Supplemental Material for

Combining Egoformative and Alloformative Cues in a Novel Tabletop Navigation Task

Michael J. Starrett, Derek J. Huffman, & Arne D. Ekstrom

Psychological Research

Corresponding author: mjstarrett@gmail.com

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Supplemental Methods

Sample Size Estimation

Type I error rate was set to the traditional value of .05. Using the lme4 package (Bates et al., 2015) in R (R Development Core Team, 2016), we created a linear mixed effects model of the Zhang et al. (2014) data with individual as a random factor in addition to pointing task, encoding method, and learning block as fixed factors. Due to a violation of homogeneity of variance, the dependent measure, absolute pointing error measured in degrees, was log transformed after which the assumptions of homogeneity of variance and normality of residuals were met. The means for each group were estimated using the emmeans R package (Lenth, 2021) and then exponentiated to back transform values to degrees prior to entering them in GLIMMPSE. The contrast was set to "all mean differences zero" and scale factors for means and variability were set to one. The result was an estimated sample size of 32 for each cell in the factorial design. Data was collected until the target sample was reached for a given condition, after accounting for any data exclusion.

Human Intelligence Task (HIT)

MTurk is a crowd-sourcing platform on which a requester (i.e., experimenter) can post batches of HITs (i.e., sign-ups), which workers (i.e., participants) can then complete for rewards (i.e., remuneration for participation). The HIT corresponding to these experiments was only visible and available to workers with an internet protocol (IP) address within the United States who had at least a 95% approval rate and at least 1000 approved HITs. The HIT instructions shown to prospective workers can be found in the online supplemental materials (Figure S1).

Qualtrics Survey

The MTurk HIT linked directly to a Qualtrics Survey (Qualtrics, Provo, UT) comprising the consent form, demographic questions, instructions for downloading and running the standalone application that administered the experiment, fields for submitting attention checks from the experiment, and validity checks regarding participants' use of strategies. A print version of the interactive survey can be found in Appendix A of the online supplemental materials.

Target Familiarization Task

Participants viewed a black screen where a model of one target store rotated clockwise about its vertical axis at 30° per second for three seconds (90° total) such that the storefront was orthogonal to the participants viewpoint halfway through rotation. A text label that indicated the target store name (e.g., Bike Shop) was present below the rotating model for the duration of rotation. In this fashion, each of the eight target stores in the environment were shown in a randomized order; the order randomization and presentation were repeated three times such that each participant viewed each store three times (24 total viewings).

Population of Target Stores in the city Virtual Environment (cVE)

To populate any given cVE, the lists of all possible identities and colors were each shuffled and the first 24 colors in the color list were applied to each of the 24 identities (2.02×10^{26} possible permutations). Eight of the 24 possible store identities, now with an assigned color, were then randomly selected to be populated in each of the eight target locations in the assigned cVE (2.97×10^{10} possible permutations). This was done to mitigate any potential for a specific store identity or color to bias spatial representations. For each participant eight store identities and colors were randomly selected, without replacement, and applied to the eight target stores in the cVE. These stores were then placed randomly in the eight target locations for whichever of the three cVEs was assigned. Thus, there were 14,967 unique identity-color-location-environment combinations possible.

Supplemental Results

For each of the three encoding tasks, errors were z-scored for each encoding task condition and averaged across participants. The resulting standardized data is referred to generally as encoding error. Encoding error was entered into a 3 (Encoding Task: route, tabletop, timed map) $\times$ 6 (Block: 1–6) $\times$ 2 (Pointing Task: JRD, SOP) mixed analysis of variance with Encoding Task and Pointing Task as between-subject factors and Block as a within-subject factor. For testing of assumptions see Figure S5, left panel. Results are shown in

Table S4). Nonparametric boxplots of encoding error across blocks is shown for each encoding condition in **Figure S6**; for completeness JRD and SOP are plotted separately, despite a lack of any statistically significant effects related to Pointing Task. We did not have any a priori hypotheses about encoding conditions, so no additional follow-up analyses were conducted. All encoding modalities show improvement across repeated encoding experiences, but with differing trajectories and total change. Both the encoding and pointing tasks in these experiments result in improvement over time, evidenced by the main effect of the Block in all analyses presented thus far.

The analysis comparing encoding performance in Experiment 2a and Experiment 2b, as in Experiment 1, could not be repeated, as Levene's test revealed a significant violation of the homogeneity assumption for the ANOVA, $F(5, 186) = 9.31$, $p < .001$ (see Supplemental **Figure S5**, right panel), making parametric statistics inappropriate for the analysis. Instead, an aligned rank transform was applied prior to conducting the ANOVA. In the resulting 3 (Encoding Task: route, tabletop, criterion map) $\times$ 2 (Pointing Task: JRD, SOP) $\times$ 6 (Block: 1–6) mixed ANOVA, a main effect of block was observed, $F(5, 930) = 120.69$, $p < .001$, as well as significant two-way interactions of Encoding Task by Block, $F(10, 930) = 22.73$, $p < .001$, and Pointing Task by Block, $F(5, 930) = 4.26$, $p < .001$. The three way interaction between Encoding Task, Pointing Task, and Block was also significant, $F(10, 930) = 4.21$, $p < .001$, which was consistent with the primary analysis of absolute angular pointing error on the pointing tasks. The reported effects remained statistically significant after a Bonferroni correction was applied to control for multiple (seven) comparisons (full ANOVA table is shown in Supplemental **Table S6**). Median z-scored performance for each block of the JRD and SOP tasks as well as individual subject scores are shown in Supplemental Figure S8.

Table S1

Demographics for each Condition across all Experiments

Learning Task Memory Task	Age			*n*		
	Range	*M*	*SD*	Female	Male	Total
Criterion Map						
JRD	[20, 35]	29.88	4.19	8	24	32
SOP	[18, 35]	29.34	4.01	9	23	32
Hybrid						
JRD	[21, 35]	30.78	3.55	11	21	32
SOP	[23, 35]	31.25	3.29	12	20	32
Route						
JRD	[22, 35]	30.34	3.31	13	19	32
SOP	[20, 35]	31.58	3.48	11	20	31
Timed Map						
JRD	[19, 35]	30.66	4.46	11	21	32
SOP	[24, 35]	30.56	3.27	7	25	32

Note. JRD = judgements of relative direction; SOP = scene- and orientation-dependent pointing.

Table S2

Properties of Generated Target Stores

Store Identities	Colors				
	Name	Hexadecimal	RGB		
Bakery	Amethyst	#F0A3FF	240	163	255
Barber Shop	Blue	#0075DC	0	117	220
Bike Shop	Caramel	#993F00	153	63	0
Camera Store	Damson	#4C005C	76	0	92
Candy Shop	Ebony	#191919	25	25	25
Clothing Store	Forest	#005C31	0	92	49
Coffee Shop	Green	#2BCE48	43	206	72
Comic Shop	Honeydew	#FFCC99	255	204	153
Computer Store	Iron	#808080	128	128	128
Flower Shop	Jade	#94FFB5	148	255	181
Game Shop	Khaki	#8F7C00	143	124	0
Grocery	Lime	#9DCC00	157	204	0
Hardware Store	Mallow	#C20088	194	0	136
Ice Cream Shop	Navy	#003380	0	51	128
Jewelry Store	Orpiment	#FFA405	255	164	5
Laundromat	Pink	#FFA8BB	255	168	187
Library	Quagmire	#426600	66	102	0
Liquor Store	Red	#FF0010	255	0	16
Music Store	Sky	#5EF1F2	94	241	242
Pet Shop	Turquoise	#00998F	0	153	143
Pharmacy	Uranium	#E0FF66	224	255	102
Post Office	Violet	#740AFF	116	10	255
Restaurant	Wine	#990000	153	0	0
Toy Store	Xanthin	#FFFF80	255	255	128
	Yellow	#FFFF00	255	225	0
	Zinnia	#FF5005	255	80	5

Note. This table shows the 24 possible store identities as well as the 26 possible colors that could be applied to the exterior walls.

Table S3

Counts of Datasets Excluded from Analyses

Learning Task	JRD	SOP	Total
Route	11	2	13
Timed Map	26	7	33
Hybrid	14	4	18
Criterion Map	8	12	20
Total	59	25	84

Note. JRD = judgements of relative direction; SOP = scene- and orientation-dependent pointing.

Table S4

Comparing Learning Performance in Experiment 1

Effect	*F* ratio	*df*	*p*-value	$p_{corrected}$
Learning Task	0.18	2, 186	.835	> .999
Memory Task	6.26	1, 186	.013	.093
Learning Task × Memory Task	12.98***	2, 186	< .001	< .001
Block	121.68***	5, 930	< .001	< .001
Learning Task × Block	22.69***	10, 930	< .001	< .001
Memory Task × Block	4.54**	5, 930	< .001	.003
Learning Task × Memory Task × Block	4.28***	10, 930	< .001	< .001

Note. $N = 192$. *df* = degrees of freedom; $p_{corrected}$ = *p*-value adjusted for seven comparisons in the family of tests.

**$p < .01$, corrected. ***$p < .001$, corrected.

Table S5

Hybrid Utilization Kendall Rank Correlations

Correlation with Hybrid Utilization	*df*	τ	*p*-value
JRD			
Learning Error	30	.19	.141
Memory Error	30	.28	.025
SOP			
Learning Error	30	.04	.785
Memory Error	30	.17	.169

Note. df = degrees of freedom; τ = Kendall rank correlation coefficient; JRD = judgements of relative direction; SOP = scene- and orientation-dependent pointing.

Table S6

Comparing Learning Performance in Experiment 2

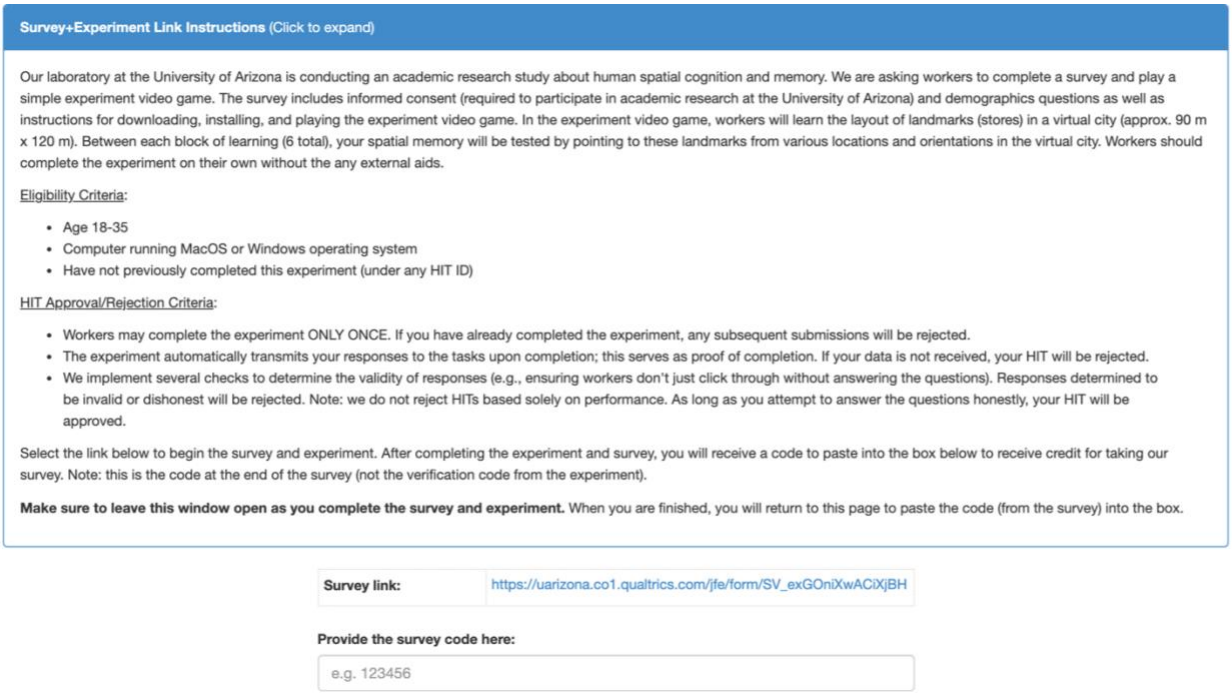
Effect	*F* ratio	*df*	*p*-value	$p_{corrected}$
Learning Task	0.19	2, 186	.828	> .999
Memory Task	0.06	1, 186	.807	> .999
Learning Task × Memory Task	0.07	2, 186	.936	> .999
Block	120.69***	5, 930	< .001	< .001
Learning Task × Block	22.73***	10, 930	< .001	< .001
Memory Task × Block	4.26**	5, 930	< .001	.005
Learning Task × Memory Task × Block	4.21***	10, 930	< .001	< .001

