

# Experimental investigation into micro-navigation and localisation of binaural audio for visually impaired people

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## December 2016 - February 2017

- A wrist band for the visually impaired to assist them locate a bus stop and identify a bus, as part of student exchange program.

## March 2017 - June 2017

- User Studies
- Experiment 1 - Experimental investigation into micro navigation for visually impaired people
- Experiment 2 - Experimental investigation into localisation of binaural audio for visually impaired people.

# Motivation

- While working on tactile feedback to help visually impaired navigate in Germany, I realised that locating a place is a very big problem for them.
- A visually impaired person I knew could navigate in his home without a stick but needed help the moment he stepped out. He did not have problem when he was travelling by bus but could not walk to the bus stand on his own
- I wanted to investigate how they navigated, oriented and identify scope for change and improvement.

# User Studies

Observation while travelling and interviews with visually impaired people studying/ working in Mumbai.

Users	II
Age	24 - 50 years
Education	12th pass
Language	English, Hindi
Navigation Frequency	On a daily basis

# Findings

- Locating bus stops and platforms by themselves is difficult
- Unavailability of micro details in maps
- GPS based maps - good enough but not sufficient for micro navigation
- Real time audio feedback can be missed

# Findings

- Details about shops around the bus stop helps to confirm
- Instructions by visually impaired people are different as compared to a sighted person
- Visually impaired people orient with respect to sound
- They use sound to confirm orientation

# How do the visually impaired describe their route

“Using the cattle catch on the road cross the road and take the footpath. Take a left after crossing a medical shop near a vadapav wala”

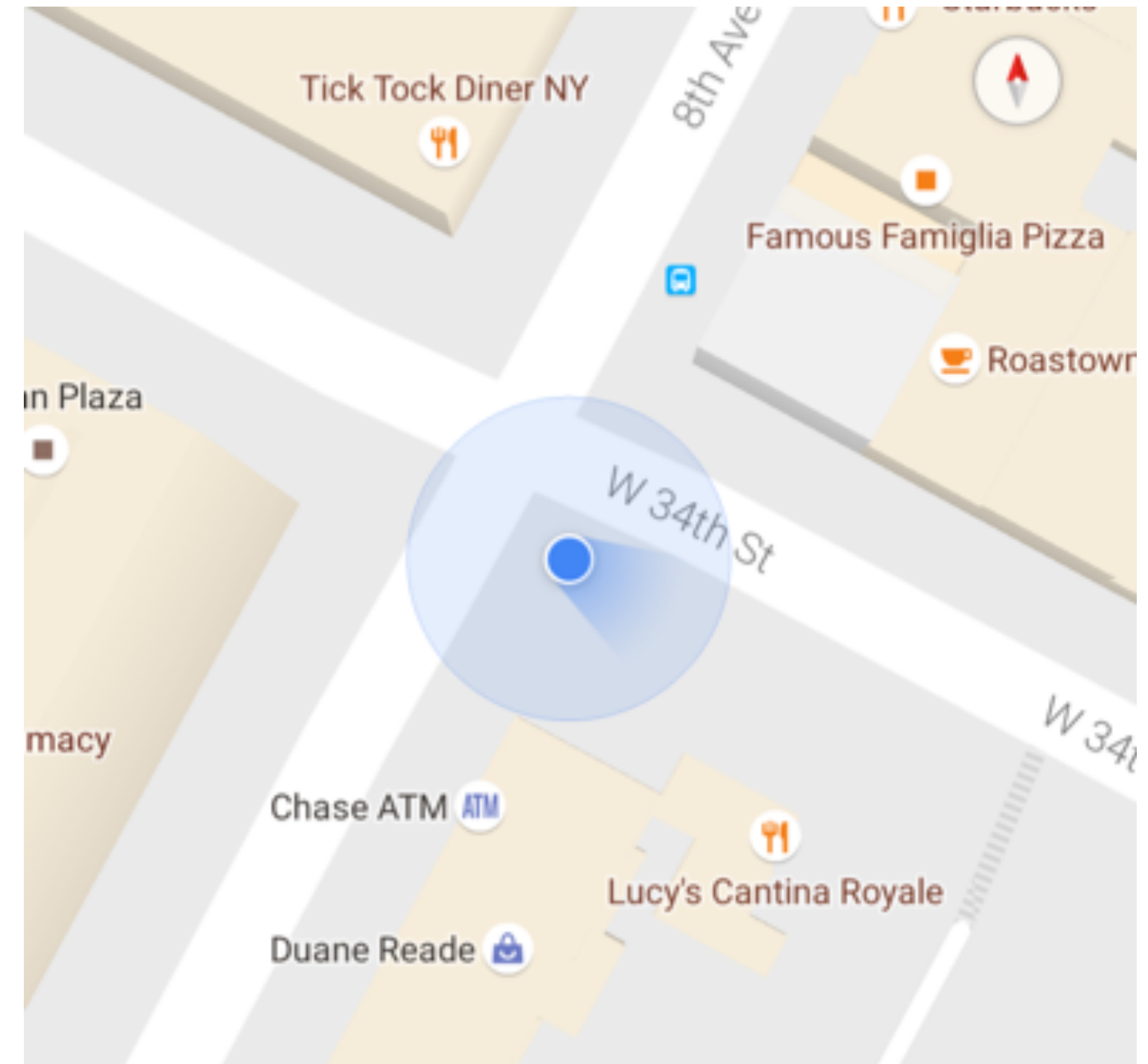
Class of contextual Informantion	Example	% of visually impaired who used this information
Directional	Left/right, north/south	75
Structural	Road, monument, building	75
Environmental	Lake, tree	37.5
Textual-structural	Cheda bookshop, Laxmi restaurant	25
Textual-area/street	JVLR, Rajiv Chowk	12.5
Numerical 1	First, second	62.5
Numerical 2	100 m. 45°	12.5
Descriptive	Steep, tall, red	25
Temporal/distance	Walk until you reach...or just before you get to...	100
Sensory	Sound of cars passing or smelling a bakery	87.5
Motion	Bus passing, doors opening	50
Social contact	Asking people for help	100
Small Shops	Tea stall, Cobbler	75

# Experimental investigation into micro navigation for the visually impaired

Hypothesis - If the visually impaired themselves create maps other visually impaired will find it convenient to navigate since they give descriptions of the environment.

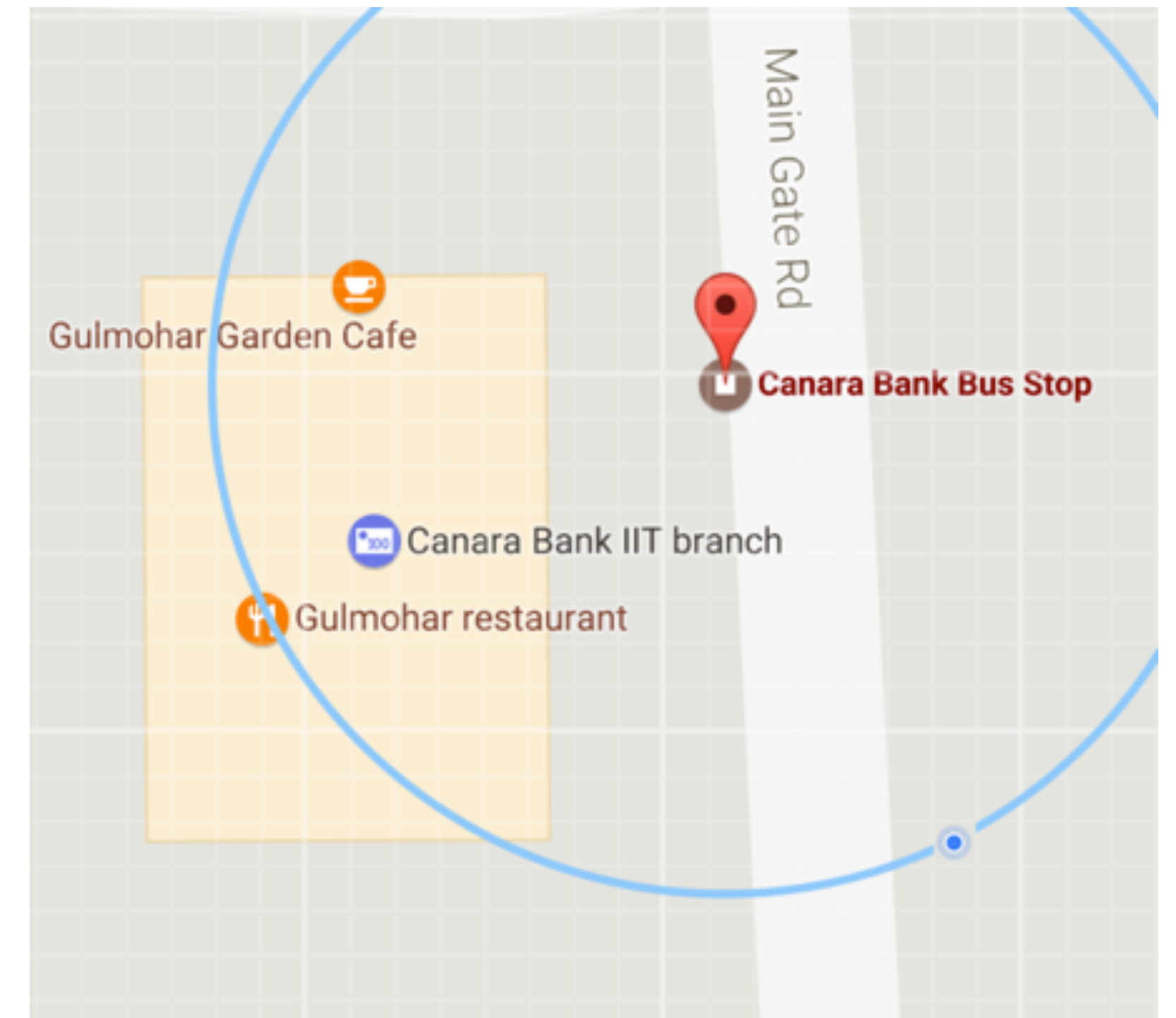
# Motivation

- Most orientation and micro navigation aids are highly visual based.
- It is difficult to micro navigate within small areas using Maps based on GPS
- Visually impaired describe their regular routes quite differently when compared to sighted people



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- It is difficult to micro navigate within small areas using Maps based on GPS.
- Visually impaired describe their regular routes quite differently when compared to sighted people
- Sighted person says, “Go straight and take a left next to the green building. Then after the Canara Bank turn right on to Sharda street...”
- Visually Impaired says, “Walk straight till you hear the chai wala. There is a medical shop near it. Then turn left... (P3, user studies)”

# Background Work (lit review)

- Evaluation of spatial displays for navigation without sight [17](James R. Marston, 2006).
- A discussion on why it is difficult for a visually impaired person to navigate like a sighted person was done by [13] (Michele A. Williams, 2014 )
- Even if provided verbally, description of routes by sighted people makes it difficult for a visually impaired person to navigate as compared to instructions from other visually impaired people[16] (Nicholas A, 2005).
- The issue of locating the bus stop or right platform has been discussed in ‘An Observational Study on Usability Issues in Mumbai Local Trains’ by Shikha Agarwal, IDC (Christian Gold, 2013)[10].

# Intervention

- **Design of instructions**
  - The instructions were designed prior to the experiment wherein, the moderator walked with a visually impaired travelled through a route that he regularly uses.
- **Prototype for conducting the experiment**
  - The instructions were altered according to the findings from the pilot study. Then an application was made for android devices to access instructions



# Method

- Each user has to navigate through two paths using two different methods for within subject evaluation.
- Both the paths are similar in terms of distance and hurdles.
- The methods were given to users in random order.
- Participants were briefed and trained about the prototype

# Prototype I

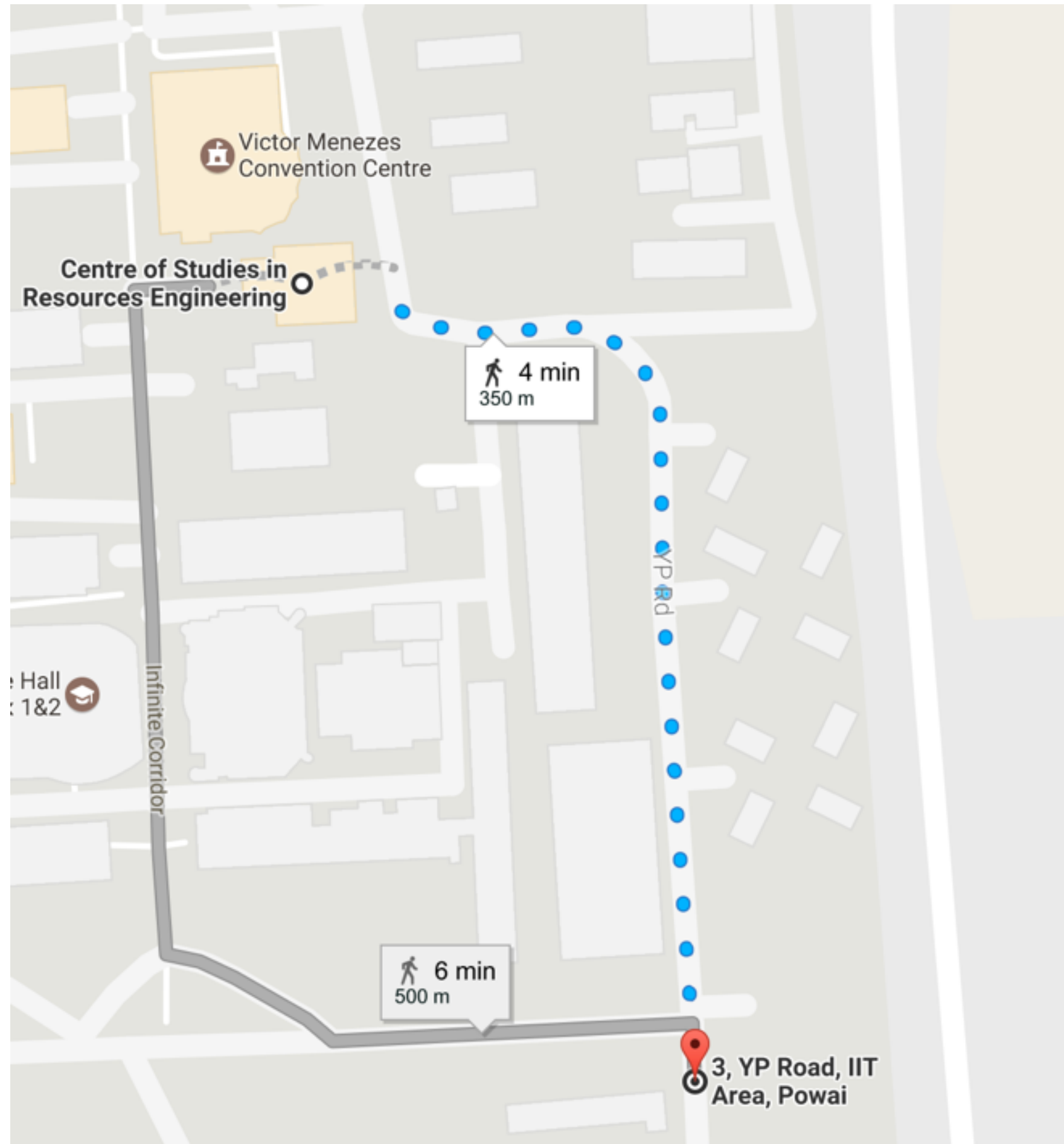
- Application made using instructions from a visually impaired person
- Help will be provided only if the user asks for it. The nature of help and number of times help was asked was noted down for analysis.



