Effects of Spatial Framing and Sex Differences on Object Location Memory

Nevaan M. Perera

St. Lawrence University

Author Note

Nevaan M. Perera, Department of Psychology, St. Lawrence University.

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Correspondence concerning this article should be addressed to Nevaan M. Perera, SMC # 2073, St. Lawrence University, Canton, NY 13617. Contact: nmpere15@stlawu.edu

Abstract

The current experiment investigated if sex differences in object location memory partially depend on the way the spatial task is framed: egocentric frame (observer-to-object spatial relations) or allocentric frame (object-to-object spatial relations). Participants explored a virtual maze while learning the location of six common objects within the maze. Participants recalled object location by placing objects within a top-down view of the maze and by pointing to objects from different locations within the maze. This experiment served as a pilot study and lacked power to detect significant effects. However, the pattern of data suggests that males performed better than females in both the object placement and pointing tasks. Furthermore, participants tested using an egocentric frame-of-reference performed better than participants tested using an allocentric frame-of-reference. The predicted interaction pattern is visible for the object location map task but not for the angular pointing task. A fully powered follow-up experiment is needed to directly test these effects.

Keywords: allocentric, egocentric, spatial memory, object-location

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Using a map, knowing our location in a novel environment, and remembering where we kept an item in a room, are skills requiring spatial cognition. Spatial cognition is the acquisition, interpretation, organization, and use of knowledge from the environment; it is how humans encode, remember, and navigate through complex environments (Waller & Nadel, 2013). Spatial cognition consists of domains such as spatial perception, which is the ability to be aware of spatial relations and objects around oneself (Donnon, DesCoteaux, & Violato, 2005), mental rotation, which is the ability to rotate 2-dimensional and 3-dimensional objects in one's mind (Shepard & Metzler, 1971), and spatial memory, which is memory for geographical information such as the layout of one's hometown, or the interior of a house (Myers, 2016).

Men typically have a significant advantage in spatial abilities over women (Hedges & Nowell, 1995). For example, males outperform females at computer and real world navigational tasks (Coluccia & Louise, 2004), mental rotation (Linn & Peterson, 1985; Parson et al., 2004), and distance perception (Brown, Lahar & Mosley, 1998), while women only outperform men at object location; however, this advantage only occurs when the task is two-dimensional (Voyer, Postma, Brake, 2007).

One hypothesis to explain this variability is that males and females encode spatial information in significantly different ways (Madson, & Trafimow, 2001; Novak, Murali, & Driscoll, 2015). Males typically use an allocentric encoding strategy, which is representing objects in relation to other objects or their locations (Jones & Healy, 2006); . In contrast, females typically rely on an object's visual features (Jones & Healy, 2006), and a strategy called egocentric encoding, which is representing objects in relation to oneself (Wen, Ishikawa, & Sato, 2013) Figure 1 provides a visual representation of this concept

When measuring spatial abilities in psychological experiments, most tasks favored the allocentric encoding strategy (Novak, Murali, & Driscoll, 2015), which could explain why males significantly outperform females at spatial tasks. In other words, females may not have worse spatial abilities than males, but instead spatial tasks and measurement criteria are biased against a female's preferred spatial encoding strategy. A recent study investigated this hypothesis by testing individuals' abilities to imagine the relative locations of objects from a perspective other than their own (Tarampi, Heydari & Hegarty, 2016). Participants viewed an array of objects arranged in a circle, with one object in the center of the circle. Participants then had to draw an arrow pointing to one of the objects in the array from the perspective of the central object. For some participants, the task was described as a spatial task at which males typically have the advantage; for other participants, the task was described as a social task for which females typically have the advantage. The researchers found that females did significantly worse than males in the spatial group, but sex differences were almost non-existent in the social group. This shows that when females were encouraged to think in terms of perspective-taking as a social task, they did as well as men. The study also showed that males performed well in both the spatial and social groups, while females performed well in only the social group. This shows that encoding strategies do not affect males, but do affect females. This was the first study to demonstrate that simple encouragement of different thinking styles could yield different results in males and females.

Nowak, Murali, & Driscoll (2015) revealed that when participants were asked to navigate through a computerized maze using a joystick, men outperformed women significantly. One reason for this could be the fact that the task was designed in an allocentric manner that favored men. Interestingly, men self-reported using an allocentric strategy to complete the task, while women reported using an egocentric approach. Furthermore, the preferred strategy affected results in a manner that individuals who reported allocentric encoding did significantly better than individuals who preferred egocentric encoding; this makes sense because spatial memory was measured using an allocentric task.

These past studies reveal potential explanations for the repeatedly observed sex differences in spatial cognition skills. The current experiment sought to extend upon this seminal research and to address several gaps in the literature. Firstly, Tarampi et al. (2016) investigated the effects of task framing and sex on perspective taking; we are interested in investigating if their results apply to a different spatial cognition domain, spatial memory. Research has found that males perform better than females at memory tasks in geo-spatial navigation (Lovden et al, 2007) while females perform better than males in memory tasks for emotional events (Canli, Desmond, Zhao, & Gabrieli, 2002). If males and females tend to rely on different navigation strategies (egocentric vs. allocentric), then perhaps manipulating the way in which object location memory tasks are framed (egocentric vs. allocentric) would reduce these sex differences. Secondly, many spatial cognition experiments have mostly been 2-dimensional, paper-pen tasks (Tarampi et al., 2016) or computerized 3-dimensional tasks, but in small-scale, unnatural environments (Nowak et al, 2015). As a result, we do not know if the above results apply when people encode information in 3-dimensional, real-life, large-scale environments.