Note. N = 192. *df* = degrees of freedom; $p_{corrected}$ = *p*-value adjusted for seven comparisons in the family of tests.

**p < .01, corrected. ***p < .001, corrected.

Figure S1

Human Intelligence Task Listing from Amazon Mechanical Turk



Survey+Experiment Link Instructions (Click to expand)

Our laboratory at the University of Arizona is conducting an academic research study about human spatial cognition and memory. We are asking workers to complete a survey and play a simple experiment video game. The survey includes informed consent (required to participate in academic research at the University of Arizona) and demographics questions as well as instructions for downloading, installing, and playing the experiment video game. In the experiment video game, workers will learn the layout of landmarks (stores) in a virtual city (approx. 90 m x 120 m). Between each block of learning (6 total), your spatial memory will be tested by pointing to these landmarks from various locations and orientations in the virtual city. Workers should complete the experiment on their own without the any external aids.

Eligibility Criteria:

- Age 18-35
- Computer running MacOS or Windows operating system
- Have not previously completed this experiment (under any HIT ID)

HIT Approval/Rejection Criteria:

- Workers may complete the experiment ONLY ONCE. If you have already completed the experiment, any subsequent submissions will be rejected.
- The experiment automatically transmits your responses to the tasks upon completion; this serves as proof of completion. If your data is not received, your HIT will be rejected.
- We implement several checks to determine the validity of responses (e.g., ensuring workers don't just click through without answering the questions). Responses determined to be invalid or dishonest will be rejected. Note: we do not reject HITs based solely on performance. As long as you attempt to answer the questions honestly, your HIT will be approved.

Select the link below to begin the survey and experiment. After completing the experiment and survey, you will receive a code to paste into the box below to receive credit for taking our survey. Note: this is the code at the end of the survey (not the verification code from the experiment).

Make sure to leave this window open as you complete the survey and experiment. When you are finished, you will return to this page to paste the code (from the survey) into the box.

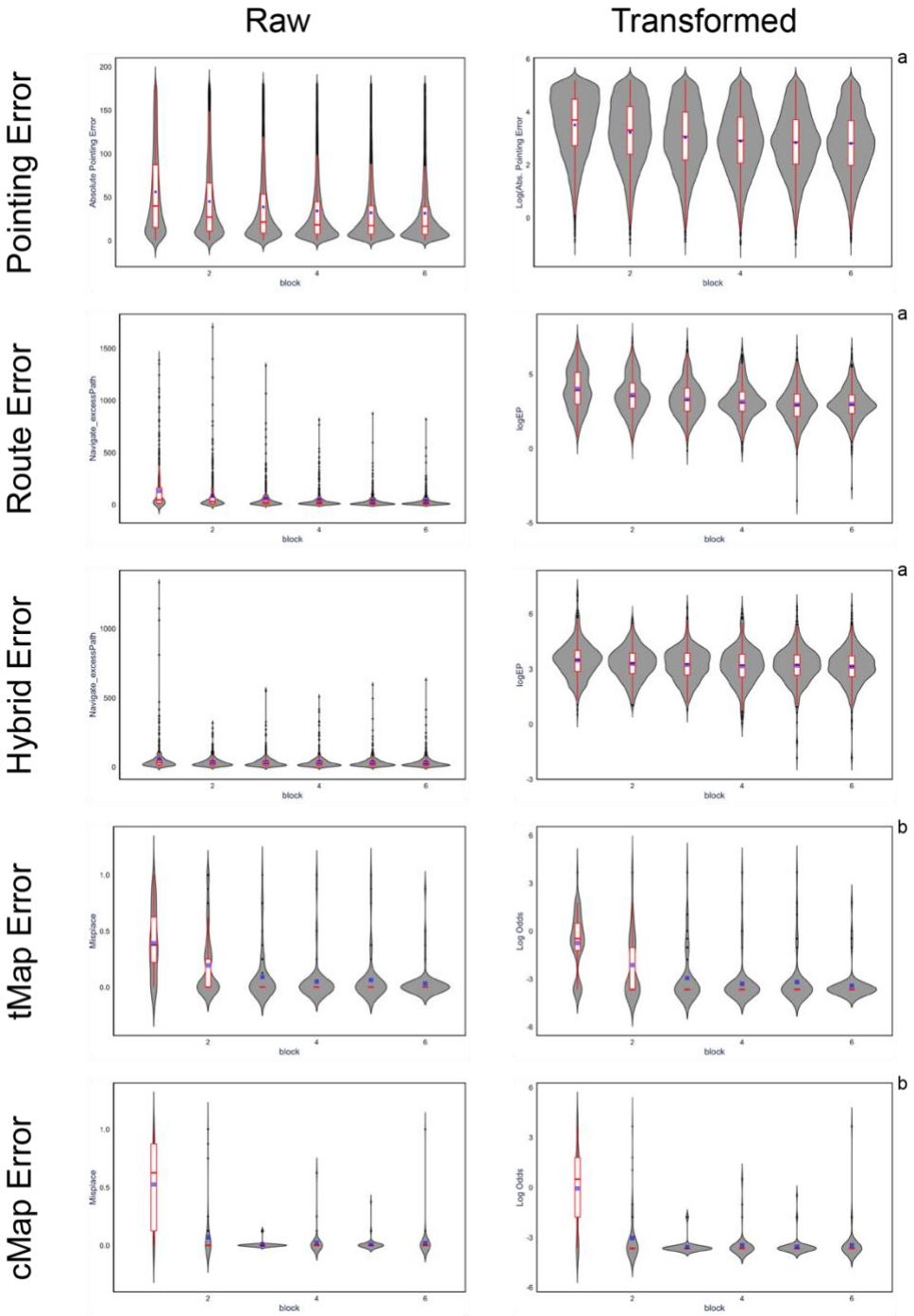
Survey link: https://uarizona.co1.qualtrics.com/jfe/form/SV_exGOniXwACiXjBH

Provide the survey code here:

e.g. 123456

Figure S2

Distribution of Absolute Pointing Error before and after Log Transformation



Note. Box plots (red) show median and quartile ranges, violin plots (gray) show continuous distribution of error, and "x" circles (blue) show the mean. Map = timed map; cMap = criterion map.

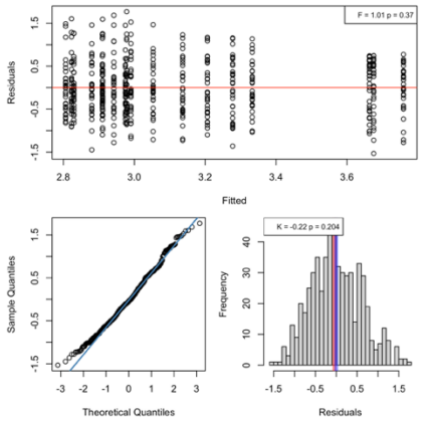
[a] Log transformation applied.

[b] Logit transformation applied.

