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Exploring Gender Differences in Spatial Orientation Ability on Representing Cognitive Map

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Abstract This study examines that there are gender differences of spatial orientation skills in drawing cognitive maps which represent narrative space after reading a book. Because there was no previous research proposing specific way of measuring accuracy of spatial orientation skill in cognitive map, we propose a new experimental tool which helps interpret cognitive maps quantitatively in the aspect of spatial orientation ability. Result from this experiment shows there is no significant gender difference in recalling the number of places of narrative spaces. However, we found that men perform better than women in locating places accurately in cognitive map. This result provides evidence that men have better spatial orientation ability in representing cognitive map of narrative space. Finally, we discuss various possibilities of interpretation, the visuo-spatial working memory (VSWM) span and systemizing information. The limitation will be discussed.

Keywords Cognitive Map, Gender Differences, Spatial Orientation ability, Visuo-Spatial Working Memory (VSWM), Systemizing

1. Background / Objectives and Goals

There has been a plethora of researches on spatial orientation skills, which is the complex of abilities used for locating themselves with respect to a point of reference or an absolute system of coordinates, in the aspect of gender differences. Those researches has investigated spatial orientation skills in various environments including real environments (Malinowski & Gillespie, 2001) (Sadalla & Montello, 1989; Lawton, 1996; Lawton, Charleston, & Zieles, 1996) (Schmitz, 1997) (Kirasic, Allen, & Siegel, 1984; Montello & Pick, 1993; Saucier et al., 2002), simulated environment like 3-D computer simulations (Moffat, Hampson, & Hatzipantelis, 1998; Lawton & Morrin, 1999; Sandstrom, Kaufman, & Huettel, 1998; Waller et al., 2001), (O'Laughlin & Brubaker, 1998), and map (McGuinness & Sparks, 1983; Miller & Santoni, 1986). With an intensive research of previous studies, Coluccia and his colleague assumed the gender difference emerges only when the task requires high workload and Visuo-Spatial Working Memory (VSWM). They pointed out that VSWM is determinant factor in gender difference of spatial orientation ability, indicating that men would show better performance than women, because of their large VSWM span. In this study, we examine a bunch of cognitive maps of narrative space which is closely related to VSWM. because research on gender difference in cognitive map is almost uncharted territory. Though there have been already such a number of researches on spatial orientation ability on gender difference in various environment, a study on cognitive map of narrative space which is closely related to VSWM is almost uncharted territory. Therefore, in this study, we investigate the gender difference in spatial orientation ability with cognitive maps of narrative space quantitatively and qualitatively.

The concept of cognitive map was first introduced by Tolman (1948) to account the navigational ability that helps rats reach to food box in a maze, when familiar way has been blocked. The term, cognitive map, has been used for various purpose of people's concept of geographic maps such as road maps. Based on Lynch's idea that 'the observer of an environment selects, organizes, and endows with meaning what he see' (1960), Bjornson extended the concept of cognitive map to literature. He suggested the extended concept of cognitive map to refer a global mental representation of the literary text that includes both spatial information and meanings the reader endows. Furthermore, Jameson suggested the concept of cognitive map should be

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extended from purely spatial to social domain (1988). However, in this study, we focus on narrow concept of cognitive map that is mental model of spatial relation, through representing narratives space. More specifically, this study aims to reveal gender difference of spatial orientation ability which is reflected in cognitive maps.

It seems that there are mainly two difficulties in drawing cognitive map of narrative space. The first, to transform temporal dimension of languages into the spatial nature of maps, remembering spatial information which is partially distributed over all the text is required. The more the number of interacting element to be maintained simultaneously, the more cognitive load is required in working memory (Marcus, Cooper & Sweller, 1996). In other words, because the task, drawing cognitive map of narrative space, requires a high load of VSWM, it is difficult task. The second is that there are two steps which is ambiguous in the middle of transforming textual information into visual representation (Marie, 2003). According to Marie, there are three stage, textual information, mental models of space, and visual representation. Both between textual information and mental models of space, and between mental models of space and visual representation, there are incompleteness of texts and informational gap because visual representation is very explicit compared to textual information or mental models of space.

Just reading also needs long term memory to remember a global representation, and sketch-pad of short term memory or episodic memory to remember smaller textual units. To represent the memory more explicitly, it is expected that high cognitive load would be needed.

