The effect of the task locations on a pointing task performed in a VR spatial navigation study

by

Nora Maleki, B.A.

A thesis submitted in partial fulfillment of the requirements
for the degree of Bachelor of Science
Department of Cognitive Science
Institute of Cognitive Science

submitted to

University of Osnabrück

First Supervisor: M.Sc. Tracy Lorraine Sánchez Pacheco
Second Supervisor: Prof. Dr. rer. nat. Gordon Pipa
Submitted: August 2022

Declaration of Authorship

I, Nora Maleki, hereby certify that the work *The effect of the task locations on a pointing task performed in a VR spatial navigation study* presented here is, to the best of my knowledge and belief, original and the result of my own investigations, except as acknowledged, and has not been submitted, either in part or whole, for a degree at this or any other university.

Nora Maleki, 980385

Eidesstattliche Erklärung

Hiermit erkläre ich, Nora Maleki, dass ich die vorliegende Arbeit *The effect of the task locations on a pointing task performed in a VR spatial navigation study* selbständig und nur unter Benutzung der angegebenen Literatur und Hilfsmittel angefertigt habe. Die Stellen, die anderen Werken – auch elektronischen Medien – im Wortlaut oder dem Sinn nach entnommen sind, sind durch Quellenangaben im Text deutlich gekennzeichnet. Die Arbeit wurde bisher in gleicher oder ähnlicher Form keiner anderen Prüfungsbehörde vorgelegt und auch noch nicht veröffentlicht.

Nora Maleki, 980385

Abstract

This thesis is investigating the effect of starting locations from which a pointing task in a spatial navigation study inside a virtual reality (VR) city was performed. The experiment consisted of two parts, i.e., exploration and testing. In the exploration part, the participants were instructed to freely explore the city. After five exploration sessions, a testing session took place where the participants were put in 28 different locations in the city, and from each, they had to perform 12 trials. They were shown a photo of a building inside the city. The task was to indicate the direction of the building.

The experiment is a Ph.D. project designed mainly with a social context, realized by placing human agents inside the city in front of context meaningful and non-meaningful buildings. Two main dependent variables were measured in this study, i.e., the absolute angular deviation from the target building and the reaction times. In order to investigate those factors, it was important to have knowledge about the effect of the locations the tasks are performed. This led to this work.

In this work, the effect of the starting locations on the absolute angular deviation from the target and the reaction times were analyzed with linear mixed models. The results showed significant effects of some locations but not others on the dependent variables. It appeared that the difference could be due to the placement of the different locations in the city. The ones that were closer to the edges had better performances than the ones in the middle of the city. This could be caused by the opportunity to eliminate some directions if it was clear that the city does not exist on a side of a location. Furthermore, it seemed that there could be also other factors or interactions of starting locations with other factors which might better explain the data.

Acknowledgements

First and foremost, I would like to thank my supervisor, M.Sc. Tracy Sánchez Pacheco for her patience, guidance, and understanding, not only during this supervision but since the time I got the honor to get to know her and learn from her.

I would like to thank Tracy and Prof. Dr. Pipa for giving me the opportunity to work on this project and for their help and support.

It is close to five years since I last had the chance to be with my family. There is no possibility to thank them enough for consistently giving me their infinite love and support from another side of the world, helping me through ups and downs, and helping me get here, to where I am today.

I would like to thank Linus and Özge for being there for me with their love and support.

Last but definitely not least, I would like to thank Tracy Sánchez Pacheco, Kaya Gärtner, and Mohammad Ghorbani for gathering the data used in this thesis, which without this work would not have been possible.

Contents

1. Introduction **1**

2. Methodology **3**
- 2.1. Participants . . . 3
- 2.2. Data gathering . . . 3
- 2.3. Experimental Design . . . 4
  - 2.3.1. City . . . 4
  - 2.3.2. Application and Technology . . . 4
- 2.4. Experimental Procedure . . . 5
  - 2.4.1. Exploration . . . 5
  - 2.4.2. Testing . . . 6
- 2.5. Analysis method . . . 9
  - 2.5.1. Preprocessing . . . 10
  - 2.5.2. Analysis . . . 12
  - 2.5.3. Code accessibility . . . 13

3. Results **14**
- 3.1. Summary statistics of dependent variables . . . 14
  - 3.1.1. Absolute angular deviation . . . 14
  - 3.1.2. Reaction times . . . 15
- 3.2. Extremes at starting locations . . . 15
  - 3.2.1. Absolute angular deviation . . . 15
  - 3.2.2. Reaction times . . . 17
- 3.3. Linear mixed effects model . . . 17
  - 3.3.1. Absolute angular deviation . . . 17
  - 3.3.2. Reaction times . . . 21

4. Conclusion **26**

References **28**

A. List of starting locations **31**

B. Additional plots **36**

C. Forms **42**

List of Figures

2.1. The virtual city 5
2.2. Distribution of starting locations 7
2.3. Target buildings 8
2.4. Start of trial cue 8
2.5. Trial's target photo positions 9
2.6. The countdown timer 9

3.1. Distribution of the absolute angular deviation 14
3.2. Distribution of reaction times 15
3.3. Best starting location based on angular deviation 16
3.4. Worst starting location based on angular deviation 16
3.5. Locations of best and worst starting locations in city 17
3.6. Fastest starting location 18
3.7. Slowest starting location 18
3.8. Locations of fastest and slowest starting locations in city . . . 19
3.9. Residuals of LMM absolute angular deviation by starting location 19
3.10. Significance and meaningfulness (absolute angular deviation predicted by starting location) 22
3.11. Residuals of LMM RT by starting location 25
3.12. Significance and meaningfulness (RT predicted by starting location) 25

A.1. Starting locations 1-4 32
A.2. Starting locations 4-12 33
A.3. Starting locations 13-20 34
A.4. Starting locations 21-28 35

B.1. Distribution of absolute angular deviation from the target, reaction times and distance to target 36
B.2. Box plot of absolute angular deviation from the target, reaction times and distance to target 36
B.3. Box plot by subject 37
B.4. Box plot per starting location 38
B.5. Box plot per consecutive trials at each starting location 39
B.6. Angular deviation from the target in all trials 40

B.7. Angular deviation of starting locations from the target by meaningfulness 40
B.8. Absolute angular deviation of the fastest starting location . . 41
B.9. Density of absolute angular error against reaction times . . . 41

List of Tables

3.1. Absolute angular deviation by starting locations 19
3.2. Significant locations in absolute angular deviation predicted by starting location 21
3.3. RT predicted by starting locations 22
3.4. Significant locations in RT predicted by starting location . . . 24

A.1. Starting locations' information 31

Imagine a long blackout, the eyes are closed and there is no sound. The consciousness is slowly coming back and the question arises: where am I?

1. Introduction

Spatial navigation entails the orientation and movement planning in an area. In the field of Cognitive neuroscience, it is investigated how space, "the abstract of all co-existence" (Spencer, 1867), is processed by the brain, memorized, and retrieved for navigation.

Over the past centuries, theories were developed about how space and the relation to its objects, thus distance, is represented in the brain, e.g., Cassirer (1955) categorizes spatial knowledge in three different temporal levels: first a close encounter with the objects and their spatial relation to one another that allows for interaction with them. The second level contains a wider space that allows for building the relationship between routes and mental maps. Realizing the relations of the places, routes, etc using the symbolic system to represent a space is the last level (Cassirer, 1955).

Performing studies outside of the laboratory condition could have difficulties regarding control of the surrounding environment, replicability and ecological validity. VR is a reachable solution for these problems (Chicchi Giglioli et al., 2017; Diersch & Wolbers, 2019; Pan & Hamilton, 2018). VR offers a range of advantages compared to conducting the experiment in the real world. From VR experiments, in addition to the classical behavioral data such as response times, a broader range of variables can be recorded, e.g., movement of the body, hands, head, and eyes (Pan & Hamilton, 2018). Needless to say that these variables can be gathered in a controlled environment when utilizing VR as the method of measurement (McIlvenny, 2020). These can be also very beneficial for spatial navigation studies.

Human beings are born and grow up in social environments. They take the social aspects of their surroundings as their own (Berger & Luckman, 1967). They interact with society and interpret reality by what their culture is constructed of (Siegel & White, 1975). These aspects are also applicable in spatial navigation. Kuehn et al. (2018) shows that the social components can even be more powerful factors for encoding space when their participants perform consistently more accurately as they have to guess the position of the human agent as the target in comparison to the position of an object.

The present work is a small part of the Human-A project, a Ph.D. project built and executed at the Neuroinformatics department of the institute of

Cognitive Science at the University of Osnabrück. Human-A is a spatial navigation experiment in a small European fictive VR city. The study conducted in this environment aims more at the social aspects and their effects on learning the space by using the functionality of some buildings, i.e., the social meaning of shops, e.g., bakery, bookstore, and adding human agents to the environment. The participants get the chance to explore and learn about the city before the test session. Testing is a pointing task performed from different locations in the city, showing photos of buildings from the city and asking them to point towards them. The behavioral data gathered from the tasks consist of the angular deviation of the participant's chosen direction from the actual target location, and reaction times data.

The Human-A study leans toward the social factors of spatial navigation, hence it is essential for validity to check whether the other existing factors in the experiment could be confounding. One of those factors is the different locations from which the participants perform the tasks, i.e., the different starting locations.

Investigating the effect of the social aspects of the environment entails having built a mental map and knowing the city, then it is hypothesized in this thesis that the change in starting locations has no effect on the angular deviation from the target building and as well has no effect on reaction times.

2. Methodology

This thesis is a small part of the Human-A project, a Ph.D. project of M.Sc. Tracy Sanchez Pacheco, at the Neuroinformatics department of Cognitive Science institute of the University of Osnabrück. The project contains different M.Sc. and B.Sc. theses work.

2.1. Participants

A total number of 23 participants (12 male, mean age of 23.1 years, SD = 4.1) took part in the experiment. The participants were all students of the University of Osnabrück. Before the start of the first exploration session all participants were informed about the procedure of the experiment and gave their written consent to taking part in the study (see appx. C, Einverständniserklärung). The participation was voluntary and only students with no health issues were selected (see appx. C, Anamnese). The participants were compensated by test-subject hours and/or 5€ per hour.

Due to the Covid-19 pandemic sessions were conducted according to the laboratory hygiene regulations with a mask and under the 3G rule.

3 participants were excluded due to not being able to comply with the experimental requirements, i.e., attending the different sessions in less than 3 days and more than 4 hours apart.

2.2. Data gathering

The data used in this work is gathered with the hard work of Tracy Sánchez Pacheco, Kaya Gärtner, and Mohammad Ghorbani.

2.3. Experimental Design

2.3.1. City

This study was conducted in a virtual reality (VR) city with an area of about 1 (virtual) km^2. The city (see figure 2.1) consisted of 284 buildings. 56 buildings were used in the experimental task of which 4 were global landmarks, 26 were `context meaningful` locations, e.g., shops, construction sites, and 26 were residential, `not context meaningful` buildings. These 56 buildings had human agents in front of them and some artwork on one of their walls. Human agents belonging to the meaningful areas took the pose of an act according to the functionality of that store `(meaningful)` (see figure 2.3a), e.g., had a book in the hand in front of a bookstore, or were just standing in front of the residential building `(standing human agent)` (see figure 2.3c).

A sun with a detectable origin was avoided in the city, no street was named and no building was numbered to implicitly direct the participants to prioritize their spatial learning. Furthermore, there were borders around the city so that participants cannot exit the city area.

2.3.2. Application and Technology

The experiment was implemented with unity game engine (Haas, 2014) version 2019.4.11f1. The assets of the city, e.g., buildings, and streets were obtained from a previous study called SpaRe, made also at the University of Osnabrück. Buildings and streets were built with blender (Hess, 2010) version 2.83 LTS (Long Term Support), as were also the human agents picked from the Adobe Mixamo ("Mixamo," 2008) collection. They were modified to interact with an object that underlined the context (meaningfulness) of the area, i.e., holding a book in front of a book store.

The experiment consisted of two separate parts, i.e., exploration and testing. Each section had the option to choose the language of the instructions, i.e., German and English. The experiment was conducted using an HTC Vive Pro Eye VR Headset. For the virtual moving purposes inside the virtual city, the participants were given an Index valve controller to navigate inside a city by moving its joystick. They had the option of choosing between right or left controller according to their handedness preference.

