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# Self-evaluations of navigation ability: a big data approach

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## INTRODUCTION

### Background:

- A previous study has reported effects of age and sex on self-reported navigation ability<sup>1</sup>
- A recent meta-analysis of the effect of sex differences on navigation ability did not consider self-reported navigation ability<sup>2</sup>
- Sea Hero Quest is a phone-based navigation game with data from over 4 million users<sup>3</sup>
- Previous studies using the Sea Hero Quest dataset reported effects of demographic variables (e.g., age, sex, home environments) on objective navigation performance<sup>4,5</sup>

### Questions:

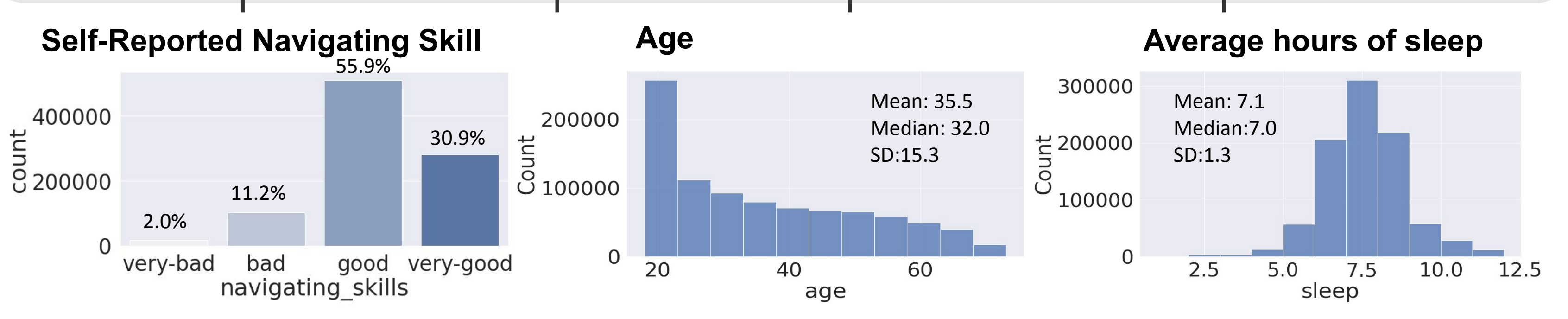
- Primary  
Are demographic variables related to **self-reported** navigating skills (SRNS)?
- Secondary  
What is the structure of demographic characteristics in the Sea Hero Quest dataset? Are there any subpopulations? Does each subpopulation have different navigating skills?

## EXPLORATORY DATA ANALYSES

### Descriptive Statistics

• N = 90,945

Gender	Handedness	Education	Home Environment	Daily commuting time
Male: 52.4% Female: 47.6%	Left handed: 10.1% Right handed: 89.9%	Tertiary: 35.2% Secondary: 64.8%	City: 31.1% Suburban/Mixed: 51.7% Rural: 17.2%	<30 mins: 39.3% 30-1hr: 35.3% >1hr: 35.4%



### Bivariate Spearman Correlation

	age	gender	hand	nav skills	sleep	edu	commute	env
age	1	-0.038	-0.017	0.033	-0.22	-0.2	-0.12	-0.049
gender	-0.038	1	0.032	0.23	-0.044	0.012	0.098	0.047
hand	-0.017	0.032	1	0.0019	0.0055	0.011	-0.013	-0.015
nav skills	0.033	0.23	0.0019	1	0.0059	-0.034	0.1	1.3e-05
sleep	-0.22	-0.044	0.0055	0.0059	1	0.099	-0.052	0.0066
edu	-0.2	0.012	0.011	-0.034	0.099	1	-0.012	-0.012
commute	-0.12	0.098	-0.013	0.1	-0.052	-0.012	1	0.059
env	-0.049	0.047	-0.015	1.3e-05	0.0066	-0.012	0.059	1