Research Question: Would the gender difference of spatial orientation ability emerge in drawing cognitive map of narrative space?

2. Methods

This was exploratory study carried out in one of university in Seoul, Korea. 57 undergraduate students who registered for introductory cognitive science course participated in this experiment. Majors of students were various. The experiment was conducted during a spring semester. Participants were instructed to read the story of the novel, 'Chronicle of a Death Foretold' for two weeks. In class, they are required to draw a fictional town map individually in A4-size paper. Participants were debriefed at the end of the semester and awarded class credit for their participation.

To measure spatial orientation ability quantitatively, we made new frame named Frame of spatial orientation ability measurement (FOM), which means a frame for spatial orientation ability measures. At first, we made a standard frame which exactly reflects master map drawn in previous research conducted with same fiction (Marie, 2003). We referred all items marked on the master map. And, we divided the map to 8 section equally based on cardinal points.

Each of cognitive maps submitted had their separate cardinal points. To compare and assess accuracy of location of all those maps submitted fairly, certain criterion was needed. We selected two items which were the most often mentioned among those cognitive maps. The two most often referred items were House of Nassar and Square (see Figure 2). Based on those two items, we built an axis as criteria to help arrange and compare a number of cognitive maps. Number 23 and 7 on the left picture of Figure 1 is House of Nassar and Square, respectively. The reason why we selected the most often mentioned items was to make an axis that can include as many cognitive maps as possible in our research.

All the cognitive maps drawn with pen or pencil were scanned and transformed to JPEG file. We utilized a graphic tool, Adobe InDesign, to overlay those map files on FOM, respectively. First, size and position of all maps should be adjusted to be fitted to FOM, based on the location of the square. Because, usually square is located on center of the map, but sometimes they are not and the sizes of square vary. Then, the maps should be arranged by the axis of FOM. The thick vertical line on Figure 3 is the axis, from center of the square to house of Nassar. The other thick line in rectangular shape in center of the picture is square. After all these processes are done, we counted items which are marked in correct location.

In this study, we considered items located within 45 degree from original location as correct one. The blue lines on FOM that separate a map to eight pieces are just used for reference to measure the degree. In the early stage of this research, we tried to count items section by section. However, assessing whether items are marked in correct location by section line seems inaccurate. Because, though the location is close to the one in FOM, they are not counted as correct one if they are not in same section. Figure 4 and 5 are samples of them. As you see in figure 4, the map is rotated 90 degree toward right to be fitted to the axis of square and house of Nassar.

Figure 5 shows a variety of mapping style of cognitive maps submitted. The first and second vertical line shows usual mental representation of space which we intended to investigate. However, two maps at the bottom of third vertical line seem to represent a specific event, instead of drawing the space. Because these maps are not appropriate for this study, 15 maps which are similar to these were eliminated from all 57 maps submitted.

