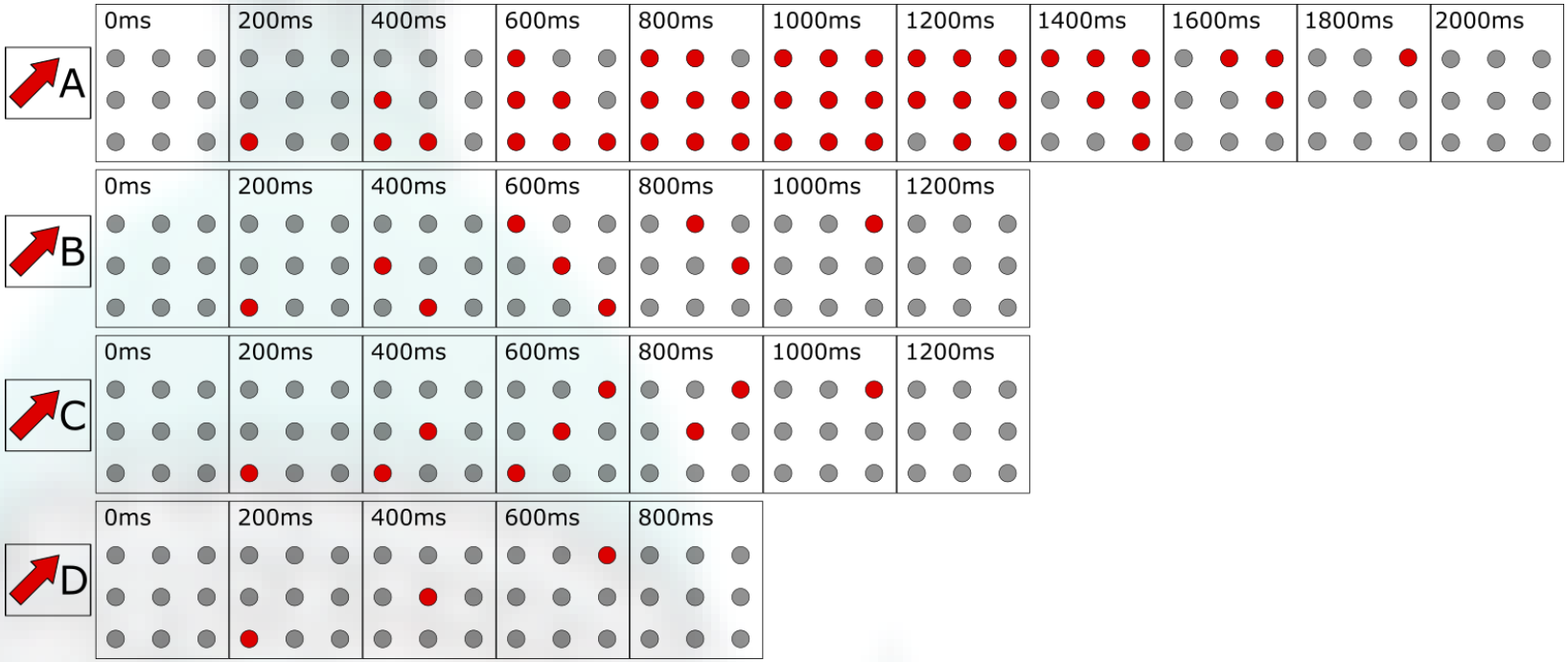
# Vibration Patterns to Communicate Directions

**Cardinal Pattern Types:**



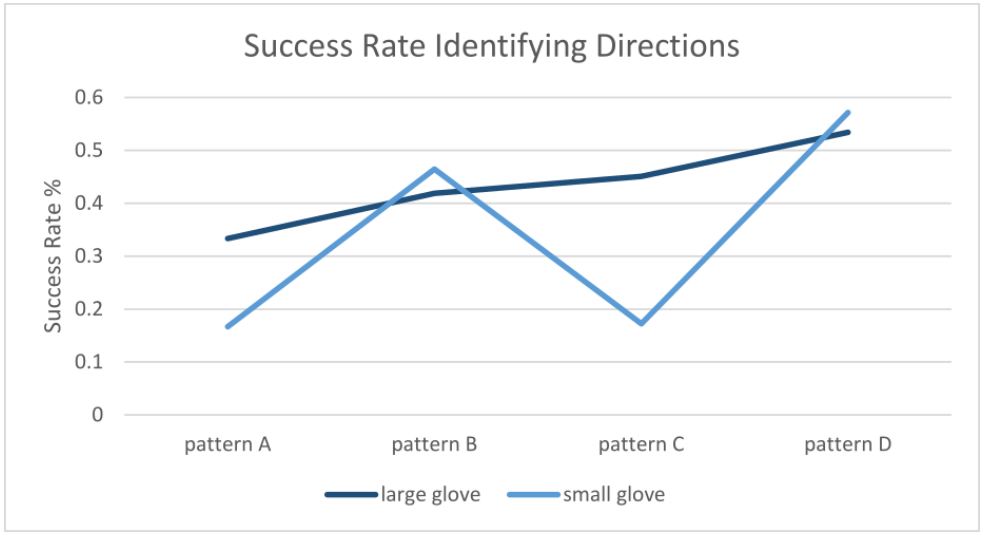
# Vibration Patterns to Communicate Directions