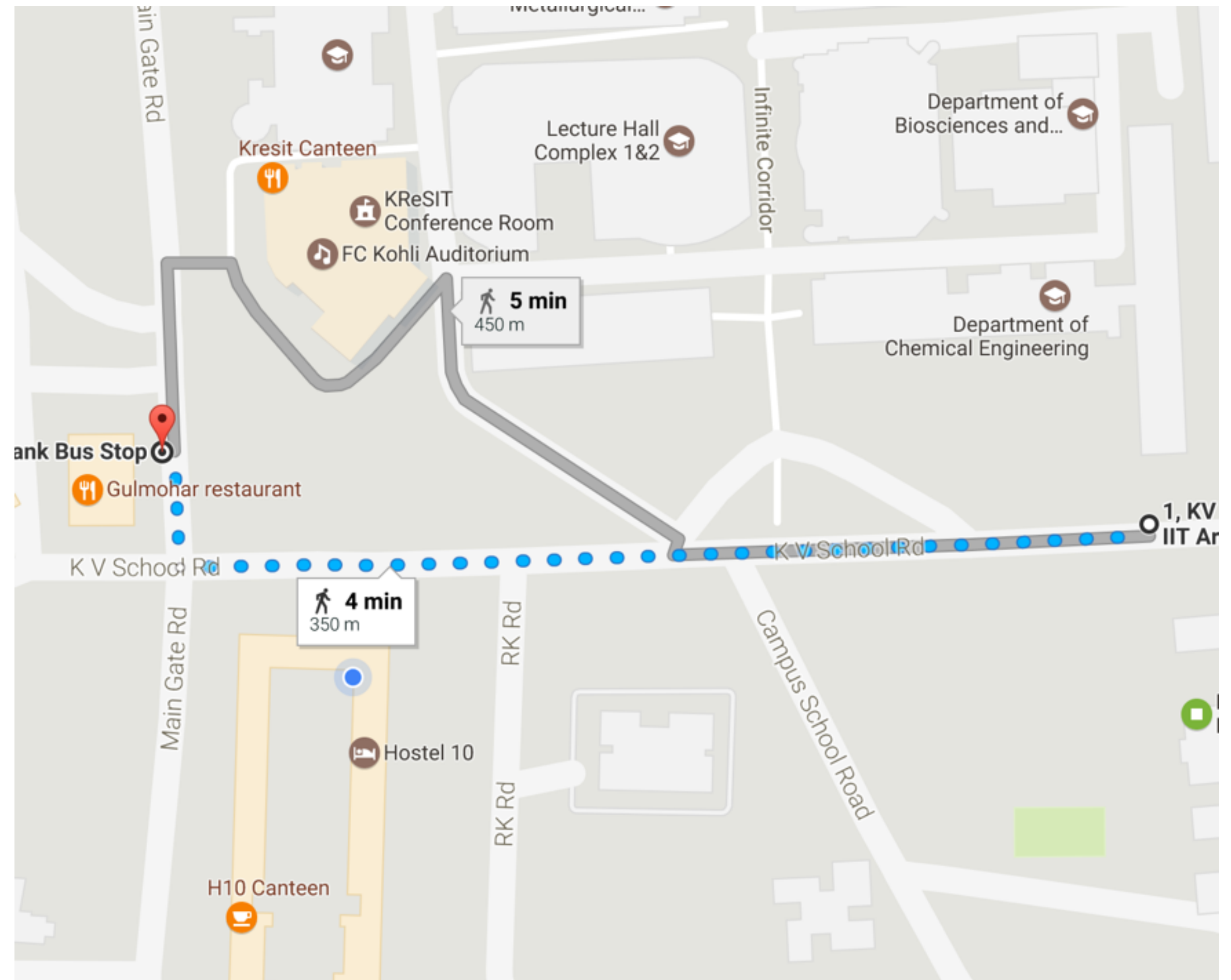
# Prototype 2

- Traditional map with navigation turned on.
- If the participant's device does not have compass, data or GPS then they were provided with a device.

# The two routes

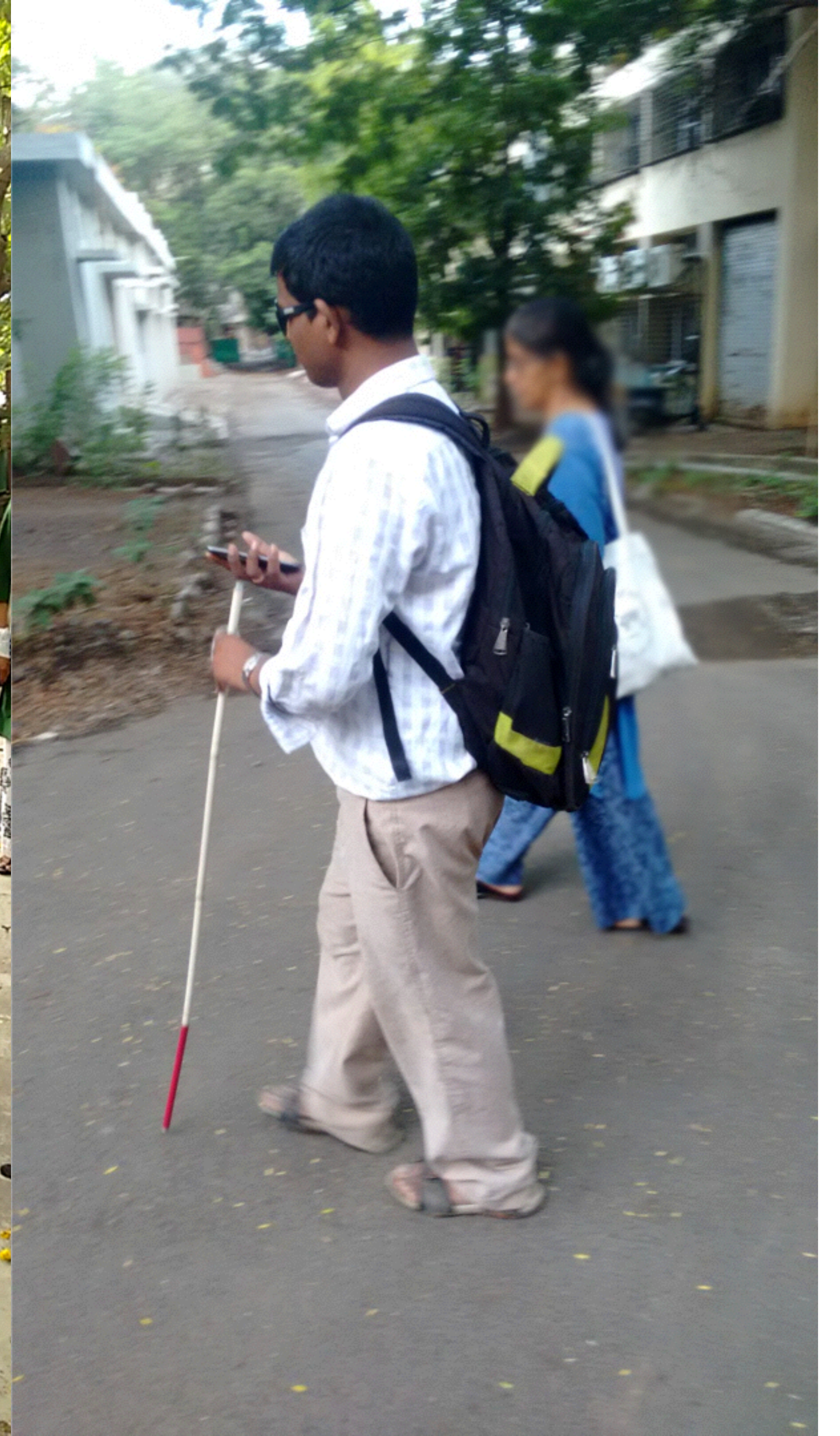


Prototype 1



Prototype 2

# Participants navigating using prototype I

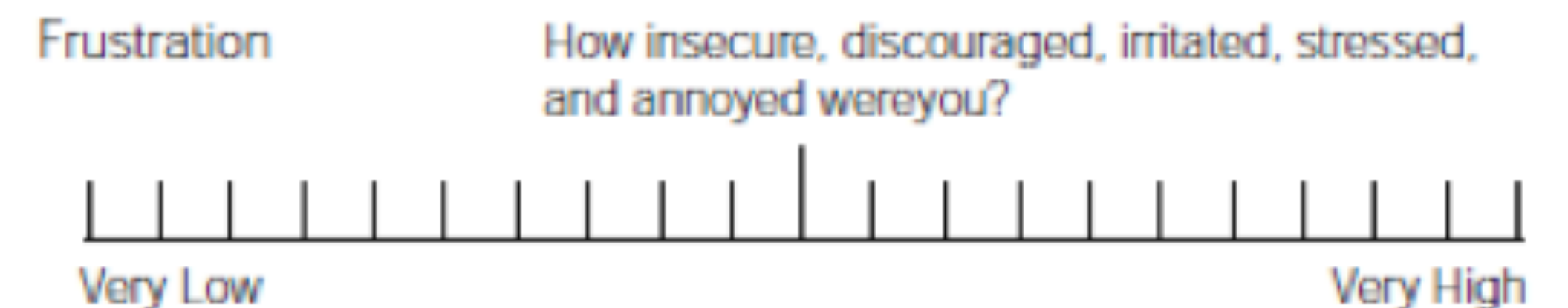
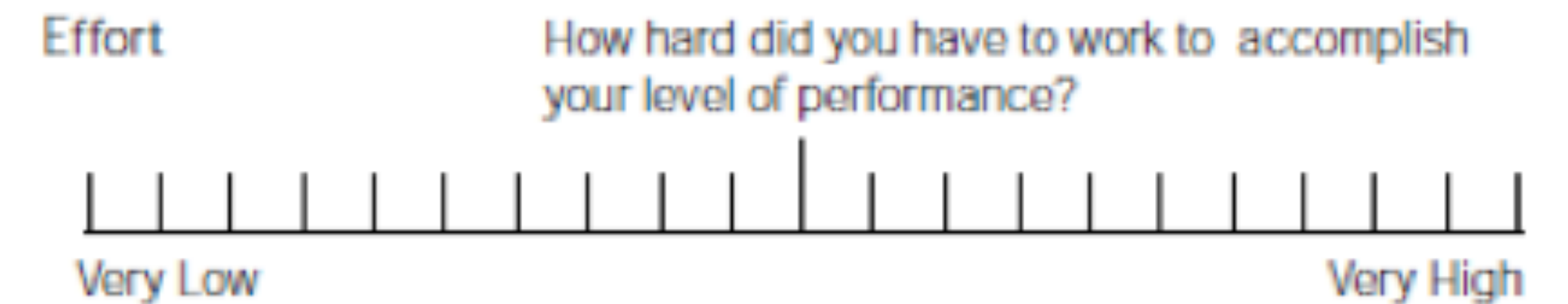
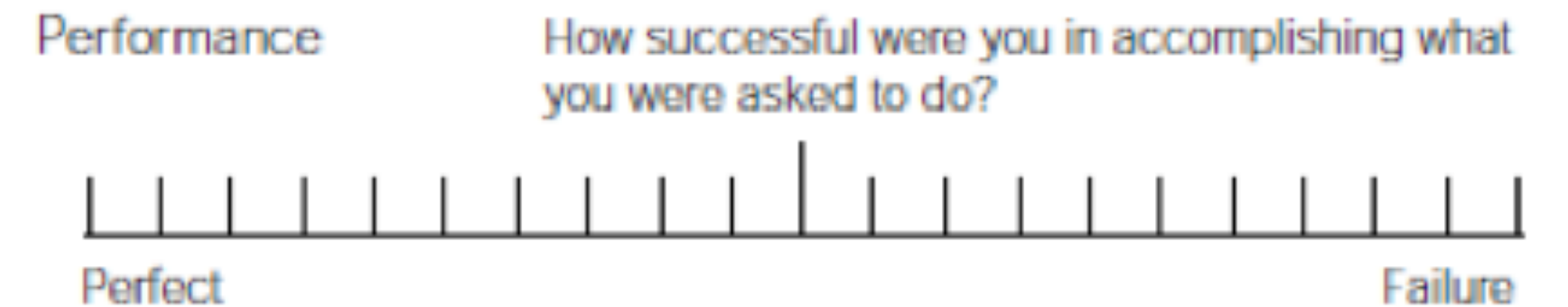
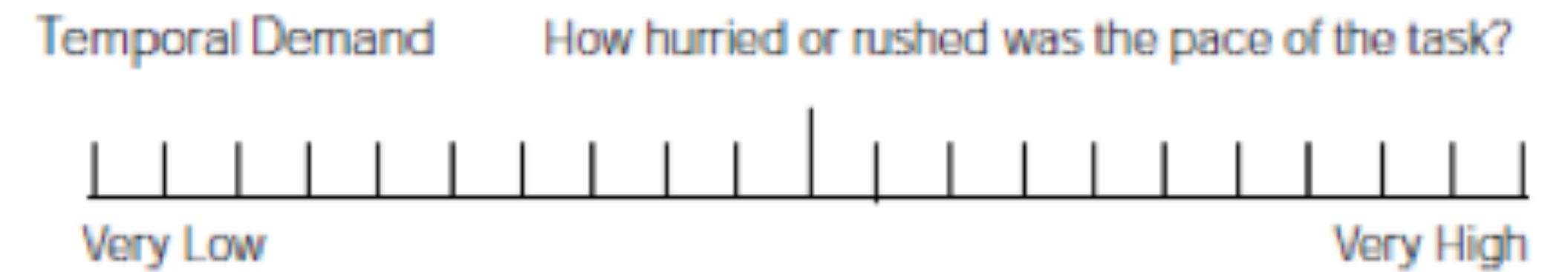
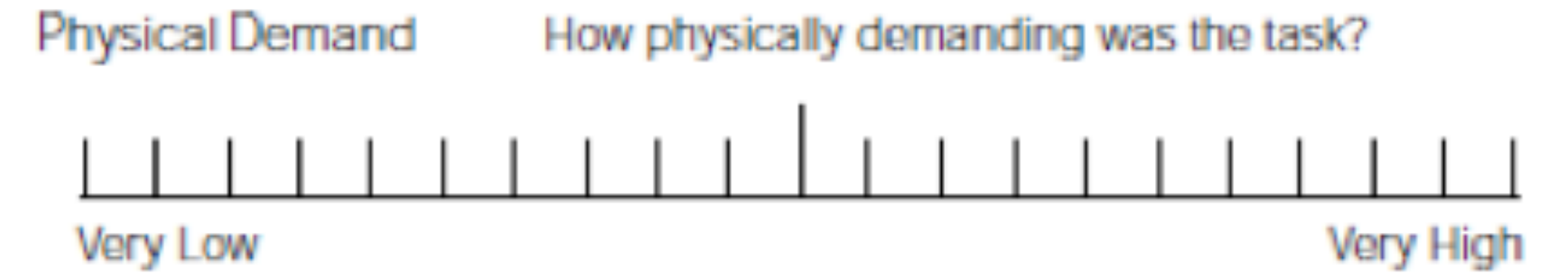
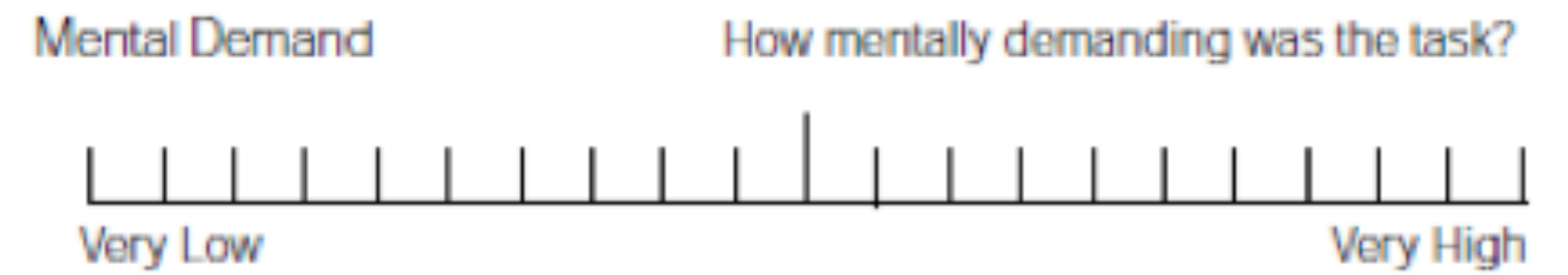