In the present pilot study, we investigated if sex differences for object location memory in large scale environments depend on task framing. Task framing was manipulated by using either allocentric or egocentric language when testing participants' spatial abilities. We hypothesized a main effect of sex, with males performing better than females overall, and an interaction effect, with males outperforming females in the allocentric group, but seeing no or reduced sex differences in the egocentric group.

Our study is important to understand how males and females remember spatial information. The results could be useful to provide useful insight into how math and science are taught in school; this is because working with and remembering numbers is considered a form of spatial task. Women do significantly worse at math and science tests around the united states (Benbow, & Stanley, 1983). Thus, if lectures, exams and projects are geared towards a woman's way of thinking, women may perform as well as men in these domains.

Method

Participants

Thirty-three undergraduate students (13 males; 20 females, M_{age} = 19, *SD* = 0.96, age range = 18-22 years) participated in the study for course research credit. The students were recruited from an online recruitment system named ORSEE.78.8% identified as white or Caucasian; 3% Black or African American; 3% Asian; 3% as Hispanic; 3% as Multi-racial; and 3% preferred not to disclose. Three percent were college Seniors, 12.1% were college Juniors, 63.6% % were Sophomores, and 21.2% were Freshman.

Materials

Computer and Virtual Reality System.

The experiment was conducted in virtual reality (VR). The reason we used virtual reality is because it was easier to create and manipulate an environment that was suited to our needs. The VR system used was the HTC Vive, which allows participants to be immersed in a 3D computer generated environment. The HTC Vive system employs a headset with a dual AMOLED 3.6" diagonal screen, and a field of view of 110 degrees, and two SteamVR tracking controllers. The headset is worn over the participants head to see the virtual environment, and the controllers are used to move around in the environment. The VR system was connected to a high processing Asus computer with a GTX 1070 NVIDIA graphics card.

Virtual Mazes.

All virtual environments were designed using Unity 3D. Two VR environments were created for the study: The first maze was used to train participants on how to use VR (Training Maze). It consisted of a square shaped room with a white and green floor, white walls, and a roof. A blue wall ran across half-way through the room.

The second maze was used for participants to learn the location of six common objects (Learning Maze). The objects included a lamp, bike, chair, plant, stove, and barrel. This maze was enclosed in a rectangle, and consisted of a combination of hallways and rooms. The walls and floor were colored light grey. There was no roof, so participants could see an open sky if they looked up. No more than one object was placed in the same room. A top-down view of the maze is shown in Figure 2. This was the maze that participants explored, and then were tested on their object location memory.

Object placement task.

The first task (Object Placement Task) required participants to drag and drop objects on a top-down view map to where they thought those objects were located. A straight-line distance formula was used to calculate the error in object placement. A list of the objects they encountered was shown to the left of the maze. Each object name had a movable square next to it that participants could drag and drop to where they thought the object was in the maze. This computer program was written using the Python programming language. According to participant's condition, the tasks were framed as follows:

> Allocentric Condition [a black dot was presented at the starting location]: "The dot represents the starting location. Drag and drop the objects to where you think they were in the maze" (Figure 3).

Egocentric Condition [a human figure was placed at the starting location]: "Imagine you are the person standing at the starting location. Drag and drop the objects to where you think they were in the maze" (Figure 3).

Angular pointing task.

The second task (Angular Pointing Task) required participants to point from one visible object, to another, not visible object; this too was done on a top-down view of the map the participants explored. The error was the pointing angle. Participants were presented with an image of a portion of the maze in which an object was located. It was required that they drew a red line toward where they thought the other object was located. Importantly, the other object was not visible in the current image on screen. This computer program was written using the Python programming language. According to participant's condition, the tasks were framed as follows:

Allocentric Condition [black dot was presented next to the object]: Look at the dot next to the (object name). Draw an arrow to the (object name) relative to the dot. (Figure 4)

Egocentric Condition [human figure was presented next to the object] "Imagine you are the person standing next to the (object name). Draw an arrow to the (object name) relative to yourself. (Figure 4)

Questionnaires.

At the end of the study, the participants completed 4 questionnaires. The demographics questionnaire gathered data on the participant's demographic information including age, sex, race/ethnicity, and year in school. The Video Game Experience Questionnaire assessed how much participants currently played video games. Items were scored from 1 (*Very frequently*) to 6 (*Never*). The three items in the questionnaire were, "How often do you play fist-person video games? (e.g, Counter Strike, Halo), "How often do you use Virtual reality?" and "How many hours per week do you spend playing first-person video games?"