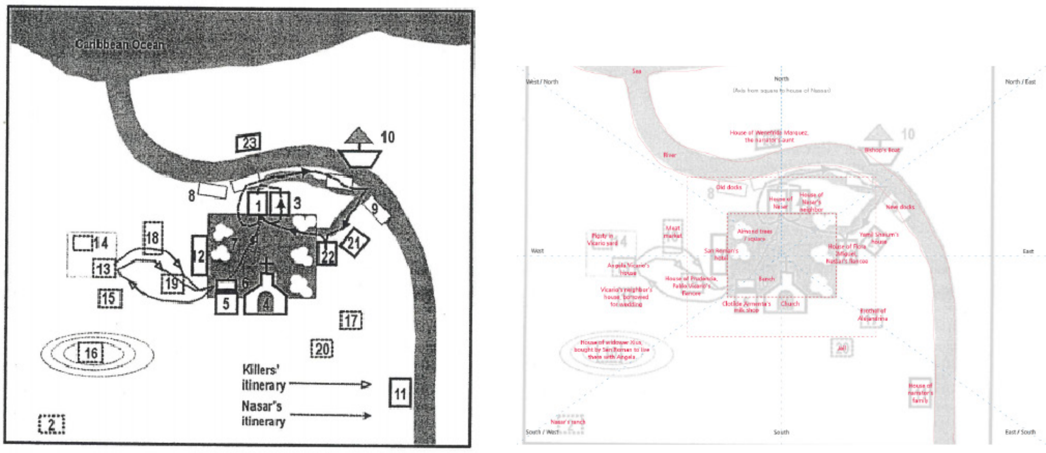


Figure 1. A master map by Marie and FOM overlaid on master map

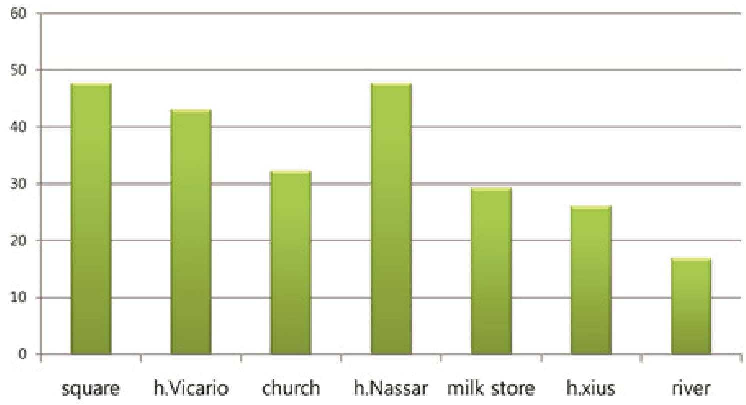


Figure 2. Frequency of Items referred in cognitive maps

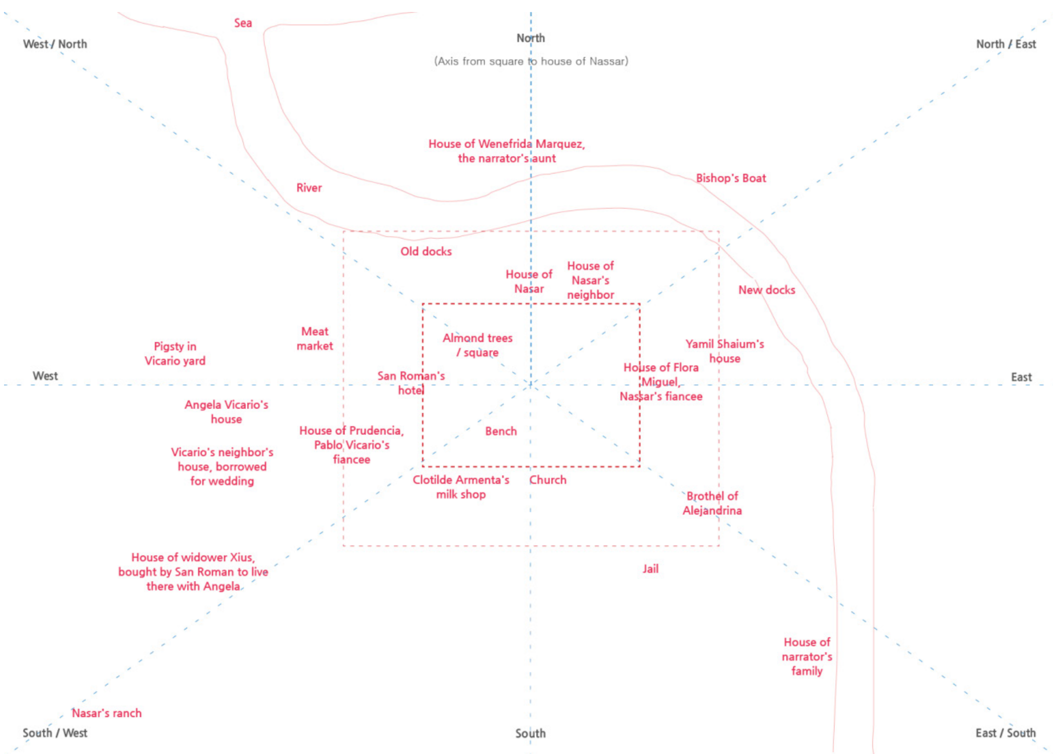


Figure 3. FOM, a newly developed frame for analyzing cognitive maps in the aspect of spatial orientation ability

