Evaluating Models of Male Bathroom Behavior to Optimize Saturation Efficiency in Design of Public Spaces

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Abstract

Our observational study aims to quantitatively characterize the male behavior in bathrooms that guide their choice of urinals and provides a perceptual basis for this phenomenon. Participants in each configuration of urinals were recorded in multiple groups by order in which they chose their urinals. These observations were recorded using disguised participant observation where a team member pretended to text near the entrance while plugging data into a spreadsheet. We then simulated the collected data on different models that resemble possible decision strategies and were then evaluated against the observed set. Our study discusses different metrics that can be associated to a configuration of urinals which can be used to compare and design restrooms/public spaces with cognitive considerations of personal space in a holistic approach to understand the system.

Introduction

How does a sense of personal space affect the selection of urinals and how exactly do we choose the right urinal? With so many spots to choose from, we can begin to unravel a pattern that can offer us insight of how and why a person chooses their position relative to others. We hypothesize that given the choices between unoccupied urinals, people choose the one that is the "maximum" distance away from other occupied urinals as a result of the visual system engaging in a perceptual level computation on the ensemble of urinals. There is strong evidence for our visual system's ability to perform computations on ensembles of objects in the environment to influence our decisions (Walker, 2013), whether it be average size in an array of dots, (Ariely, 2001) or the shortest path in a given arrangement of scenes (Bonner, 2017). A possible physiological explanation of this conscious choice is likely related to personal space instantiated by the amygdala. In a neuroscience article titled "Personal space regulation by the human amygdala", the researchers suggest that the amygdala is responsible for our sense of interpersonal distance by showing that individuals with complete amygdala lesions lacked any sense of personal space while healthy individuals showed "amygdala activation upon close personal proximity" (Kennedy, Glascher, Tyszka, Adolphs, 2009). Urinal positioning may involve similar activation within the amygdala through potential violations of personal space. Through disguised participant observation of 29 configurations (Figure 1), we collected our data upon when and where multiple users chose to position themselves relative others. We can use this information to design a restroom that helps tackle the issue of personal space. We can create restrooms that help the users maintain a sense of personal space without requiring them to separate so far from each other. Our population can be defined as male students and some faculty members, which would likely be similar to the general patterns of males using the urinals. Our observations took place at 12:50 and 1:50 as those times offer the largest sets of data as it's midday when many students have classes and have just recently left class. It was the optimal time to capture multiple users having to choose which urinal to take in the presence of others.

N = # of occupied urinals in configuration	Frequency of observations
N = 1	5
N = 2	6
N = 3	9
N = 4	6
N = 5	3
Total	29

Figure 1: Observation of urinal configurations categorized by the number of occupied urinals

Method

Data Collection

To collect the data for our hypothesis, we used covert participant observation of participants in Warren Lecture hall restroom. From near the entrance of the restroom I would record the sequence in which people selected their urinals onto my phone. To the participants I appeared to just be texting on my cell phone. I went to record data only at the 50 minute mark of each hour for 10 minutes as that was when classes were ending or more specifically 11:50, 12:50, and 1:50 on a Thursday. These ends of classes resulted in restroom rushes in which many had to select urinals besides others. Additionally with so many users, they would be less concerned with a bystander on his cell phone. I had also stood far away enough that their personal space would not be violated. With these methods I would hope to avoid the Hawthorne effect of changed participant behavior as a result of their knowledge of being observed. The multiple configurations of users choosing urinals was recorded on a spreadsheet detailing when urinals were chosen in order grouped by number of simultaneous participants. The urinals were labeled one through six starting from the shortest one closest to the entrance. If 4 users came at the same time I would record the selection by inputting which urinal they had chosen in order with a value of N=4, ranking 4 out of 6 of the urinals with 1st, 2nd, 3rd, and 4th. Those with a value of 0 were unoccupied. We had N indicate group size and numbered each urinal with the order in which they were selected. The unoccupied urinals give us insight as to how far users would position away from each other. For the construct of personal space, distance between users can be used as its operational definition when it comes to urinal selection. This recording method also gives us the position preferred relative to the entrance.