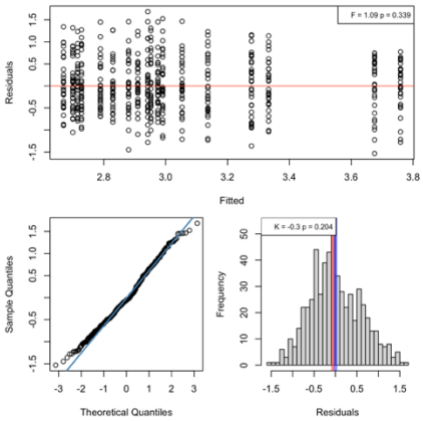
Figure S3

Testing ANOVA Assumptions for Primary Analyses

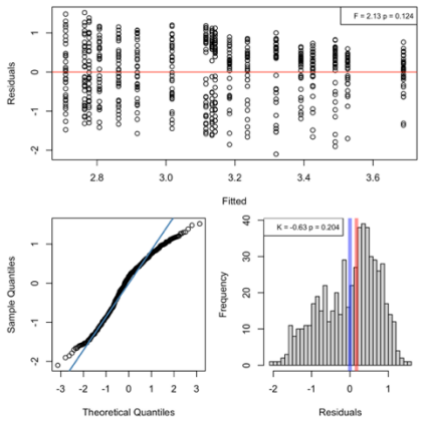
Experiment 1a



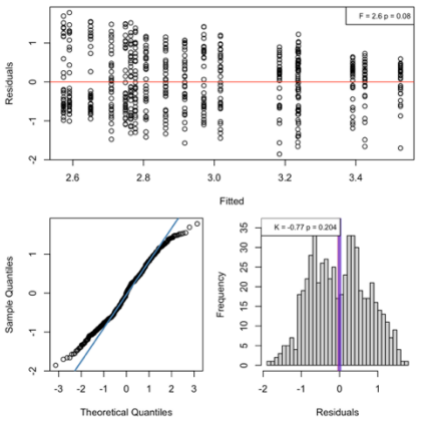
Experiment 2a



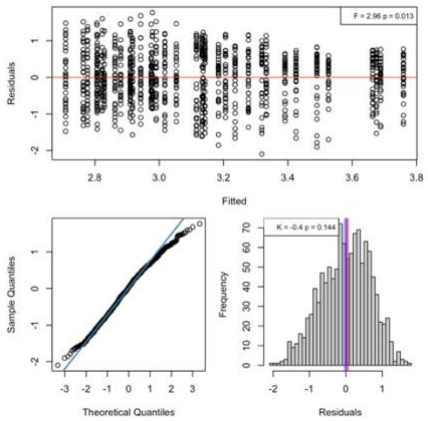
Experiment 1b



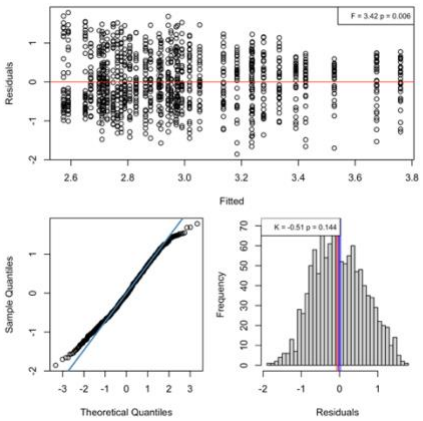
Experiment 2b



Experiment 1a & 1b



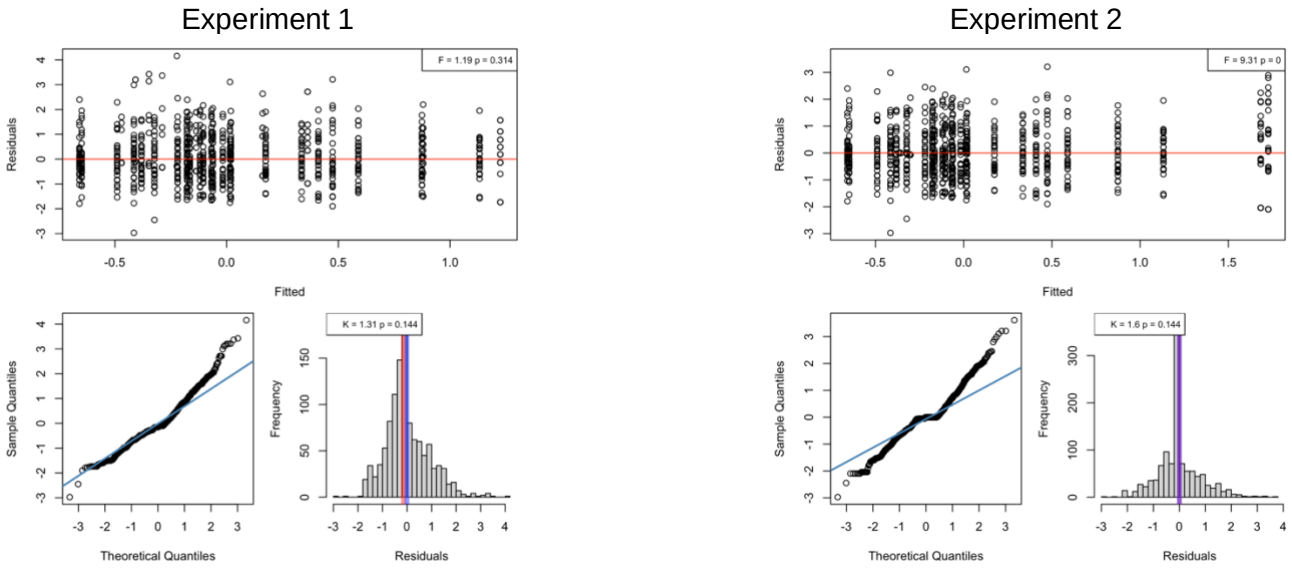
Experiment 2a & 2b



Note. For each experiment assumptions of homogeneity of variance (top plot) and normality (bottom plots) were evaluated.

Figure S4

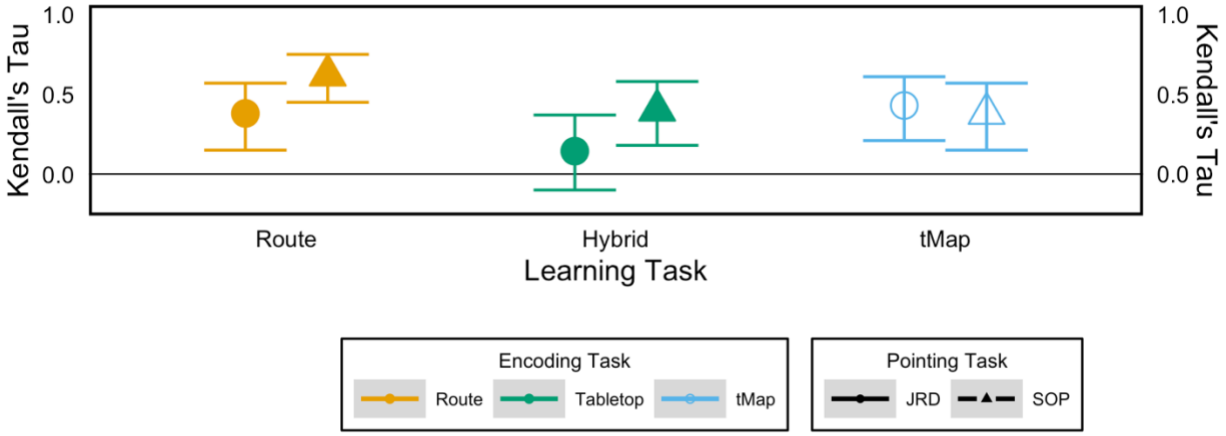
Testing ANOVA Assumptions for Learning Data



Note. Assumptions of homogeneity of variance (top plot) and normality (bottom plots) were evaluated.

Figure S5

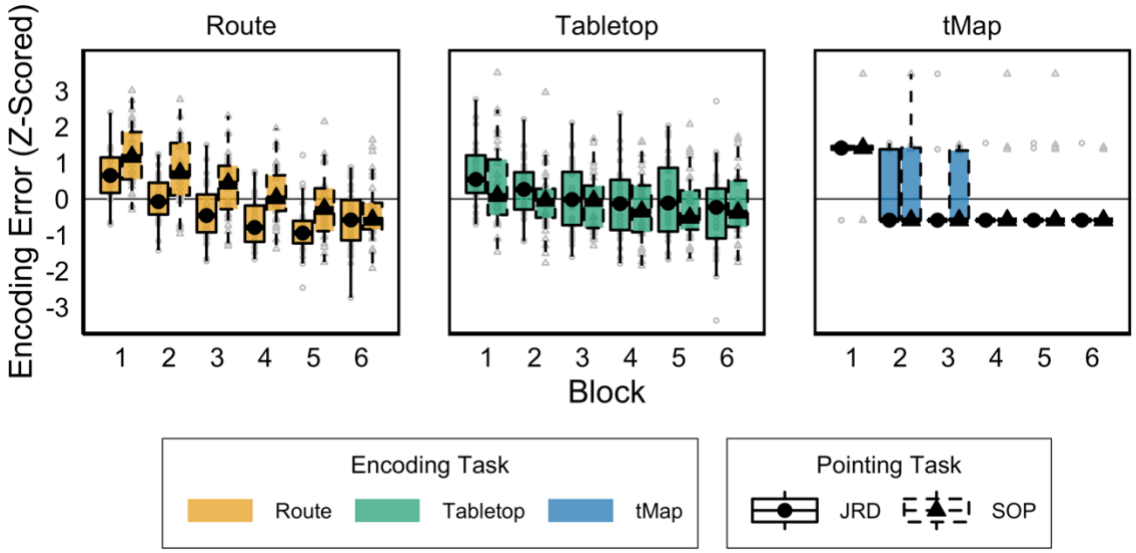
Confidence intervals for Encoding-Pointing Kendall's tau correlations



Note. The associated 95% confidence interval, generated by using Fieller et al.'s (1957) method for estimating standard error (Bishara & Hittner, 2017).

Figure S6

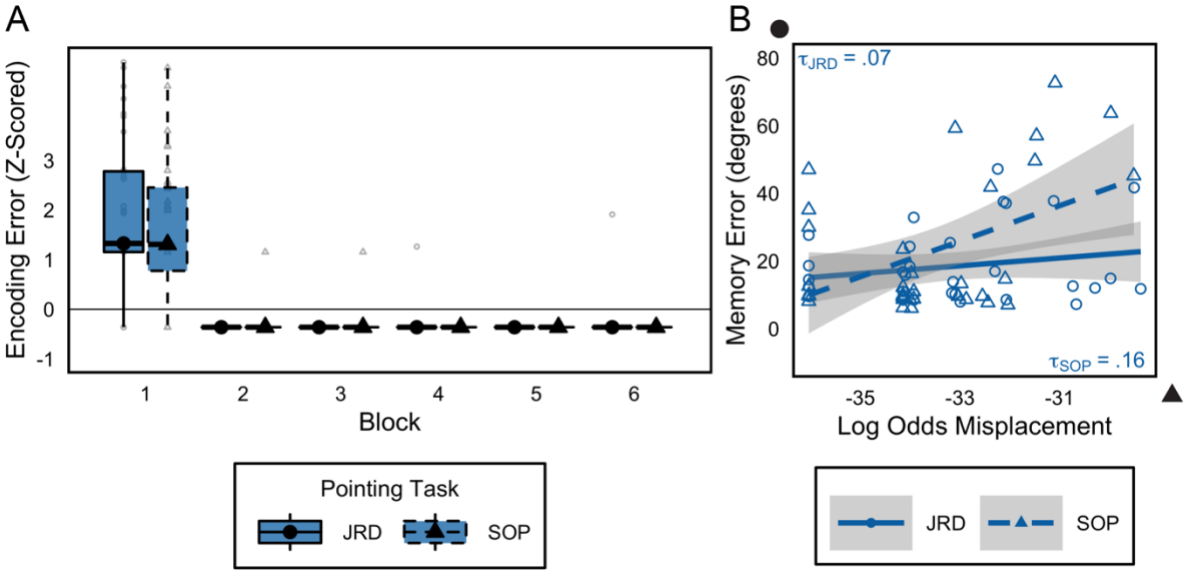
Encoding task performance for Experiment 1



Note. Standardized (z-scored) error on the encoding tasks separated by pointing task (JRD: solid lines, circles and SOP: dotted lines, triangles). Ribbons represent standard error of the mean.

Figure S7

Relationship between encoding and memory performance in Experiment 2

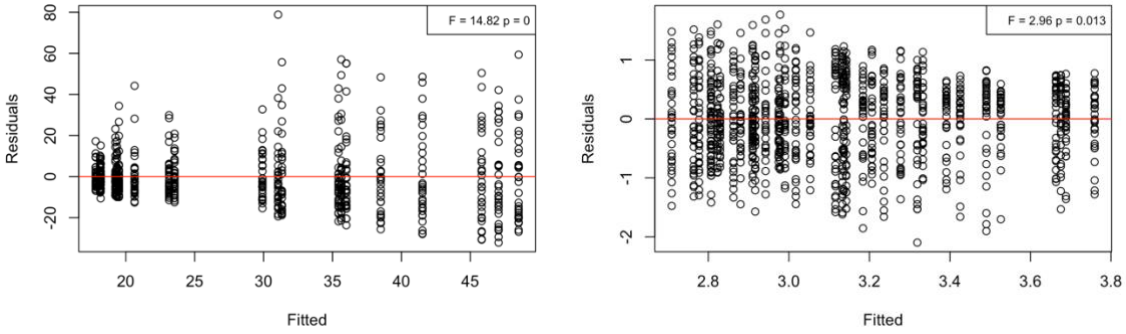


Note. Panel A: Boxplots showing standardized (z-scored) error on the learning tasks across blocks for the JRD (circles) and SOP (triangles); This plot is analogous to Figure 4, panel A, in the main text, but shows medians and ranges instead of means and standard errors. Boxes represent the median, first, and third quartile; whiskers extend to minimum and maximum values or 1.5× the respective inter-quartile range (whichever was closest to the median). Panel B: Learning error, on the x-axis, is in units of log odds converted from proportion incorrect for misplacement error for cMap learning; This panel is analogues to panel B of Figure 4. Conventions are the same as Panel A. Black circles (upper left) and triangles (lower right) denote the memory task (circle: JRD, triangle: SOP) associated with the displayed value of Kendall's Tau. Shaded region indicates standard error. cMap = criterion map, JRD = judgements of relative direction, SOP = scene- and orientation-dependent pointing.