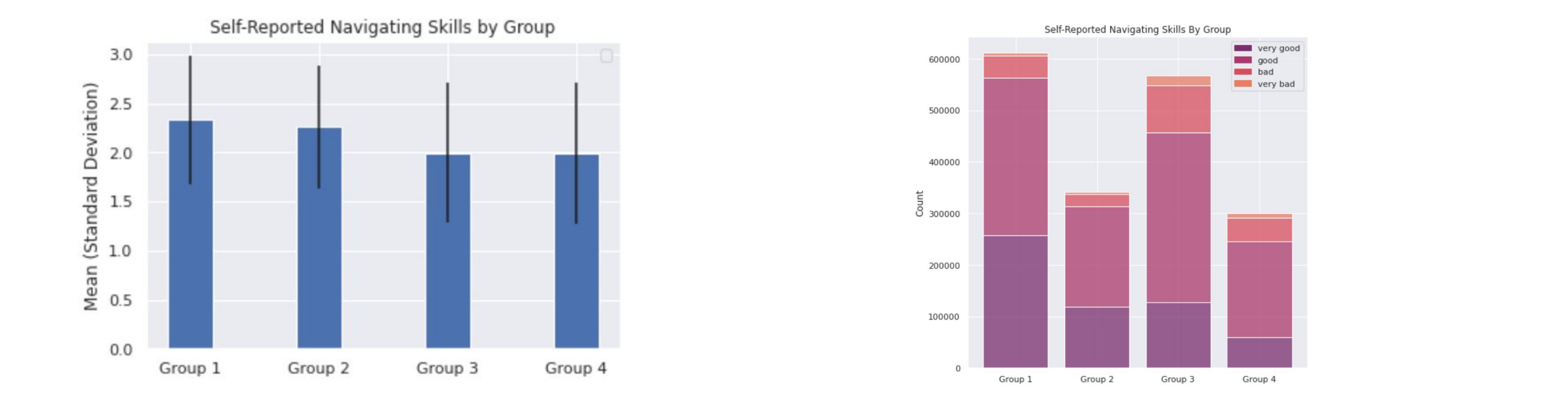
• All pairwise correlations among variables are low (< 0.3)

## FACTOR ANALYSIS

- We conducted factor analysis to see if there are latent factors underlying independent variables
- Bartlett Sphericity Chi Square Test tests whether there is a pattern among variables  
Score = 153861 ( $p < 0.001^{***}$ ), indicating there is a pattern among variables
- Kaiser-Meyer-Olkin (KMO) Test tests whether there is sufficient variance for factor analysis  
Score = 0.518 < 0.6 (KMO criterion), indicating there is not sufficient variance for factor analysis
- Overall, there is a pattern among independent variables, but there is no latent factor, so the pattern directly comes from independent variables, which can be tested by cluster analyses

## CLUSTER ANALYSES

- We conducted cluster analysis to see whether there are subpopulations in the dataset
- K-Means cluster analysis shows data can best be clustered into 4 groups  
Group 1: Males secondary (edu level), all ages  
Group 2: Males tertiary (edu level) primarily in their 20s  
Group 3: Females, secondary (edu level) all ages  
Group 4: Females tertiary (edu level) primarily in their 20s



- Means and standard deviations of self-reported navigating skills (SRNS) were similar across groups
- Chi-Square Test of Independence revealed that groups and SRNS were significantly associated  $\chi^2 = 50509.76, p < 0.001$
- Post-hoc multiple tests (Bonferroni correction) shows the frequency of each SRNS level in each group was significantly different from the expected frequency