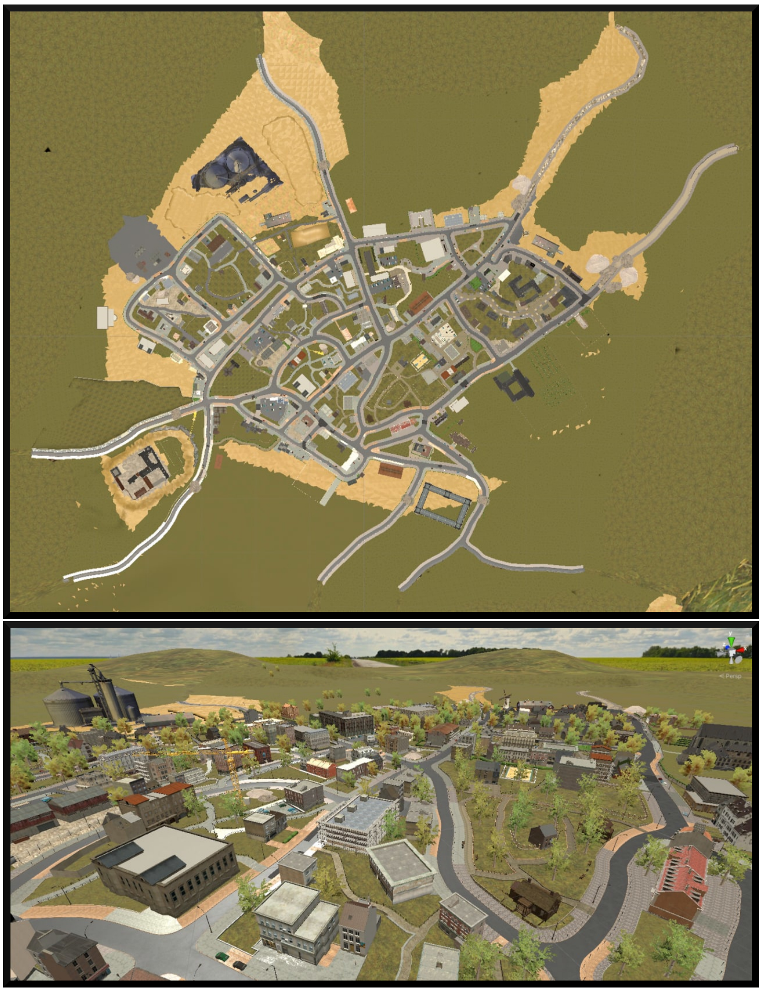


Figure 2.1.: the virtual city

2.4. Experimental Procedure

Participants were seated on a backless rotating chair that enabled them to physically rotate in the virtual city. Any forward, backward, and sideways movements were done utilizing the controllers.

2.4.1. Exploration

The exploration consisted of 5 sessions. The sessions had to be no more than 3 days and no less than 4 hours apart.

The total duration of each session was 30 minutes broken down into 10 minutes segments for breaks to reduce the possibility of motion sickness.

Before starting each segment the built-in eye-tracker of the VR Headset was calibrated and validated.

After inserting the participant ID and choosing the preferred language the exploration session started with a tutorial. The tutorial was held in a scene separate from the main city. The purpose of the tutorial was to allow the participant to move around, get acquainted with the controller, and practice the possible movement options the experiment allowed for. After participants confirmed their confidence in using the controllers the experiment was continued to the exploration session. In the main city, participants were advised to explore the city freely.

2.4.2. Testing

Testing comprised of one session of approximately 2 hours. The testing started after inputting the participant ID and choosing the language. Testing continued with a tutorial scene outside of the main city used in the experiment for participants to get acquainted with how to use the controller for performing the tasks.

Testing was a pointing task comprising 336 trials performed from 28 different starting locations in the city (see figure 2.2). At each starting location, 12 target buildings were randomly chosen from a pull of 112 targets (56 task buildings with and without human agents) for each participant individually (see figure 2.3).

Each of the four conditions of the experiment, i.e., context meaningful with human agent present `(CmA)`, context meaningful with no human agent present `(CmANo)`, non-context meaningful with human agent present `(Sa)`, non-context meaningful with no human agent present `(SaNo)` built up 25% of the trials. The starting locations themselves were consistent for all participants and their order of execution was randomized for each participant.

All movements except the rotation were blocked for the whole testing session to maintain the consistency of the participant's position in the starting locations between participants.

At each starting location, 12 consecutive trials were performed. Before the trial began a green circular loading bar `(Go cue)` was shown in the middle of the screen for 25ms (see figure 2.4). As soon as the bar was complete, it disappeared and a beep sound was played informing the participants of the start of a new trial.

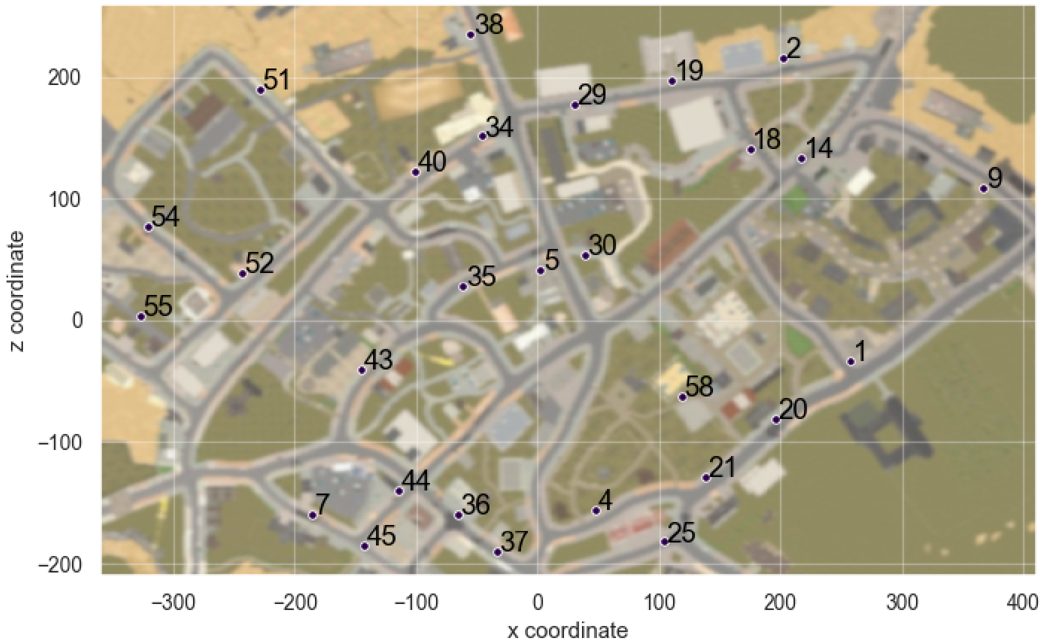


Figure 2.2.: distribution of the starting locations in the city with their IDs used in unity and for the analysis

In each trial, a photo of one of the task buildings, with or without a human agent in front of it (see figure 2.3) was presented at the top center of the screen (see figure 2.5a). The participants had the option to press the trigger button to bring the picture to the middle of the screen (see figure 2.5b). As soon as the button was released the photo moved back to the upper center part of the screen.

Since there was no visual virtual body, there was a green dashed laser beam (visible in figures 2.5b) attached to the virtual hand of the participants that moved as they moved their hands. The purpose of the laser beam was to assist the participants with the visualization of the direction they were pointing at. The maximum duration of each trial was 30 seconds. If there was no answer given to the task after 20 seconds from the start of the trial, i.e., no direction was selected by the participant indicating in which direction the target building was located from their current location, a countdown timer appeared on the bottom center of the screen (see figure 2.6) and terminated the trial after 10 seconds if there was still no answer given.

Selecting an answer for the task, i.e., selecting the direction of the target building was possible with a button press. Once pressing the button it locked the laser beam onto a direction and detached it from the hand. The participants had the option to either confirm the chosen direction with the same button or cancel it with another. Moving on to the next trial was the

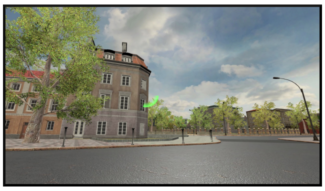
a) CmA

b) CmANo

c) Sa

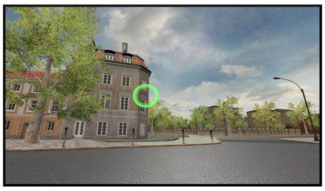
d) SaNo

Figure 2.3.: Examples of photos shown in the pointing task as target buildings. A selection of all four experimental conditions. **CmA:** context meaningful with human agent present. **CmANo:** context meaningful without human agent present. **Sa:** not context meaningful with human agent present. **SaNo:** not context meaningful without human agent present.



a) go cue loaded at 30 %

b) go cue loaded at 80 %



c) go cue completely loaded

Figure 2.4.: The circular loading bar with the duration of 25ms showed as a cue of the start of a new trial

result of either the participant confirming a direction or running out of time. Behavioral and technical data, e.g., the chosen direction, participant position, and rotation and reaction times were gathered during each trial. The human agents were present during the testing in the city at their exact designated positions and pose during the exploration sessions. A gray screen fade-out and fade-in occurred while transporting the participants from their current location to another starting location. This was to serve the purpose of decreasing the chance of motion sickness and also avoiding

a) default position, top

b) optional position, center

Figure 2.5.: The default (a) and the optional positioning (b) of target photos in each trial. The dashed green laser beam helped the participants to see where they are pointing at

Figure 2.6.: the countdown timer appears at the bottom of the screen after 20s has passed from the trial

leaking environmental information while moving inside the city.

2.5. Analysis method

The data of this experiment was gathered from unity in JSON [1] format. All the further processes for analysis were done in python (Van Rossum & Drake, 2009) v3.8. For the preprocessing the pandas (McKinney, 2010; pandas development team, 2022), numpy (Harris et al., 2020) and scipy (Virtanen et al., 2021) libraries, and for the analysis python's statmodels (Seabold & Perktold, 2010) module were utilized. Matplotlib (Hunter, 2007) and seaborn (Waskom, 2021) were used for the visualizations.

[1] Introducing JSON: https://www.json.org/json-en.html

After importing and converting the data into a pandas dataframe, the preprocessing was done to prepare the data for analysis. In this process the dependent variable `absolute_180_angle` was derived. The variable contained the absolute angular deviation of the participant's chosen direction from the actual target position.

2.5.1. Preprocessing

Different functions of pandas `(pd)` and numpy `(np)` were used for the preprocessing. In all the calculations involving directions and positions, only the right direction (x) and the forward direction (z) were taken into account. The up direction (y) was excluded as it is not relevant for the analysis at hand.

The main preprocessing steps were as follows:

1. Removed trials in which the participants did not select any direction. These were the trials that were terminated due to timeout. Hence, only the trials where their respective TimeOut variable was False were kept for the analysis. a total of 20 trials were removed.

2. Calculated the participant's chosen direction's absolute angular deviation from the actual location of the target building.

   a) Translated the target building's center position `(Tpos)` by the participant's body position `(Ppos)` to be able to derive the translated building center position *Tpos_t* to make the body position as the origin at the (0,0) coordinates.

   $$Tpos\_t_{x,z} = Tpos_{x,z} - Ppos_{x,z}$$

   The direction vector of the participant's chosen direction didn't need to be translated because unity's output for a direction was a normalized vector and therefore its origin lied already at (0,0).

   b) Now that body position was at (0,0) with respect to the translated building center position, the angle difference between the participant's chosen direction `(Cdir)` to the positive x-axis and the translated building center position `(Tpos_t)` to the positive x-axis were calculated using numpy arctan2(z, x) [2] function. This function calculated the angle in radian between the positive x-axis

[2]Numpy arctan2: https://numpy.org/doc/stable/reference/generated/numpy.arctan2.html

and the vector given to the function as a parameter.

Due to the translation done in step *a* the body position was implicitly translated to the origin (0,0), i.e., subtracting body position from body position resulted in (0,0), it was possible to pass the z and x coordinates of the `Tpos_t` and the `Cdir` to the arctan2 function separately to calculate the angle between the `Cdir` and the positive x-axis `(Cdir_to_x)` and the `Tpos_t` and the positive x-axis `(Tpos_to_x)`. The results were directly translated to degree utilizing numpy rad2deg() [3] function.

$$Tpos\_to\_x_{\theta} = np.rad2deg(np.arctan2(Tpos\_t_z, Tpos\_t_x))$$
$$Cdir\_to\_x_{\theta} = np.rad2deg(np.arctan2(Cdir_z, Cdir_x))$$

c) After creating `Tpos_to_x` and `Cdir_to_x` the angles were respectively converted to `Tpos_to_x_360` and `Cdir_to_x_360` in the 360 degree environment.

$$\begin{aligned} Tpos\_to\_x\_360_{\theta} = & \\ & if \\ & \qquad Tpos\_to\_x_{\theta} < 180 \\ & then \\ & \qquad 360 + Tpos\_to\_x_{\theta} \\ & else \\ & \qquad Tpos\_to\_x_{\theta} \end{aligned}$$

$$\begin{aligned} Cdir\_to\_x\_360_{\theta} = & \\ & if \\ & \qquad Cdir\_to\_x_{\theta} < 180 \\ & then \\ & \qquad 360 + Cdir\_to\_x_{\theta} \\ & else \\ & \qquad Cdir\_to\_x_{\theta} \end{aligned}$$

d) Calculated the angular difference between the selected direction `(Cdir_to_x_360)` and the target building `(Tpos_to_x_360)`.