$^{**}p < .01$. $^{***}p < .001$.

Figure S8

Homogeneity of Variance Comparison with Zhang et al. (2014)



Note. Plots of fitted values against residuals from the linear model used in the ANOVA with Lavene's test statistics and associated *p*-values in the top right of each plot. The left panel shows data from the comparison of Experiment 1 and Experiment 2 in Zhang et al. (2014), which shows a systematic increase in the variability of residuals for higher fitted values, suggestive of a violation of the assumption of homogeneity of variance. The right panel shows our log-transformed data from the comparison of Experiment 1a and Experiment 1b, which shows a more uniform variance across fitted values. The significance of Lavene's test in both panels is likely a result of large samples in these comparisons across experiments; we have included them to illustrate the relative degree to which each model deviates from homogeneity.

Appendix A: Qualtrics Survey

Annotations, including survey logic and response options

Questions for which response is required to proceed

Survey Flow

EmbeddedData
Random ID = ${rand://int/10000:99999}

Block: Consent (5 Questions)
Standard: Demographics (3 Questions)
Standard: Block 7 (3 Questions)

Branch: New Branch
If
If Age: Text Response Is Less Than 18
Or Age: Text Response Is Greater Than 35

EndSurvey: Advanced

Standard: Experiment (4 Questions)
Standard: Instructions (Keep this page open) (12 Questions)
Standard: Block 6 (2 Questions)
Standard: Optional Demographics (3 Questions)
Standard: MTurk Completion (1 Question)

EndSurvey:

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Consent

Thank you for participating in the study. Please read through the Consent Form, below, and check the box to indicate your informed consent to participate in this study.

University of Arizona
Consent to Participate in Research

Online Study Title: Investigating the Cognitive and Neural Bases of Human Spatial Memory during Free Navigation with Body-based Input

Principal Investigator: Arne Ekstrom, Ph.D.

Sponsors: NIH, NSF

Summary of the research

This is a consent form for participation in a research project. Your participation in this research study is voluntary. It contains important information about this study and what to expect if you decide to participate. Please consider the information carefully. Feel free to ask questions before making your decision whether or not to participate. Please select "I agree" if you decide to proceed with this study. You may print a copy of this consent form for your records.

Why is this study being done?

This is a research study to better understand how we navigate and remember where we are and where we have been. Specifically, we are interested in learning about how we find our way when we navigate and how we interact with our environment in virtual reality vs. the real-world. What sort of cues, such as moving our body compared to a joystick, affect our experience with space?

What will happen if I take part in this study?

Prior to your participation in one of the following studies, we will collect demographic information, such as age and ethnicity, which are needed to report to our sponsors. Reporting demographic information is voluntary and will not affect your ability to participate. This demographic form is not attached to any personal information.
We will ask you to participate for 1 to 4 hours. The exact procedure and duration of your participation depends upon the particular portion of the study in which you participate. You will be informed in advance about the specific subset of the following procedures in which you are being asked to participate.

You will be asked to navigate a virtual environment using the keys we prompt you to use on your keyboard in the instructions. If you experience fatigue, exhaustion, or discomfort, you may exit out of the study at any time without penalty.

How long will I be in the study? 1 – 4 Hours

How many people will take part in this study? Approximately 500 people over 6 years.

Can I stop being in the study?
Your participation is voluntary. You do not need to participate in this study. If you decide to take part in the study, you may leave the study at any time. No matter what decision you make, there will be no penalty to you and you will not lose any of your usual benefits. Your decision will not affect your future relationship with The University of Arizona. If you are a student or employee at the University of Arizona, your decision will not affect your grades or employment status.

What risks or benefits can I expect from being in the study?
A small number of subjects may experience minor temporary dizziness, disorientation, or cybersickness during the testing. If you feel any of these symptoms, you may exit out of the study. You can take breaks as needed, or discontinue if you are unable to finish.

Will I be paid for participating in the study or experience any costs?
If you are participating in partial fulfillment of the requirements for PSY150A or to earn extra credit in another psychology class, you will receive experiment participation credit at the rate of 1 credit per half hour of time. In some experiments, subjects receiving credit may have an opportunity for receiving pay in addition to getting experimental credit. Some subjects may receive an extra monetary reward based on high performance depending on the type of experiment. Participants who perform one standard deviation above the mean may earn an extra $3. Participants who perform two standard deviations above the mean may earn an extra $6.

If you are not participating for credit, you will receive cash, online money transfer or a gift card. The amount will be determined at a rate of $15-20 per hour for your participation in this experiment.

In accordance with MTurk policies, your payment may be rejected if the HIT was not completed correctly or you did not follow instructions. MTurk Worker IDs will only be collected for the purposes of distributing compensation and will not be directly associated with your survey response (if applicable). However, it may be possible to determine your identity if you have a publicly available Amazon profile.

This study contains a number of checks to make sure you are finishing the tasks honestly and completely. As long as you read the instructions and complete the tasks, your HIT will be approved. If you fail these checks, your HIT will be rejected.

Will my study-related information be kept confidential?

The information that you provide in the study will be handled confidentially. However, there may be circumstances where this information must be released or shared as required by law. The University of Arizona Institutional Review Board; other federal, state, or international regulatory agencies; or the sponsor of the study, if any, may review the research records for monitoring purposes. All efforts will be made to keep your study-related information confidential. However, there may be circumstances where this information must be released. For example, personal information regarding your participation in this study may be disclosed if required by state law. Also, your records may be reviewed by the following group (as applicable to the research): The University of Arizona Institutional Review Board or Office of Responsible Research Practices. Researchers will view your anonymous experimental data for coding and analytic purposes, but they won't link the experimental data to your identity for any purposes.
NIH Certificate of Confidentiality: To help us protect your privacy, we have obtained a Certificate of Confidentiality from the National Institutes of Health. The researchers can use this Certificate to legally refuse to disclose information that may identify you in any federal, state, or local civil, criminal, administrative, legislative, or other proceedings, for example, if there is a court subpoena. The researchers will use the Certificate to resist any demands for information that would identify you.
Any work performed on MTurk can be linked to your public profile page. Data collected from this study may be collected and used by Amazon per its privacy agreement. Your MTurk Worker ID will not be shared with anyone.

Will my study-related information be used for future research?

Information collected about you will not be used or shared for future research studies.

Who can answer my questions about the study?

For questions, concerns, or complaints about the study you may contact **Arne Ekstrom, PhD** at adekstrom@email.arizona.edu.

For questions about your rights as a participant in this study or to discuss other study-related concerns or complaints with someone who is not part of the research team, you may contact the Human Subjects Protection Program at 520-626-6721 or online at http://rgw.arizona.edu/compliance/human-subjects-protection-program.

Signing the consent form

I have read (or someone has read to me) this form, and I am aware that I am being asked to participate in a research study. I have had the opportunity to ask questions and have had them answered to my satisfaction. I voluntarily agree to participate in this study.

By selecting "I AGREE", I affirm that I have read the information in the form and that I agree to take part in this study. I do not give up any of my legal rights.

Check the box to confirm:

☐ I AGREE

Demographics

Age:

Biological Sex (Sex Assigned at Birth):

- *Male (1)*
- *Female (2)*

Gender:

- *Male (1)*
- *Female (2)*
- *Transgender (3)*
- *Agender (4)*
- *Androgyn (5)*
- *Genderqueer/Gender Nonconforming (6)*
- *Prefer not to say (7)*
- *Other (8)* _____

Honesty Statements

The goal of this research is to better understand how humans learn and remember information about their environment. To ensure the quality of the data, we ask that workers complete the experiment on their own without helpof any other person (don't get help from a friend, relative, or other individual) and without the help of any external aids (paper, pencil, other computer program, etc.). Simply complete the tasks and answer any questions to the best of your ability. This HIT does not offer bonuses for "high- performing/high-accuracy" responses.

Please certify that you will adhere to the following policiesduring the experiment:

I will complete the experiment independently, without thehelp of any other person.

☐ I agree

I will not use any external aids (paper, pen/pencil, other computer software, etc.)

☐ I agree

Experiment

Before downloading and running the experiment

Below, you will find instructions for downloading andrunning the experiment on MacOS or Windows.

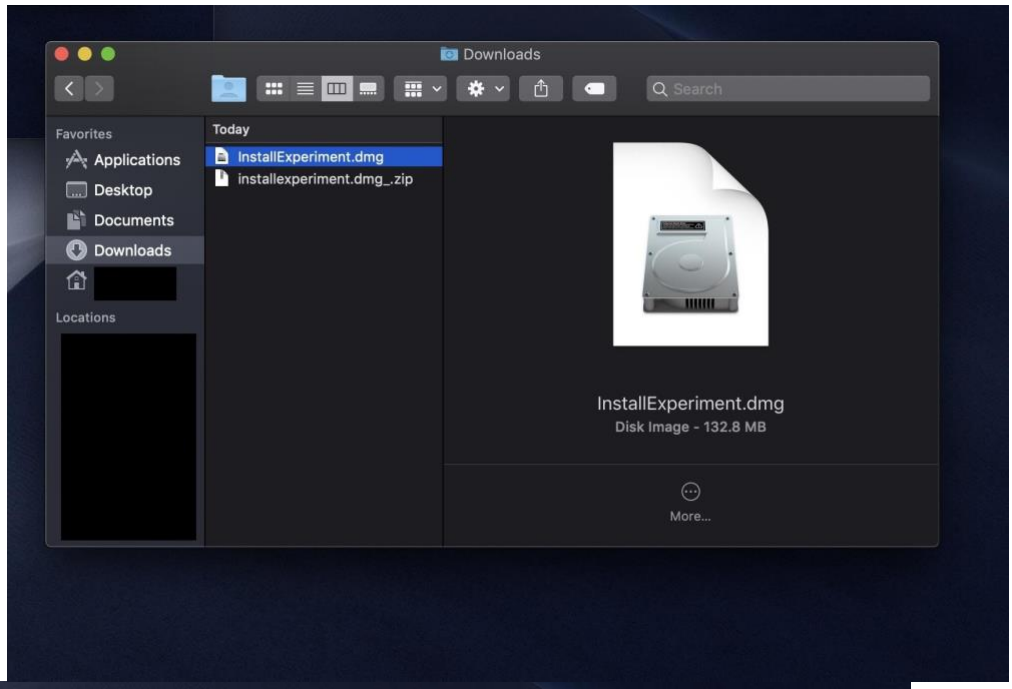
After running the experiment application, you can toggle between the full-screen experiment and this survey windowusing COMMAND+TAB (MacOS) or ALT+TAB (Windows). At the beginning of the experiment, you will receive a verification code, which you will need to enter at the bottom of this page. Once you enter your verification code, continue to the next page of this survey for detailed instructions on completing each task in the experiment. It isimportant that you read through all of the instructions before continuing the experiment.