The Way Finding Strategy Scale (Lawton, 1944; Skagerlund, Kirsh, & Dahlback, 2012) assessed route and orientation based navigation strategies on a 5-point scale from 1 (*not true at all*) to 5 (*very true*). High scores on the Way Finding Strategy Scale – Route indicate navigational strategies that depend on getting from place to place based from one's perspective; in other words, an egocentric approach. High scores on the Way Finding Strategy Scale - Orientation indicate navigational strategies that depend on one's position relative to objects in the environment; in other words, an allocentric approach. Participants were asked to think of times in past when they had to find their way, for the first time, through a novel environment. Some examples were as follows: "I asked for directions telling me how many streets to pass before making each turn", and "I appreciated the availability of someone (e,g. a receptionist) who could give me directions".

The Santa Barbara Sense of Direction (Novak, Murali, & Driscoll, 2015) assessed environmental spatial ability on a 7-point scale from 1 (*strongly agree*) to 7 (*strongly disagree*). Sample items included: "I am very good at giving directions", "I have trouble understanding directions", and "I usually let someone else do the navigational planning for long trips."

Procedure

The study consisted of three main phases: The training phase, where we taught the participants how to use and move in VR; the learning phase, where participants memorized objects in a virtual maze; and the test phase, where participants were tested on their object location memory. When participants arrived, the experimenter explained the purpose of the study and the participant read and signed the informed consent form. Next, the experimenter explained how to use the VR headset and controllers when navigating in virtual environments.

Training phase.

Participants were immersed in the training environment where we taught them how to navigate through a room. Participants practiced looking around and navigating in VR. They explored the room, walked around the wall running across the middle of the room, and came back to their starting location. One way to move through virtual environments is by teleportation. To teleport, participants must point the VR controller anywhere on the floor, and then click and hold a button on the controller, which then elicits a target; when the button is released, the participant teleports to that target location. Participants had the ability to point the target anywhere in the virtual world, but were advised to keep the target only on the floor (i.e., not pointing it at walls, and the roof) and to take short strides when moving within the environment. If participants did not follow these instructions, the experimenter reminded them of the guidelines. After participants communicated that they felt comfortable moving in the VR environment, the headset was taken off and the experimenter explained the learning phase.

Learning phase.

Participants were immersed in a virtual maze with 6 objects (The object names were not provided to the participants). They had 5 minutes to freely explore the maze, memorize the maze layout, and memorize where the objects were located. Participants were also asked to use all 5 minutes to do this. Participants knew that after the 5 minutes, we would test their memory for object location. Participants told they could talk to themselves or memorize silently.
When the 5-minute period ended, participants removed the headset and gave their controllers to the experimenter.

Testing phase.

Participants sat at the computer to complete a series of tasks that tested their object location memory. When the program started, python randomly assigned participants to either the

Allocentric or Egocentric condition. Participants first completed the object placement task and then the angular pointing task. For each task, he experimenter verbally explained the instructions and then participants were encouraged to read the instructions on the screen. The experimenter left the room while the participant completed each task. Figure 3 shows the object placement task, in which participants had to drag and drop the small object icons to where they thought that respective object was located in the maze.

Figure 4 shows an example trial from the angular pointing task, in which participants had to point (by drawing a line) from one visible object, to another object that was not visible on the screen.

Questionnaire.

Finally, participants filled out the questionnaire, which consisted of demographics, Video Game Experience Questionnaire, Wayfinding Strategy Scale, and the Santa Barbara Sense of Direction Scale.

After completing the experiment, the experimenter debriefed participants about the study and asked if they had any questions. The current study consisted of 12 egocentric-condition participants, and 21 allocentric-condition participants. The experiment duration was approximately 30 minutes.

Results

We hypothesized a main effect of participant sex, with males outperforming females overall in both the object placement and angular pointing tasks, and an interaction effect, with males outperforming females in the allocentric condition, but seeing no sex differences in the egocentric condition. We tested the difference in performance using a 2 (Sex: Female, Male) x 2 (Task Framing: Allocentric, Egocentric) between-participants linear mixed effect model with participant as a random factor. We choose a mixed effect model, because this allows us to investigate differences between, as well as, within participants.

Object placement task.

To measure error, we calculated the distance in pixels between the true object location and the remembered object location. The allocentric group (*M* = 171.83, *SD* = 263.23) did not have greater distance error than the egocentric group (*M* = 87.11, *SD* = 178.11), $t(29) = -1.82$, $p = .079$. Furthermore, female participants (*M* = 170.68, *SD* = 263.33) did not have greater distance placement error than the male participants (*M* = 95.39, *SD* = 188.06), $t(29) = -1.69$, $p = .101$. Thus, the mixed model revealed that there was no significant main effect of sex or task framing. There was also no significant interaction, $t(29) = 0.67$, $p = .510$ (Figure 5)

Angular pointing task.

To measure error, we calculated the angular deviation between the true object location and the remembered object location. The allocentric group (*M* = 27.57, *SD* = 38.38) did not have greater distance error than the egocentric group (*M* = 19.06, *SD* = 29.64), $t(29) = -0.99$, $p = .331$. Female participants (*M* = 29.37, *SD* = 40.56) did not have greater distance placement error than the male participants (*M* = 16.94, *SD* = 24.63), $t(29) = -1.54$, $p = .134$. The mixed model revealed that there was no significant main effect of sex or task framing. There was also no significant interaction, $t(29) = 0.02$, p = .981.