[3] Numpy rad2deg: https://numpy.org/doc/stable/reference/generated/numpy.rad2deg.html

They were directly converted to the signed 2 quadrant environment.

$$signed\_180\_angles_\theta = ((Tpos\_to\_x\_360_\theta - Cdir\_to\_x\_360_\theta) + 180)\%360 - 180$$

e) The final step was to create `absolute_180_angles`, the dependent variable for the main analysis in LMM. This variable stored the absolute value of the angular differences contained in `signed_180_angles`. The reason for using absolute values was that the direction of the deviation was not a deciding factor in how accurate the participants performed the pointing task. Taking the absolute values was done with numpy abs() [4] function.

$$absolute\_180\_angles_\theta = np.abs(signed\_180\_angles_\theta)$$

3. Calculated the Euclidean distance from the participant's body position to the target building for each trial. This was done using the Euclidean distance function [5] of scipy spatial.

$$body\_to\_target_{dis} = Euclidean\_distance((Ppos_x, Ppos_z), (Tpos_x, Tpos_z))$$

2.5.2. Analysis

Due to the hierarchical structure of the data, Linear Mixed Models (LMM) were chosen as the method of analysis. For that the MixedLM function [6] from python's statmodels module were used. Subject ID is the grouping component of all the models.

Independent variables

1. **Starting locations:** the 28 different starting locations were spread out through the city. See the full list of the locations in appx. A.

2. **Distance to the target:** this variable is the distance of the participant to the target building at each starting location.

[4]Numpy absolute: https://numpy.org/doc/stable/reference/generated/numpy.absolute.html

[5]Scipy spatial Euclidean distance: https://docs.scipy.org/doc/scipy-1.8.0/reference/generated/scipy.spatial.distance.euclidean.html#scipy.spatial.distance.euclidean

[6]Statsmodels function for linear mixed effects model: https://www.statsmodels.org/dev/generated/statsmodels.regression.mixed_linear_model.MixedLM.html

Dependent variables

1. **Absolute angular deviation** `(absolute_180_angles)`: the absolute value of the angular deviation of the direction chosen by the participant from the actual location of the target building shown at each trial. The following model was used to predict this dependent variable.

$$\textit{absolute angular error} \sim \textit{starting locations} + (1|\textit{subject})$$

2. **Reaction times** `(RT)`: this variable stored the duration between the start of each trial and the time the participants confirmed a direction as their response. The beginning timestamp of the trial was directly after the go cue was completed and the end timestamp instantly after the response was given. Calculating the duration was done in unity.

$$RT = end\_timestamp - begin\_timestamp$$

The following model were used to predict this dependent variable.

$$\textit{reaction times} \sim \textit{starting locations} + (1|\textit{subject})$$

2.5.3. Code accessibility

To access the codes written for the analysis of this thesis, please refer to Maleki (2022).

3. Results

The data from a total of 23 participants with an average of 335 and a total of 7708 trials were used for the analysis. The starting location IDs were identical to the building IDs inside the unity environment and were not replaced with new numbers for the analysis.

3.1. Summary statistics of dependent variables

3.1.1. Absolute angular deviation

This variable had a mean of 48.08 with a standard deviation of 44.30, and a median of 33.70. (See figure 3.1)

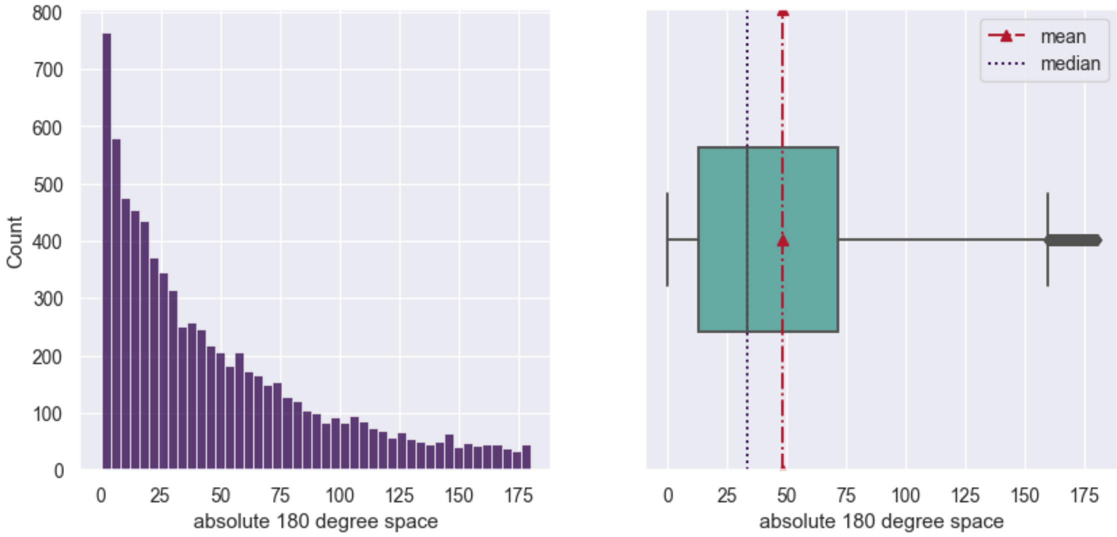


Figure 3.1.: distribution of the absolute angular deviation

3.1.2. Reaction times

This variable had a mean of 7.77 with a standard deviation of 5.56, and a median of 6.06. (See figure 3.2)

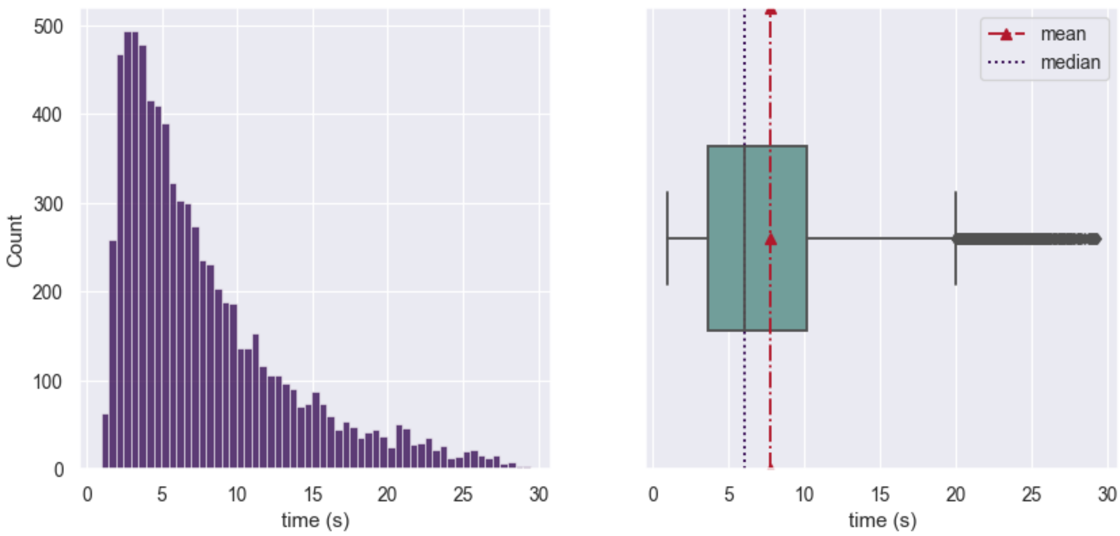


Figure 3.2.: distribution of the reaction times in the pointing task

3.2. Extremes at starting locations

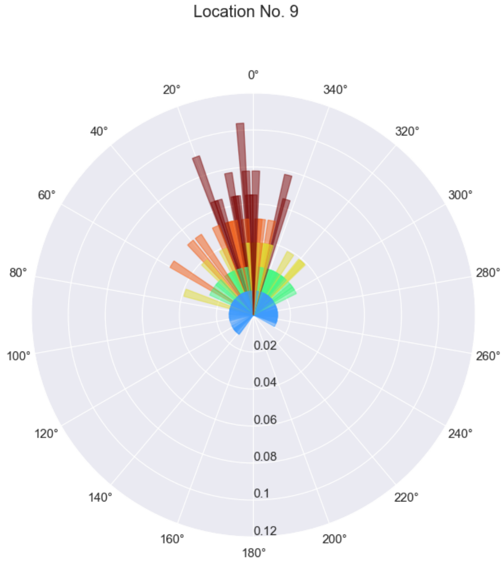
3.2.1. Absolute angular deviation

In order to find out which of the 28 starting locations were the best and worst in performance with respect to the angular deviation from the target, the minimum and maximum medians of angular deviation grouped by the starting locations were taken.

As a result the starting location with ID 9 which was a patisserie shop, therefore a context meaningful location, with a median of 19.18 degrees deviation from the targets and an absolute difference of 16.03 degrees from the overall median (35.21) was the best location, i.e., had the lowest degree deviation from the target. See figure 3.3a.

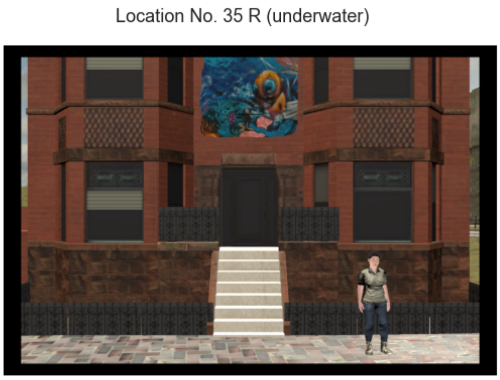
Furthermore, the starting location with ID 35, one of the residential buildings, thus not context meaningful, with the angular deviation median of 52.49 degrees away from the target and an absolute distance of 17.28 degrees from the overall median (35.21) was the worst location of performing the task with regard to the angular deviation. See figure 3.4a.

a) best starting location

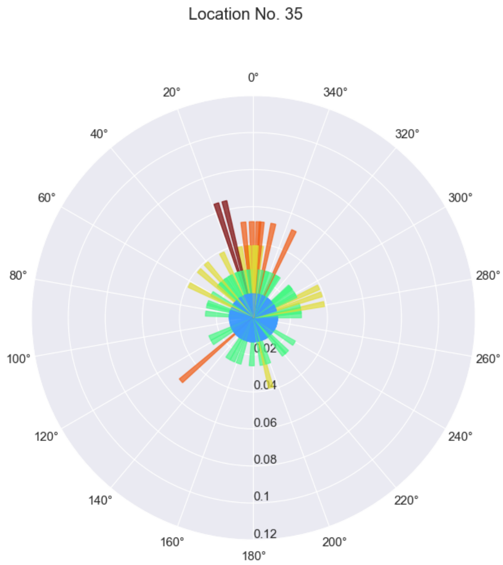


b) angular deviation at location 9 (%)

Figure 3.3.: the best starting location is chosen by taking the least median angular deviation among all starting locations.



a) worst starting location



b) angular deviation at location 35 (%)

Figure 3.4.: the worst starting location is chosen by taking the highest median angular deviation among all starting locations.

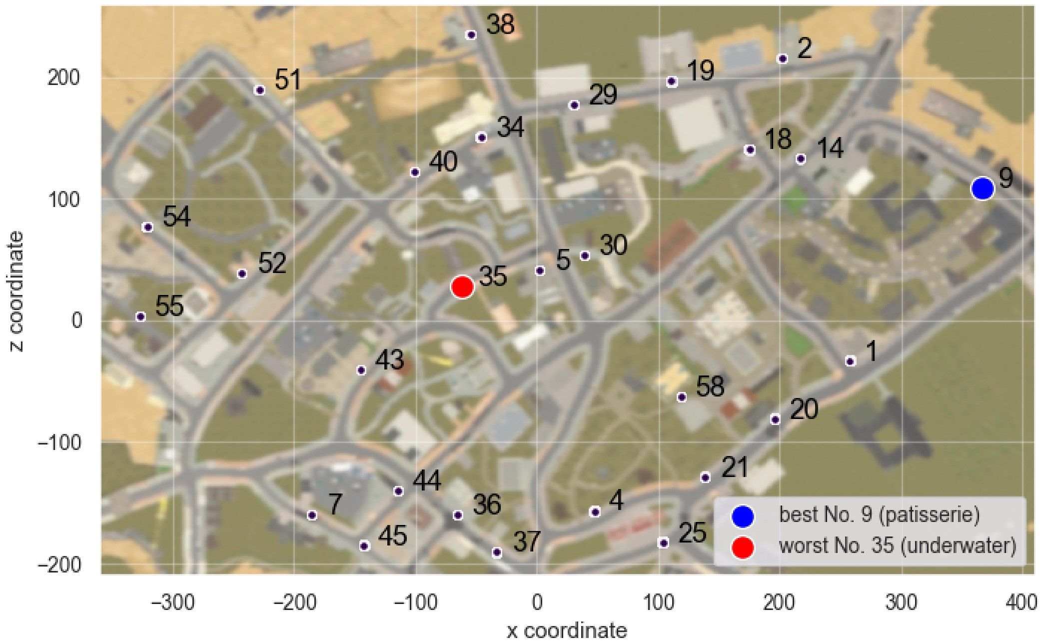


Figure 3.5.: the locations of the best and worst starting locations inside the city coordinates.