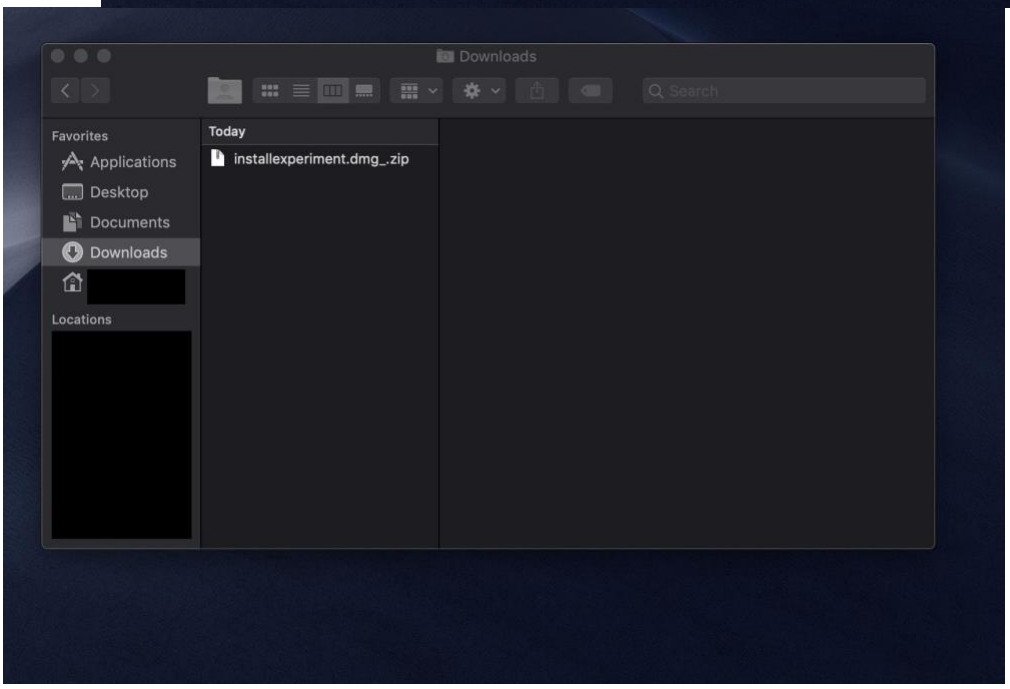
When the experiment is finished, your data will be transmitted remotely via the internet, and then the application will quit automatically. *DO NOT QUIT OR CLOSE THE APPLICATION MANUALLY.* The data transfer can take up to 5 minutes, depending on your connection. If the application has not terminated within 5 minutes of completing the experiment, manually close the applicationand notify the experimenter of the issue.

MacOS Download Instructions

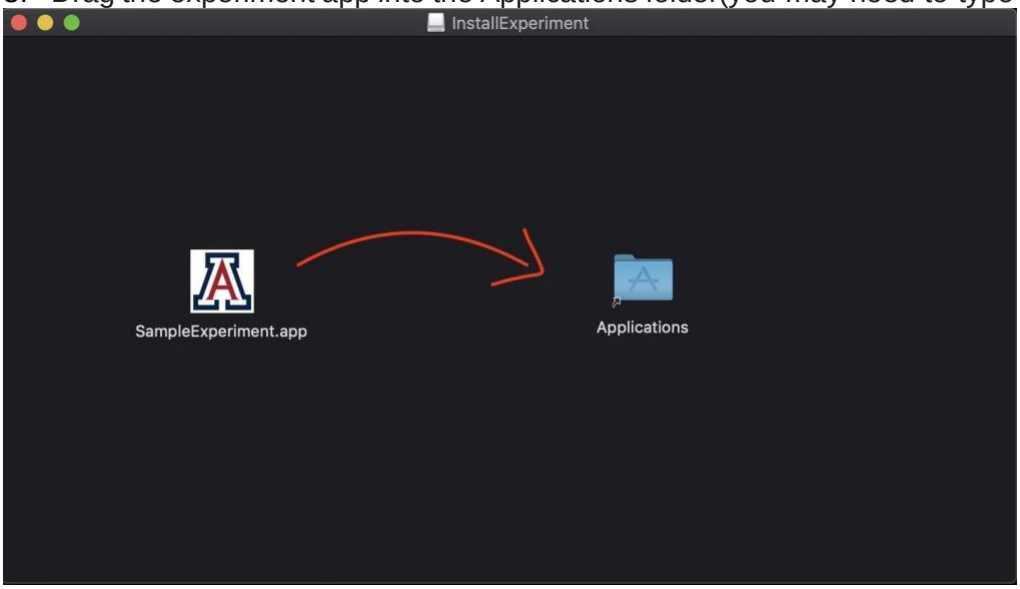
1. Download the .dmg for MacOS

2. Open the downloaded file and run the .dmg installer

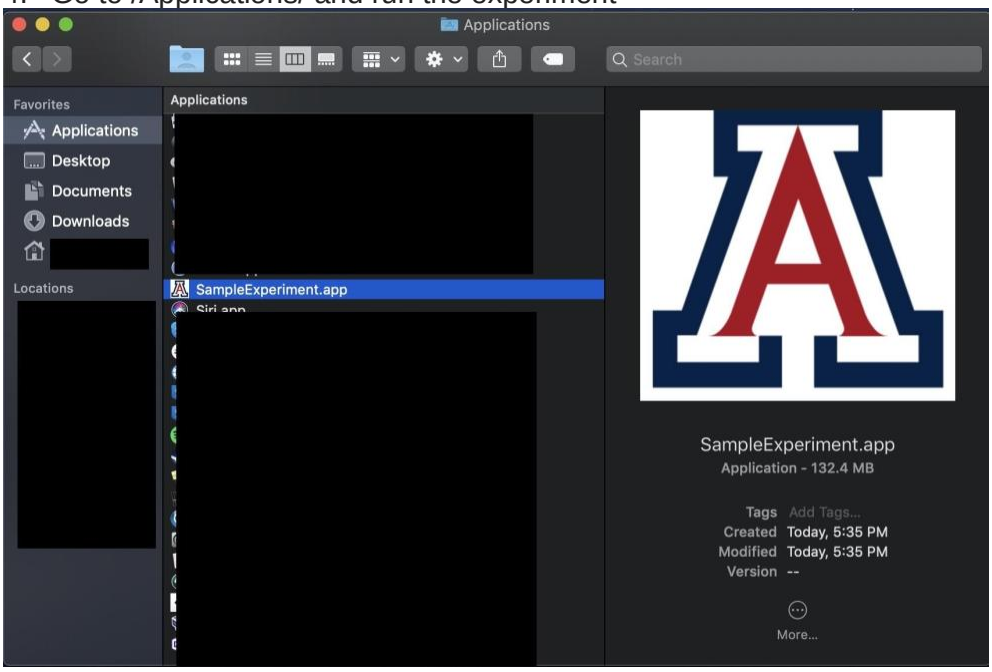




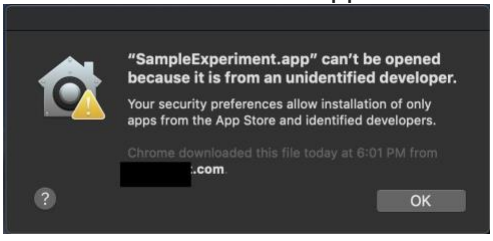
3. Drag the experiment app into the Applications folder(you may need to type your password)