Questionnaires.

Results from the video game experience questionnaire on a 6-point scale ranging from 1 (*very frequently*) to 6 (*never*) revealed that males (*M* = 3.46, *SD* = 1.12) played more video games than females (*M* = 5.80, *SD* = 0.41), $t(31) = 8.51$, $p < .005$. Furthermore, males (*M* = 3.46, *SD* = 1.12) spent more time playing video games than females (*M* = 1.46, *SD* = 2.02), $t(31) = -3.26$, $p = .002$. Our sample was not experienced with virtual reality exposure (*M* = 5.82, *SD* =

0.39); males (*M* = 5.84, *SD* = 0.37) did not show greater exposure to virtual reality compared to females (*M* = 5.80, *SD* = 0.41), *t*(31) = -0.33, *p* = .746; thus, participant's performance was not affected by prior VR experience.

Lawton's (1994) way-finding strategy scale measured orientation strategy and route strategy on a 5-point scale ranging from 1 (*not true*) to 5 (*very true*). There was no significant difference between males (*M* = 27.76, *SD = 9.26*) and females (*M* = 24.80, *SD* = 5.89) for the orientation strategy, *t*(31) = -1.13, *p* = .267. The route strategy yielded similar results, such that males (*M* = 22.61, *SD* = 2.32) and females (*M* = 22.05, *SD* = 4.27) did not differ , *t*(31) = -0.44, *p* = .666.

There was no significant difference between males (*M* = 61.30, *SD* = 7.15) and females (*M* = 64.84, *SD* = 6.29) for the Santa Barbara Scale of Direction Scale , *t*(30) = 1.48, *p* = 0.150. Table 1 provides descriptive statistics overall and by sex for all questionnaires..

Discussion

The main interest of this study was to investigate if task framing, could reduce prevalent sex differences in object location memory in large-scale, virtual environments. We did not explicitly ask participants to encode spatial information in a particular-way, so our experiment specifically addresses if priming participants to *recall* information using a certain strategy affects accuracy. Results did not yield significant differences; however, this pilot study did not have sufficient power to detect significant differences if they did exist. Therefore, we will discuss the extent to which the pattern of results is consistent or inconsistent with past research and our hypotheses. We must be cautious in assigning too much weight to these data patterns given that we had small samples per cell. A fully powered follow-up experiment is planned to test the reliability and statistical significance of these data patterns.

Based on mean differences on the object location task, men performed better than women overall. The egocentric group, regardless of sex, performed better than the allocentric group. There was a greater error difference between egocentric and allocentric conditions within female participants (107.04 pixels) compared to male participants (45.29 pixels). These results are consistent with our hypotheses, and correspond with Tarampi, Heydari, and Hegarty's(2016) study in which task framing yielded different results for males and females.

Based on mean differences on the pointing task, men performed better than women overall. The egocentric group, regardless of sex, performed better than the allocentric group. There does not appear to be a difference in error magnitude between egocentric and allocentric conditions within female participants (8.2 pixels) compared to male participants (7.9 pixels). This interaction result is inconsistent with our hypothesis, and with the object location task data pattern.

Males had a higher average score for the Way Finding Strategy Scale – Orientation (Allocentric Measure) than females, while the average between males and females for the Way Finding Strategy Scale – Route (Egocentric Measure) were equal. Given this, we expected that men would perform equally well in the allocentric and egocentric groups; however, results demonstrated that men, in terms of mean differences, did better in the egocentric group compared to the allocentric group. This contrasts with Nowak, Murali, & Driscoll's (2015) study, which demonstrated that males prefer allocentric encoding rather than egocentric encoding. This is an important point, as it is paramount to understand what type of encoding strategy men prefer. If both males and females prefer the same spatial encoding strategy we many need to adjust our assumptions about under which circumstances males and females will perform better on spatial tasks.

In terms of mean differences, men performed better than women in the both object location memory tasks. This result contrasts with Voyer, Postma, and Brake (2007) where females had better object location memory than males. However, they had participants encode information 2-dimensionally, rather than 3-dimensionally.Traditional object placement tasks require viewing an array of objects on a paper, and placing those objects in the correct place once they have switched locations. The task by Voyer et al (2007) may not have required egocentric or allocentric encoding, but rather another way of thinking. On the other hand, participants in our study encountered objects one at a time, in a 3-dimensional environment, and may have required the allocentric or egocentric encoding strategy to remember them, which could be why men performed better at the task.

The fact that the current study did not yield significant results could be attributed to several shortcomings. Firstly, we had an extremely small sample size. Our power analysis revealed that the optimal sample size would be 128 participants; however, the study only had 33 participants. When this number is further broken down into our four independent groups (male/female, allocentric,/egocentric), we have with approximately 8 people per group.This resulted in large variability and individual differences. However, even though the sample was not large enough to yield significant results, the results are promising for a full experiment that could yield significant differences. Secondly, depending on how participants recalled and placed the objects, the object placement task could produce inconsistent results. For example, if a participant placed an object in the opposite corner of the same room where the real object was, the error would be somewhat large. However, if another participant placed that same object in a different room, but right next to the wall where the real object was supposed to be, the error would be small. This is because we used a straight-line equation to measure the error, and walls are not taken into consideration. Therefore, although we obtained a smaller error in the second example, the first participant recalled where the object was more accurately (as the participant in the first example placed the object in the same room, and the participant in the second example placed it in a different room). Finally, although our participants encoded the information in 3-dimensions, we tested them using a 2-dimensional task; this raises the question if we could obtain similar results if we tested them in a 3-dimensional world.