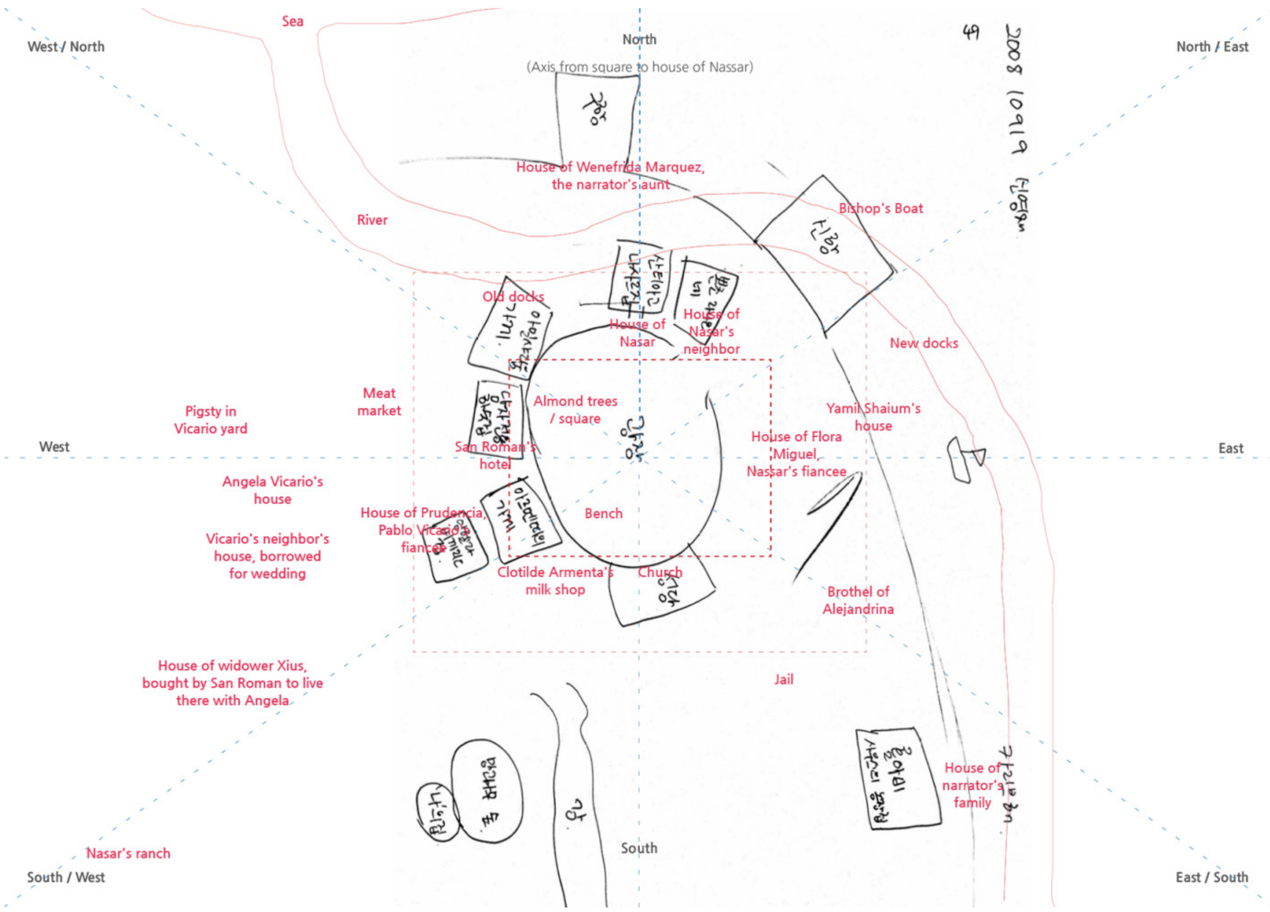
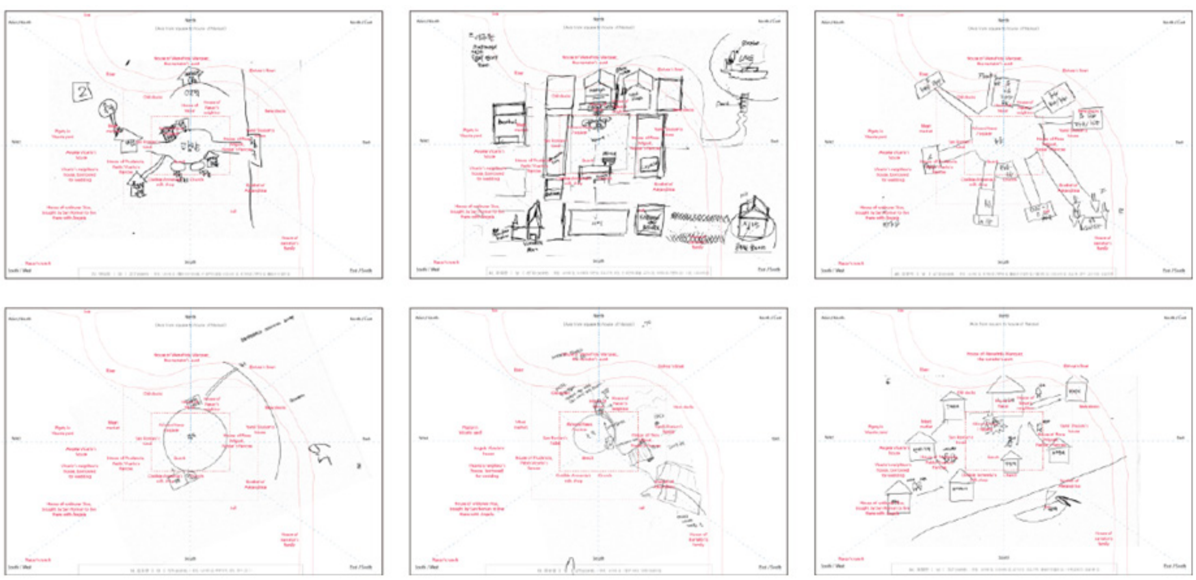