# Quantitative data

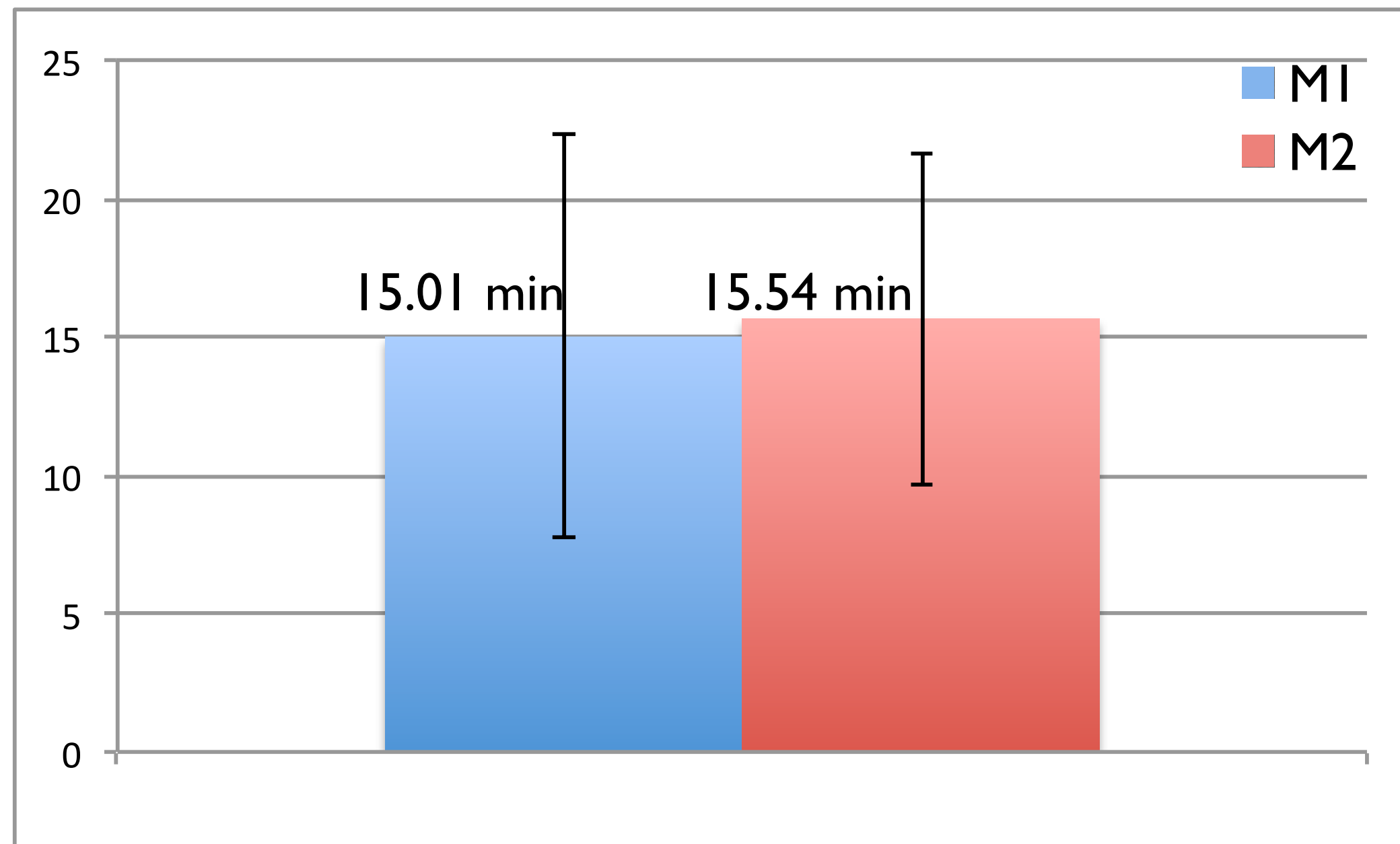
- Time taken to reach destination
- No. of times they listen to the instructions before reaching each check point.
- No. of errors
- No. of times the participant sought help

# Post Experiment

- The participants were interviewed right after the experiment
- Participants were asked to fill NASA task load index with the help of a sighted volunteer.
- This is followed by an evaluation technique developed by NASA to assess the relative importance of 6 factors in determining how much workload one experienced.