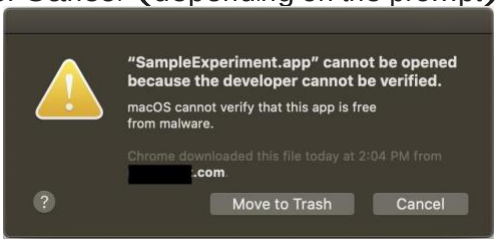


4. Go to /Applications/ and run the experiment

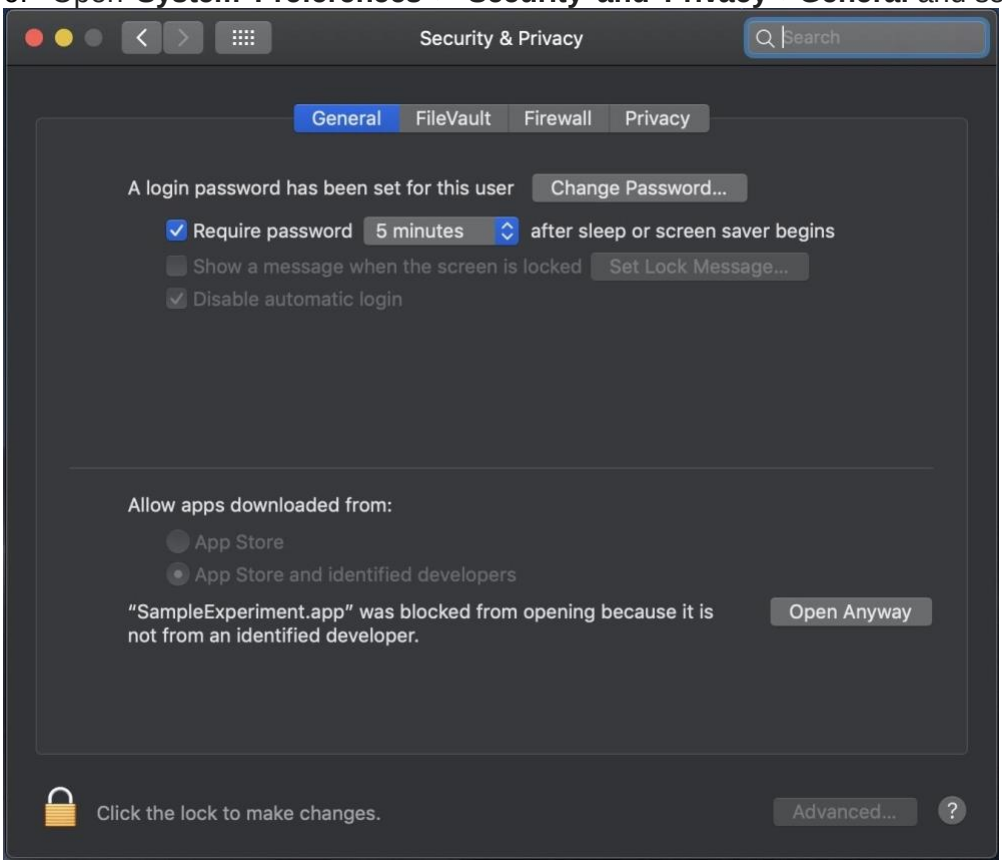


5. If Mac OS blocks the app from running, click “OK” or“Cancel” (depending on the prompt)

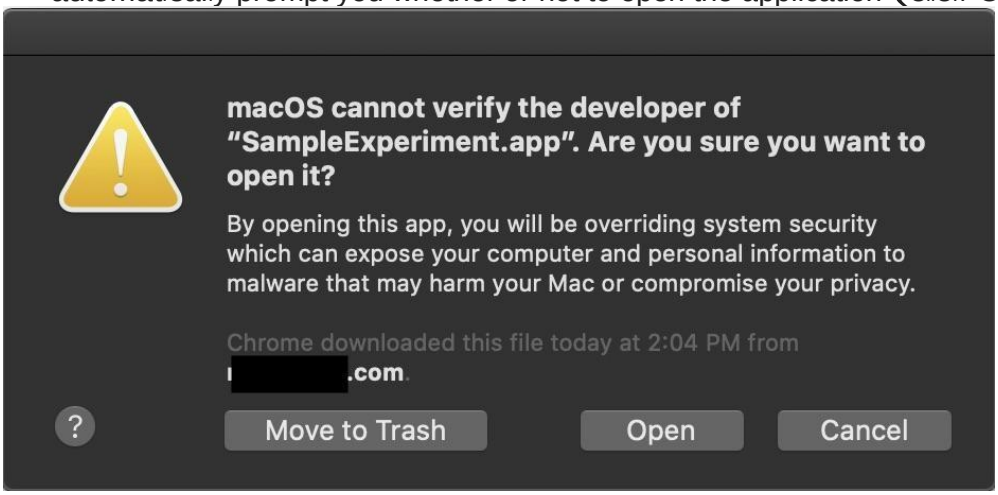




6. Open **System Preferences > Security and Privacy >General** and select “Open Anyway”



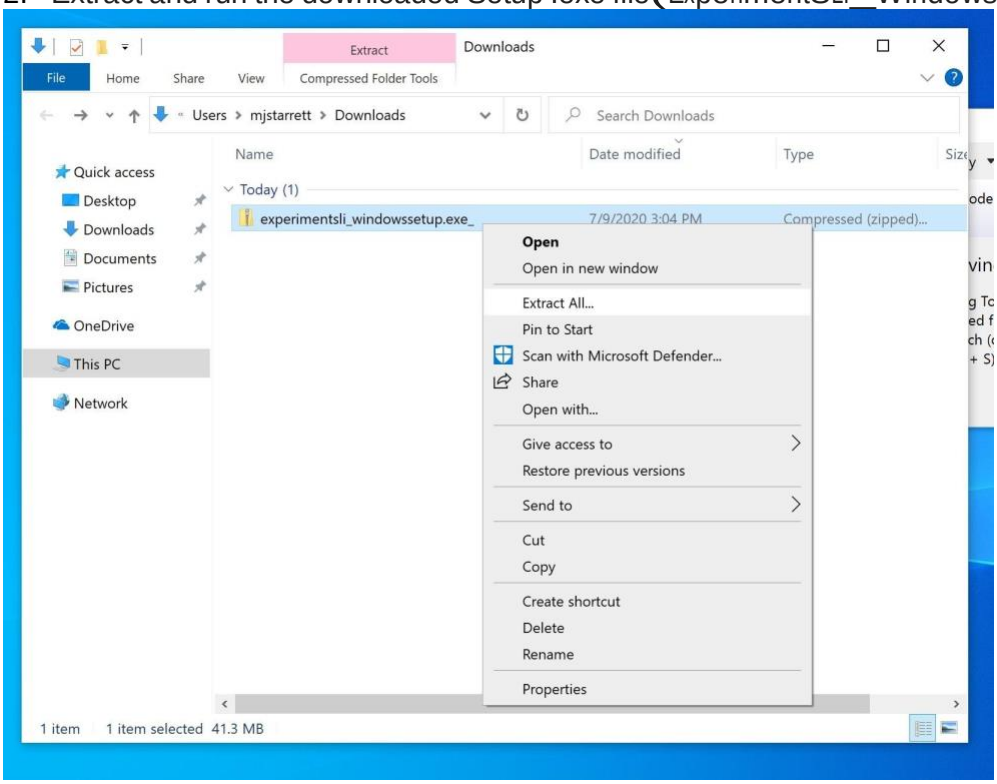
7. Go back to applications and you should be able to runthe experiment normally, or Mac OS will automatically prompt you whether or not to open the application（click “Open”）

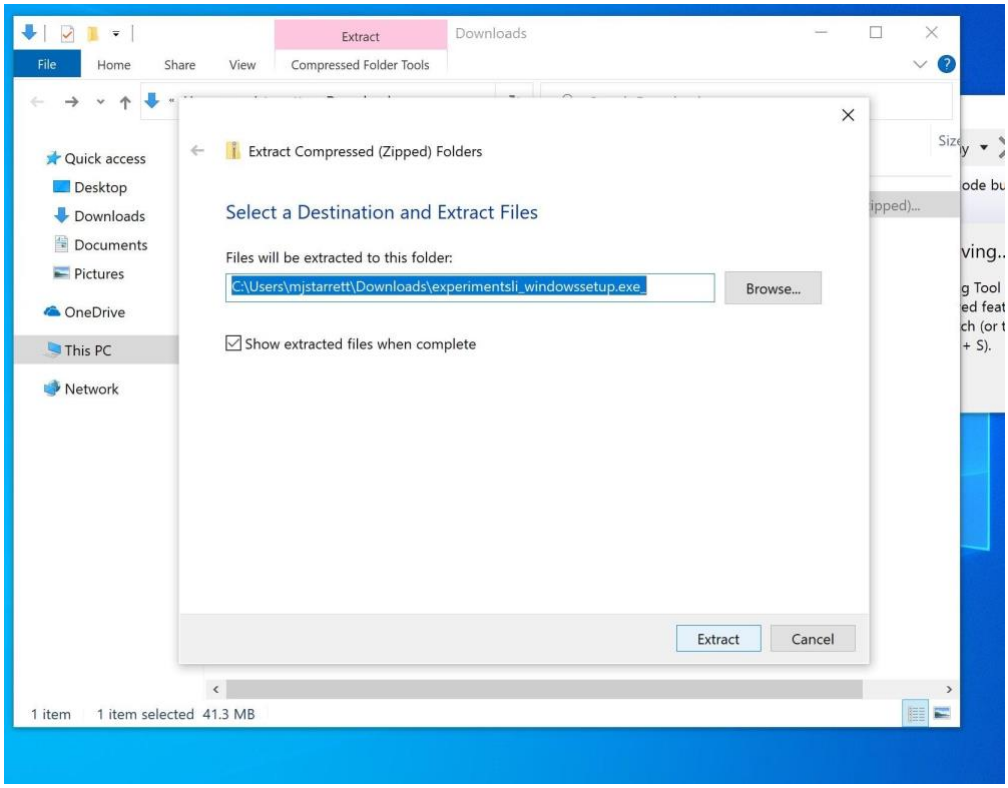


Windows Download Instructions

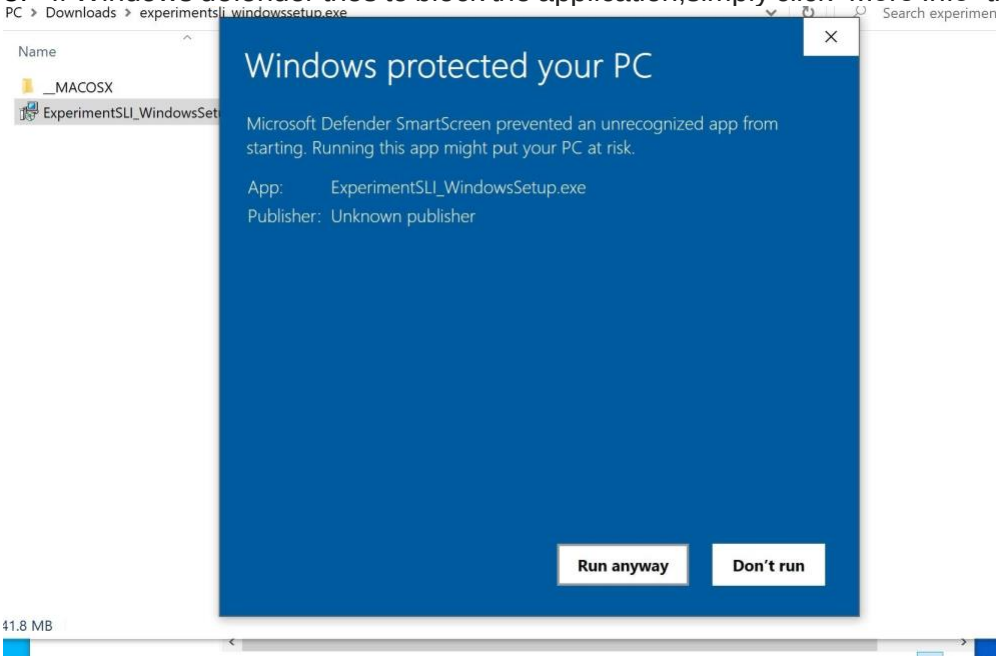
1. Download the Windows installer

2. Extract and run the downloaded Setup .exe file(ExperimentSLI_WindowsSetup.exe)

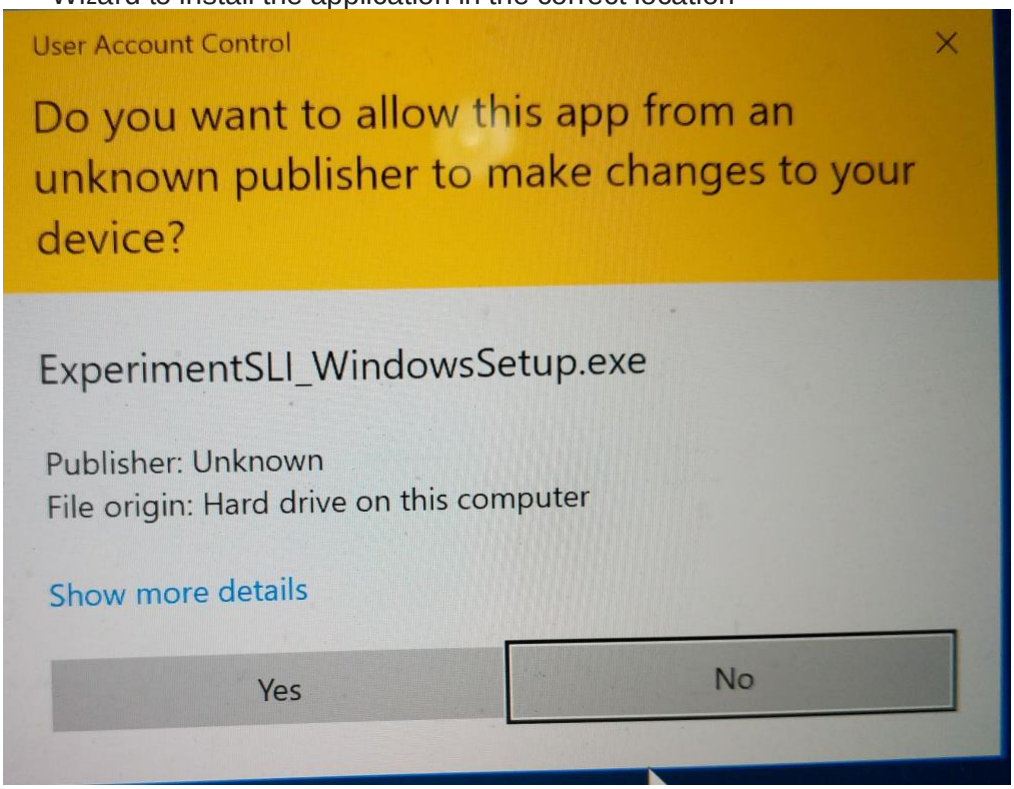




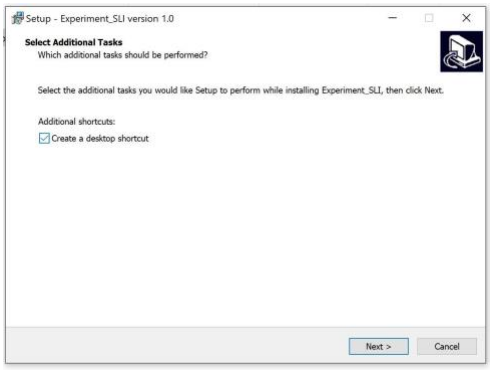
3. If Windows defender tries to block the application,simply click “More Info” then “Run Anyway”