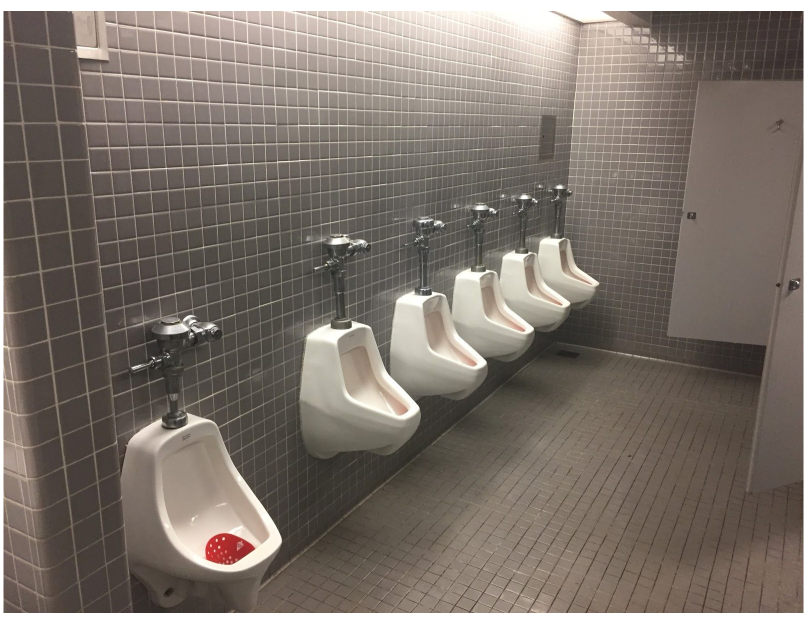

Figure 2: Layout of the urinals where the observations took place (men's restroom by WLH)

Data Preparation

The behavioral data collected from the field was first transferred onto an Excel spreadsheet (.csv) and then finally uploaded to a Pandas dataframe for analysis. In the context of this discussion, a configuration will be defined as a fixed set of unoccupied and occupied urinals in a single unit of measurement. In our dataset, a configuration was represented as an array of 6 elements, with 0 indicating an unoccupied urinal and the occupied urinals as an sequential set of integers starting from 1, corresponding to the order of insertion resulting to the current configuration. These configurations in the dataset were further categorized by the number of occupied urinals making up the configuration, denoted as n-configurations with n ranging from 1 to 5 out of 6 possible choice of urinals in our observational setting.

To test our hypothesis we created two simple models of decision making in a given configuration and compared their effectiveness in predicting observed human behavior that was reflected in our collected data. To evaluate the models, we took the set of observed configurations from our dataset and transformed them into their former configurations by "removing" the most recently occupied urinals. These previous configurations were then passed in as parameters to each of the models and the resulting configuration simulated by the models were then compared to the label configurations provided by our observations. However, our hypothesis emphasized the role of distance from an occupied urinal as a key feature in the computation involved in our decision of urinals, so the distance function associated with the resulting configuration from the models were also compared to the distance function associated with the configuration that was actually observed. The average distance function of a given configuration will be defined as the sum of the smallest distances between a each position to its closest occupied urinal, multiplied by the ratio of occupied to total urinals in the configuration. Furthermore, the marginal distance of an unoccupied urinal will refer to the change in the average distance of the configuration ensuing from the occupation of the initially unoccupied urinal to the configuration. Given this, the maximum marginal distance will then refer to the maximum change in the distance function associated with the potential updated configuration.

```
#Prepare the dataset
data = pd.read_csv("urinal_dataset.csv")
data.columns = ['Urinal 1', 'Urinal 2', 'Urinal 3', 'Urinal 4', 'Urinal 5', 'Urinal 6']
print(data)
```

	Urinal 1	Urinal 2	Urinal 3	Urinal 4	Urinal 5	Urinal 6
0	0	0	0	1	0	0
1	0	0	0	0	0	1
2	0	0	0	0	1	0
3	0	0	1	0	0	0
4	0	2	0	0	1	0
5	0	2	0	1	0	0
6	0	2	0	0	0	1
7	0	1	0	0	0	2
8	1	0	0	0	2	0
9	0	0	0	2	0	1
10	0	2	0	0	1	0
11	3	0	2	0	1	0
12	1	0	0	2	0	3
13	0	1	0	2	0	3
14	3	0	2	0	1	0
15	0	2	1	0	0	3
16	0	1	0	3	0	2
17	0	1	0	2	0	3
18	0	3	0	2	0	1
19	0	0	1	0	2	3
20	0	3	0	1	0	2
21	0	1	0	2	4	3
22	1	0	3	0	4	2
23	4	3	0	2	0	1
24	0	3	2	0	1	0
25	0	1	4	3	2	5
26	4	0	1	0	2	3
27	4	3	0	1	0	2
28	4	3	0	1	5	2