In conclusion, the present study was a pilot study that provided us valuable information for conducting a full experiment in the future. We obtained large mean differences, but large variability and small sample size made it unlikely for us to measure significant differences. The study would provide important information on the true magnitude of sex differences on object location memory tasks and how the way in which spatial skills are measured affects performance.

In the future, we would like to investigate if social and cultural factors attribute to the usage of different spatial strategies. Is it a social construct for women to think in terms of themselves and men to think in terms of the environment? Would we find similar results between individualistic and collectivist cultures?

Furthermore, the results of the study could benefit how tasks that require spatial thinking are constructed. For example, STEM subjects such as math, computer science, and statistics are domains that require spatial abilities that are significantly underrepresented by women. This may be because the material could be taught using an allocentric approach, placing women in a disadvantage. The current study is a stepping stone in understanding how to help humans better learn, process, and retrieve spatial information. This line of research could also inform how educational systems, mobile-applications, and street road maps are made, which could be currently constructed in an allocentric manner.

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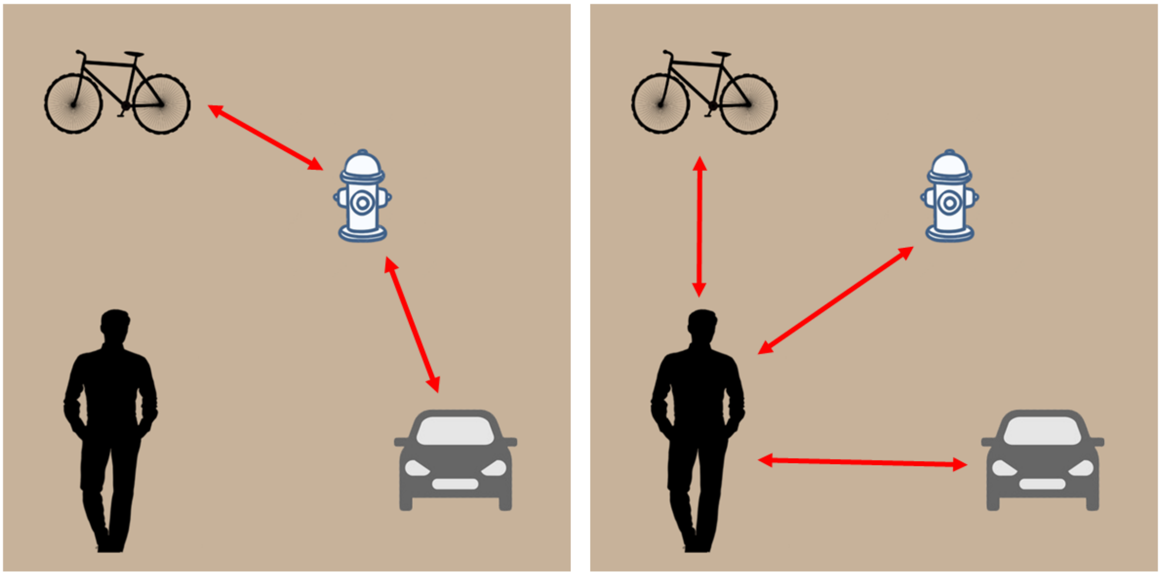

Figure 1. The left image shows Allocentric encoding where the individual perceives the fire hydrant location relative to other objects in the environment, such as the car and bicycle. The right image depicts Egocentric Encoding, where the individual perceives the fire hydrant, car, and bicycle location relative to themselves.