**Ordinal Pattern Types:**

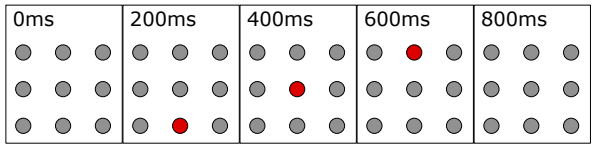


# Optimal Vibration Patterns

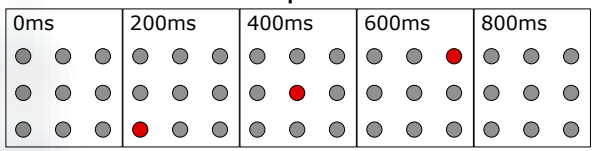
- Experiment conducted with 122 people
- Vibration pattern D at the longer time period proved the most effective with a 61% accuracy, well above the guess rate of 13%




Cardinal pattern D

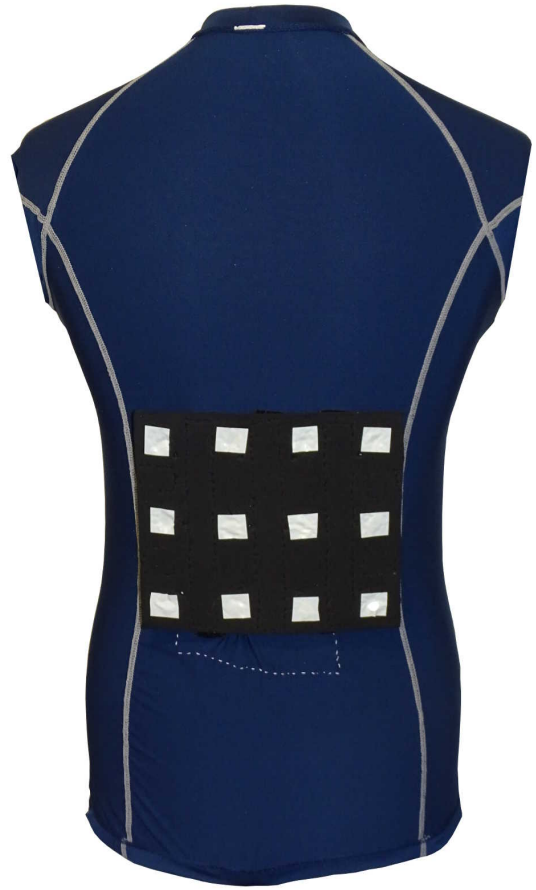



Ordinal pattern D

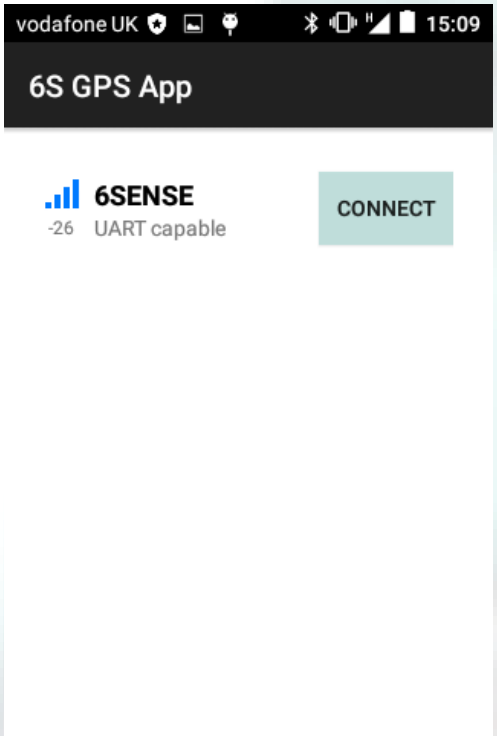


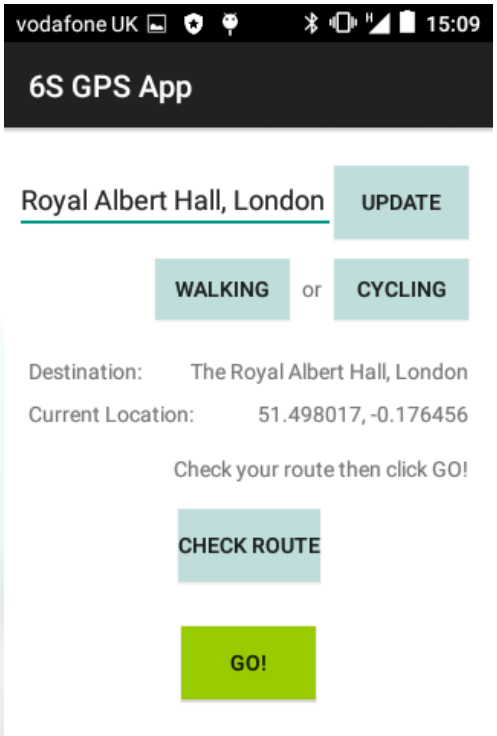
# The Sixth Sense - Device

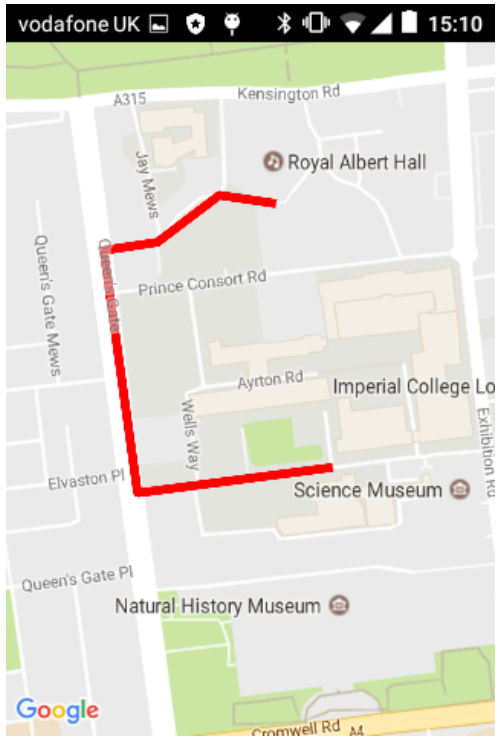
- Suitable areas of the body for vibrotactile communication are the back of the neck, the back of the hands and the back
- Location testing found that the lower back was the most suitable
- Vibration patterns for the device were designed around the best performing pattern from the previous experiment