3.2.2. Reaction times

To find the fastest and the slowest performance among the 28 starting locations, the medians of reaction times grouped by the starting locations were Calculated.

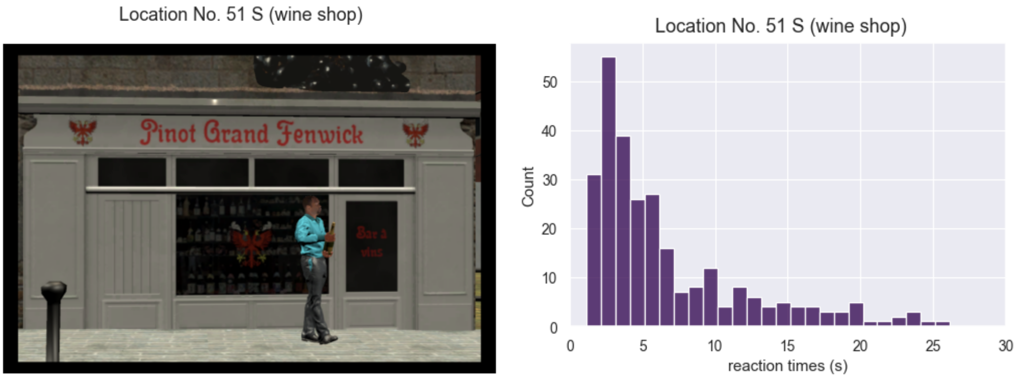
The starting location number 51 which was a wine shop, hence a context meaningful location. This location with a median of 4.63s and the absolute difference of 1.38s from the overall median of RT (6.01) was the fastest location (see figure 3.6a).

Furthermore, the starting location 35, the residential not context meaningful location with the highest median of RT, 7.75s, and an absolute distance of 1.74s from the overall median (6.01) was the slowest location among the 28 (see figure 3.7a).

3.3. Linear mixed effects model

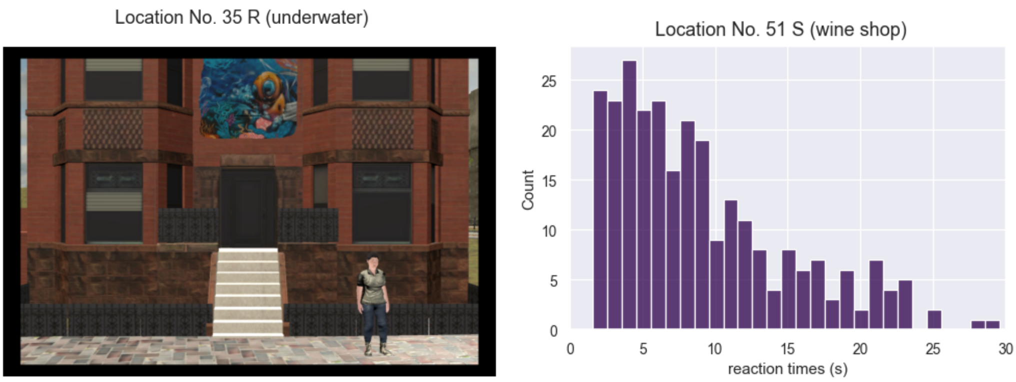
3.3.1. Absolute angular deviation

For choosing the intercept for the model the overall mean of absolute angular deviation, 48.09 degrees, was taken into account. The starting location No. 20



a) fastest starting location b) reaction times at location 51 (%)

Figure 3.6.: the fastest starting location is chosen by taking the least median reaction time among all starting locations.



a) slowest starting location b) distribution of reaction times at location 35 (%)

Figure 3.7.: the slowest starting location is chosen by taking the highest median of reaction times among all starting locations.

(fast food) which was a meaningful location with a mean absolute angular deviation of 48.07 degrees was chosen since its mean absolute angular deviation was the closest to the overall mean among starting locations by 0.02 degrees absolute difference.

The LMM model was fitted using that reference location, No. 20. The results (see table 3.1) show a significant effect of 12 starting locations listed in the table 3.2 on the dependent variable. From the 12 locations with a significant effect, 7 were meaningful locations and from the 15 non-significant locations, 6 were meaningful (see figure 3.10). The variance between subjects was 174.867. The residuals show a slight skew (see figure 3.9)

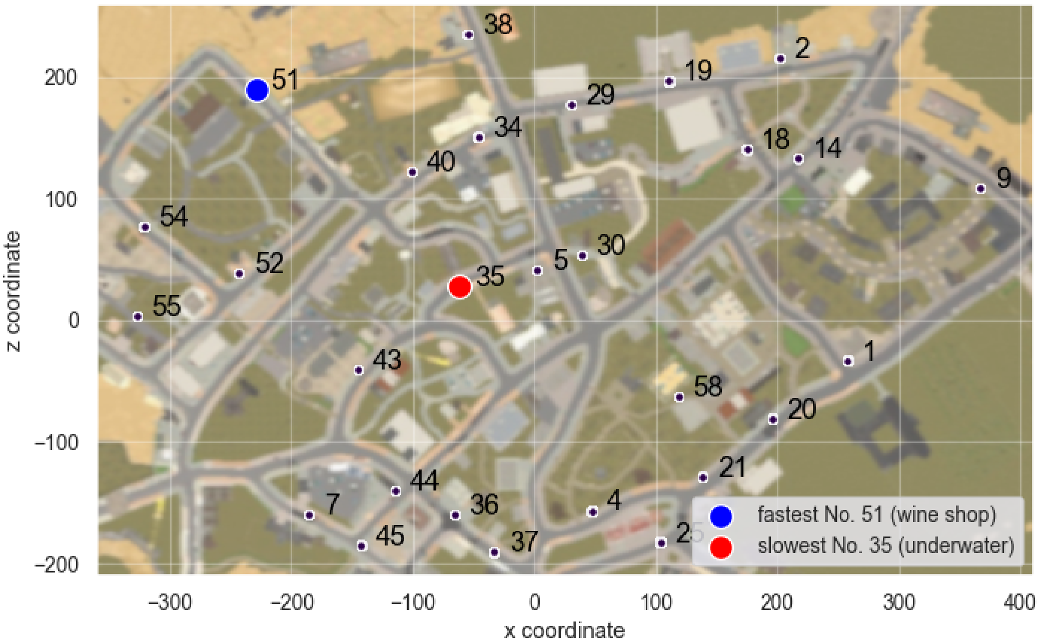


Figure 3.8.: the locations of the fastest and the slowest starting locations inside the city coordinates.

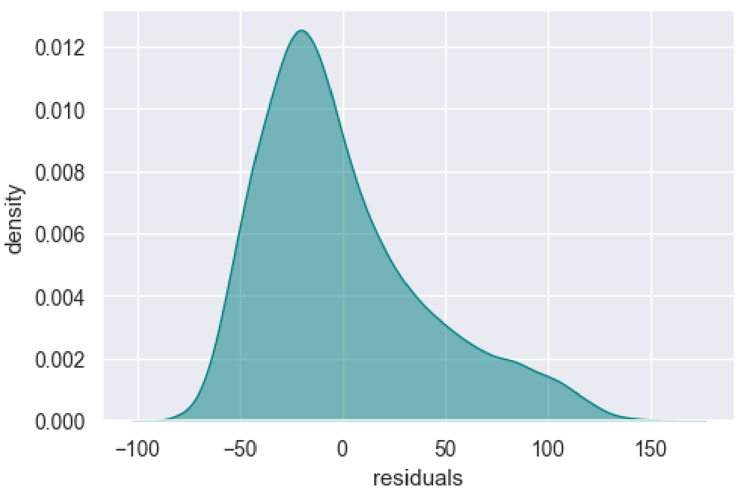


Figure 3.9.: Residuals of LMM absolute angular deviation by starting location.

Table 3.1.: The results of the model absolute angular deviation by starting locations. "Loc" stands for location. z-score(=$\beta/SE(\beta)$)

Predictor	Coef. β	SE (β)	z-score	P> $\|z\|$
Intercept	48.066	3.717	12.933	**<.001**

[Loc.1]	-1.335	3.524	-0.379	0.705
[Loc.2]	**-14.540**	**3.524**	**-4.126**	**<.001**
[Loc.4]	-2.269	3.524	-0.644	0.520
[Loc.5]	**14.709**	**3.524**	**4.174**	**<.001**
[Loc.7]	**-9.310**	**3.531**	**-2.637**	**0.008**
[Loc.9]	**-20.563**	**3.524**	**-5.835**	**<.001**
[Loc.14]	-6.695	3.524	-1.900	0.057
[Loc.18]	3.932	3.531	1.114	0.265
[Loc.19]	-5.040	3.524	-1.430	0.153
[Loc.21]	-2.832	3.531	-0.802	0.423
[Loc.25]	**-8.855**	**3.524**	**-2.513**	**0.012**
[Loc.29]	**8.787**	**3.524**	**2.493**	**0.013**
[Loc.30]	**11.587**	**3.527**	**3.285**	**0.001**
[Loc.34]	-1.073	3.527	-0.304	0.761
[Loc.35]	**17.333**	**3.537**	**4.900**	**<.001**
[Loc.36]	0.918	3.524	0.261	0.794
[Loc.37]	-0.949	3.524	-0.269	0.788
[Loc.38]	**-8.841**	**3.524**	**-2.509**	**0.012**
[Loc.40]	3.126	3.524	0.887	0.375
[Loc.43]	3.882	3.524	1.101	0.271
[Loc.44]	-2.338	3.524	-0.663	0.507
[Loc.45]	-2.755	3.527	-0.781	0.435
[Loc.51]	0.365	3.524	0.104	0.917
[Loc.52]	**12.917**	**3.531**	**3.658**	**<.001**
[Loc.54]	**-12.374**	**3.534**	**-3.502**	**<.001**
[Loc.55]	4.253	3.527	1.206	0.228
[Loc.58]	**18.807**	**3.527**	**5.332**	**<.001**
subject_id Var	174.867	1.311		

Table 3.2.: Significant locations in absolute angular deviation predicted by starting location

	Location ID-name	mean	meaningfulness
1	2 (boulangerie)	33.53	meaningful
2	5 (Maraz cafe)	62.77	meaningful
3	7 (bear)	38.73	non-meaningful
4	9 (patisserie)	27.50	meaningful
5	25 (alligator)	39.21	non-meaningful
6	29 (restaurant)	56.85	meaningful
7	30 (purpul bat)	59.63	non-meaningful
8	35 (underwater)	65.28	non-meaningful
9	38 (bike shop)	39.22	meaningful
10	52 (la cantine)	60.93	meaningful
11	54 (tree)	35.77	non-meaningful
12	58 (basketball court)	66.85	meaningful

In comparison to the starting location No. 20 (fast food restaurant), the reference point, the starting location No. 51 (wine shop) had the least difference in absolute angular deviation degree to the reference, and the starting location No. 9 (patisserie) the most. All three locations were meaningful locations.