## ORDINAL LOGISTIC REGRESSION

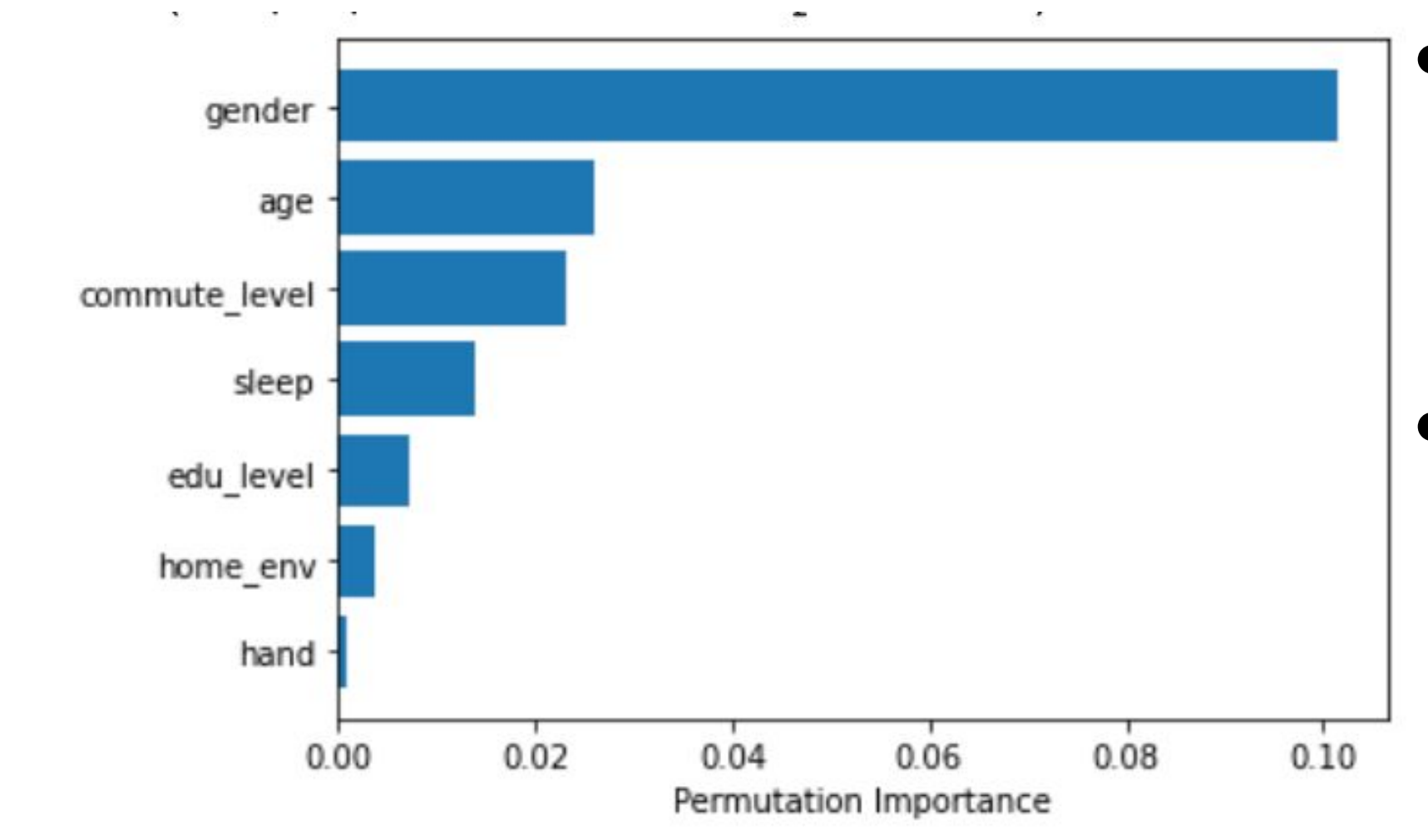
Factor	Coefficient	Standard Error	95%CI	Interpretation on predicting self-reported navigating skills
age	0.024***	0.003	[0.019, 0.030]	• Older people +
gender (male = 1)	0.899***	0.004	[0.891, 0.908]	• Male > Female
age by gender	0.148***	0.004	[0.140, 0.156]	• Males have a stronger age effect
handedness (left = 1)	-0.021**	0.007	[-0.034, -0.008]	• Left-handed < Right-handed
sleep	0.067***	0.002	[0.062, 0.071]	• Longer daily sleep time +
education level	0.130***	0.004	[0.121, 0.138]	• Higher education +
commute level	0.187***	0.002	[0.182, 0.191]	• Longer commute time +
home environment	-0.031***	0.002	[-0.035, -0.026]	• More city-like home environment -

\*\*\*  $p < 0.001$  \*\*  $p < 0.01$

- Gender is the strongest predictor, followed by commute level and age by gender interaction