Figure 4. One of the sample cognitive maps rotated 90 degree clockwise to get same direction with FOM



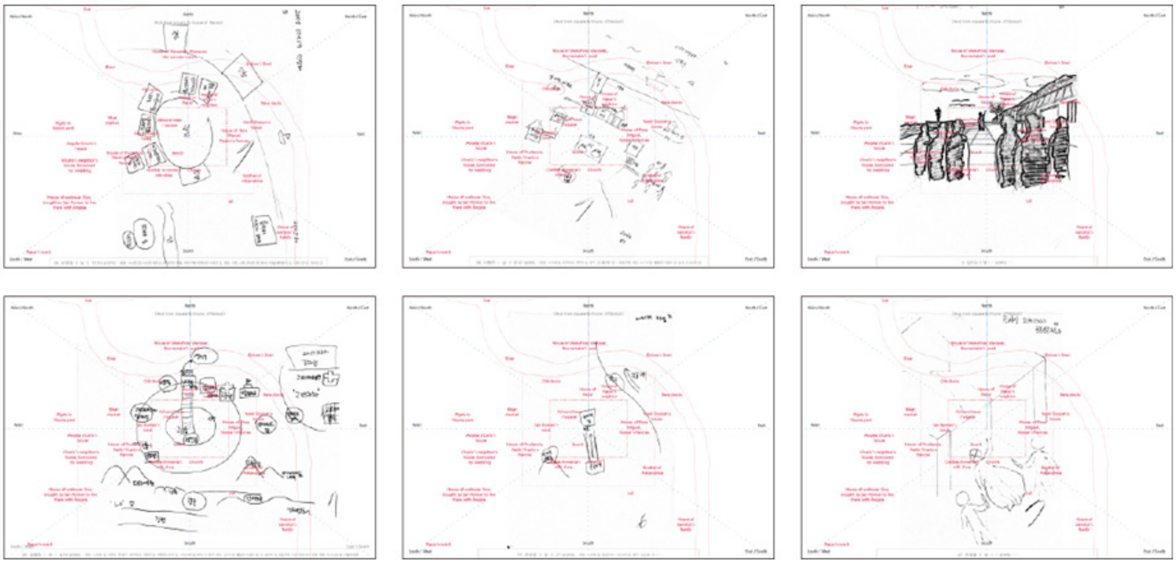


Figure 5. Sample of cognitive maps overlaid on the FOM

3. Results

3.1. General Information

The items marked in correct place, every items marked, gap between items that match and every item marked, and accuracy rate are presented in table 1. All number of participant were 57, however, the maps we could use for this study were only 42. The average number of places marked in correct place, all items marked, gap between items marked in correct place and every items marked, and accuracy rate is 4.26, 7.79, 3.55, and 0.57, respectively.