3.3.2. Reaction times

The starting location No. 7 (bear) which was a non-meaningful location was chosen as the intercept for the model RT predicted by starting locations. This decision was made based on the comparison of medians of RT from each starting location to the overall median of 6.01s. Here the median was

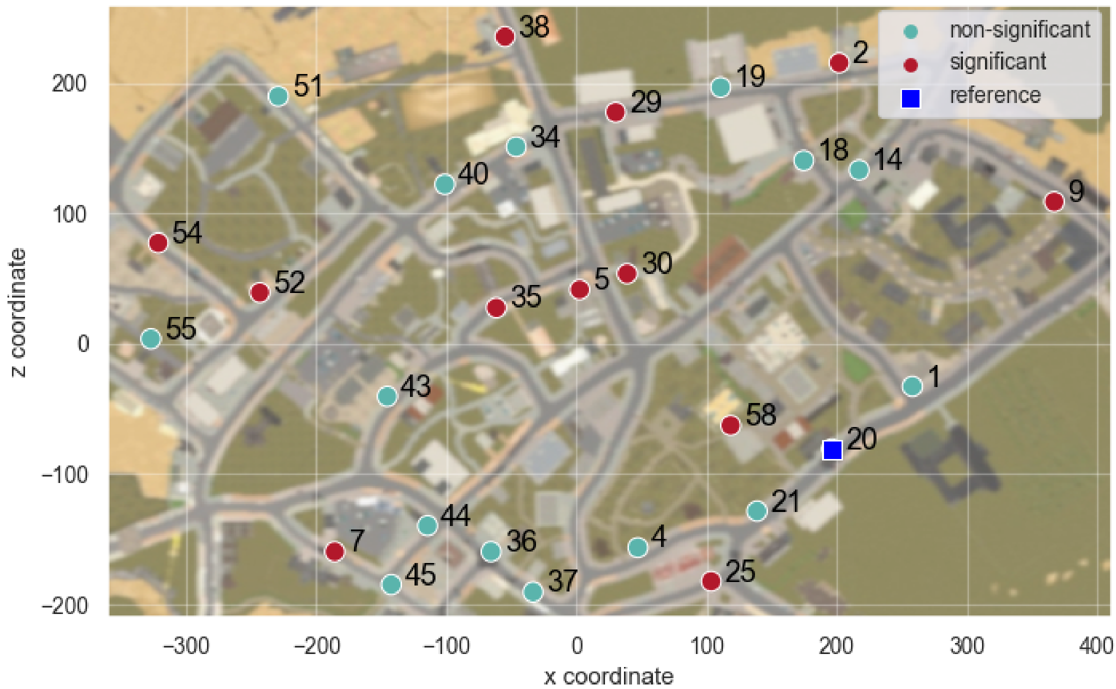


Figure 3.10.: Significance and meaningfulness of LMM results of absolute angular deviation predicted by starting location

considered as the measure of central tendency because the medians were more normally distributed than means. Location No. 7 had a median of 6.02s and an absolute difference of 0.01s from the overall median. However, starting location No. 29 (restaurant) had also the same difference from the overall median. Hence their mean difference to the overall mean of RT was also secondarily taken into account for the final choice. Location No. 7 had a smaller absolute difference of 0.03s compared to location No. 29 with an absolute difference of 0.55s to the mean.

The LMM model was fitted using reference location No. 7. The results (see table 3.3) showed a significant effect of 7 starting locations (listed in the table 3.4) on the dependent variable. From the 7 locations with a significant effect, 2 were meaningful locations and from the 20 non-significant locations, 12 were meaningful (see figure 3.12). The subject variance of the reaction times was 3.762. Residuals of this analysis were slightly skewed (see figure 3.11).

Table 3.3.: The results of the model RT predicted by starting locations

Predictor	Coef. β	SE (β)	z-score	P> $\|z\|$
Intercept	7.736	0.512	15.116	0.000

[Loc.1]	-0.335	0.443	-0.757	0.449
[Loc.2]	-0.676	0.443	-1.526	0.127
[Loc.4]	**-1.047**	**0.443**	**-2.365**	**0.018**
[Loc.5]	0.821	0.443	1.854	0.064
[Loc.9]	-0.287	0.443	-0.649	0.516
[Loc.14]	0.542	0.443	1.224	0.221
[Loc.18]	0.863	0.444	1.946	0.052
[Loc.19]	**-1.220**	**0.443**	**-2.755**	**0.006**
[Loc.20]	**-1.078**	**0.443**	**-2.435**	**0.015**
[Loc.21]	-0.314	0.444	-0.708	0.479
[Loc.25]	-0.434	0.443	-0.979	0.327
[Loc.29]	-0.516	0.443	-1.165	0.244
[Loc.30]	0.733	0.443	1.654	0.098
[Loc.34]	0.446	0.443	1.006	0.315
[Loc.35]	**1.323**	**0.444**	**2.978**	**0.003**
[Loc.36]	-0.207	0.443	-0.468	0.640
[Loc.37]	**0.945**	**0.443**	**2.134**	**0.033**
[Loc.38]	-0.128	0.443	-0.290	0.772
[Loc.40]	0.780	0.443	1.762	0.078
[Loc.43]	**0.929**	**0.443**	**2.098**	**0.036**
[Loc.44]	-0.312	0.443	-0.704	0.482
[Loc.45]	0.470	0.443	1.060	0.289
[Loc.51]	**-1.042**	**0.443**	**-2.353**	**0.019**
[Loc.52]	0.340	0.444	0.766	0.444
[Loc.54]	0.438	0.444	0.987	0.323
[Loc.55]	0.128	0.443	0.289	0.772
[Loc.58]	-0.290	0.443	-0.655	0.512
subject_id Var	3.762	0.223		

Table 3.4.: Significant locations in RT predicted by starting location

	Location ID-name	mean	median	meaningfulness
1	4 (gorilla)	6.69	5.62	non-meaningful
2	19 (bottle spray)	6.52	5.28	non-meaningful
3	20 (fast food)	6.66	5.80	meaningful
4	35 (underwater)	9.08	7.75	non-meaningful
5	37 (house)	8.68	6.69	non-meaningful
6	43 (daisy)	8.66	6.89	non-meaningful
7	51 (wine shop)	6.69	4.63	meaningful

In comparison to starting location No. 7 (the reference point), starting location No. 55 had the least difference in RT to the reference and the starting location No. 35 the most. All three locations were non-meaningful buildings.

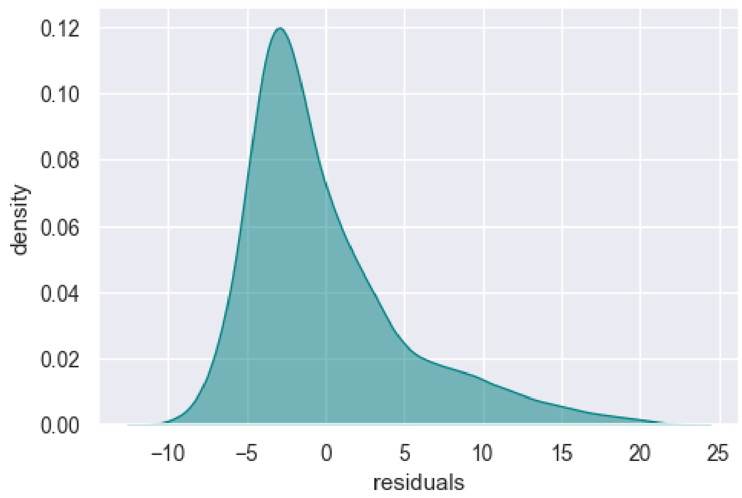


Figure 3.11.: Residuals of LMM RT by starting location.

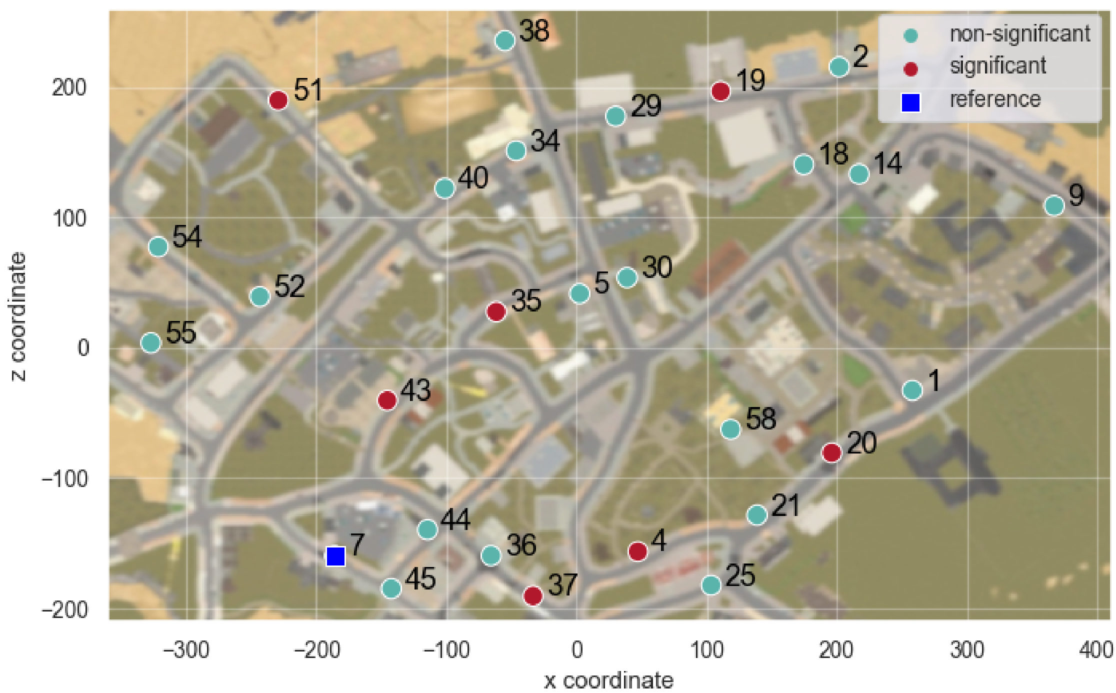


Figure 3.12.: Significance and meaningfulness of LMM results of RT predicted by starting location

4. Conclusion

The work of this thesis was based on the question of whether or not the task's starting locations affected the two dependent variables targeted in this analysis, i.e., the absolute angular deviation and the reaction times.

As for the best and worst locations, No. 9 and No. 35 respectively, it seemed that being located inside or on the edges of the city could affect the outcome. At location No. 9, it is possible that a very large portion of the angular possibilities are eliminated due to the fact that if the participant sees that there is no part of the city on one side of where they are, it will be highly unlikely to point there.

Furthermore, due to this elimination, there would be also a higher likelihood of pointing by chance and making small errors. Similarly for the starting location No. 35, due to it being about the center of the city, it is more likely to get widely located targets around the starting location, and therefore the error rate could rise. This could also be one of the explanations for location 35 being the slowest starting location. The spread of the targets could cause the participants the need to think more accurately about the target.

The results of the LMM, absolute angular deviation as a function of starting location, seemed to show that almost half of the starting locations affect the outcome significantly. There are some factors that should be taken into consideration for this outcome. There seems to be a slight trend of having a better performance in the starting locations that lie on the edge of the city and their view is not blocked by buildings.

Looking at the results of predicting RT by starting locations, clearly, the minority of the starting locations affect the reaction times significantly. From those, it is also possible that the locations being located on the edges of the city or inside make the difference.

In conclusion, this thesis cannot reject the null hypothesis that the starting locations do not have an effect on the absolute angular deviation and reaction times for all the locations. Based on the residuals of the models which are not completely normally distributed, it can be concluded that there are other factors as well affecting the outcome. Other factors such as distance to target and context (meaningfulness) of the starting locations, and their interactions with the starting locations should also be taken into account to find the best model for explaining the variance. Furthermore, the independent variables trial id per starting location which contains the 12 consecutive trials performed from each starting location can be also a factor to investigate.

References

Berger, P. L., & Luckman, T. (1967). *The social construction of reality*. Anchor. (Cit. on p. 1).

Cassirer, E. (1955). *The philosophy of symbolic forms: Volume 2: Mythical thought*. Yale University Press. (Cit. on p. 1).

Chicchi Giglioli, I. A., Pravettoni, G., Sutil Martín, D. L., Parra, E., & Raya, M. A. (2017). A novel integrating virtual reality approach for the assessment of the attachment behavioral system. *Frontiers in psychology*, *8*, 959 (cit. on p. 1).

Diersch, N., & Wolbers, T. (2019). The potential of virtual reality for spatial navigation research across the adult lifespan. *Journal of Experimental Biology*, *222*(Suppl_1), jeb187252 (cit. on p. 1).

Haas, J. K. (2014). A history of the unity game engine (cit. on p. 4).

Harris, C. R., Millman, K. J., van der Walt, S. J., Gommers, R., Virtanen, P., Cournapeau, D., Wieser, E., Taylor, J., Berg, S., Smith, N. J., Kern, R., Picus, M., Hoyer, S., van Kerkwijk, M. H., Brett, M., Haldane, A., del Río, J. F., Wiebe, M., Peterson, P., . . . Oliphant, T. E. (2020). Array programming with NumPy. *Nature*, *585*(7825), 357–362. https://doi.org/10.1038/s41586-020-2649-2 (cit. on p. 9)

Hess, R. (2010). *Blender foundations: The essential guide to learning blender 2.6*. Focal Press. (Cit. on p. 4).