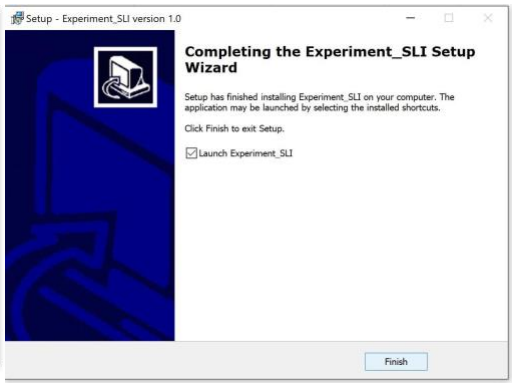


4. When prompted to allow the application to make changes, select “Yes” — this allows the Setup Wizard to install the application in the correct location



5. Follow the Setup Wizard instructions; after installation, check the box to launch the application and click “Finish”





Enter Your Verification Code

When the application opens, you will be provided with a verification code. Enter your code below and then continueto the next page to receive instructions for completing theexperimental tasks. Please read all the instructions on the next page before continuing in the experiment application.

Validation will pass if the following condition is met:
Matches Regex /RTESOP[0-9]{4}/i
Or
Matches Regex /RTEJRD[0-9]{4}/i
Or

Matches Regex /MAPSOP[0-9]{4}/i
Or
Matches Regex /MAPJRD[0-9]{4}/i
Or
Matches Regex /HYBSOP[0-9]{4}/i
Or
Matches Regex /HYBJRD[0-9]{4}/i
Or
Matches Regex /TMTSOP[0-9]{4}/i
Or
Matches Regex /TMTJRD[0-9]{4}/i

Instructions (Keep this page open)

Instructions

Please read through the instructions, in their entirety, before beginning the experiment. You should be familiar with the tasks you are performing and the controls used to performthem.

KEEP THIS PAGE OPEN DURING THE EXPERIMENT!

TIP: If you are using a single screen, the app will run in full screen. You can toggle between the full-screen experiment and the instructions using COMMAND+TAB (MacOS) or ALT+TAB (Windows). If you are using 2 monitors, we recommend having the instructions open inone and the application open in the other

Overview

- You will learn the layout of a large, neighborhood-sized environment, and your spatial knowledge of that environment, and its layout, will be tested by having you point to various landmarks from memory

Virtual Environment

- The environment is approximately 100 x 140 meters in size (a few city blocks)
- The environment is bounded by four walls and contains streets, sidewalks, grass, buildings, and other props that make up the aesthetics
- While there are many buildings and stores, the environment contains *eight (8) target stores*, which will be the focus of the experiment

Target Stores

- Target stores look different from other buildings in the environment
- All of the target stores are identical in structure, but each has a unique identity
- Target stores can be distinguished from one another by any of three cues:
  - **Name** (text on sign)
  - **Color** (exterior walls and sign front)
  - **Icon** (shown in each of the four windows and on the rooftop).

Ground view of an example target store, not present in the experiment

Aerial view of the same example target store

Experiment (The application will automatically guide you through the experiment)

- Familiarization Phase **(repeats 3 times)**
  - You will learn the identities of eight (8) landmarks (target stores) located in the environment, which you will learn and memorize in the next part of the experiment
  - Each of the eight target stores will be shown rotating on the screen (5 seconds each), in a randomized order, with the name shown below the rotating store
- Learning and Memory Phase **(repeats 6 times)**
  - Spatial learning (learn the correct location of all 8 target store landmarks)
    - *Described in the next section*, "HOW TO PLAY"
  - Spatial Memory (pointing)
    - *Described in the next section*, "HOW TO PLAY"
  - Take a break, if needed, before continuing

NOTE: For most, if not all, of the tasks you complete, your responses will be statistically analyzed based on accuracy and speed

- We ask that you **prioritize accuracy over speed** (i.e., it is more important that you answer correctly and less important that you answer quickly)
- **Avoid excessive guessing or "clicking through" the tasks**, (this may result in your data being flagged as unusable and being excluded from subsequent analyses or reporting)

Display This Question:

If Verification Code Text Response Matches Regex /RTESOP[0-9]{4}/i

HOW TO "PLAY"

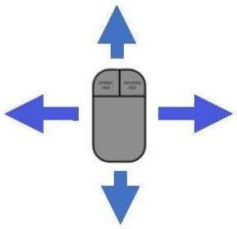
Learning Task (first-person navigation)

- Goal: Starting from a randomized location in the environment, navigate to each target store in a randomized order, as instructed. Note, you will need to remember the identity of the store you are looking for. If you forget, you can identify the current target by its door being open. Move into the area just outside the door to register that you have successfully arrived. Navigate to all 8; 6 blocks.
- Controls:

An open door indicates the current target store

A representation of the region that will register arrival at a target store (not visible in-game)

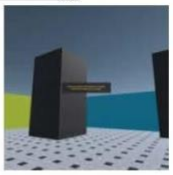
***WASD** – Translate the 1st-person avatar ("you")*



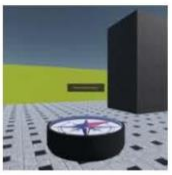
***Mouse (Trackpad)** – Look around (rotate head)*

Spatial Memory Task (landmark pointing)

- Goal: At the start of each trial, orient yourself, to the best of your ability. Then, a compass will appear with text indicating a target to point at. Rotate the compass arrow so the red part of the needle points toward the location of the specified target. 56 questions per block; 6 blocks.
- Controls:

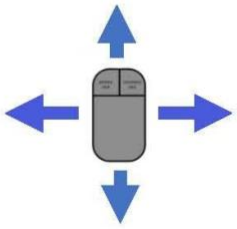


Orienting phase



Pointing phase

***[RETURN]** – Confirm orientation/confirm answer*
***L/R Arrows** – Rotate the compass arrow counter-clockwise/clockwise, respectively*



***Mouse (Trackpad)** – Look around (rotate head); orienting phase only*

Display This Question:

If Verification Code Text Response Matches Regex /RTEJRD[0-9]{4}/i

HOW TO "PLAY"

Learning Task (first-person navigation)

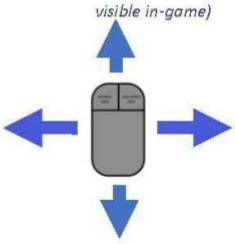
- Goal: Starting from a randomized location in the environment, navigate to each target store in a randomized order, as instructed. Note, you will need to remember the identity of the store you are looking for. If you forget, you can identify the current target by its door being open. Move into the area just outside the door to register that you have successfully arrived. Navigate to all 8; 6 blocks.

An open door indicates the current target store

A representation of the region that will register arrival at a target store (not visible in-game)

- Controls:

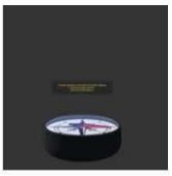
WASD – Translate the 1st-person (large) avatar



***Mouse (Trackpad)** – Look around (rotate head)*

Spatial Memory Task (landmark pointing)

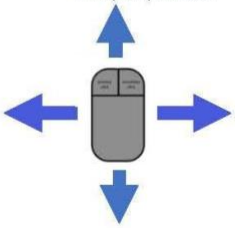
- Goal: Each Question will ask you to generate an imagined heading and point to a target store (e.g., "Imagine you are at *A*, facing *B*; point to *C*.") Rotate the compass arrow so the red part of the needle points toward the location of the specified target based on the imagined heading. 56 questions per block; 6 blocks.



The compass with a sample question

- Controls:

***[RETURN]** – Confirm answer*
***L/R Arrows** – Rotate the compass arrow counter-clockwise/clockwise, respectively*



***Mouse (Trackpad)** – Not Used*

Display This Question:

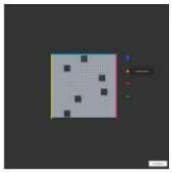
If Verification Code Text Response Matches Regex /MAPSOP[0-9]{4}/i

HOW TO "PLAY"

Learning Task (target placement)

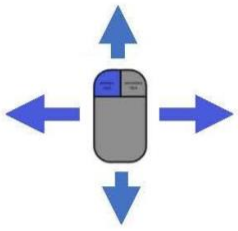
- Goal:
  During the study phase, take as much time as you need to study the locations of the target stores in the environment (hover over a target store to display its name). During the test phase, click and drag each store to the ***correct position and rotation*** based on the study phase. Study-test repeat until a test ***score of 100%*** is achieved; 6 blocks.

Study phase in a sample envir.



Test phase in a sample envir.

- Controls:

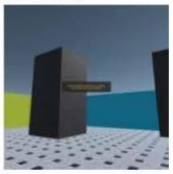


A *– Rotate the selected target counter-clockwise*
D *– Rotate the selected target clockwise*
[esc] *– Return currently selected target to pre-selection location*

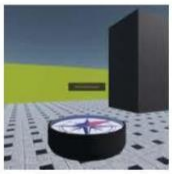
Primary click *– select/drag (hold)*
Mouse (Trackpad) *– Move cursor*

Spatial Memory Task (landmark pointing)

- Goal: At the start of each trial, orient yourself, to the best of your ability. Then, a compass will appear with text indicating a target to point at. Rotate the compass arrow so the red part of the needle points toward the location of the specified target. 56 questions per block; 6 blocks.

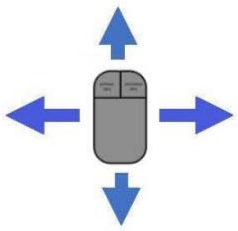


Orienting phase



Pointing phase

- Controls:



[RETURN] *– Confirm orientation/confirm answer*
L/R Arrows *– Rotate the compass arrow counter-clockwise/clockwise, respectively*

Mouse (Trackpad) *– Look around (rotate head); orienting phase only*

Display This Question:

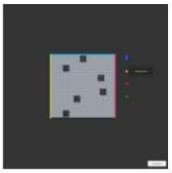
If Verification Code Text Response Matches Regex /MAPJRD[0-9]{4}/i

HOW TO "PLAY"

Learning Task (target placement)

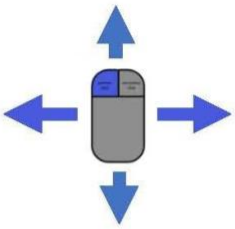
- Goal: During the study phase, take as much time as you need to study the locations of the target stores in the environment (hover over a target store to display its name). During the test phase, click and drag each store to the ***correct position and rotation*** based on the study phase. Study-test repeat until a test ***score of 100%*** is achieved; 6 blocks.