3.2. Benefit Findings

One-way analyses of variance (ANOVA) were conducted to analyze the gender difference in spatial orientation ability. The ANOVA indicated that men have a tendency to perform better than women in locating items in correct place, $F(1, 40) = 3.346$, $p < .1$, while there are no significant gender difference in recalling every items (see Fig.6).

The ANOVA also indicated that there are distinctive significant difference on gap between items marked in correct place and every items marked, and accuracy rate. According to the result, men shows smaller gap between items marked in correct place and every items marked, $F(1,40) = 8.331$, $p < .01$, and have a significantly higher accuracy rate, $F(1,40) = 6.986$, $p < .05$ than women (see Fig.7 and Fig.8).

3.3. Discussions and Implications

There are three interpretations of this gender difference in spatial orientation ability according to Coluccia and his colleague (Coluccia and Louse, 2004). First, there are evolutionistic theories hypothesizing that memory system women have has been specialized for object location since prehistoric age (Silverman and Eals, 1992). Women had to care of their family and daily supplies while men hunted developing their memory system in the aspect of Euclidean and configuration property. In other words, the gender difference in spatial orientation ability is attributed from traditional sex role. The second reason is assumed that men and women have different strategies in orientation task (Lawton, 1994). Men seem to employ a survey strategy, which utilize a global reference point and Euclidean information. The strategy is more useful in navigating than route strategy, which utilize landmarks and instructions on how to get to destination. Women usually have the route strategy. The third is personality. ‘Spatial anxiety’ or ‘fear to get lost’ reduces ability to catch cues for navigation. Because women have spatial anxiety while men shows confidence in finding way, it is hypothesized that men tend to have better spatial orientation ability (Lawton, 1996; Kozloswki and Bryant, 1977). Lastly, VSWM span is pointed as key determinant of gender difference in spatial orientation ability (Coluccia and Louse, 2004). Because our task had several difficult steps which require high level of VSWM, and it seems that there are significant gender difference in VSWM, it seems that the gender difference appears more distinctively in the result. With these factors previously referred about gender difference in spatial orientation ability, we suggest that gender difference in systemizing ability may have affected to our result. Systemizing, as one of two key mode of thought (Baron-Cohen, 2002), help to comprehend the rules controlling the behavior of a system and to construct lawful systems. Furthermore, with systemizing, we may predict and control these system (Goldenfeld, Baron-Cohen & Wheelwright, 2005). In our task, information on space should be scattered partially over the whole story. Considering characteristics of our task that include compiling partial information systematically, it is hypothesized that the ability of systemizing would affect to our task that reconstructing narrative space given partially to a piece of drawing.

Table 1. General information (N = 42)

	Gender	Mean	Std.Deviation	N
Correct Placement	**Men**	4.62	2.145	29
	Women	3.46	1.127	13
	Total	4.26	1.951	42
Every Placement	**Men**	7.48	2.530	29
	Women	8.46	3.045	13
	Total	7.79	2.701	42
Gap between Correct Placement and Every Placement	**Men**	2.90	1.633	29
	Women	5.00	3.109	13
	Total	3.55	2.371	42
Accuracy Rate	**Men**	.62	.185	29
	Women	.45	.207	13
	Total	.57	.206	42

Table 2. Result of ANOVA

		Sum of Square	df	Mean Square	F	Sig.
Correct Placement	**Between Groups**	12.061	0	12.061	3.349	.075
	Within Groups	144.058	40	3.601		
	Total	156.119	41			
Every Placement	**Between Groups**	8.599	1	8.599	1.184	.283
	Within Groups	290.472	40	7.262		
	Total	299.071	41			
Gap between Correct Placement and Every Placement	**Between Groups**	39.715	1	39.715	8.331	.006
	Within Groups	190.690	40	4.767		
	Total	230.405	41			
Accuracy Rate	**Between Groups**	.258	1	.258	6.986	.012
	Within Groups	1.477	40	.037		
	Total	1.736	41			