Hunter, J. D. (2007). Matplotlib: A 2d graphics environment. *Computing in Science & Engineering*, *9*(3), 90–95. https://doi.org/10.5281/zenodo.5773480 (cit. on p. 9)

Kuehn, E., Chen, X., Geise, P., Oltmer, J., & Wolbers, T. (2018). Social targets improve body-based and environment-based strategies during spatial navigation. *Experimental Brain Research*, *236*(3), 755–764 (cit. on p. 1).

Maleki, N. (2022). The effect of the task locations on a pointing task performed in a VR spatial navigation study. (Cit. on p. 13).

McIlvenny, P. (2020). The future of 'video'in video-based qualitative research is not 'dumb'flat pixels! exploring volumetric performance capture and immersive performative replay. *Qualitative Research*, *20*(6), 800–818 (cit. on p. 1).

McKinney, W. (2010). Data Structures for Statistical Computing in Python. In S. van der Walt & J. Millman (Eds.), *Proceedings of the 9th Python in Science Conference* (pp. 56–61). https://doi.org/10.25080/Majora-92bf1922-00a. (Cit. on p. 9)

Mixamo. (2008). https://www.mixamo.com/. (Cit. on p. 4)

Pan, X., & Hamilton, A. F. d. C. (2018). Why and how to use virtual reality to study human social interaction: The challenges of exploring a new research landscape. *British Journal of Psychology*, *109*(3), 395–417 (cit. on p. 1).

pandas development team, T. (2022). *Pandas-dev/pandas: Pandas* (Version v1.4.2). Zenodo. https://doi.org/10.5281/zenodo.6408044. (Cit. on p. 9)

Seabold, S., & Perktold, J. (2010). Statsmodels: Econometric and statistical modeling with python. *9th Python in Science Conference* (cit. on p. 9).

Siegel, A. W., & White, S. H. (1975). The development of spatial representations of large-scale environments. In H. W. Reese (Ed.). JAI. https://doi.org/https://doi.org/10.1016/S0065-2407(08)60007-5. (Cit. on p. 1)

Spencer, H. (1867). *First principles*. Williams; Norgate. (Cit. on p. 1).

Van Rossum, G., & Drake, F. L. (2009). *Python 3 reference manual*. CreateSpace. (Cit. on p. 9).

Virtanen, P., Gommers, R., Oliphant, T. E., Haberland, M., Reddy, T., Cournapeau, D., Burovski, E., Peterson, P., Weckesser, W., Bright, J., van der Walt, S. J., Brett, M., Wilson, J., Millman, K. J., Mayorov, N., Nelson, A. R. J., Jones, E., Kern, R., Larson, E., . . . SciPy 1.0 Contributors. (2021). SciPy 1.0: Fundamental Algorithms for Scientific Computing in Python. *Nature Methods*, *17*, 261–272. https://doi.org/10.5281/zenodo.5796897 (cit. on p. 9)

Waskom, M. L. (2021). Seaborn: Statistical data visualization. *Journal of Open Source Software*, *6*(60), 3021. https://doi.org/10.21105/joss.03021 (cit. on p. 9)

Appendix

Appendix A.

List of starting locations

Table A.1.: Starting locations' information. "AAD" stands for absolute angular deviation, "RT" for reaction times, and "Loc." for location.

	Loc. ID	Loc. name	Context	AAD mean	AAD median	RT mean	RT median
1	1	foxes	non-meaningful	46.73	35.66	7.4	5.62
2	2	boulangerie	meaningful	33.53	23.52	7.06	5.23
3	4	gorilla	non-meaningful	45.8	29.54	6.69	5.33
4	5	Maraz cafe	meaningful	62.77	51.25	8.56	7.49
5	7	bear	non-meaningful	38.73	25.52	7.74	6.02
6	9	patisserie	meaningful	27.5	19.18	7.45	5.49
7	14	pub	meaningful	41.37	27.83	8.28	6.42
8	18	balloons	non-meaningful	51.97	35.07	8.58	6.92
9	19	bottle spray	non-meaningful	43.03	28.01	6.52	5.28
10	20	fast food	meaningful	48.07	35.36	6.66	5.8
11	21	coffee store	meaningful	45.18	29.53	7.42	5.89
12	25	alligator	non-meaningful	39.21	28.96	7.3	5.57
13	29	restaurant	meaningful	56.85	41.6	7.22	6
14	30	purple bat	non-meaningful	59.63	37.57	8.48	6.4
15	34	fish and chips	meaningful	47.02	35.35	8.18	6.2
16	35	underwater	non-meaningful	65.28	52.49	9.08	7.75
17	36	motorbike	meaningful	48.98	37.95	7.53	6.29

18	37	house	non-meaningful	47.12	37.38	8.68	6.69
19	38	bike shop	meaningful	39.22	31.61	7.61	5.65
20	40	dianthus	non-meaningful	51.19	37.99	8.52	6.35
21	43	daisy	non-meaningful	51.95	34.29	8.66	6.89
22	44	tool shop	meaningful	45.73	32.48	7.42	5.49
23	45	green store	meaningful	45.29	30.35	8.21	6.33
24	51	wine shop	meaningful	48.43	43.26	6.69	4.63
25	52	la cantine	meaningful	60.93	47.16	8.09	6.55
26	54	tree	non-meaningful	35.77	21.2	8.18	6.27
27	55	bird	non-meaningful	52.32	37.7	7.85	5.6
28	58	basketball court	meaningful	66.85	49.85	7.45	5.83

a) 1 (foxes) non-meaningful

b) 2 (boulangerie) meaningful

c) 4 (gorilla) non-meaningful

d) 5 (Maraz cafe) meaningful

Figure A.1.: Starting locations 1-4

a) 7 (bear) non-meaningful

b) 9 (patisserie) meaningful

c) 14 (pub) meaningful

d) 18 (balloons) non-meaningful

e) 19 (bottle spray) non-meaningful

f) 20 (fast food) meaningful

g) 21 (coffee store) meaningful

h) 25 (alligator) non-meaningful

Figure A.2.: Starting locations 4-12

a) 29 (restaurant) meaningful

b) 30 (purple bat) non-meaningful

c) 34 (fish and chips) meaningful

d) 35 (underwater) non-meaningful

e) 36 (motorbike) meaningful

f) 37 (house) non-meaningful

g) 38 (bike shop) meaningful

h) 40 (dianthus) non-meaningful

Figure A.3.: Starting locations 13-20

a) 43 (daisy) non-meaningful

b) 44 (tool shop) meaningful

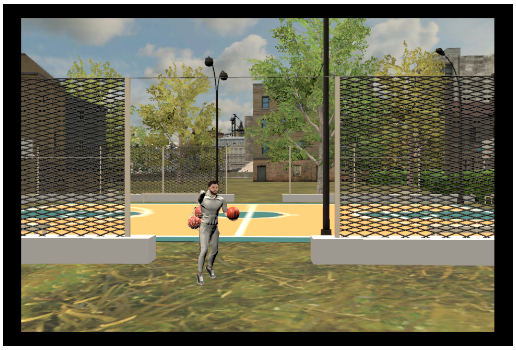
c) 45 (green store) meaningful

d) 51 (wine shop) meaningful

e) 52 (la cantine) meaningful

f) 54 (tree) non-meaningful

g) 55 (bird) non-meaningful



h) 58 (basketball court) meaningful

Figure A.4.: Starting locations 21-28

Appendix B.

Additional plots

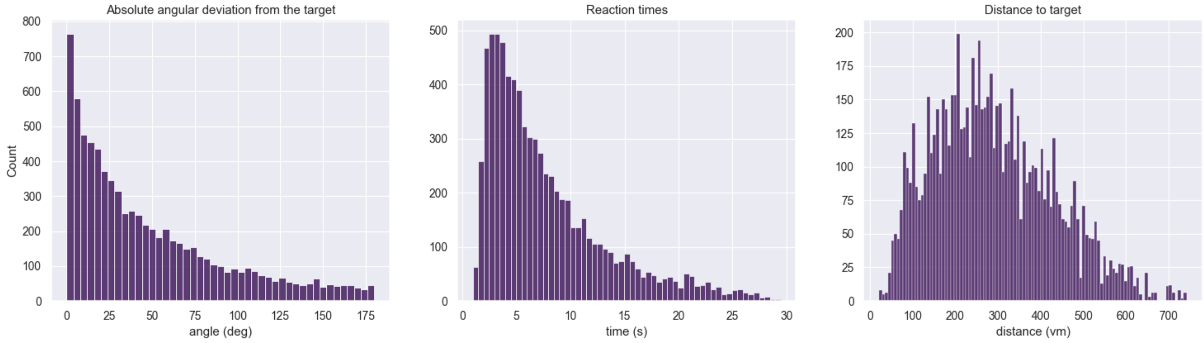


Figure B.1.: Distribution of absolute angular deviation from the target, reaction times and distance to target. "vm" stands for virtual meter.

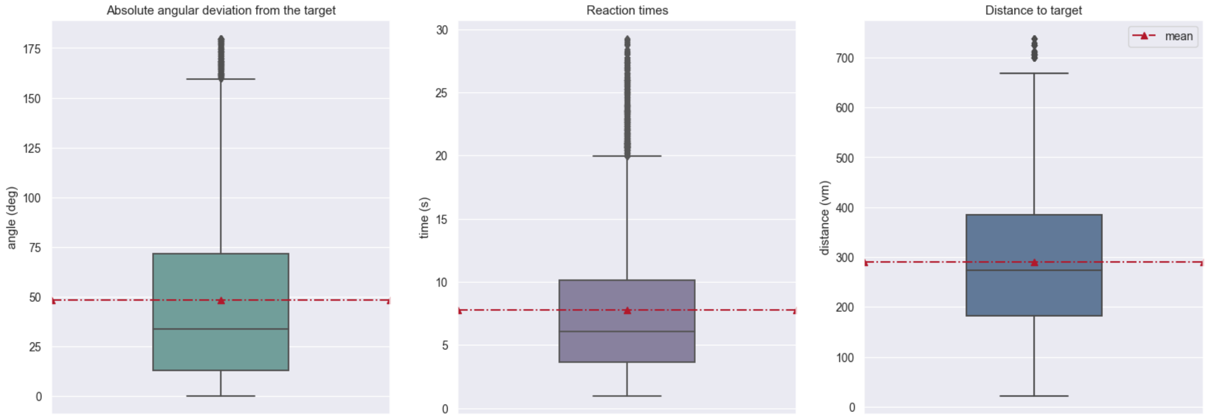


Figure B.2.: Box plot of absolute angular deviation from the target, reaction times and distance to target. "vm" stands for virtual meter.

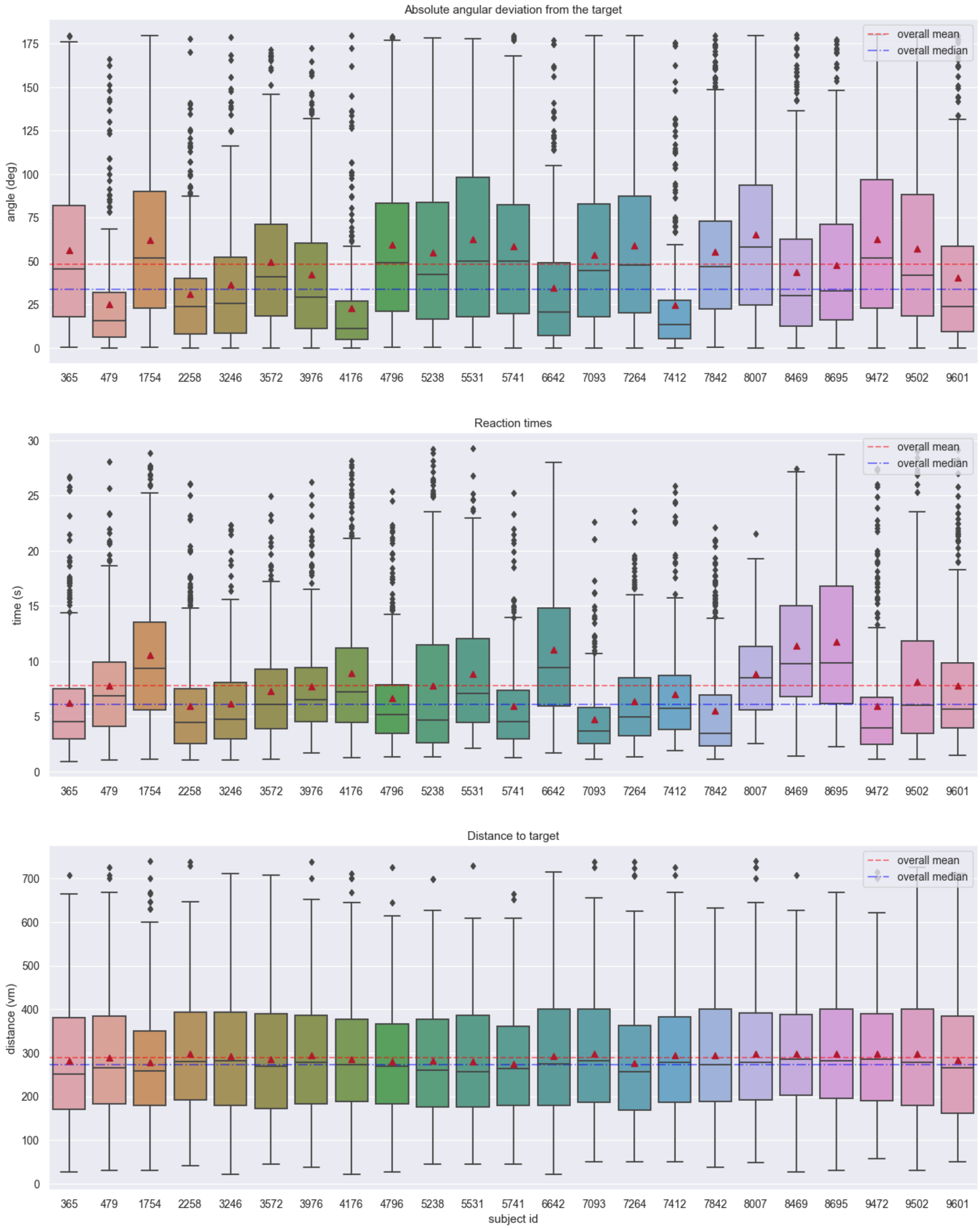


Figure B.3.: Absolute angular deviation, reaction times and distance to target by subject. Red triangles depict the mean and ”vm” stands for virtual meter.