Fig 3: Urinal data uploaded to a Pandas dataframe on Jupyter Notebook's iPython kernel. The dataset and models can be found on: https://github.com/mjhong97/Cogs-13-Final-Project

The Random Model

The random model will serve as the control for our comparison between our behavioral model which maximizes the distance between occupied urinals in a configuration and the data the we recorded from the field. The algorithm will find all the unoccupied urinals in the configuration and simulate the next occupation in the configuration by randomly choosing a number corresponding to a position of an unoccupied urinal. To simulate random behavior and compare the model's effectiveness in predicting our observed configurations, each configuration sample was reverted to its previous configuration (n-1 configuration) . This earlier configuration was passed in as a parameter for the model to predict the next possible configuration and the resulting change in the average distance of the configuration.

Maximize Distance Model

However, we suspect that randomness cannot account for all of the observed configurations and that there is an underlying perceptual mechanism that drives the decision making in our choice of urinals in public restrooms. If people base their choice of urinal to maximize their privacy in the bathroom, their decisions would be the result of a perceptual level computation and we would observe that randomness wouldn't be the best fit for our observed configurations. We reproduced this computational process in our maximum distance model by choosing the unoccupied urinal that would result in the maximum marginal average distance of the configuration. If a configuration has multiple unoccupied urinals with the maximum marginal distance, the model delegates the decision to the random model.

Results

To evaluate the prediction accuracy of our models, we compared the observed configuration to the output of two models, each given all 29 configurations in our dataset. We were also interested in the comparison of the average distance function of the observed configuration to the values in the models' configurations. Due to the inherent randomness of the model, we simulated both models 1000 times each on dataset to cancel out the possible noise from the random decision. During the simulation, the random model was able to predict 25.76% of observed configurations from given its previous configuration and the outcome configuration had a smaller average distance in 17.24% of the sample, on average. The maximum distance model was able to predict the observed configuration in 41.55% of the sample configurations, on average. The configurations produced by the maximum distance model also had an average distance equal or greater to the average distance of the sample configuration as expected, due to the core logic of its algorithm. However, the model was also able to predict the correct average distances in 62.07% of the samples on average, meaning that although the model failed to predict the configuration in ~60% of the sample, this means that in about 15% of those missed predictions, the predicted outcome had the same distance function as the observed configuration.

A notable pattern in the observed configurations is the distribution of the first occupied urinal across the dataset. There is a significant skew in the dataset that favors the first occupied urinal to be towards the latter half of the configurations, namely from Urinals 4 to Urinals 6, than the first 3 Urinals of the configuration. One explanation for this result is that Urinal 1 is the closest urinal to the entrance of the restroom where the observations were made.

```
Random Dist:  0.25
Max:  [4, 3, 0, 1, 0, 2]
Max Dist:  0.5
Config:  [4, 3, 0, 1, 5, 2]
Dist:  0.2
Random:  [4, 3, 0, 1, 5, 2]
Random Dist:  0.2
Max:  [4, 3, 5, 1, 0, 2]
Max Dist:  0.2
PREDICTION ACCURACY
Random : 0.3793103448275862   0.1724137931034483
Max : 0.3793103448275862 0.6206896551724138
------------------------------------------------------------------------
Final results after  1000  simulations:

Random model's configuration prediction:  0.2575517241379321
Random model's distance prediction:  0.17241379310344918
Max_distance model's configuration prediction:  0.41551724137930407
Max_distance model's distance prediction:  0.6206896551724296
```

Figure 4: Results from 1000 simulations of the models on the dataset

	Urinal 1	Urinal 2	Urinal 3	Urinal 4	Urinal 5	Urinal 6	Total
First Occupied	10.3%	6.89%	10.3%	17.24%	34.49%	20.69%	100%