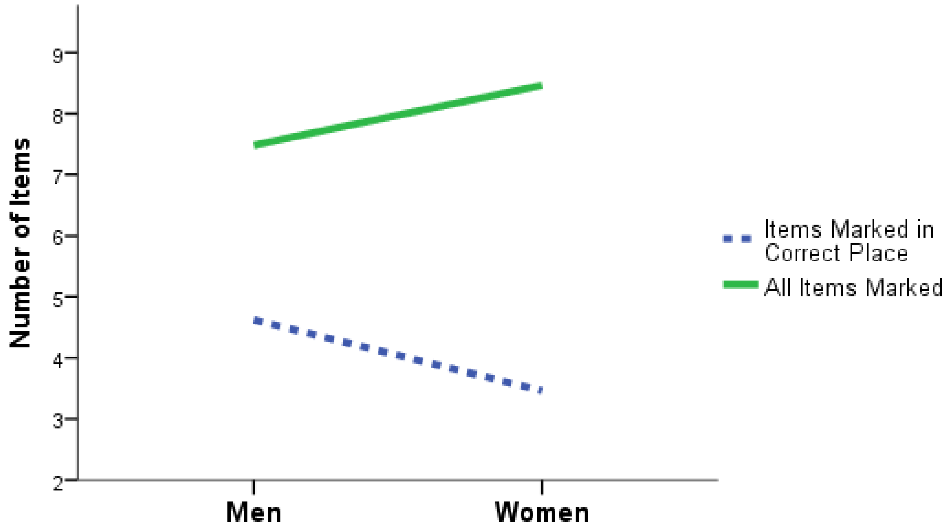


Figure 6. Gender Difference in Number of Items Marked in Correct Place and All Items Marked

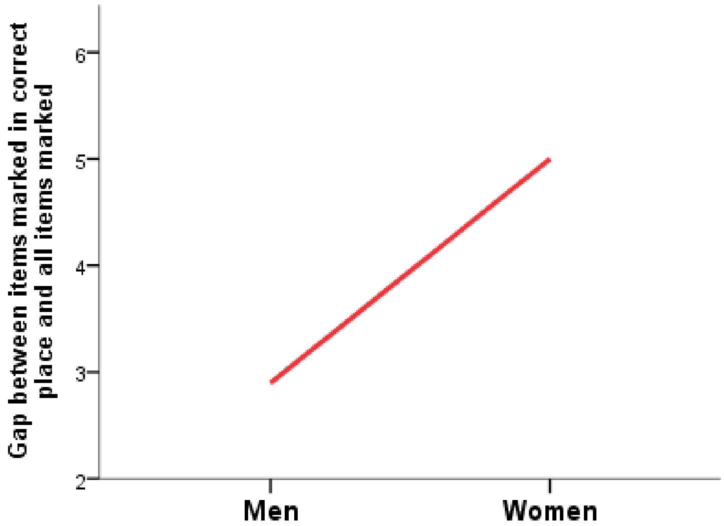


Figure 7. Gap between items marked in correct place and all items marked

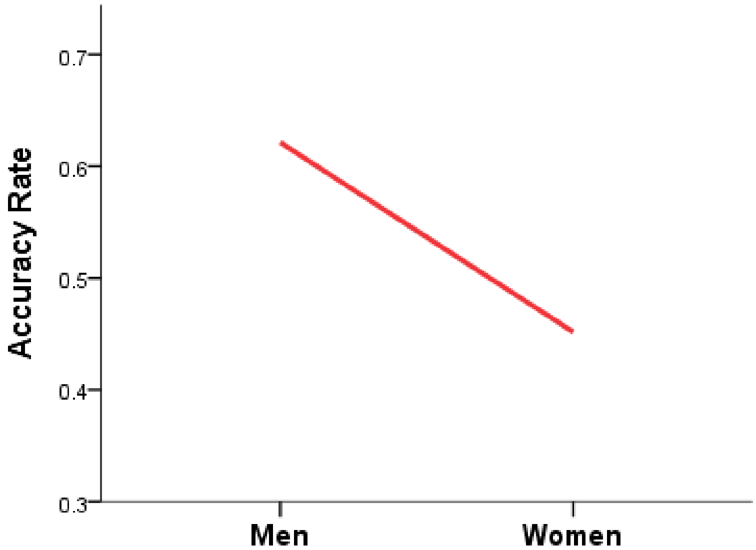


Figure 8. Accuracy rate between men and women

REFERENCES

[1] Bjornson, R. (1981). Cognitive Mapping and the Understanding of Literature. *Substance* 30: 51-62.

[2] Baron-Cohen S (2002). The extreme male brain theory of autism. *Trends in Cognitive Science* 6, 248-254.

[3] Coluccia, E., & Louse, G. (2004). Gender differences in spatial orientation: A review. *Journal of Environmental Psychology 24,* 329–340. doi:10.1016/j.jenvp.2004.08.006.