# The Sixth Sense - Application

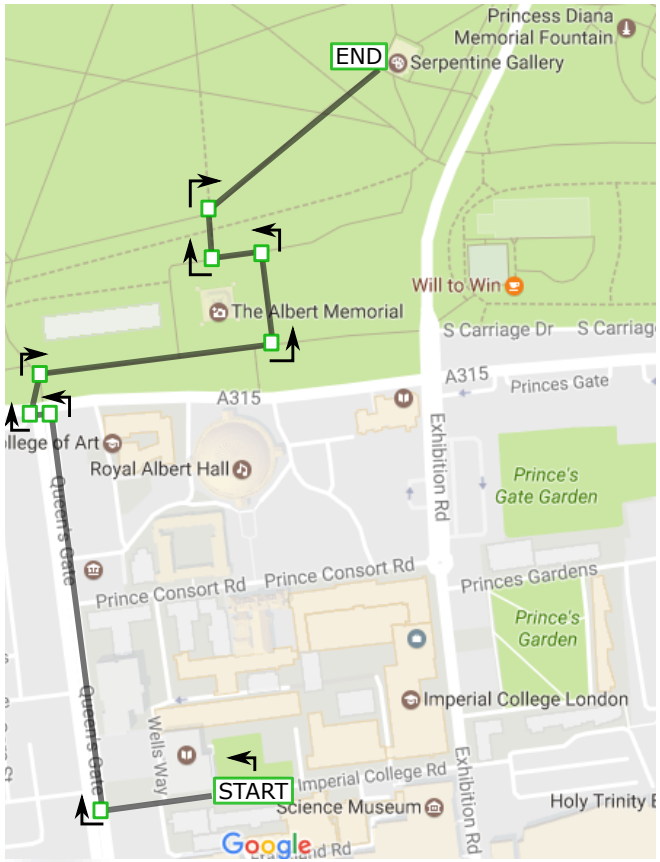


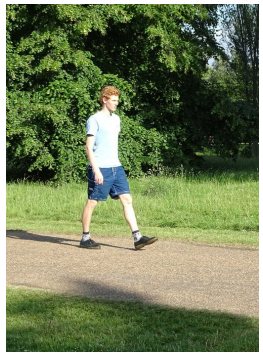
# The Sixth Sense - Experiment

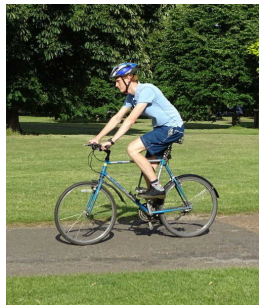
- Test subjects were given navigation tasks around Imperial College
- Over the course of the experiment 48 directions were tested, 46 of which were followed correctly without hesitation, all test subjects reached their destination



# Future Work

- There are a number of different ways the project could progress:
  - Assisting visually impaired people to navigate to new places
  - Incorporate the device into car seats for drivers or handle bars for cyclists
  - Use the gloves to inform a surgeon doing robotic assisted surgery that they are approaching the edge of the working area





# Conclusion

- Patterns of vibration do have an intuitive directional meaning