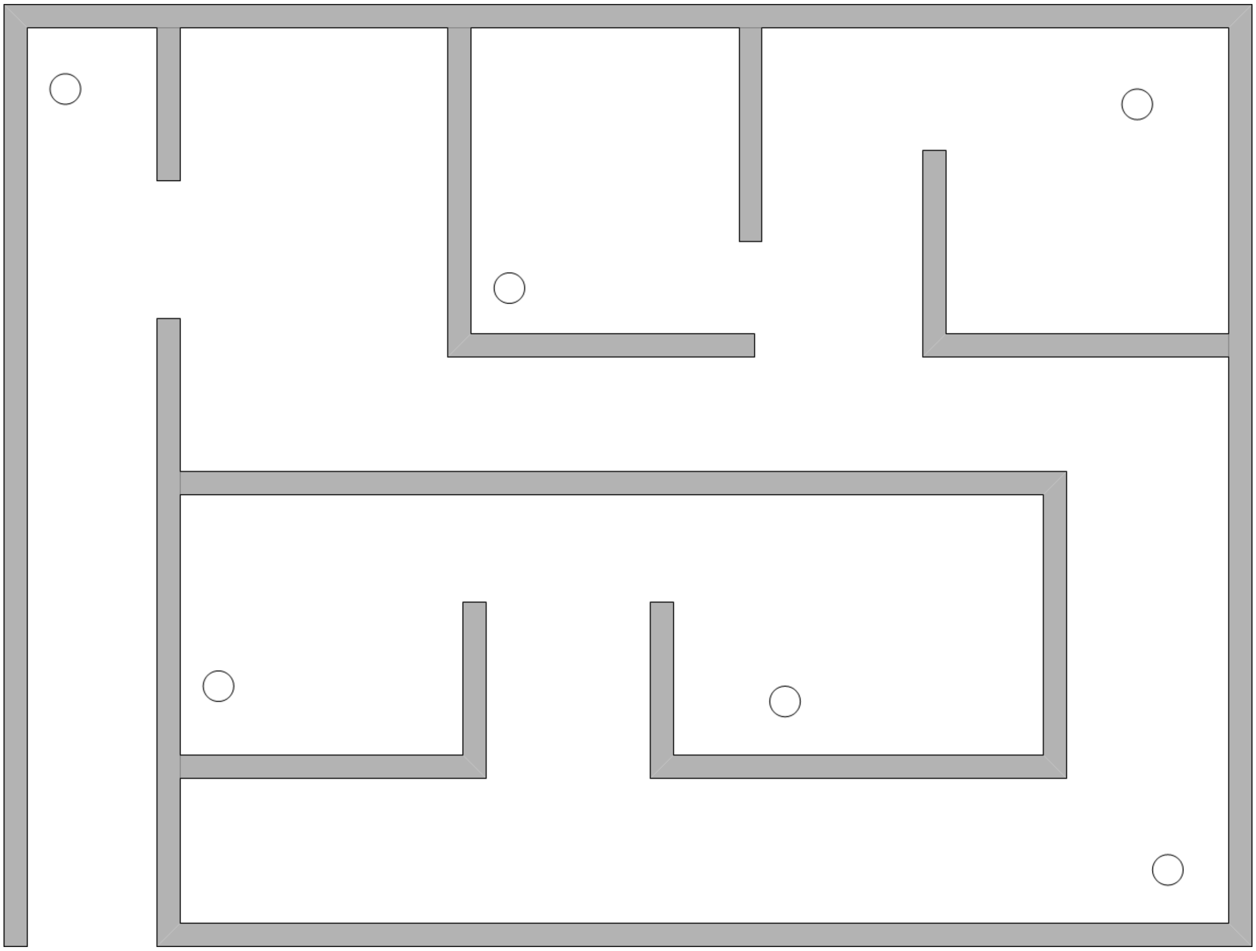

Figure 2. Top-down view of the virtual ‘Learning Phase’ map. Each open circle indicate the true location of the six objects.

Figure 3. Object Placement Task: The image on top depicts the allocentric condition. Participants were told that the dot represented the starting location.The image on the bottom depicts the egocentric condition. Participants were told to imagine they were the person at the starting location.