[4] Jameson, F. (1988). Cognitive mapping. *Marxism and the interpretation of Culture,* eds. N. Cory and L. Grossberg, 347-60. Urbana: University of Illinois Press.

[5] Kirasic, K. C., Allen, G. L., & Siegel, A. W. (1984). Expression of configurational knowledge of large-scale environments: students' performance of cognitive tasks. *Environment and Behavior, 16*(6), 687–712.

[6] Lawton, C. A. (1996). Strategies for indoor way-finding: the role of orientation. *Journal of Environmental Psychology*, 16, 137–145.

[7] Lawton, C. A., Charleston, S. I., & Zieles, A. S. (1996). Individual and gender related differences in indoor wayfindings. *Environment and Behavior, 28(2),* 204–219.

[8] Lawton, C. A., & Morrin, K. A. (1999). Gender differences in pointing accuracy in computer simulated 3D mazes. *Sex Roles, 40*(1/2), 73–92.

[9] Lawton, C. A. (1994). Gender differences in way-findings strategies: relationship to spatial ability and spatial anxiety. *Sex Roles, 30*(11/12), 765–779.

[10] Lynch, K. (1960). *The Image of the City.* Cambridge: MIT Press.

[11] Montello, D. R., & Pick, H. L. (1993). Integrating knowledge of vertically aligned large-scale spaces. *Environment and*

Behavior, 25, 457–484.

[12] Moffat, S. D., Hampson, E., & Hatzipantelis, M. (1998). Navigation in a virtual maze: Sex differences and correlation with psychometric measures of spatial ability in humans. *Evolution and Human Behavior, 19*, 73–87.

[13] Malinowski, J. C., & Gillespie, W. T. (2001). Individual differences in performance on a large scale, real word wayfinding task. *Journal of Environmental* Psychology, *21*, 73–82. doi:10.1006/jevp.2000.0183.

[14] McGuinness, D., & Sparks, J. (1983). Cognitive style and cognitive maps: sex differences in representations of a familiar terrain. *Journal of Mental Imagery, 7*(2), 91–100.

[15] Miller, L. K., & Santoni, V. (1986). Sex differences in spatial abilities: strategic and experimental correlates. *Acta Psychologica, 62*, 225–235.

[16] Marcus, N., Cooper, M., & Sweller, J. (1996). Understanding instructions. *Journal of Educational Psychology, 88*(1), 49–63.

[17] Marie, L. (2003). Cognitive maps and the construction of narrative space. In Herman (eds), *Narrative Theory and the Cognitive Science*, California: CSLI Publications.

[18] O'Laughlin, E. M., & Brubaker, B. S. (1998). Use of landmarks in cognitive mapping: gender differences in self report versus performance. *Personality and Individual Differences, 24*(5), 595–601.

[19] Sadalla, E. K., & Montello, D. R. (1989). Remembering changes in direction. *Environment and Behavior, 21,* 346–363. doi: 10.1177/0013916589213006.

[20] Schmitz, S. (1997). Gender related strategies in environmental development: effect of anxiety on wayfinding in and representation of a three-dimensional maze. *Journal of Environmental Psychology, 17,* 215–228.

[21] Saucier, D. M., Green, S. M., Leason, J., MacFadden, A., Bell, S., & Elias, L. J. (2002). Are sex differences in navigation caused by sexually dimorphic strategies or by differences in the ability to use the stratgies? *Behavioral Neuroscience, 116*(3), 403–410.

[22] Sandstrom, N. J., Kaufman, J., & Huettel, S. A. (1998). Males and females use different distal cues in a virtual environment navigation task. *Cognitive Brain Research, 6,* 351–360.

[23] Silverman, I., & Eals, M. (1992). Sex Differences in Spatial Abilities: Evolutionary Theory and Data. In Barkow, H., Cosmides, I., & Tooby, J. (Eds.), *The Adapted Mind*. New York:Oxford ed.

[24] Kozloswki, L. T., & Bryant, K. J. (1977). Sense of direction, spatial orientation, and cognitive maps. *Journal of Experimental Psychology: Human Perception and Performance, 3*(4), 590–598.

[25] Tolman, E. C. (1948). Cognitive maps in rats and men. *Psychological Review,* 55, 189-208.