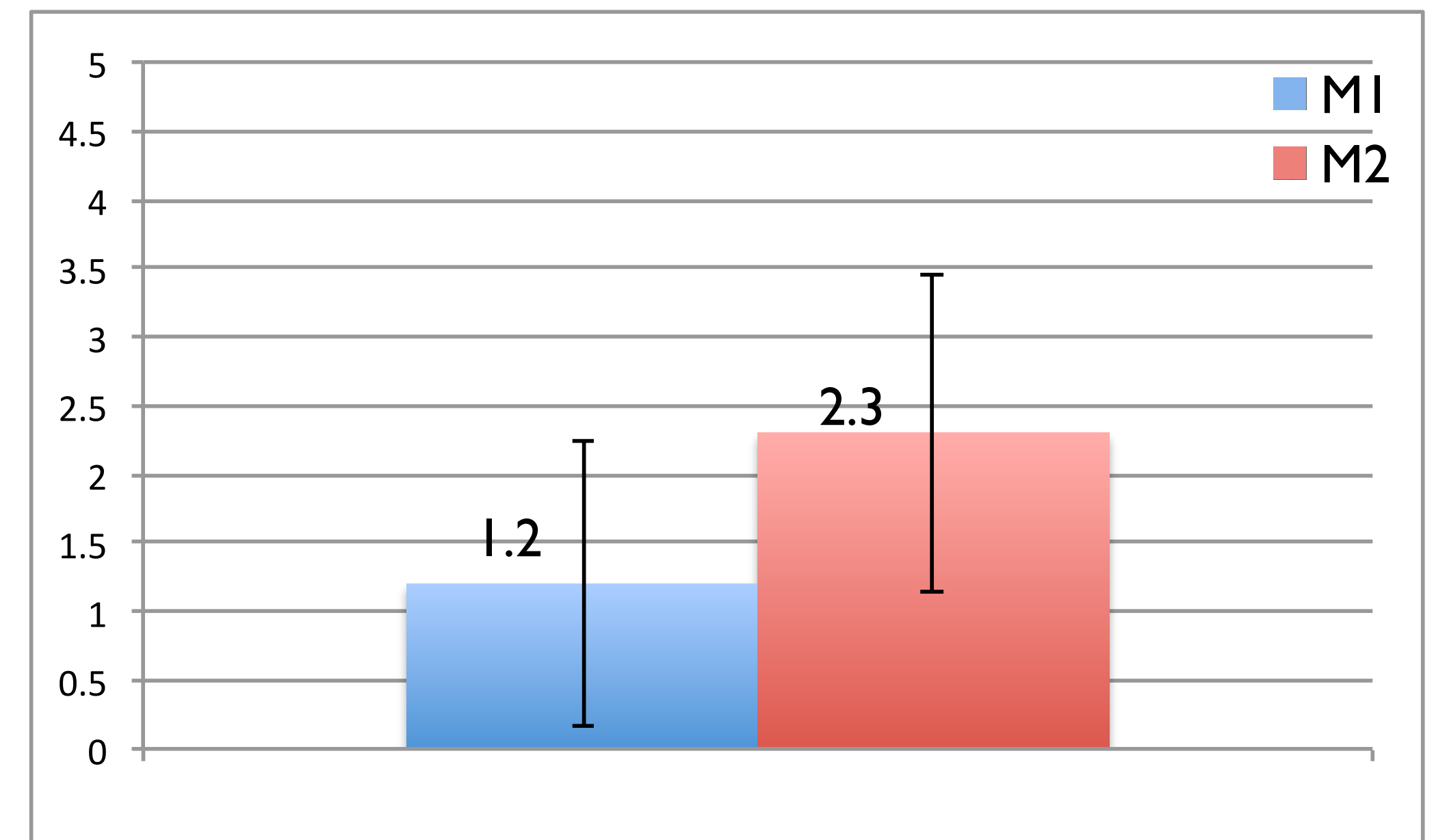
# Results



Time

$P = 0.89$

Insignificant

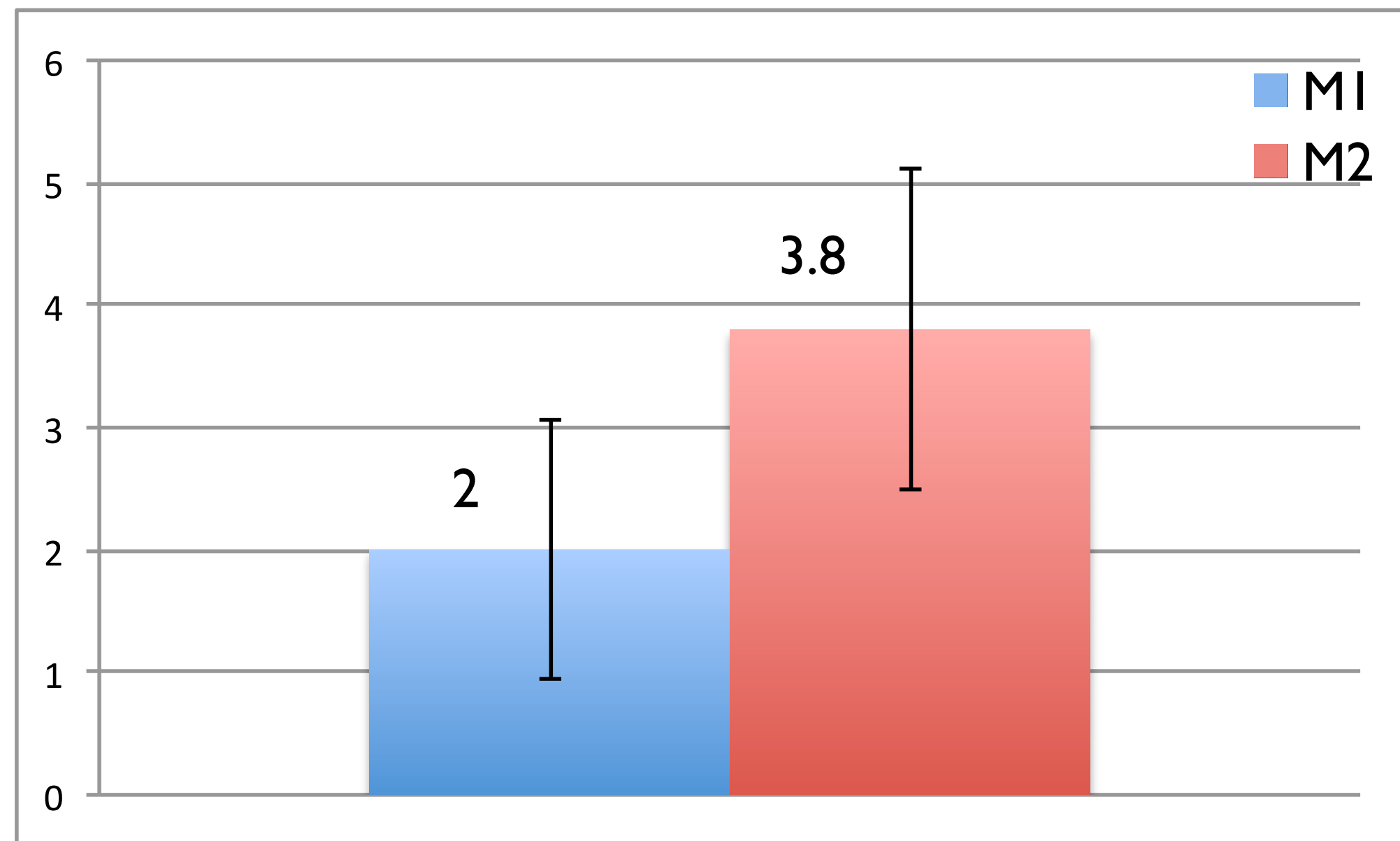


No. of errors

$P = 0.02$

Insignificant

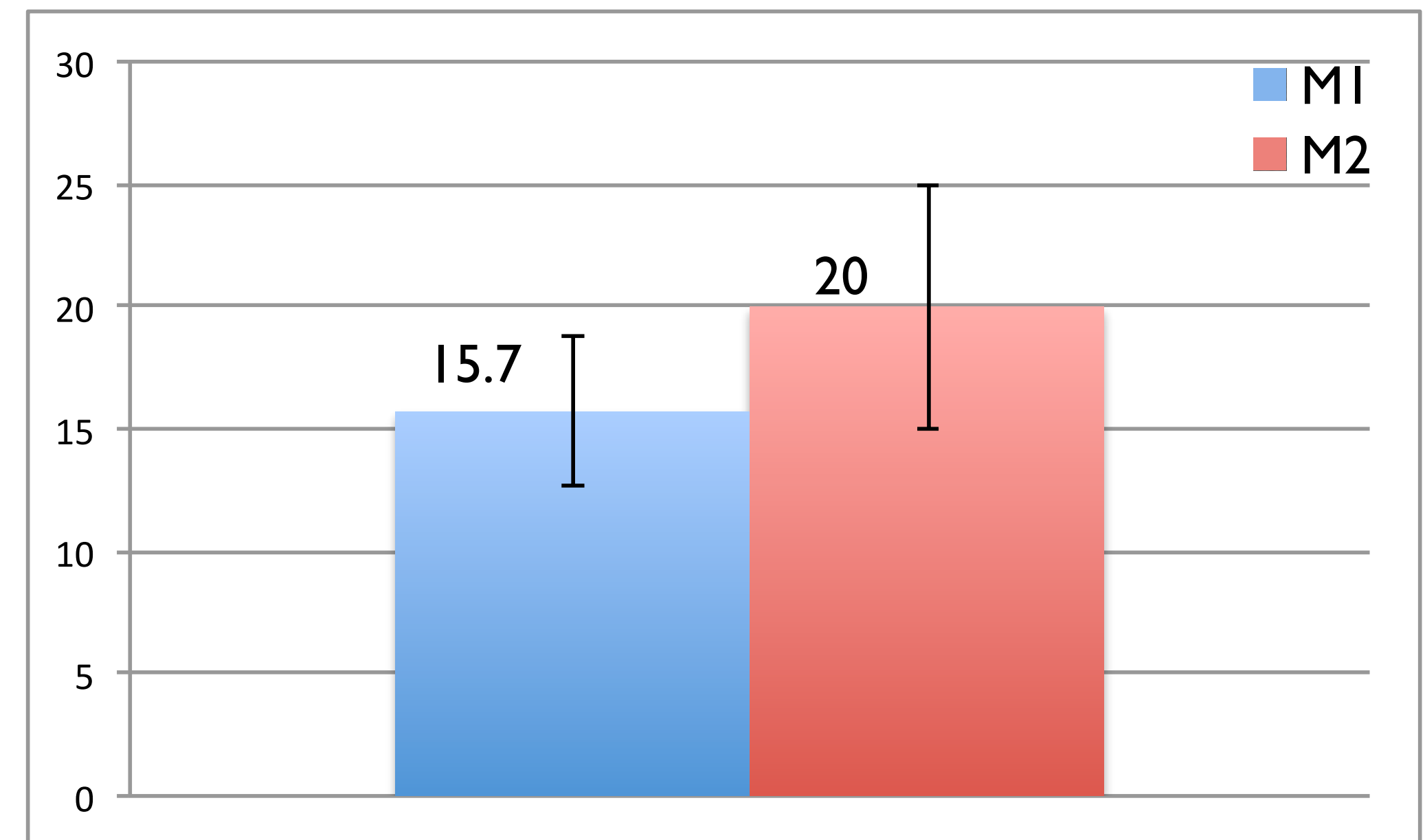
# Results



No. of times help was asked

$P = 0.0007$

Significant

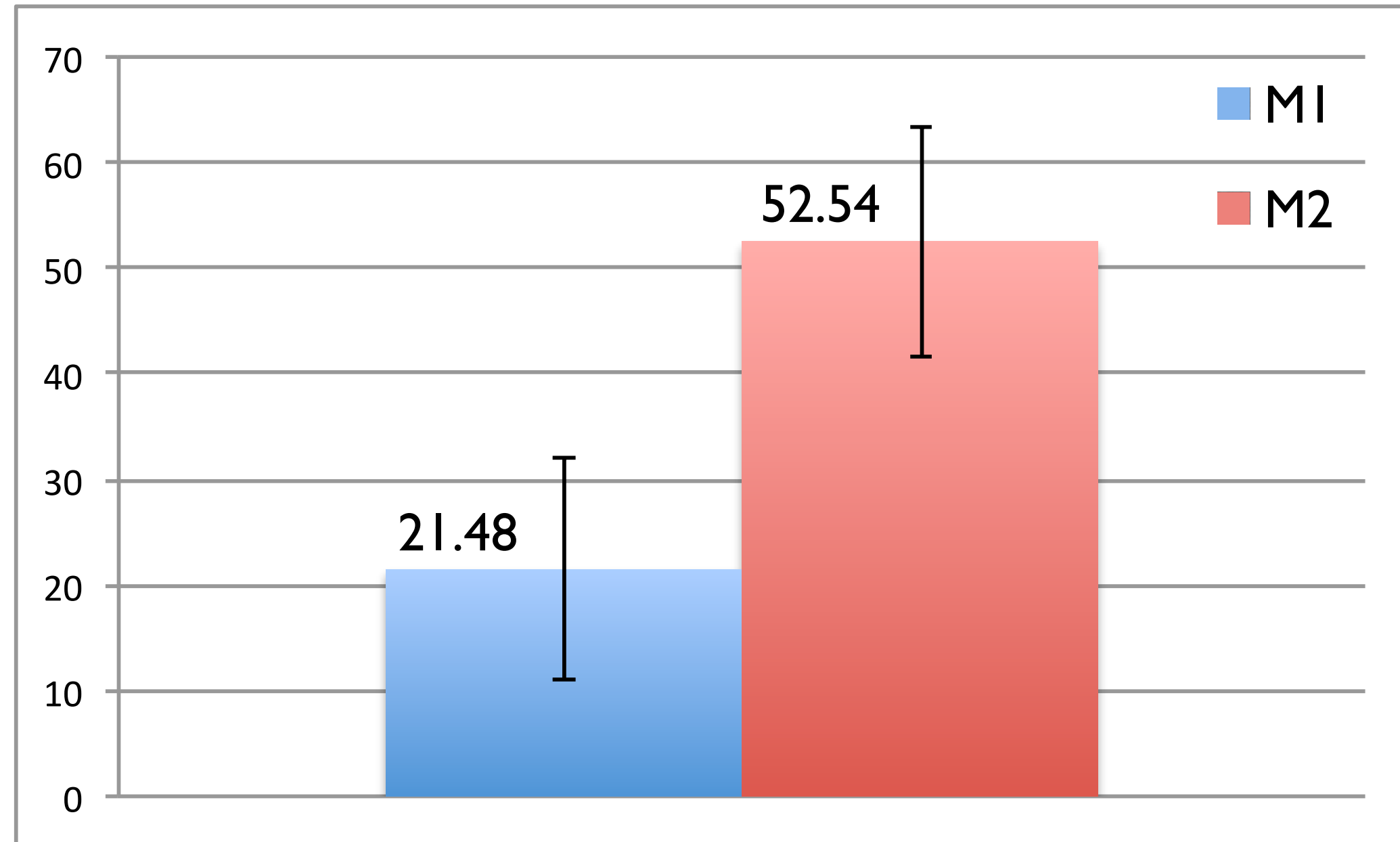


No. of times participant listened to instructions

$P = 0.009$

Significant

# Results



WWL

P = 0.0004

Significant

# Qualitative Findings

- Understanding Google maps took longer
- The instructions give scope for error recovery by themselves
- While navigating using Google maps, the participants had problem orienting during the beginning but it reduced anxiety by mentioning the remaining distance to navigate

# Design Implications

- While navigating, continuous feedback is necessary to reduce anxiety and provide confirmation
- Orientation cues that are purely directional such as north or south should not be given for visually impaired people
- Along with physical description, an additional sensory feedback is preferable to reduce errors.
- GPS helps in calculating current position and this can be combined with descriptions to help people micro navigate

Experimental investigation into localisation of binaural audio for visually impaired people.

# Motivation

- The visually impaired rely highly on the auditory feedback. They orient with respect to sound in many cases.
- Will they be able to orient themselves better, if they already know the 3d ambient sound of an environment? If sighted people can use street view before travelling, can the visually impaired use binaural sound recordings before commuting to a new place?

# Background

- ARGUS project gives binaural cues in 3D space in the form of stereo audio for predetermined routes. [14] (Spiller, 2014).
- 3D sound cue is given to cyclists, while riding, to reduce cognitive load of reading sign boards [18] (Matthijs Zwinderman, 2011)
- While navigating to unfamiliar places there is an anxiety which can be reduced by providing the information during the planning phase[15] and most visually impaired people plan their journey before starting
- Spatial display used auditory virtual reality that presented the audible spatial information (waypoint direction and distance) through small air-tubes inserted into the ear [17](James R. Marston, 2006).

## Stereo

Stereo = two different channels of audio signal, recorded with two microphones spaced apart (or with a single microphone with two elements)

No stereo recordings are binaural.

In a stereo, you get slightly different sound waves hitting each mic, resulting in different sounds recorded in each channel

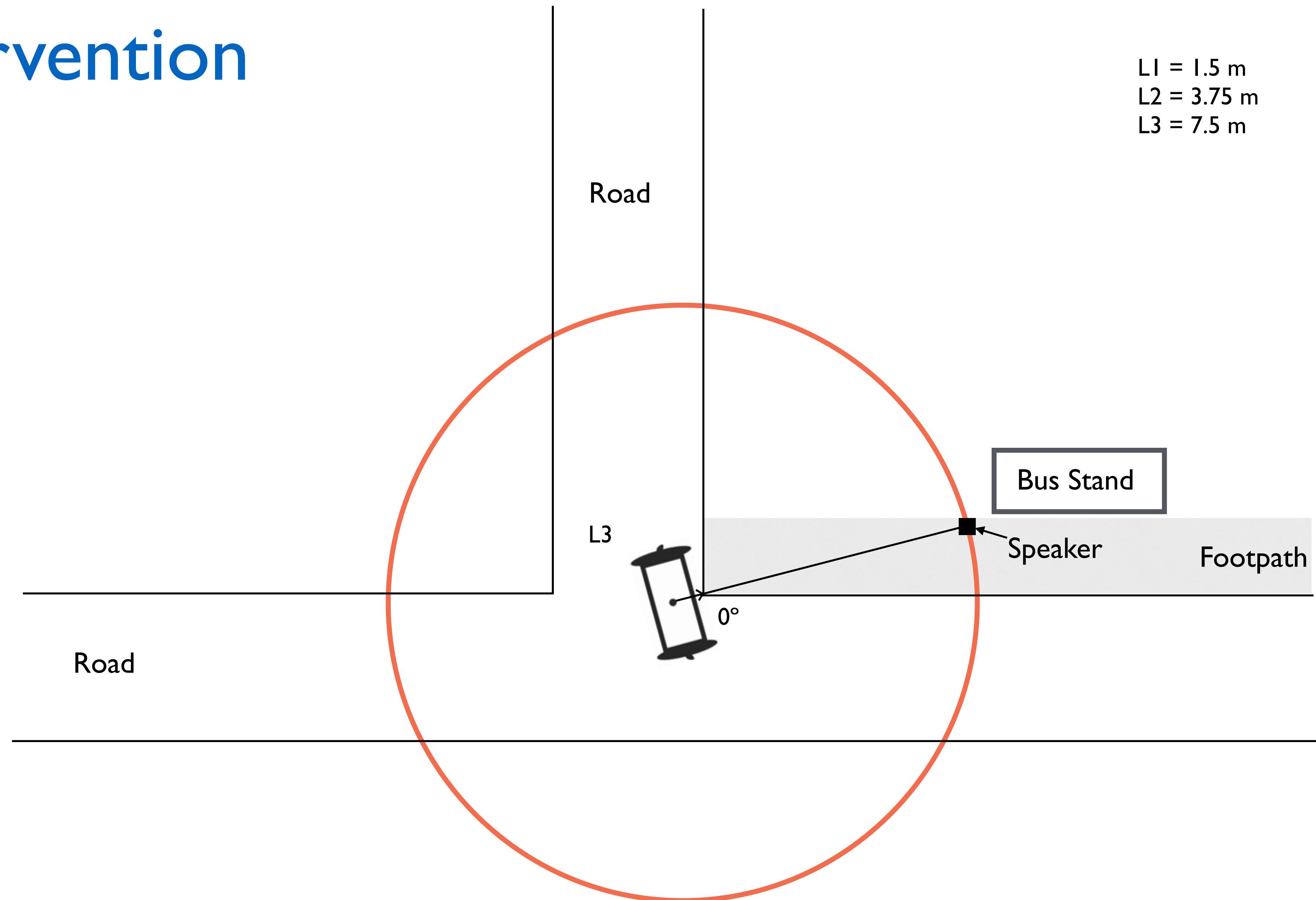
## Binaural

Binaural = two different channels of audio, recorded on either side of a human or artificial head, preferable in the ears

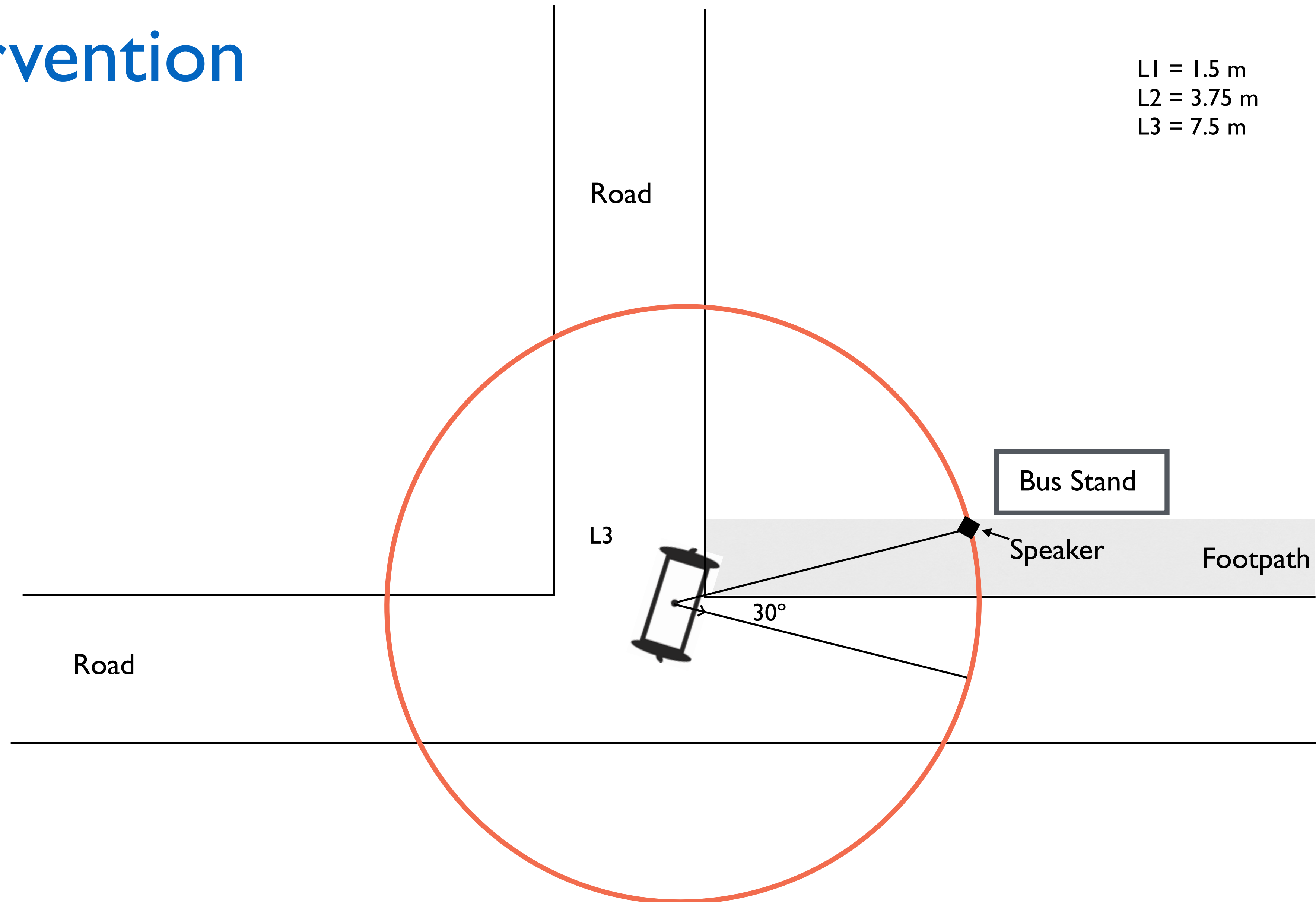
All binaural recordings are stereo

Binaural is a recording technique that replicates the way we naturally hear sounds.