- The prototype enabled users to accurately navigate simple routes
- Users felt that the device gave them a sense of direction

# References

1. S. D. Novich and D. M. Eagleman, "Using space and time to encode vibrotactile information: toward a estimate of the skin's achievable throughput", Experimental Brain Research, vol. 233, no. 10, pp. 2777-2788, 2015
2. P. Bach-y Rita, C. C. Collins, F. A. Saunders, B. White and L. Scadden, "Vision substitution by tactile image projection", Nature, vol. 221, pp. 963-964, 1969
3. S. K. Nagel, C. Carl, T. Kringe, R. Martin and P. Knig, "Beyond sensory substitution - learning the sixth sense", Journal of Neural Engineering, vol. 2, no. 4, p. R13, 2005

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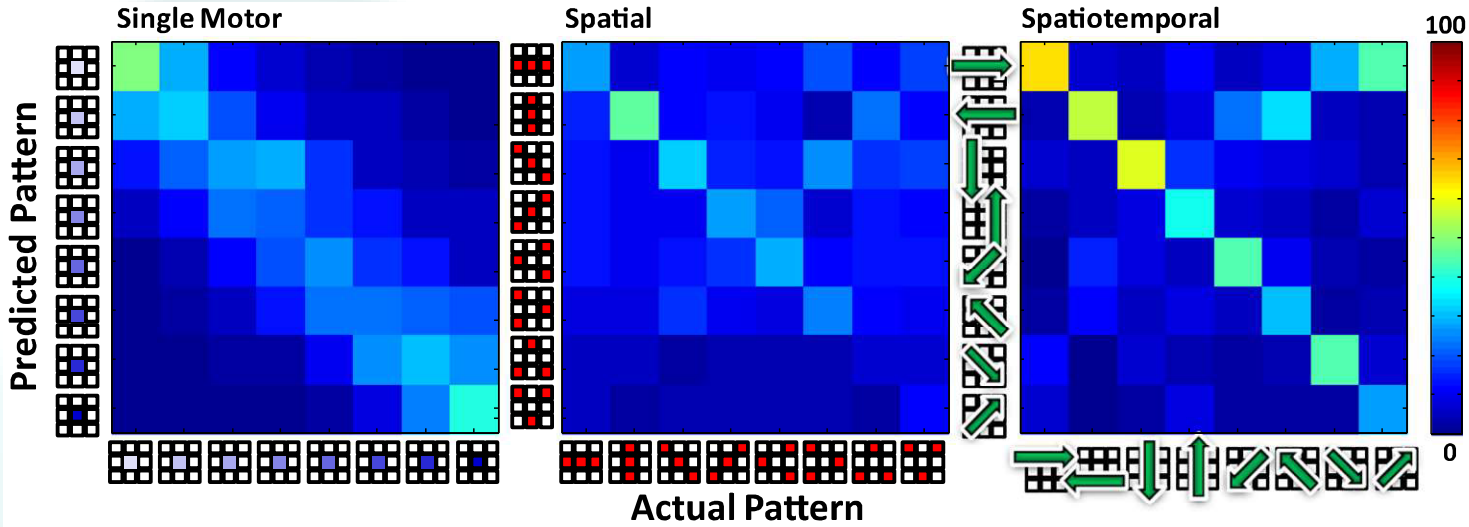
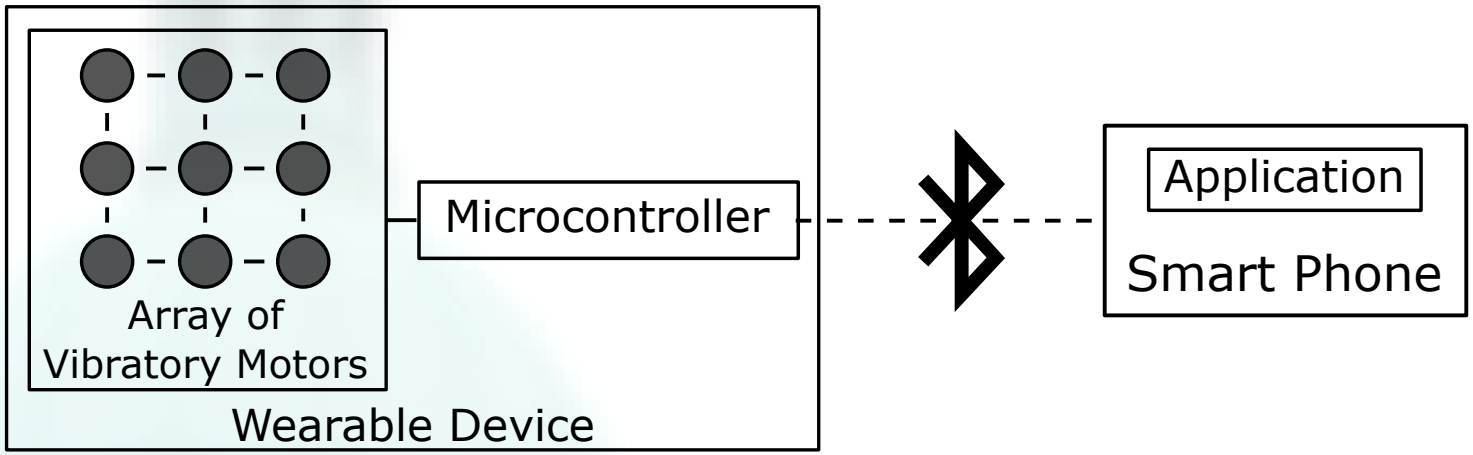
# Appendices