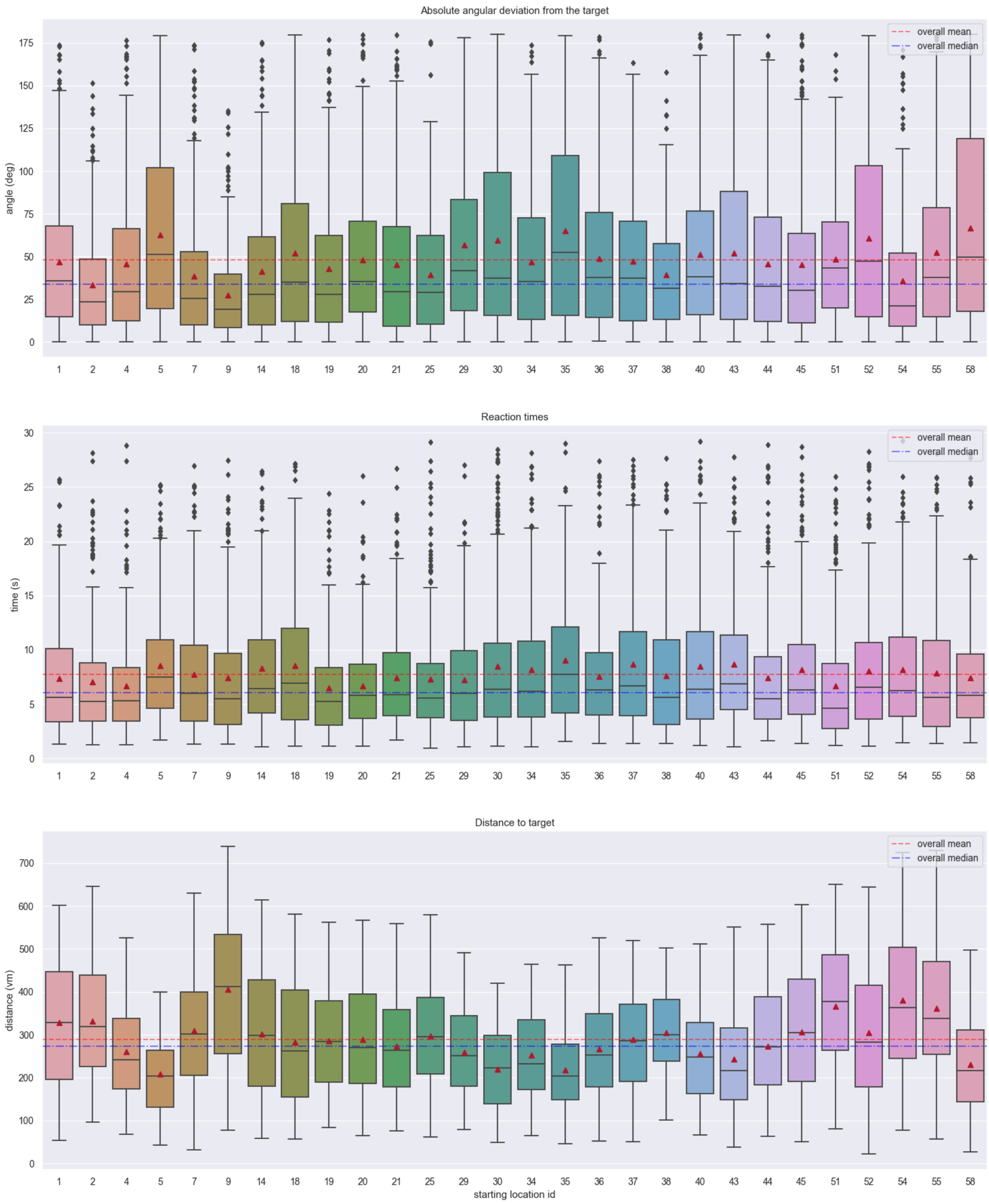


Figure B.4.: Absolute angular deviation, reaction times and distance to target at each starting location. Red triangles depict the mean and "vm" stands for virtual meter.

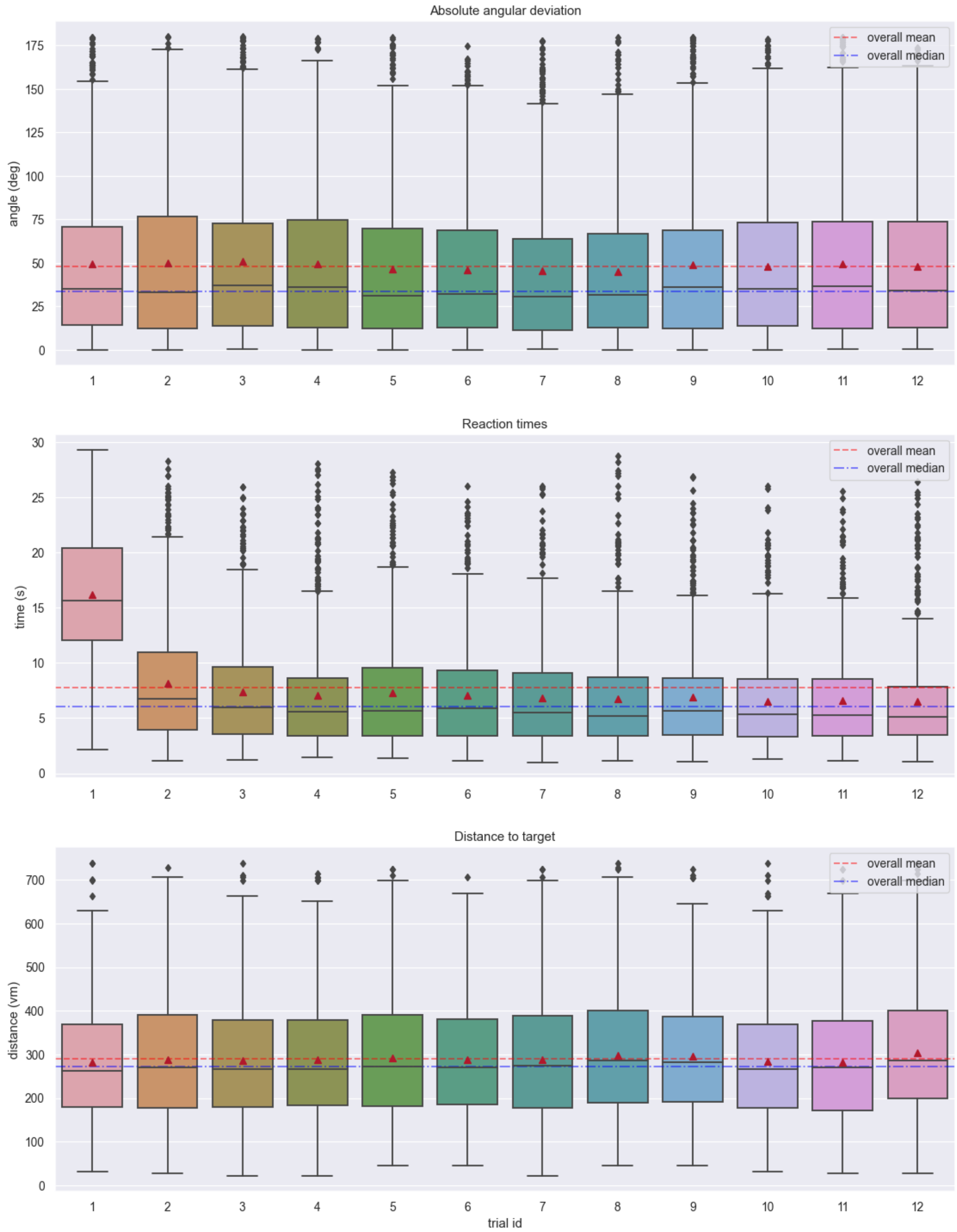


Figure B.5.: Absolute angular deviation, reaction times and distance to target per consecutive trials at each starting location. Red triangles depict the mean and "vm" stands for virtual meter.

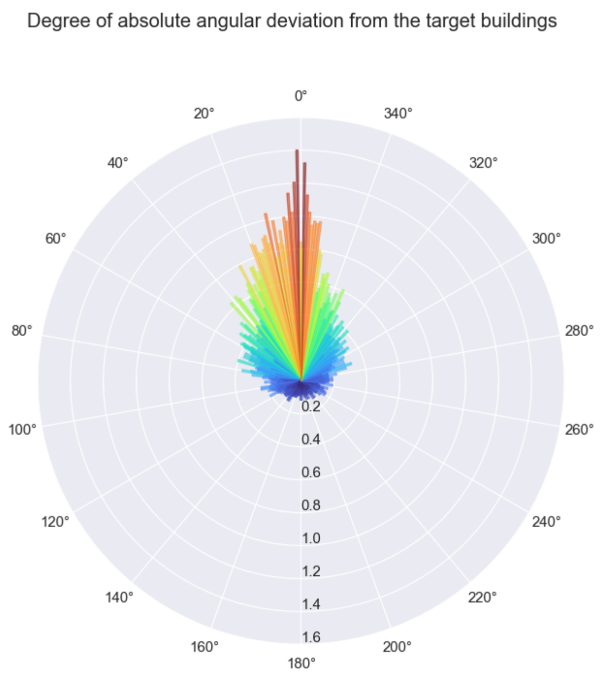


Figure B.6.: Angular deviation from the target in all trials

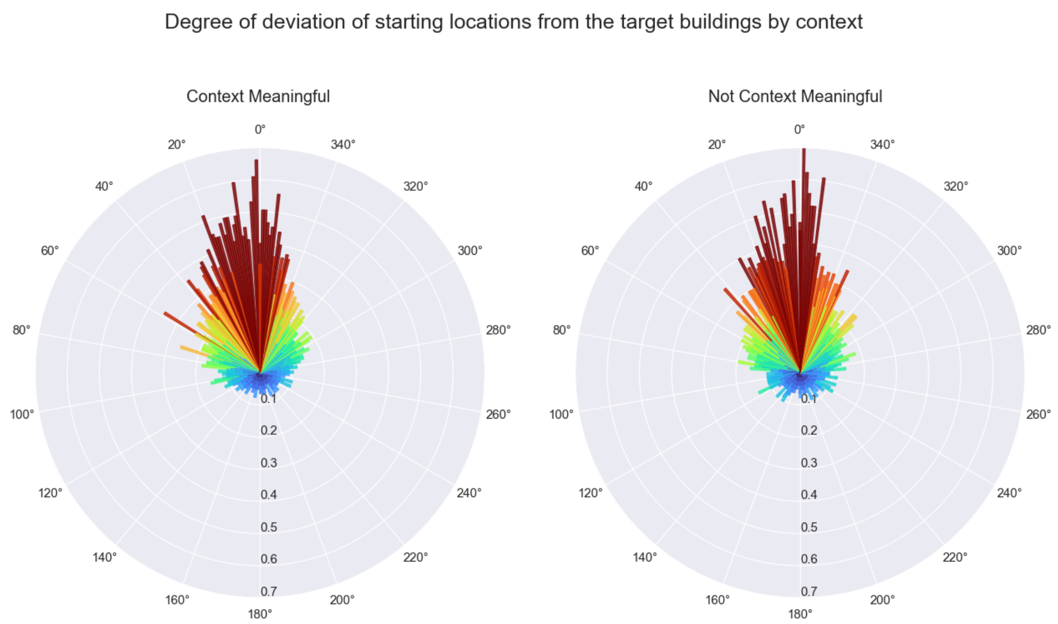


Figure B.7.: Angular deviation of starting locations from the target by meaningfulness.