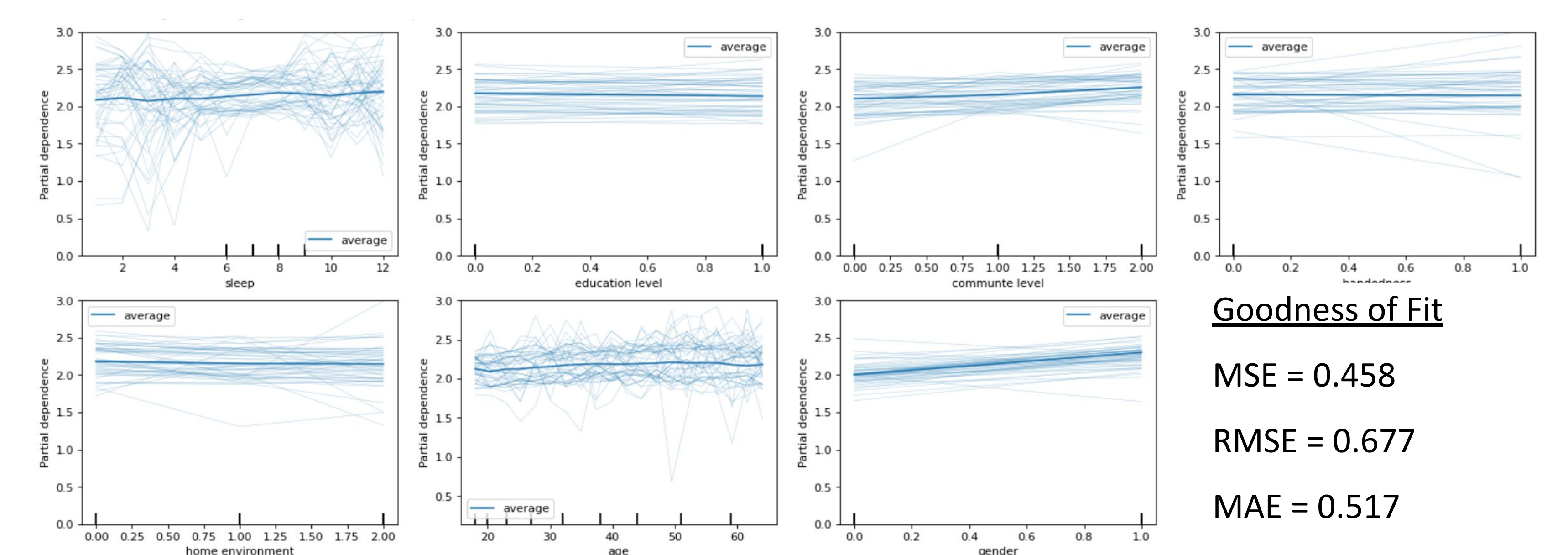
## RANDOM FOREST REGRESSION

### Feature Importance



- Gender is the most important factor in predicting self-reported navigating skills, followed by age, commute level, sleep, education level, home environment, and handedness
- The feature importance ranking is consistent with the effect size ranking in logistic regression analyses except that the rankings of sleep and education were swapped

## Partial Dependence Plots with Individual Conditional Expectation



### Goodness of Fit

MSE = 0.458  
RMSE = 0.677  
MAE = 0.517

- Partial Dependence Plot shows the marginal effect a feature has on the predicted outcome
- Marginal Effect: the effect of a predictor by marginalizing over all other predictors
- The marginal effect of
  - sleep on self-reported navigating skills (SRNS) is positive: more hours of sleep was related to reporting higher scores
  - age on SRNS is positive: older people reported higher scores
  - gender on SRNS is positive: males reported higher navigating skills than females
  - commuting time on SRNS is positive: longer commuting times were related to reporting higher scores

## DISCUSSION & CONCLUSIONS

### Conclusions:

- Primary - Relations between demographic characteristics and self-reported navigating skills (SRNS)
  - Gender, age and average commuting time affects SRNS
  - Gender is the strongest predictor but all predictors are weak
  - Men reported greater skills than women
  - Older people, especially men, reported greater skills than younger people (aging trend was more evident in men than in women)
- Secondary - structure of demographic variables or subpopulations:
  - No latent factor
  - People can be clustered into 4 groups that mainly differ by age, gender, and education
  - Clusters and SRNS were significantly associated, consistent with the regression and random forest analyses

### Limitations:

- Individual Level Prediction Accuracy is Low (Variation is large)
  - People with the same demographic characteristics can have different self-report navigating skills
  - People with the same SRNS can have various demographic characteristics
  - Thus, the demographic information in this dataset is insufficient to conduct individual level predictions on SNRS

### Future Direction:

- Including objective measures to see if people with different demographic characteristics underestimated or overestimated themselves.

## REFERENCES

1. van der Ham, et al. (2021). Quality of self-reported cognition: Effects of age and gender on spatial navigation self-reports. Aging & mental health, 25(5), 873-878.
2. Nazareth, A., et al. (2019). A meta-analysis of sex differences in human navigation skills. Psychonomic bulletin & review, 26(5), 1503-1528.
3. Coughlan, G., et al. (2019). Toward personalized cognitive diagnostics of at-genetic-risk Alzheimer's disease. Proceedings of the National Academy of Sciences, 116(19), 9285-9292.
4. Coutrot, A., et al. (2018). Global determinants of navigation ability. Current Biology, 28(17), 2861-2866.
5. Coutrot, A., et al. (2020). Cities have a negative impact on navigation ability: evidence from 38 countries. Biorxiv.