Novich and Eagleman [1]


Array of
Vibratory Motors
Microcontroller
Application
Smart Phone
Wearable Device

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| ↑ | 12 | 3 | 1 | 1 | 1 | 0 | 0 | 1 |
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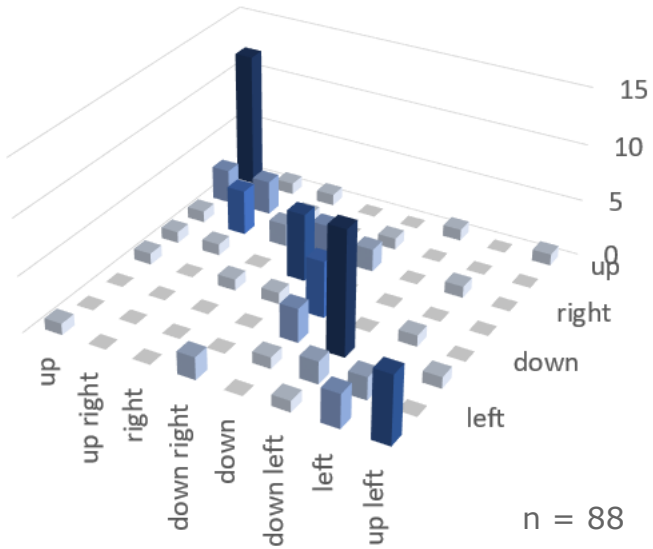
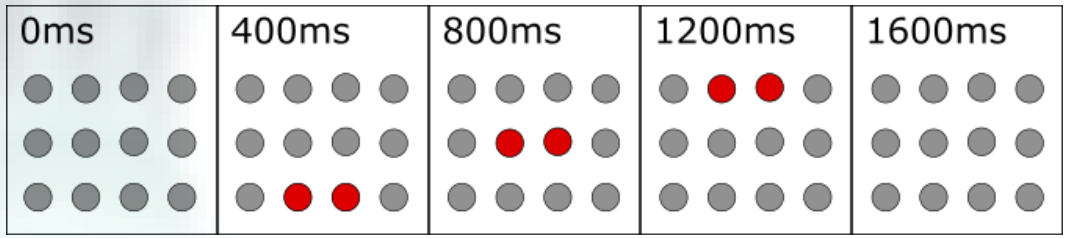


## Original "forwards" pattern




## Improved "forwards" pattern