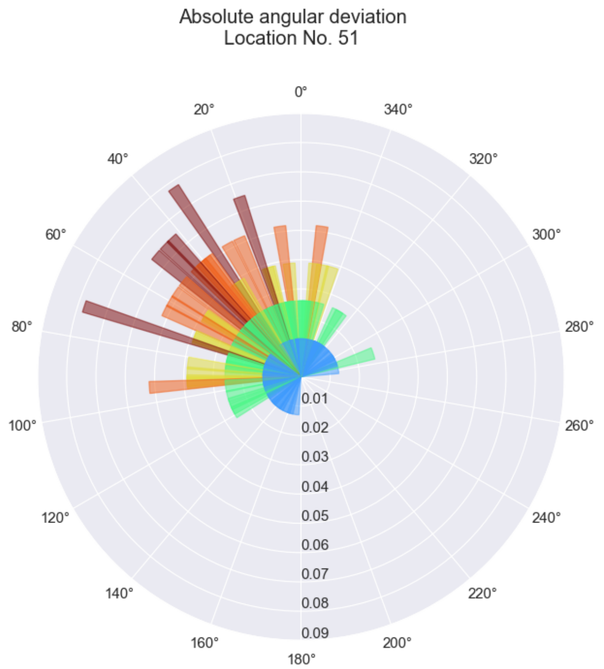


Figure B.8.: Absolute angular deviation of the fastest starting location, location No. 51.

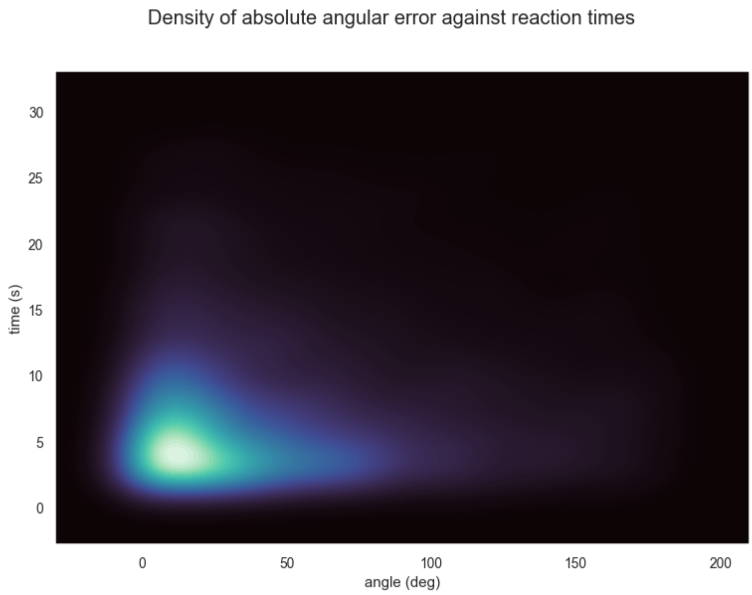


Figure B.9.: Density of absolute angular error against reaction times.

Appendix C.

Forms

Einverständniserklärung

Titel der Studie: Untersuchung des Effektes von menschlichen Avataren auf räumliches Lernen und räumliche Navigation in einer virtuellen Stadt unter Einbeziehung des Blickverhaltens

Zweck der Studie: Das Ziel des vorliegenden Forschungsprojekts ist es, den Effekt von menschlichen Avataren auf das Lernen durch aktive Navigation in einer virtuellen Stadt zu untersuchen. Zu diesem Zweck werden wir menschliche Avatare strategisch neben Gebäuden innerhalb einer virtuellen Stadt platzieren. Auf Basis der erhobenen Daten werden wir evaluieren, ob die Teilnehmer sich die Teile der Stadt, in denen wir Avatare platziert haben, besser merken konnten.

Projektleitung: Prof. Dr. Peter König, Dr. med. Sabine König, Prof. Dr. Gordon Pipa, Tracy Sánchez (Lic.), Institut für Kognitionswissenschaften, Wachsbleiche 27, 49082 Osnabrück

Sehr geehrte Studienteilnehmerin, sehr geehrter Studienteilnehmer, hiermit bitten wir Sie um Ihre Einwilligung zur Teilnahme an dem oben genannten Forschungsvorhaben und zur Nutzung Ihrer personenbezogenen Daten, wie sie Ihnen in der Probandeninformation und der Aufklärung näher erläutert worden sind.

I. Allgemeines

Hiermit erkläre ich, ___________, geboren am _________, dass ich durch die Projektleitung mündlich und schriftlich über das Wesen, die Bedeutung, die Risiken und Folgen der wissenschaftlichen Untersuchungen im Rahmen der o.g. Studie informiert und aufgeklärt wurde und ausreichend Gelegenheit hatte, meine Fragen mit der Projektleitung zu klären.

Mir ist bekannt, dass ich das Recht habe, meine Einwilligung jederzeit ohne Angabe von Gründen und ohne nachteilige Folgen für mich zurückzuziehen. Mir ist bekannt, dass meine Daten nach Abschluss der Datenerhebung nur in anonymisierter Form gespeichert, analysiert und veröffentlicht werden. Dies führt dazu, dass ein späteres Löschen meiner Daten nicht mehr möglich ist, da die Daten nicht mehr meiner Person zugeordnet werden können.

Ich habe eine Kopie der schriftlichen Studieninformation und der Einwilligungserklärung erhalten.

Ich erkläre, dass ich freiwillig bereit bin, an der wissenschaftlichen Studie, die für mich aus 5 wiederholten Erkundungen in der virtuellen Stadt „Westbrück", die jeweils 45 Minuten dauern werden und einer Testsession in der virtuellen Umgebung, die ungefähr 120 Minuten dauern wird, teilzunehmen. Die Erkundungs- und Testsessions finden jeweils an unterschiedlichen Tagen statt.

Insbesondere erkläre ich mich damit einverstanden,

1. dass die in der Studie aufgenommenen Daten in anonymisierter Form gespeichert und analysiert werden, auch auf elektronischen Datenträgern;
________ (Initialen Proband)

2. dass meine persönlichen Daten zu Zwecken der Vergütung und Dokumentation gespeichert werden. Diese persönlichen Daten werden nur in Papierform und nicht mit den experimentellen Daten verbunden aufgehoben.
________ (Initialen Proband)

3. dass an dieser Studie folgende beteiligte Wissenschaftler Zugang zu den erhobenen anonymisierten experimentellen Daten zum Zweck der Durchführung und wissenschaftlichen Verwertung der Studie haben: Prof. Dr. Peter König, Dr. med. Sabine König, Prof. Dr. Gordon Pipa, Tracy

Sánchez, Institut für Kognitionswissenschaften, Universität Osnabrück;
________ (Initialen Proband)

4. dass die Studienergebnisse und die Studiendaten in anonymisierter Form, die nach heutigem Stand der Technik keinen Rückschluss auf meine Person zulässt, veröffentlicht werden; die Veröffentlichung kann zum Beispiel in einer wissenschaftlichen Zeitschrift oder im Internet erfolgen;
________ (Initialen Proband)

5. dass meine Daten, im Sinne der guten wissenschaftlichen Praxis, in anonymisierter Form der Öffentlichkeit über eine Creative Commons Lizenz (CC0) zugänglich gemacht werden;
________ (Initialen Proband)

6. dass ich aktiv eine virtuelle Stadt erkunde. Anschließend werde ich Orientierungstests in der virtuellen Stadt durchführen. Während des Navigationstrainings werde ich eine virtuelle Realitätsbrille tragen. Die Messungen finden in einem Labor des Instituts für Neurobiopsychologie der Universität Osnabrück statt
________ (Initialen Proband)

7. dass die in der Studie aufgenommenen Daten entsprechend der Empfehlung durch die DFG mindestens 10 Jahre lang aufbewahrt werden.
________ (Initialen Proband)

II. Ausschlusskriterien, Verhaltensregeln

II.1 Ausschlusskriterien

Ich versichere, den mir vorgelegten Anamnesebogen wahrheitsgemäß ausgefüllt zu haben. Mir ist bewusst, dass während des Trainings in der virtuellen Stadt „Seekrankheits-“ ähnliche Symptome („Bewegungsübelkeit“) wie Schwindel und Übelkeit auftreten können. Des Weiteren ist mir bewusst, dass das Tragen der virtuellen Brille ein Druckgefühl bis hin zu leichten Kopfschmerzen und ein Verspannungsgefühl im Nacken auslösen kann.

II.2 Zustimmung zur Einhaltung von Verhaltensregeln

Ich wurde vor der Durchführung der Studie darauf hingewiesen, dass ich vor oder während der Untersuchung auftretendes körperliches oder psychisches Unwohlsein der Projektleitung unverzüglich mitzuteilen habe. Ich wurde zusätzlich informiert, dass ich jederzeit während des Experimentes eine Pause einlegen darf.

III. Datenschutzrechtliche Einwilligungserklärung

Einblick in die anonymisierten Daten durch Dritte findet statt:

Ich bin damit einverstanden, dass die erhobenen Daten in anonymisierter Form in wissenschaftlichen Zeitschriften und über eine Creative Commons Lizens (CC0) im Internet veröffentlicht werden. Dies bedeutet, dass die Daten frei zugänglich sind und frei analysiert und veröffentlicht werden dürfen.

IV. Aufwandsentschädigung

Ich bin damit einverstanden, dass ich für die Teilnahme an der Studie mit 5€ pro Stunde für die Zeit der Exploration und Messungen in VR vergütet werde. Alternativ, wird mir auf Wunsch ein Teil der Zeit entsprechend in Versuchspersonenstunden bestätigt. Weitere Vorteile wurden nicht zugesagt.

V. Unterschrift

Ich erkläre hiermit, dass ich freiwillig und unter Kenntnis der oben genannten Punkte an der Studie „Untersuchung des Effektes von taktiler Wahrnehmungserweiterung auf räumliches Lernen und räumliche Navigation in einer virtuellen Stadt unter Einbeziehung des Blickverhaltens“ teilnehme.

Osnabrück, den ______________ ____________________________ (Unterschrift Proband)

Osnabrück, den ______________ ____________________________ (Unterschrift Projektleitung)

ALLGEMEINE ANAMNESE (A1)

Bei Problemen mit dem Ausfüllen wenden Sie sich bitte an die studienbegleitenden Mitarbeiterinnen und Mitarbeiter!

VP-Nummer			
Geschlecht:	□ m □ w □ andere	**Datum**:	

Nervensystem

Bewusstseinsstörungen □ ja □ nein

Krampfanfälle (Epilepsie) □ ja □ nein

Schwindel/Gleichgewichtsstörung □ ja □ nein

Seekrankheit/“Bewegungsübelkeit“ z.B. beim Autofahren □ ja □ nein

Tinnitus □ ja □ nein

Kopfschmerz □ gelegentlich □ oft □ nein

Migräne □ gelegentlich □ oft □ nein

Tremor (Zittern) □ ja □ nein

Gedächtnisprobleme □ ja □ nein

Sprach- oder Sprechbeschwerden □ ja □ nein

Verhaltensstörungen □ ja □ nein

Halluzinationen/Wahnvorstellungen □ ja □ nein

Weiteres:
Wenn „ja“, welche: □ ja □ nein

Psychopharmaka
Wenn „ja“, welche: □ ja □ nein

Augen

Sehstörung □ ja □ nein
Wenn „ja“, welche:

Seheinschränkung □ ja □ nein
Wenn „ja“, welche:

Art der Sehhilfe

Stärke der Sehhilfe

Doppelbilder □ ja □ nein

Lichtempfindlichkeit/-scheuheit □ ja □ nein

Weiteres:
Wenn „ja“, welche:

Bewegungsapparat
Schmerzen □ ja □ nein
Wenn „ja“, welche:

Schwäche □ ja □ nein

Steifigkeit □ ja □ nein

Rückenprobleme □ ja □ nein

Weiteres (auch Verlust von Körperteilen):

Bei Problemen mit dem Ausfüllen wenden Sie sich bitte an die studienbegleitenden Mitarbeiterinnen und Mitarbeiter!