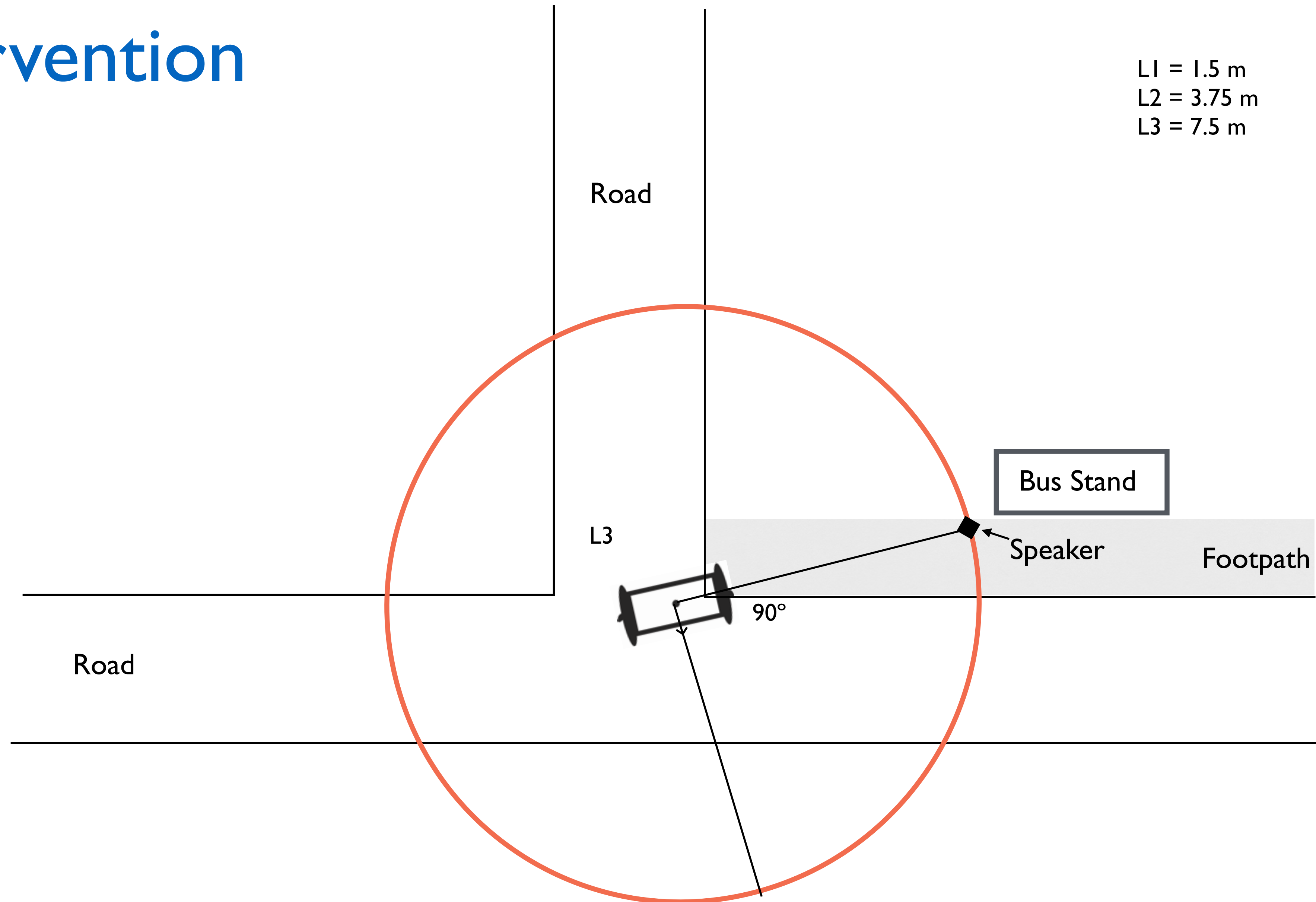
# Intervention



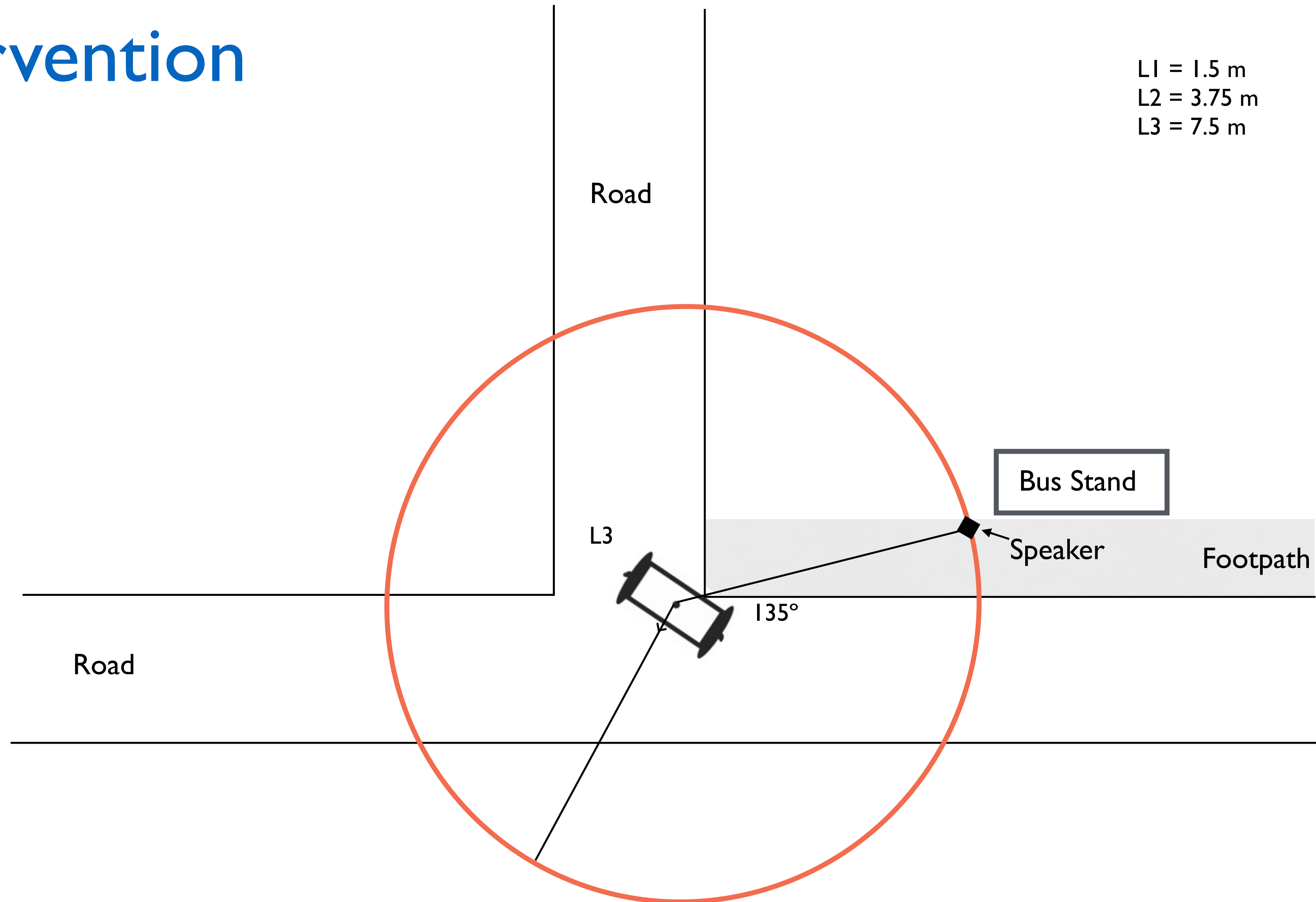
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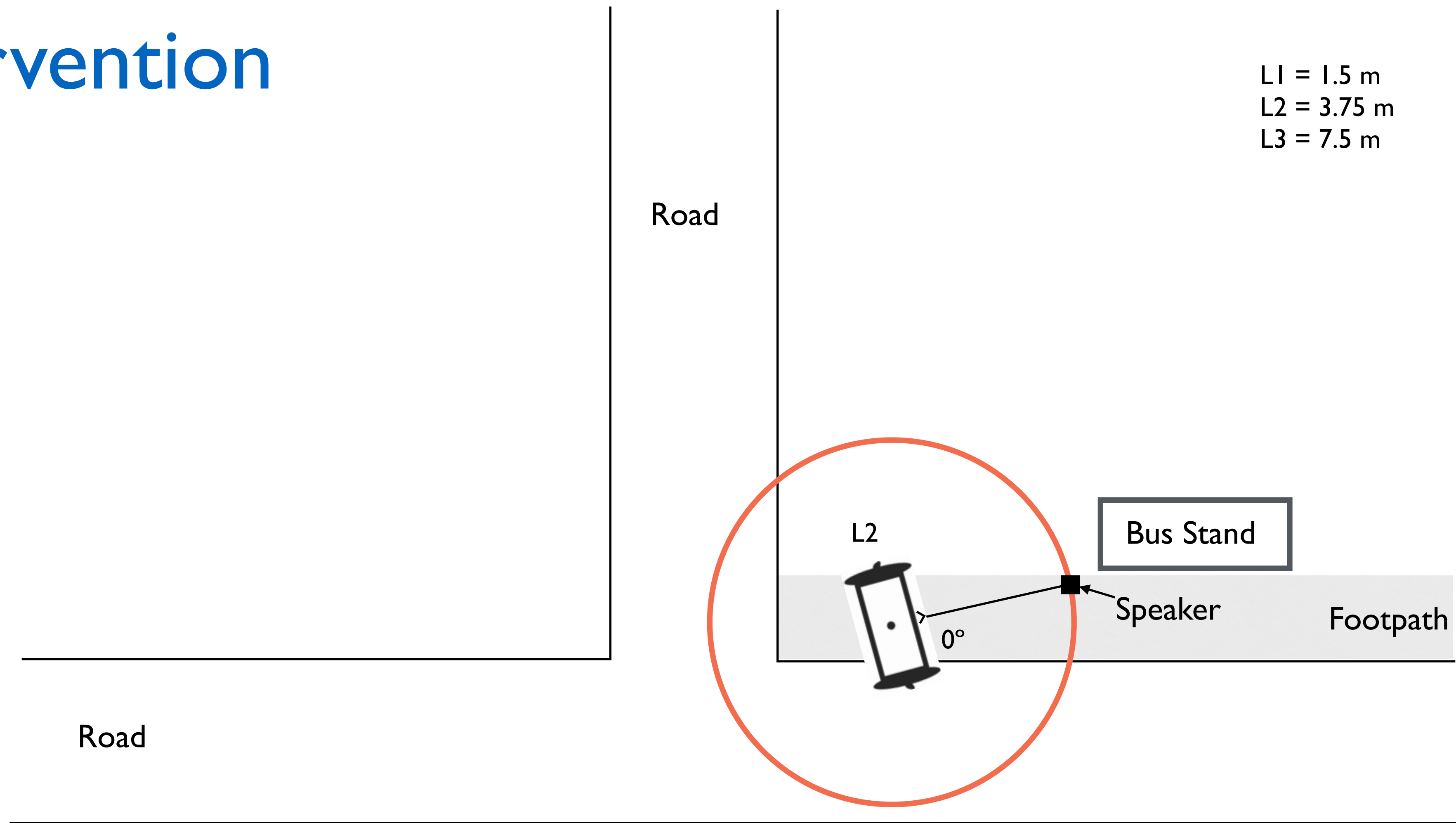
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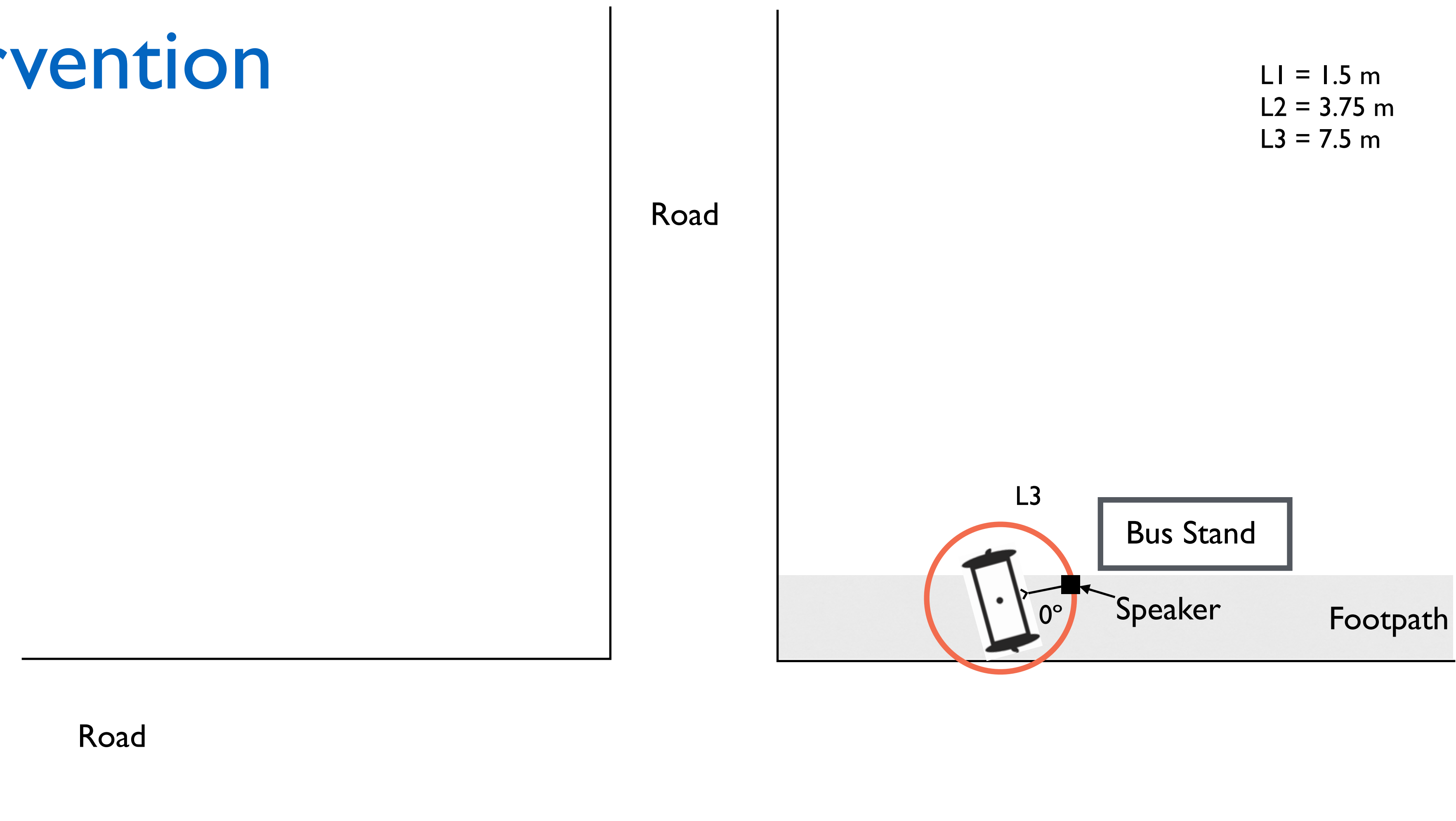
# Intervention



# Intervention



# Intervention



# Recording I

# Recording 2

# Recording 3

# Method

- Participants sit in a stationary chair
- They do not move their head and body
- They listen to recordings and point in the direction of sound
- A gap of 2 mins like a palette cleanser is provided