Figure 5: Frequency ratios of the first occupied urinal of each configuration in the dataset

Discussion

Summary

The results from the simulation of the models show that the male decision making behavior in public restrooms can be better modelled with an approach to maximize the distance between occupied urinals than attributing the configuration to chance. In our simulation, the maximum distance model performed 16% better on average than the random model in predicting observed configurations and 45% better in predicting the distance function from the resulting configuration. However the data suggests to there are other factors that influence this process which the models failed to account for. For example, the distance of the unoccupied urinal to the entrance of the bathroom seemed to be a notable feature, as indicated by the significantly higher chance for the first 2 occupations in a configurations to be at the latter half of the configuration farthest from the door. However, this might also be a strategy to maximize privacy in our choice of urinals. Research by Kranakis and Krizanc (2010) supports this claim, as their research explored various models that maximized privacy to model our decision making process in public restrooms.

Design Implications

Although the scope of our study was looking at the decision behavior observed in one restroom, this phenomenon has been observed almost universally in other similar urinal layouts. Our data shows that people's decision in choosing their urinals are significantly influenced by a strategy to maximize distance from other occupied urinals in the configuration, to ultimately maximize privacy in their interaction in public restrooms. Given that people universally experience the phenomenon of computing the maximum distance from each other in public restrooms, it suggests an inherent flaw in the way urinals are designed and in the thinking behind the design of urinals. The metrics in this study can be used in thinking about what is truly efficient in designing urinals and public restrooms. Designers of urinals and bathrooms tend to think only in terms of efficiency of space and not in terms of the cognitive processes involved in using public restrooms. Our data shows that because of this decision-making, urinals often go unused which is an inefficient design. By designing for privacy, the amount of urinals can be maximized to fit the needs of the users of the public restroom. Privacy is assumed by the user in the setting of a public restroom and yet our data shows that this is a significant concern in users. There is evidence that suggests there is a positive correlation between a user's distance from other occupied urinals and the same user's delay in onset of urinating (Middlemist, Knowles, 1976). This not only speaks to public restrooms but also to the broader problem of designing privacy for public settings.For example, there are often empty chairs in a dining hall or food court when individuals that are dining take up entire tables with four or more chairs. Because of the desire for privacy in public spaces, those chairs will remain empty even as the dining area fills up. To make the seating arrangement more efficient, some dining areas have implemented more bar areas for individuals to sit at. This suggests that we can better study and design for privacy and to optimize space efficiency if we take cognitive considerations and assess the behavioral data produced by the system.

Limitations and Possible Directions

There are several limitations and possible confounds to our study that should be addressed. First, as discussed in the implications, the entrance of the bathroom relative to the configuration of urinals seem to contribute to this phenomenon. Randomness (or at least pseudo-random generation provided by the standard Python library) was also inherent in our models for bathroom behavior, but it was operationally only a substitute for features corresponding with a deeper complexity in this phenomenon beyond the scope of pure distance metrics in the configuration. Perhaps a more sophisticated model can better capture the nuances of this phenomenon by having the weighted probability of each position in a configuration conditioned on its initial configuration as a feature in the said model.

Another feature that could be operationalized for further studies is a measure of decision time. A negative correlation between the time to make a decision in a given configuration and the distance function of that configuration would support our hypothesis as it would suggest the presence of the computational task engaged in our choice of urinals and would provide another dimension for analysis. Furthermore, for better training of the model, a larger and more diverse dataset of configurations would yield better results at predicting configurations.

Finally, we only looked a single setting of bathroom for this analysis, but different settings could be observed to evaluate the effectiveness of different models. For example, maximizing distance may not be a less/more of a strategy to maximize privacy in a different configuration of urinals with different layouts or designs. With this, we would be able to calculate the configuration's privacy coefficient, which would indicate the how much the strategy to maximize distance between one's neighbors can account for the observed behavior in that specific configuration. Gender might also play a role in this phenomenon as not only are female restrooms designed differently from males restrooms, studies indicate that men are affected more by social phobia than women, especially in the context of public restrooms (Turk, 1998). It would be interesting to see the differences or similarities in the models of bathroom behavior reveal about male and female bathroom behavior.

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