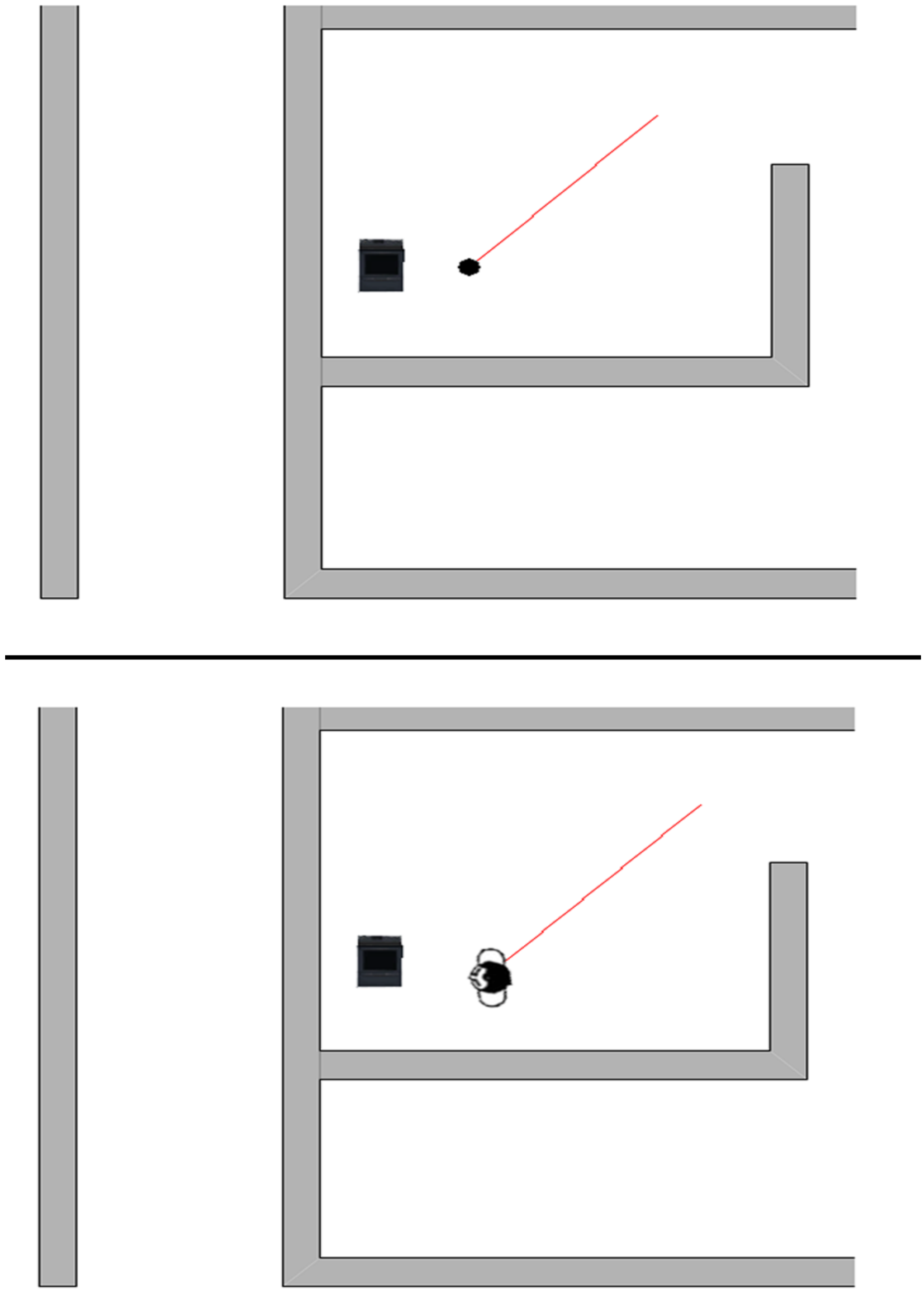

Figure 4. Angular Pointing Task: The image on top depicts the allocentric condition. Participants were told to point to another object location relative to the black dot. The image on the bottom depicts the egocentric condition. Participants were told to imagine they are the person in the image and to point to another object location relative to themselves.

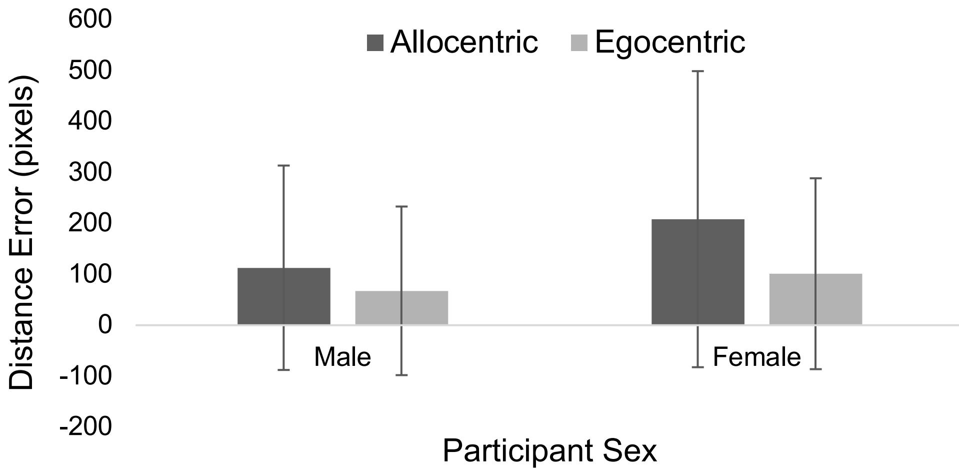

Figure 5. Effect of participant sex (male, female) and task framing (allocentric, egocentric) on distance error for the map location task. Error bars represent standard deviations.

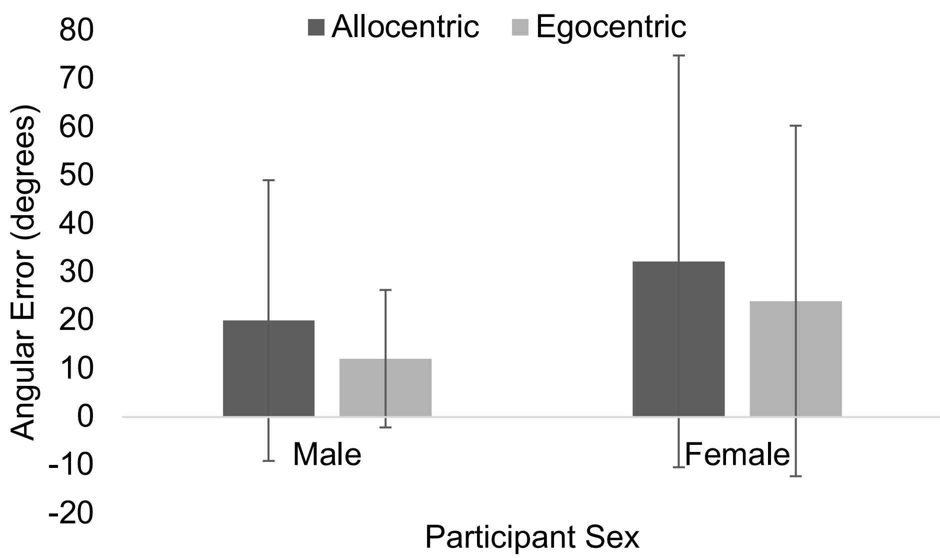

Figure 6. Effect of participant sex (male, female) and task framing (allocentric, egocentric) on angular error for pointing task. Error bars represent standard deviations.