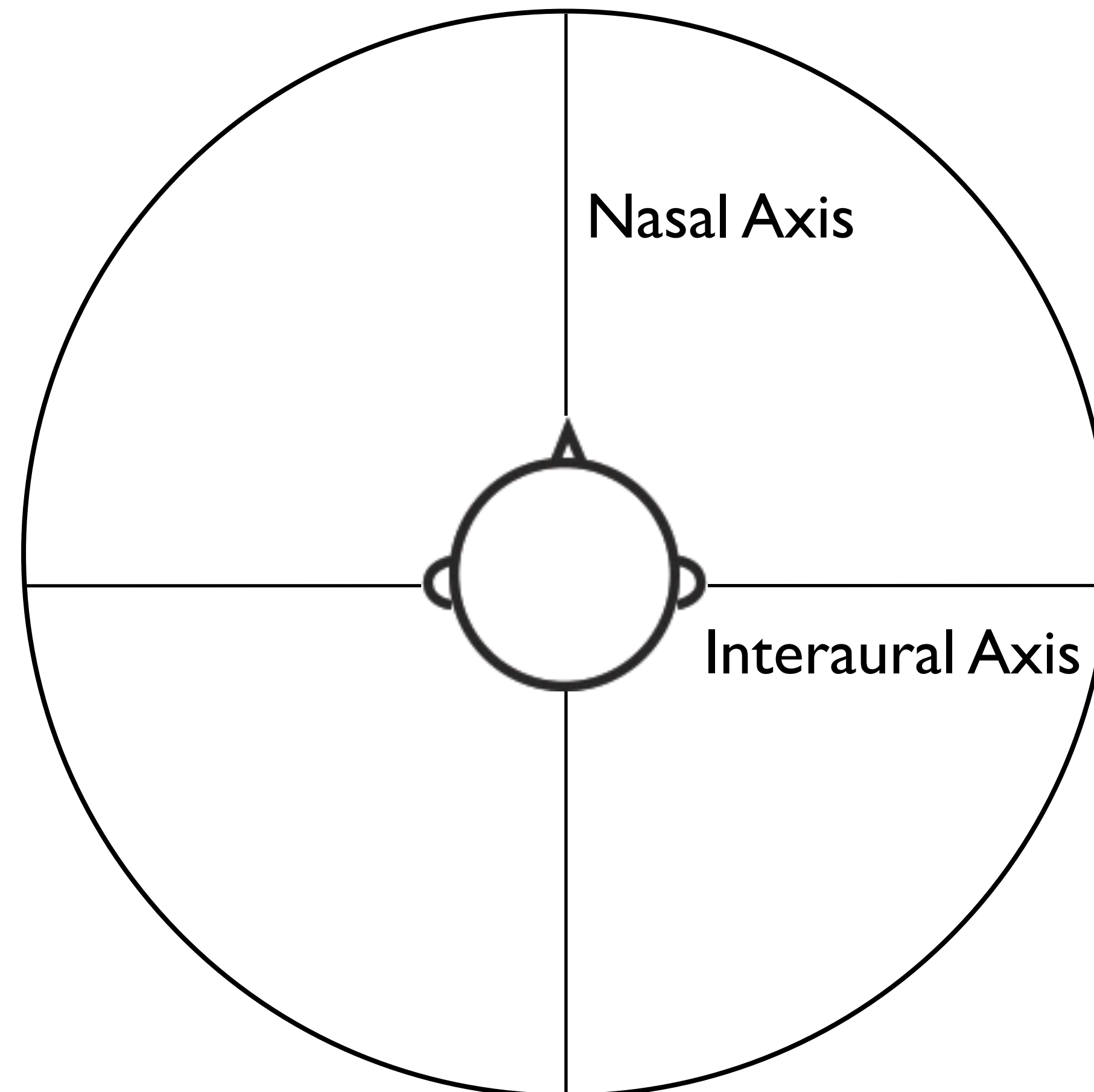


# Method

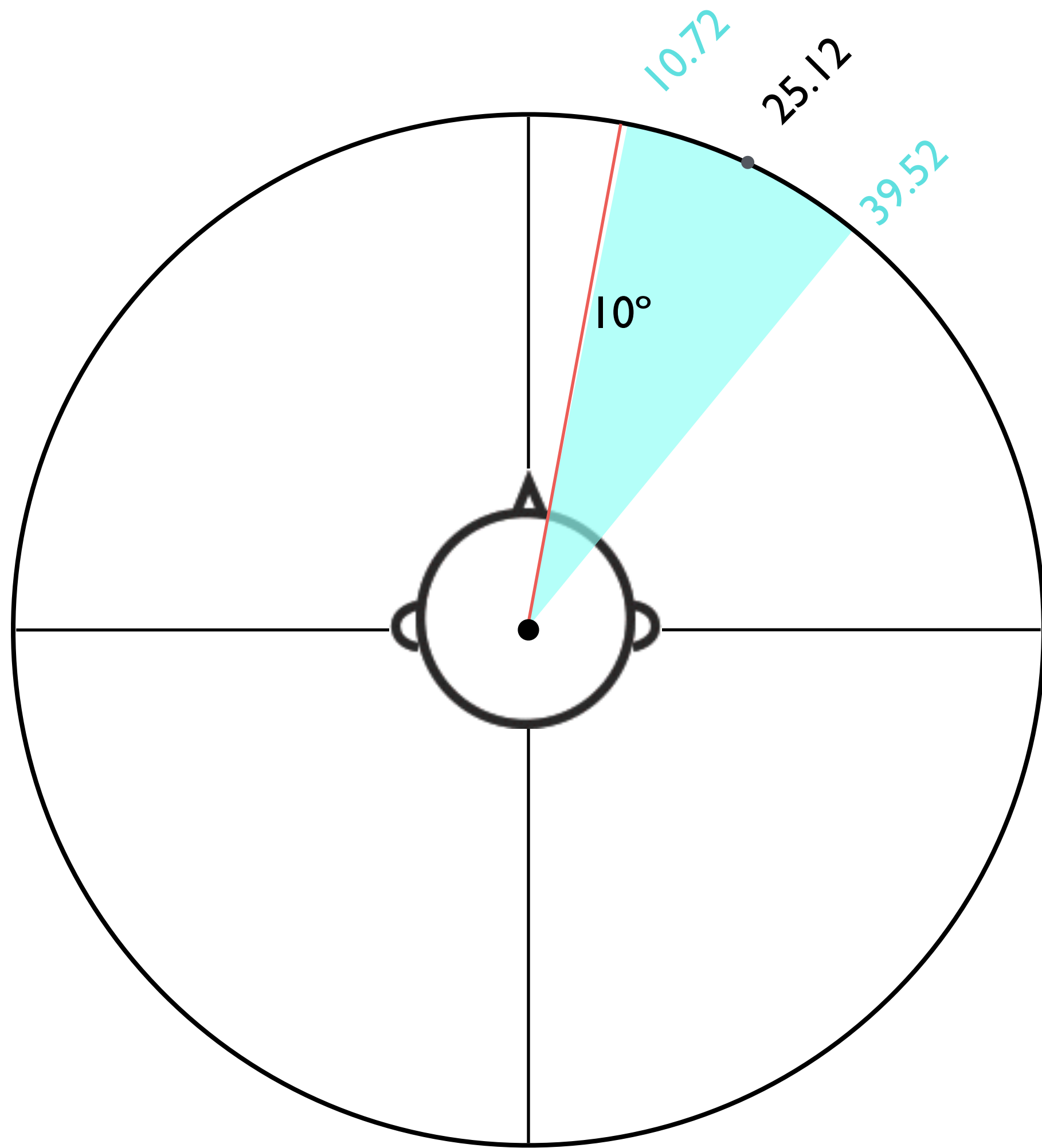
- For distance, step count for the distance is taken
- Stride length is measured and multiplied by step count to determine depth perception