Study phase in a sample envir.



Test phase in a sample envir.

- Controls:

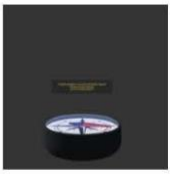


A – Rotate the selected target counter-clockwise
D – Rotate the selected target clockwise
[esc] – Return currently selected target to pre-selection location

***Primary click** – select/drag (hold)*
***Mouse (Trackpad)** – Move cursor*

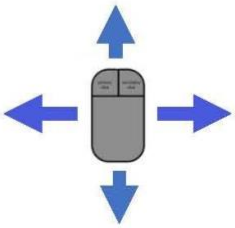
Spatial Memory Task (landmark pointing)

- Goal:
  Each Question will ask you to generate an imagined heading and point to a target store (e.g., "Imagine you are at *A*, facing *B*; point to *C*.") Rotate the compass arrow so the red part of the needle points toward the location of the specified target based on the imagined heading. 56 questions per block; 6 blocks.



The compass with a sample question

- Controls:



[RETURN] – Confirm answer
***L/R Arrows** – Rotate the compass arrow counter-clockwise/clockwise, respectively*

***Mouse (Trackpad)** – Not Used*

Display This Question:

If Verification Code Text Response Matches Regex /HYBSOP[0-9]{4}/i

HOW TO "PLAY"

Learning Task (third-person navigation)

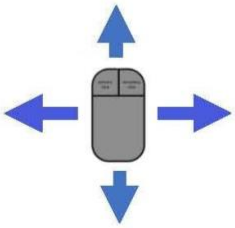
- Goal: You will guide a "remote-control" player (3rd-person) through a scale model of the environment. You can freely move yourself (1st-person) around the room. Starting from a randomized location in the environment, navigate your remote (3rd-person) player to each target store in a randomized order, as instructed. You will need to remember which store you are looking for (also, the current goal store will have an open door). Move the remote player into the area just outside the door to register your arrival. Navigate to all 8 stores; 6 blocks.

An example view of a tabletop , scale-model environment

A close up of the remote-control (3rd-person) player

- Controls:

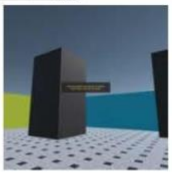
WASD *– Translate the 1st-person avatar ("you")*
OKL; *– Translate the 3rd-person avatar (remote-control player)*



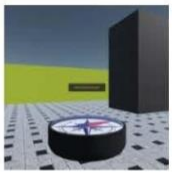
Mouse (Trackpad) *– Look around (rotate head); 1st-person avatar only*

Spatial Memory Task (landmark pointing)

- Goal: At the start of each trial, orient yourself, to the best of your ability. Then, a compass will appear with text indicating a target to point at. Rotate the compass arrow so the red part of the needle points toward the location of the specified target. 56 questions per block; 6 blocks.



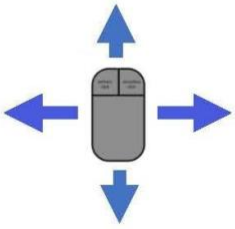
Orienting phase



Pointing phase

- Controls:

[RETURN] *– Confirm orientation/confirm answer*
L/R Arrows *– Rotate the compass arrow counter-clockwise/clockwise, respectively*



Mouse (Trackpad) *– Look around (rotate head); orienting phase only*

Display This Question:

If Verification Code Text Response Matches Regex /HYBJRD[0-9]{4}/i

HOW TO "PLAY"

Learning Task (third-person navigation)

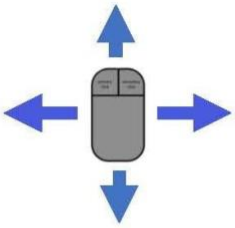
- Goal: You will guide a "remote-control" player (3rd-person) through a scale model of the environment. You can freely move yourself (1st-person) around the room. Starting from a randomized location in the environment, navigate your remote (3rd-person) player to each target store in a randomized order, as instructed. You will need to remember which store you are looking for (also, the current goal store will have an open door). Move the remote player into the area just outside the door to register your arrival. Navigate to all 8 stores; 6 blocks.

An example view of a tabletop , scale-model environment

A close up of the remote-control (3rd-person) player

- Controls:

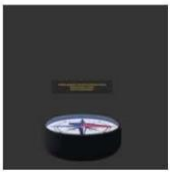
WASD *– Translate the 1st-person avatar (you)*
OKL; *– Translate the 3rd-person avatar (remote-control player)*



Mouse (Trackpad) *– Look around (rotate head); 1st-person avatar only*

Spatial Memory Task (landmark pointing)

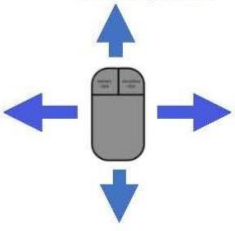
- Goal: Each Question will ask you to generate an imagined heading and point to a target store (e.g., "Imagine you are at *A*, facing *B*; point to *C*.") Rotate the compass arrow so the red part of the needle points toward the location of the specified target based on the imagined heading. 56 questions per block; 6 blocks.



The compass with a sample question

- Controls:

[RETURN] *– Confirm answer*
L/R Arrows *– Rotate the compass arrow counter-clockwise/clockwise, respectively*



Mouse (Trackpad) *– Not Used*

Display This Question:

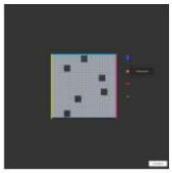
If Verification Code Text Response Matches Regex /TMTSOP[0-9]{4}/i

HOW TO "PLAY"

Learning Task (target placement)

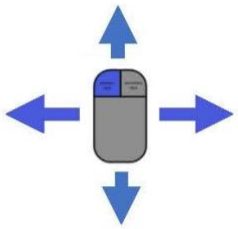
- Goal:
  During the study phase, you will have 30 seconds to study the locations of the target stores in the environment (hover over a target store to display its name). During the test phase, click and drag each store to the ***correct position*** based on the study phase. Your score will be the number of target stores (out of 8) that you place correctly; 6 blocks.

Study phase in a sample envir.



Test phase in a sample envir.

- Controls:

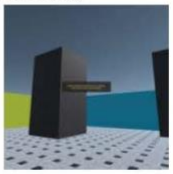


A *– Rotate the selected target counter-clockwise*
D *– Rotate the selected target clockwise*
[esc] *– Return currently selected target to pre-selection location*

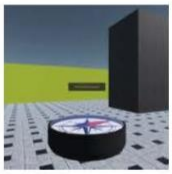
Primary click *– select/drag (hold)*
Mouse (Trackpad) *– Move cursor*

Spatial Memory Task (landmark pointing)

- Goal: At the start of each trial, orient yourself, to the best of your ability. Then, a compass will appear with text indicating a target to point at. Rotate the compass arrow so the red part of the needle points toward the location of the specified target. 56 questions per block; 6 blocks.

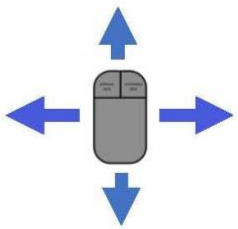


Orienting phase



Pointing phase

- Controls:



[RETURN] *– Confirm orientation/confirm answer*
L/R Arrows *– Rotate the compass arrow counter-clockwise/clockwise, respectively*

Mouse (Trackpad) *– Look around (rotate head); orienting phase only*

Display This Question:

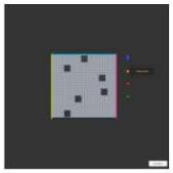
If Verification Code Text Response Matches Regex /TMTJRD[0-9]{4}/i

HOW TO "PLAY"

Learning Task (target placement)

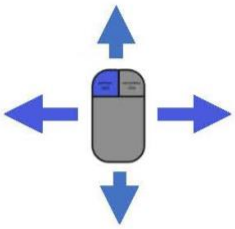
- Goal: During the study phase, you will have 30 seconds to study the locations of the target stores in the environment (hover over a target store to display its name). During the test phase, click and drag each store to the ***correct position*** based on the study phase. Your score will be the number of target stores (out of 8) that you place correctly; 6 blocks.

Study phase in a sample envir.



Test phase in a sample envir.

- Controls:

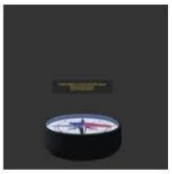


A – Rotate the selected target counter-clockwise
D – Rotate the selected target clockwise
[esc] – Return currently selected target to pre-selection location

***Primary click** – select/drag (hold)*
***Mouse (Trackpad)** – Move cursor*

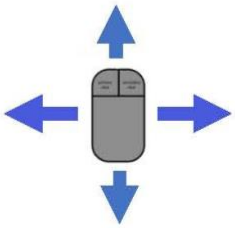
Spatial Memory Task (landmark pointing)

- Goal:
  Each Question will ask you to generate an imagined heading and point to a target store (e.g., "Imagine you are at *A,* facing *B*; point to *C.*") Rotate the compass arrow so the red part of the needle points toward the location of the specified target based on the imagined heading. 56 questions per block; 6 blocks.



The compass with a sample question

- Controls:



[RETURN] – Confirm answer
***L/R Arrows** – Rotate the compass arrow counter-clockwise/clockwise, respectively*

***Mouse (Trackpad)** – Not Used*

NOTE: You can toggle between the full-screen experimentand the instructions using COMMAND+TAB (MacOS) or ALT+TAB (Windows).

[KEEP THIS PAGE OPEN DURING THE EXPERIMENT!]

The experiment includes an ATTENTION CHECK at the end ofeach block. Enter your attention check codes, below, as you receive them:

Block 1 Attention Check	
Block 2 Attention Check	
Block 3 Attention Check	
Block 4 Attention Check	
Block 5 Attention Check	
Block 6 Attention Check	

Strategy Use

What strategies did you use to complete the experiment

☐ Memory/Mental map (remembered the locations of targets from the learning task to answer questions on the memory task)

☐ Drew a map (created a map on paper from the learning task and referred to this map to answer questions on the memory task)

☐ Had a friend/relative/other help me with either the learning or memory task

☐ None of the above

[Optional] Please provide any addition information on strategies you used to complete the learning/memory tasks

Optional Demographics

The following demographic questions are optional. They provide information, for our funding sources, about the representativeness of our sampling practices with regard tothe population. Your responses will not be used for statistical/data analysis purposes. If you do not wish to provide a response, simply ignore this page and click to continue.

Ethnicity

- ○ *Hispanic or Latino (1)*
- ○ *Not Hispanic or Latino (2)*

Race

- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☐ White
- ☐ Other

MTurk Completion

Here is your completion code: ${e://Field/Random%20ID} Copy this value and paste it into MTurk.
Once you have successfully associated the completion code with your MTurk assignment, click the "Next" button to finalize and submit your survey responses.