Appendix

Demographics Questionnaire

Please answer the following questions. All information provided will remain completely confidential and anonymous. You may skip any questions you do not wish to answer.

1. Age (in years):

2. Sex:
    - Male
    - Female

3. Race/Ethnicity
    -African-American, Black, African, Caribbean
    -Asian-American, Asian, Pacific Islander
    -European-American, Anglo, Caucasian
    -Hispanic-American, Latino(a), Chicano(a)
    -Native-American, American Indian
    -Bi-racial, Multi-racial
    -Other (please specify) ____________________

4. Year in School:
    -First Year
    -Sophomore
    -Junior
    -Senior

Video Game Experience Questionnaire

1. How often do you play first-person video games (e.g., Counter Strike, Halo).

    1. Very Frequently
    2. Frequently
    3. Occasionally
    4. Rarely
    5. Very Rarely
    6. Never

2. On average, how many hours per week do you spend playing first-person video games?

3. How often do you use virtual reality?

    1. Very Frequently
    2. Frequently
    3. Occasionally
    4. Rarely
    5. Very Rarely
    6. Never

Way-Finding Strategy Scale

Think of times in the past when you have had to find your way for the first time to a specific location in a SOMEWHAT FAMILIAR city or town (i.e., you had been to the city or town a few times before, but never to that particular location within the city). Think of times when you were driving, bicycling, or walking (after leaving the bus/train/metro) as you tried to find the location. Rate each of the following strategies for how true it would be of you in this type of situation, using the following scale:

A Not at all true
B Slightly true
C Moderately true
D Mostly true
E Very true

1. I asked for directions telling me how many streets to pass before making each turn.
2. I visualized a map or layout of the area in my mind as I went.
3. I kept track of the direction (north, south, east, or west) in which I was going.
4. I asked for directions telling me whether to turn right or left at particular streets or landmarks.
5. I kept track of where I was in relation to the sun (or moon) in the sky as I went.
6. As I went, I made a mental note of the distance I traveled on different roads.
7. I kept track of where I was in relation to a reference point, such as the center of town, lake, river, or mountain.
8. I asked for directions telling me whether to go east, west, north, or south at particular streets or landmarks.
9. I kept track of the relationship between where I was and the next place where I had to change direction.

Now think of times in the past when you tried to find your way around in a building or large complex (e.g., a shopping mall, business complex, medical center) that you had never been in before. Please rate each statement as to how true it would be of you in this type of situation, according to the following scale:

1. I could visualize what was outside of the building or complex in the direction I was heading inside the building.
2. I appreciated the availability of someone (e.g., a receptionist) who could give me directions.

3. I always kept in mind the direction from which I had entered the building or complex (e.g. north, south, east, or west side of the building.)
4. Whenever I made a turn, I knew which direction I was facing.
5. I found maps of the building or complex, with an arrow pointing to my present location, to be very helpful.
6. Clearly visible signs pointing the way to different sections of the building or complex were important to me.
7. Clearly labeled room numbers and signs identifying parts of the building or complex were very helpful in finding my way.
8. I thought of my location in the building or complex in terms of north, south, east, and west.

Santa Barbara Scale of Direction

This questionnaire consists of several statements about your spatial and navigational abilities, preferences, and experiences. After each statement, you should choose a response to indicate your level of agreement with the statement.

Strongly agree
Agree
Somewhat agree
Neither agree nor disagree
Somewhat disagree
Disagree
Strongly disagree

Questions to reverse code in bold.

1. I am very good at giving directions.
2. I have a poor memory for where I left things.
3. I am very good at judging distances.
4. My "sense of direction" is very good.
5. I tend to think of my environment in terms of cardinal directions (N, S, E, W).
6. I very easily get lost in a new city.
7. I enjoy reading maps.
8. I have trouble understanding directions.
9. I am very good at reading maps.
10. I don't remember routes very well while riding as a passenger in a car.
11. I don't enjoy giving directions.
12. It's not important to me to know where I am.
13. I usually let someone else do the navigational planning for long trips.
14. I can usually remember a new route after I have traveled it only once.
15. I don't have a very good "mental map" of my environment.

Table 1. *Questionnaire Results*

	Overall		Males		Females		t-test	
Questionnaire	Mean	SD	Mean	SD	Mean	SD	t(df)	p-value
Video Game Frequency	4.88	1.38	3.46	1.12	5.80	0.41	8.51	<0.05
Hours Video Gaming	0.58	1.44	1.46	2.02	0.00	0.00	-3.26	.002
Virtual Reality Exposure	5.82	0.39	5.84	0.37	5.80	0.41	-0.32	.746
Way-Finding (Orientation)	25.97	7.42	27.76	9.26	24.80	5.89	-1.13	.267
Way-Finding (Route)	22.27	3.6	22.61	2.32	22.05	4.27	-0.43	.666
Santa Barbara Scale	63.64	6.78	61.30	7.15	64.84	6.29	1.48	.150