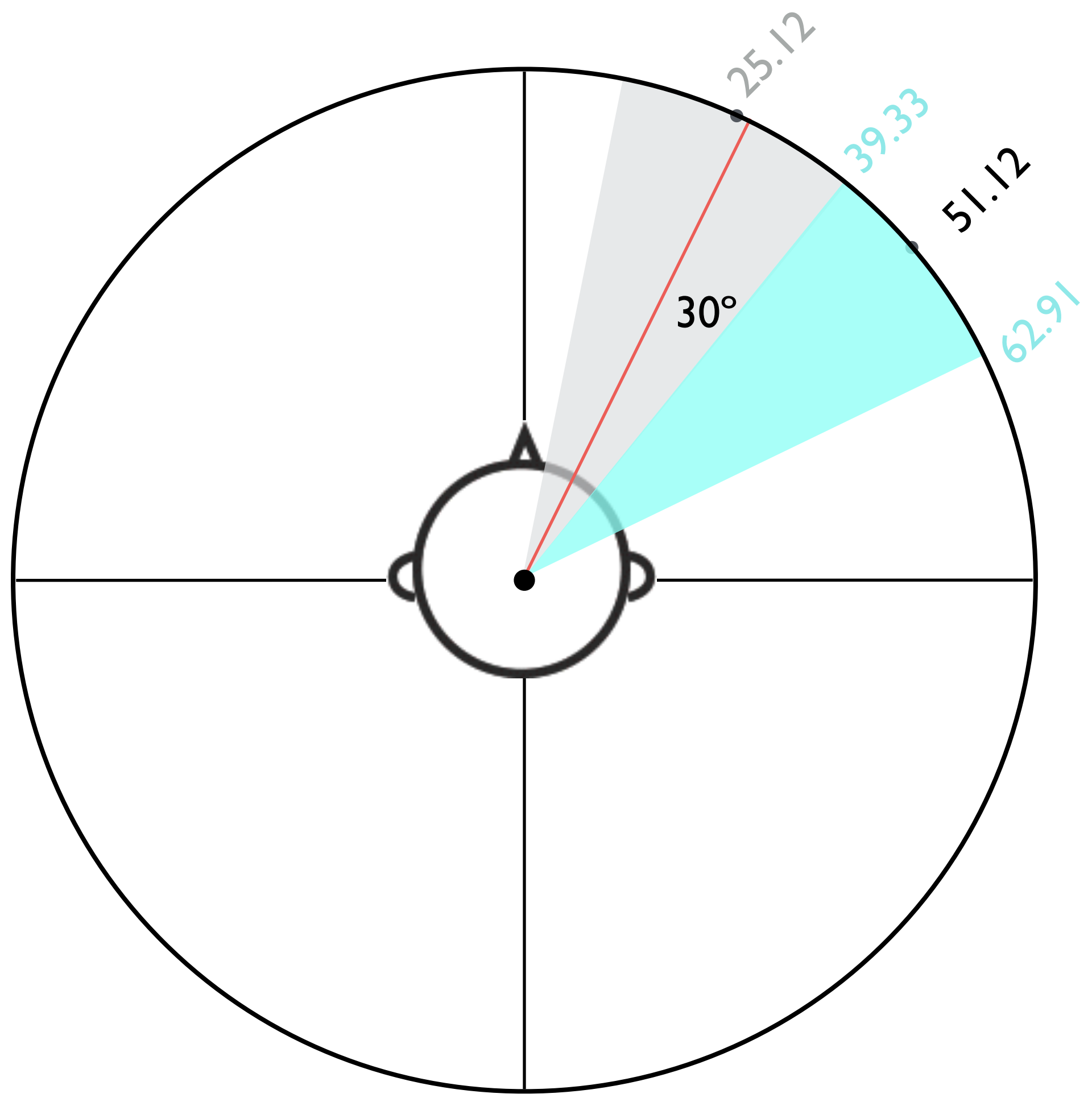


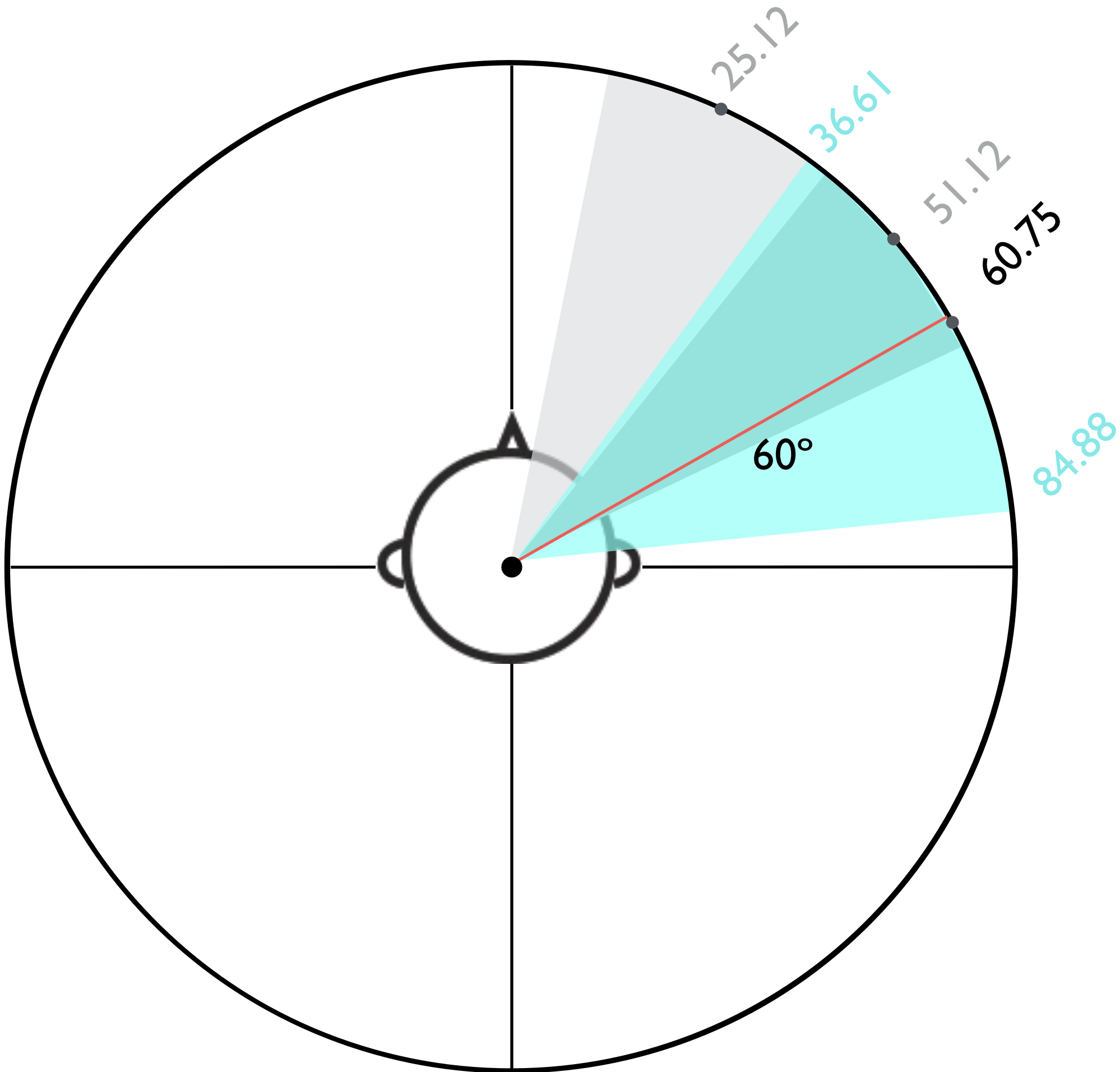
# Top view of a participant

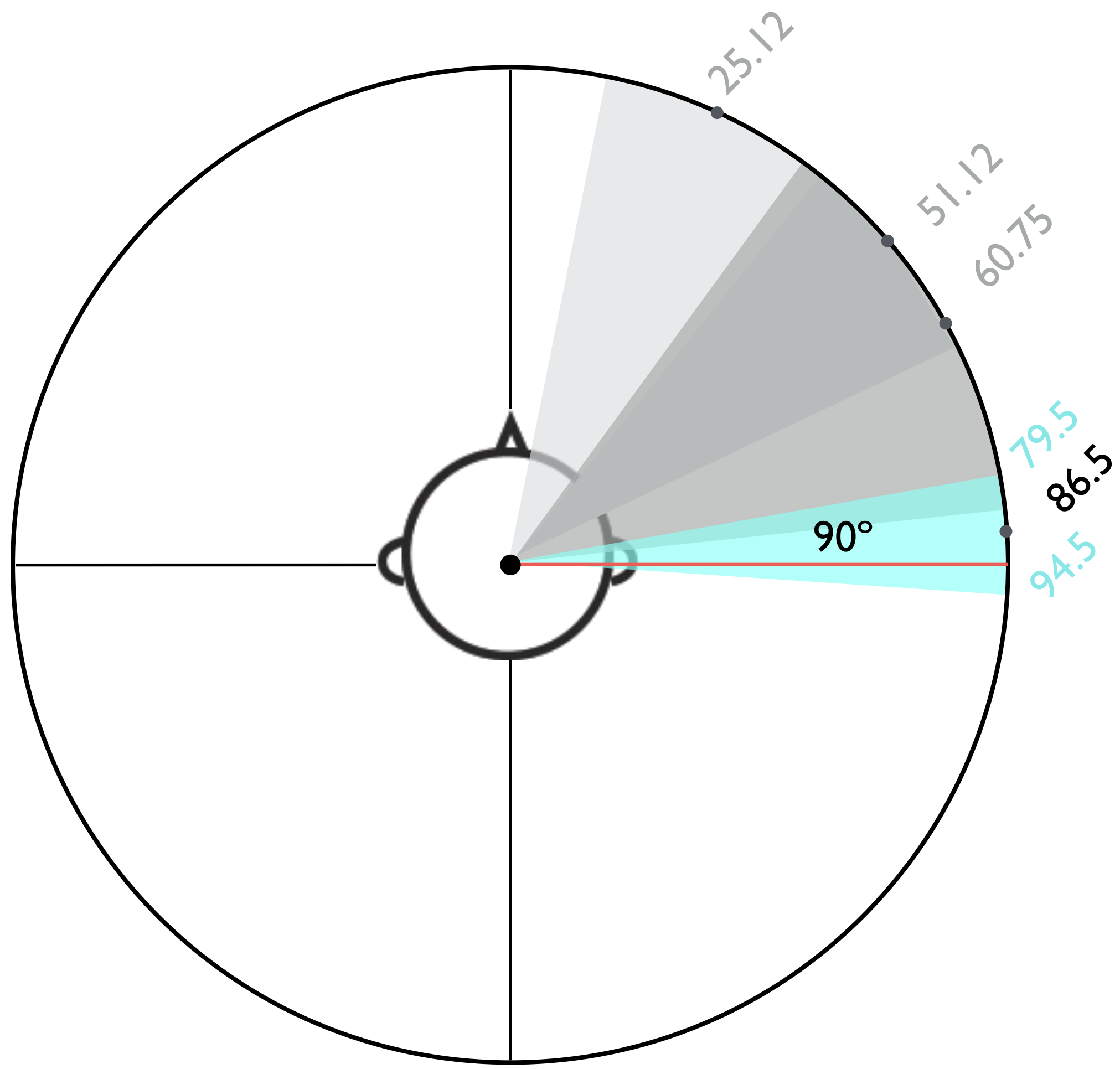


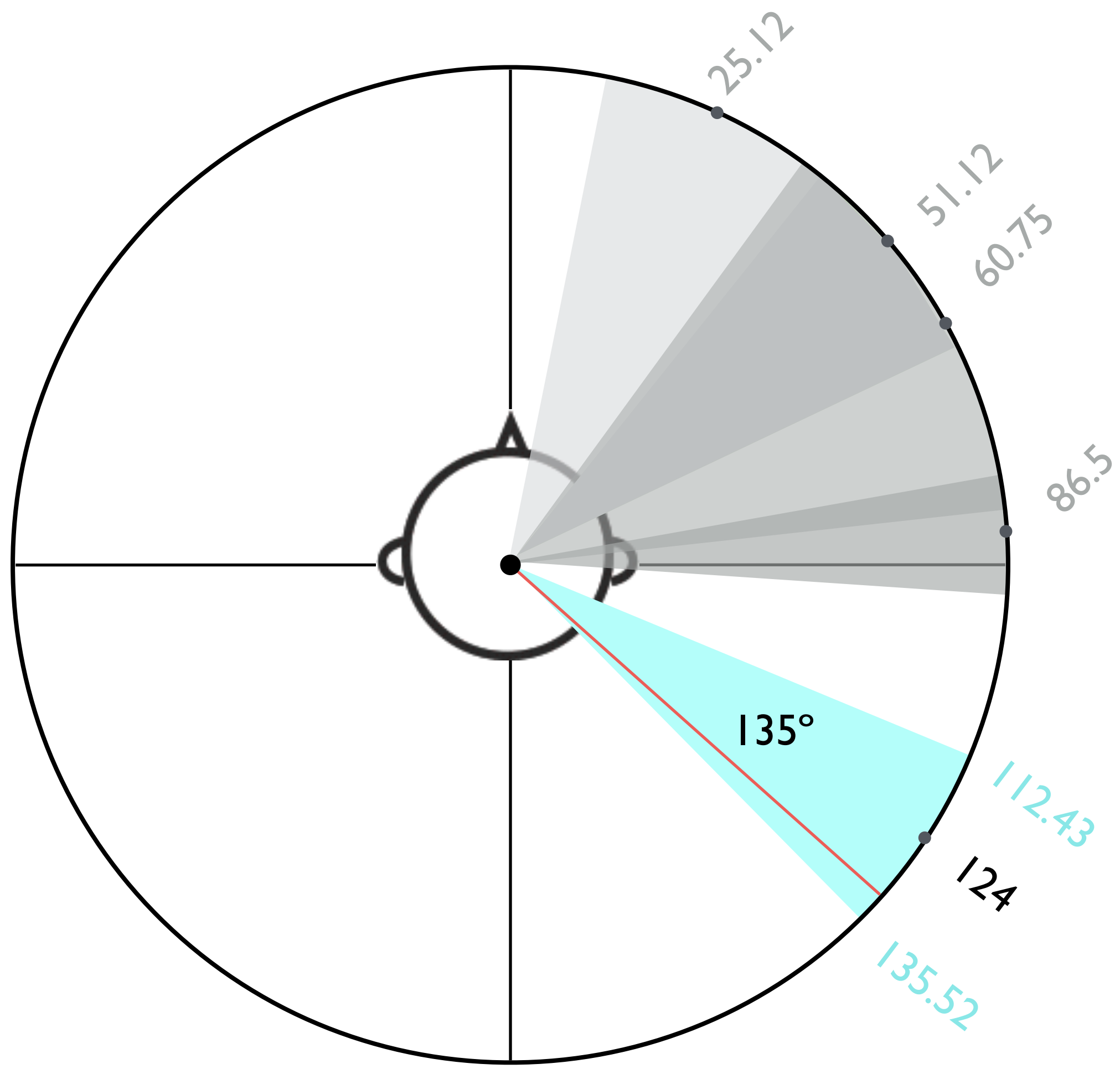
# Results

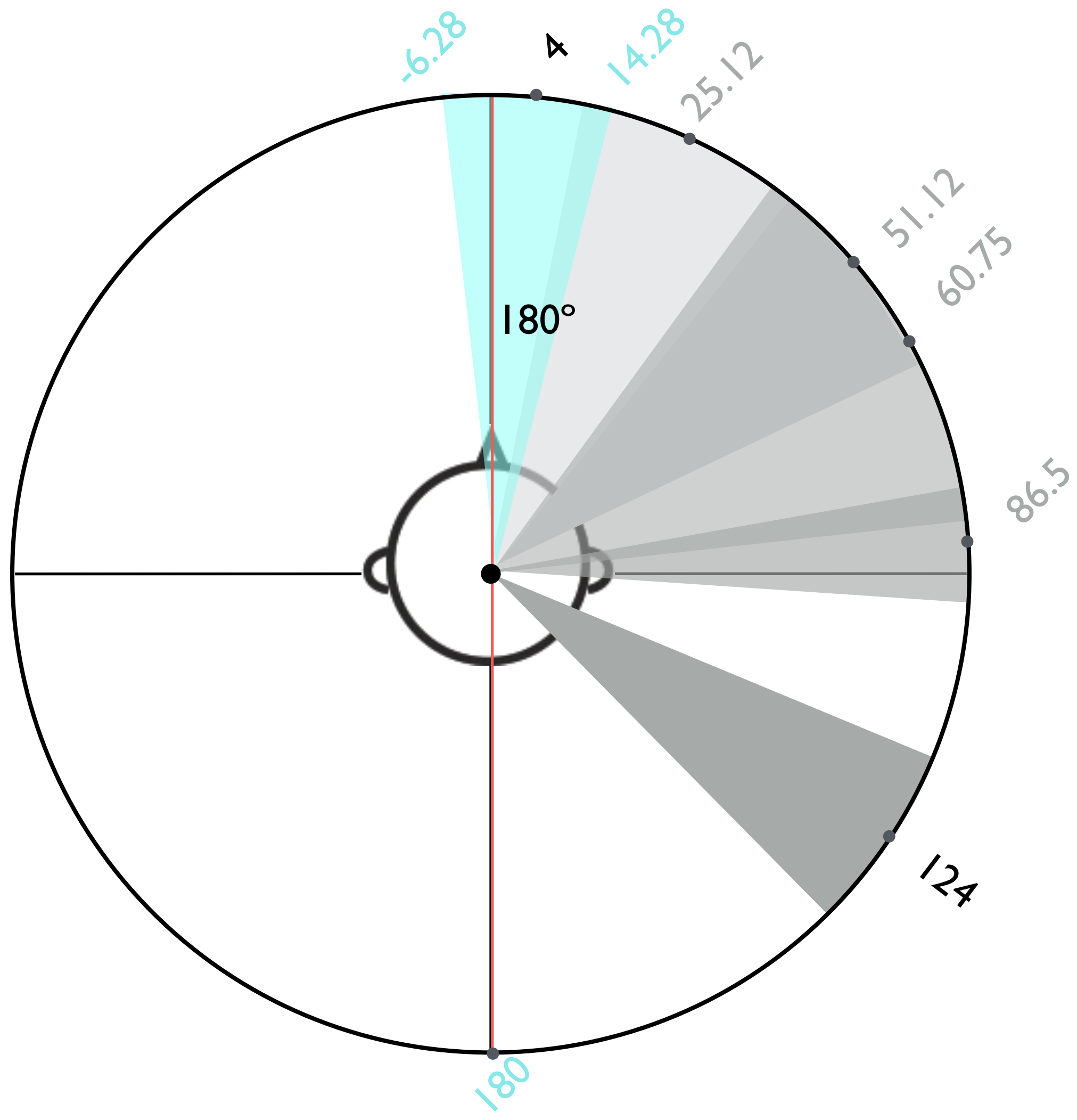




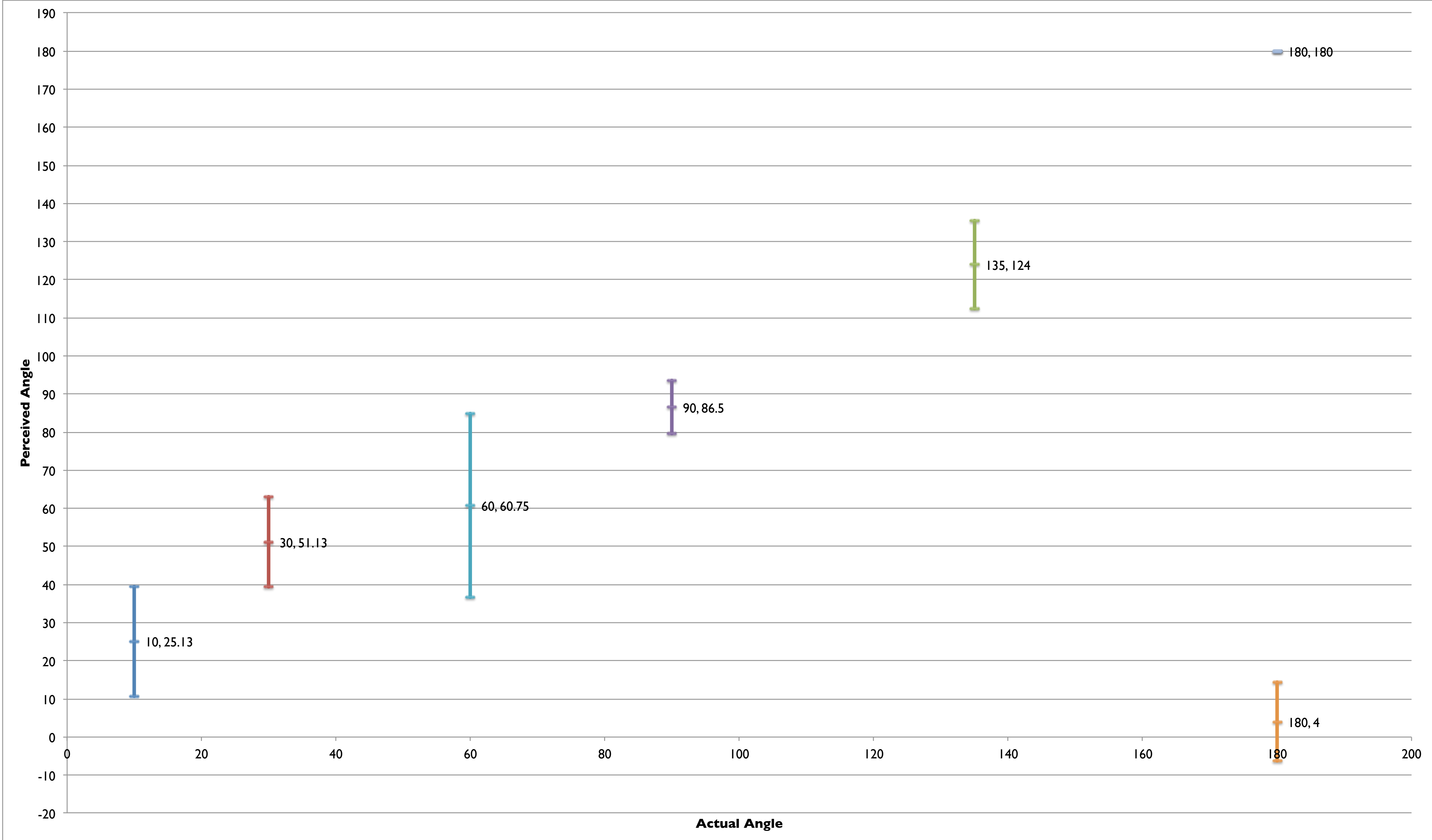




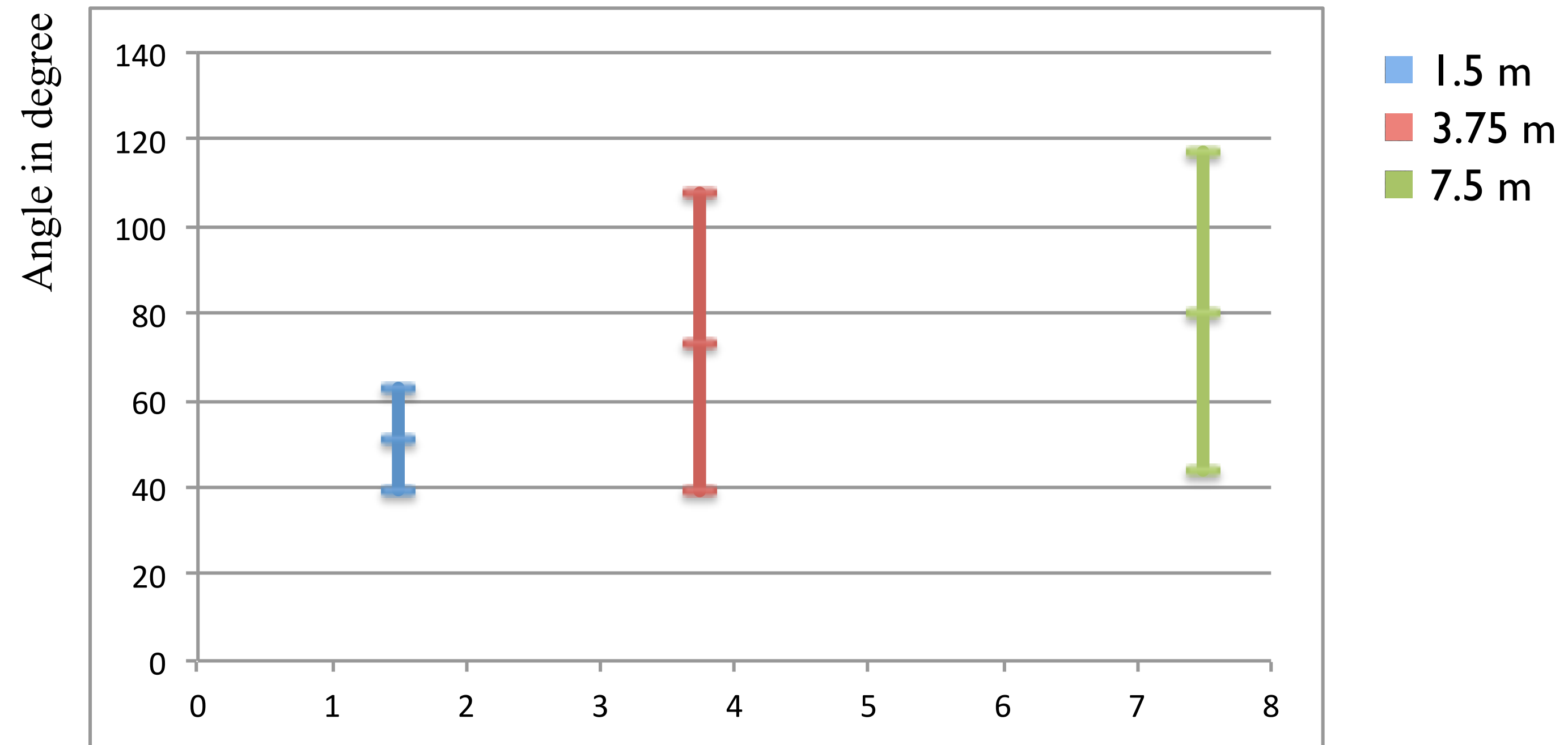




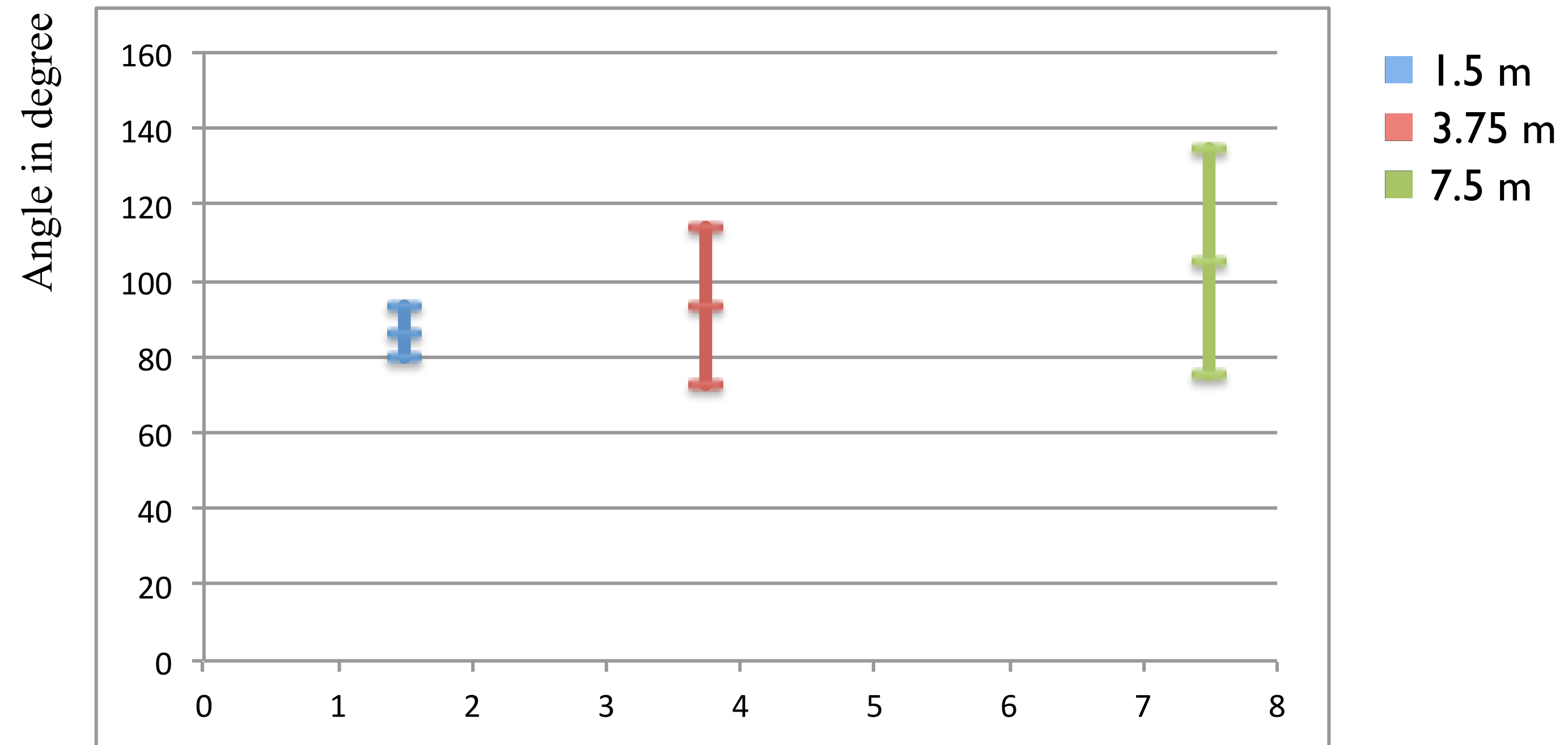
# 95% CI - 1.5m distance



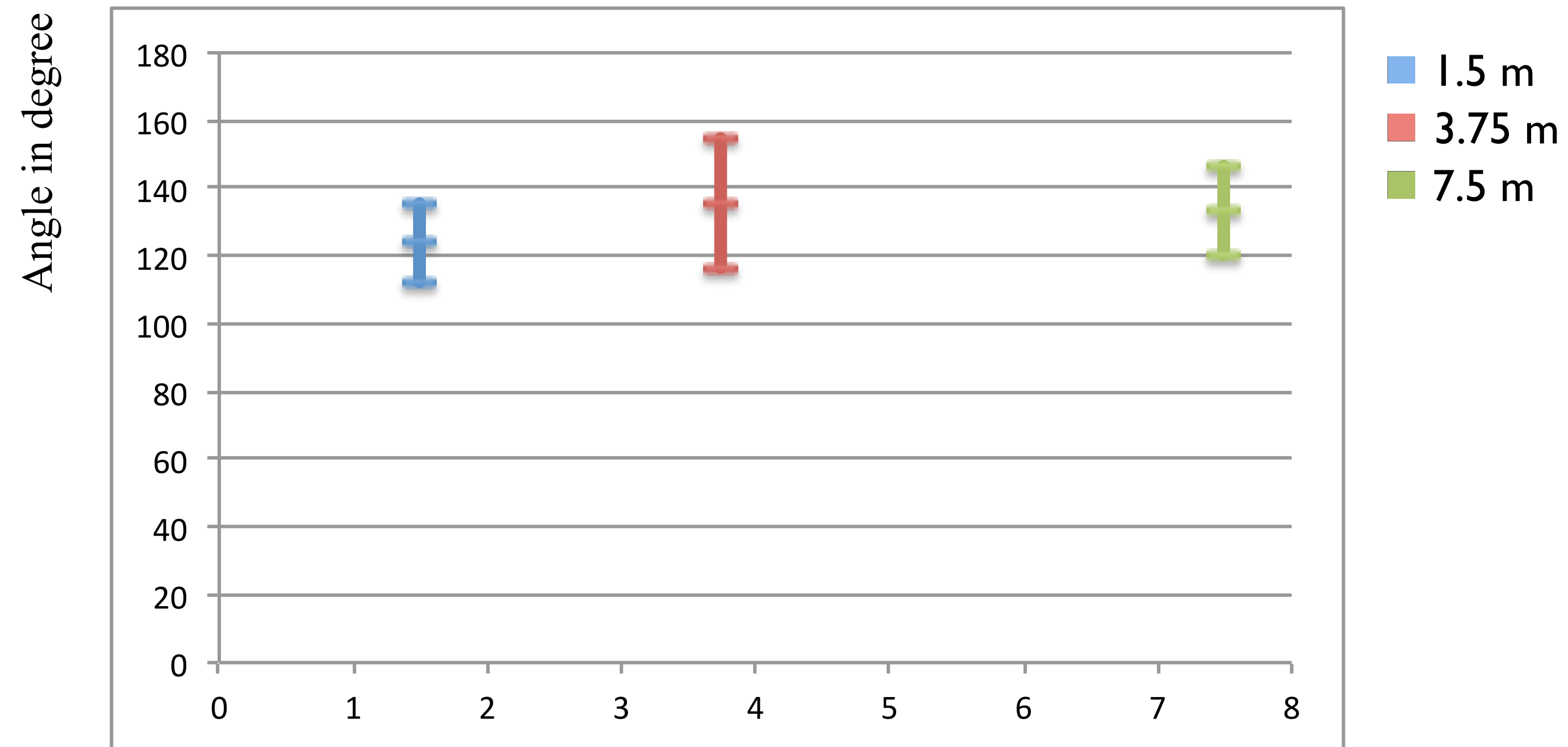
# How is 30° perceived at different depths?



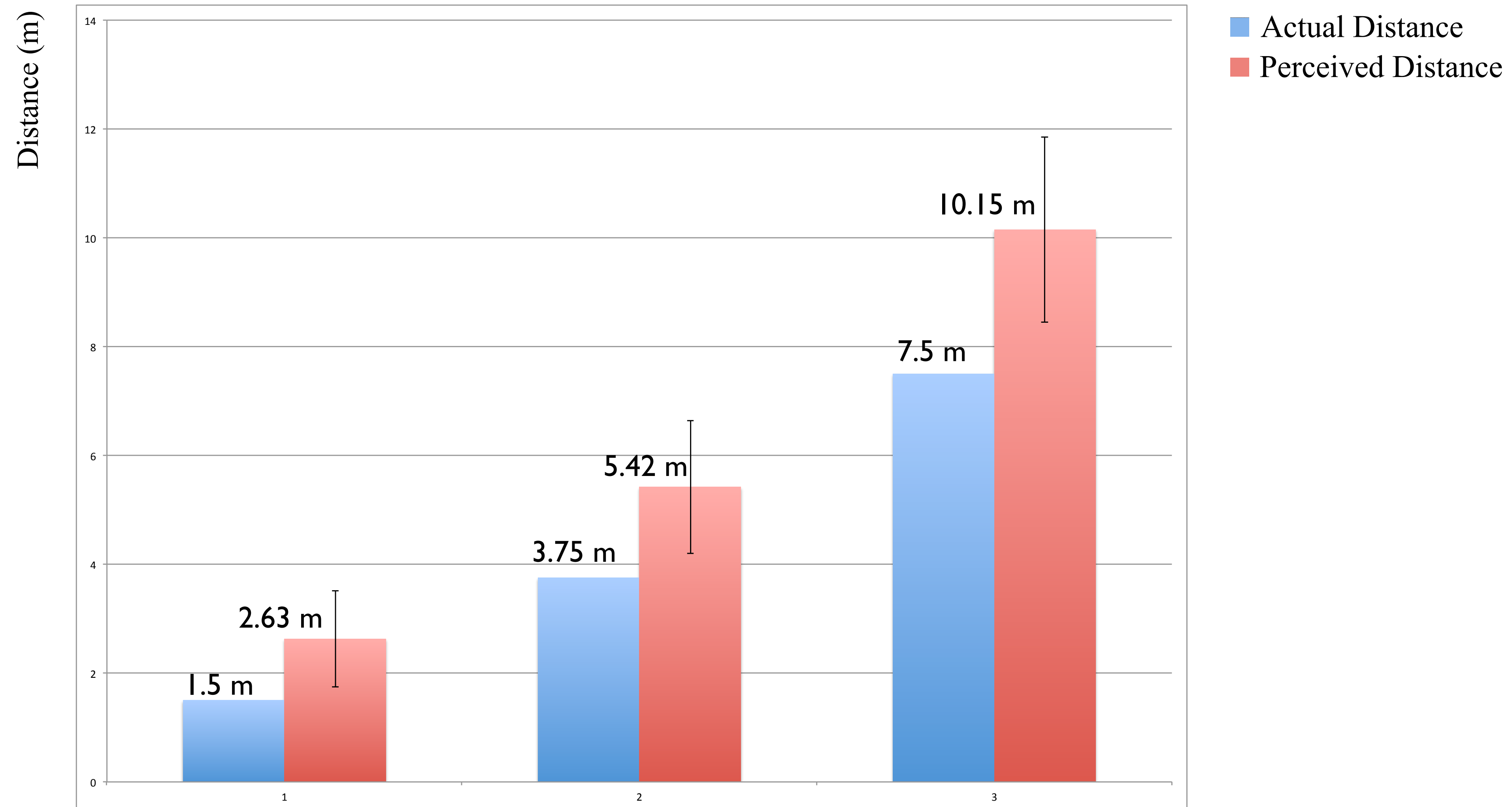
# How is 90° perceived at different depths?



# How is $135^\circ$ perceived at different depths?



# Depth Perception



# Qualitative Findings

- Since the movement of head was restricted, the participants needed reference position to identify the other directions
- Participants identified the direction of traffic flow while listening
- The angles behind the head required listening to the recording thrice at times.
- The resolution at the inter-aural axis was higher and they heard it for very less time before pointing in the direction of sound

# Design Implications

- To help visually impaired orient, the angle 0 and 180 should not be used, since they get confused
- Source at 90° and 45° can be used since there is clear distinction
- Depth cues require a reference and may work well when a person is walking towards it or away from it.
- The traffic noise or generic noise that can be given as a point source can be used in place of a song playing on speaker