

# Men to the East and Women to the Right: Wayfinding with Verbal Route Instructions

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**Abstract.** In this paper, we investigate the outdoor wayfinding performance of men and women in a shifting frame of reference with verbal route instructions given in German language. This study replicated the methodology of Ishikawa and Kiyomoto (2008) but investigated also the gender component. The participants were divided into absolute-relative (A-R) and relative-absolute (R-A) groups. They had to follow ten routes: The A-R group walked the first set of five routes with instructions given in absolute frame of reference which shifted to instructions in relative frame of reference. The R-A group, on the other hand, walked the first set of five routes with relative instructions and shifted to an absolute reference frame. In the experiment, the results showed that participants in both groups had difficulty following the absolute instructions wherein they had significantly more stops, more deviations and travelled longer off-route. The overall performance increase of participants who started with an absolute and shifted to a relative reference frame was higher than the performance decrease of participants who started with a relative and shifted to an absolute reference frame. In terms of gender, the wayfinding performance of both, men and women, was significantly better with instructions in relative than in absolute reference frame. Women made fewer stops, fewer deviations, and did not walk off the route as frequently as men. However, the gender effect was not significant.

**Keywords:** outdoor wayfinding, frame of reference, gender, verbal route instructions.

## 1 Introduction

Wayfinding is an interesting area of study as it investigates how people find their way in both familiar and unfamiliar environment. Differences lie on people's spatial abilities, with some finding it easier to locate a specific place compared to others. Clear route instructions are deemed important for people to follow any navigational task. It is necessary to place oneself in the situation of a person unfamiliar to the place and understand that people have their own preferences in finding their way. Some prefer cardinal directions (North, East, West, South) while others prefer a relative reference frame (right or left). Some prefer exact distances while others prefer approximation based on landmarks. Many researchers in various fields such as geography, psychology, architecture, engineering, and computer science have investigated such navigational differences and how to make wayfinding easier for people.

This research attempts to replicate the methodology used by Ishikawa and Kiyomoto (2008) to study the effect of ‘shifting reference frames’ on wayfinding performance of German speakers. The shifting of reference frame makes the evaluation of an individual’s level of spatial knowledge possible. In contrast to Ishikawa and Kiyomoto’s study, this research investigates gender differences in preference of frame of reference. Gender differences are analyzed based on the outdoor wayfinding performances measures used which include the number of stops, number of deviations and the off-route distances in a specific frame of reference. This research examines which frame of reference men and women are most comfortable with, and attempts to assess whether men perform better in absolute frame of reference, while women perform better in relative directions. The cultural differences between German and Japanese outdoor wayfinding allows for an interesting comparative study and a comparison to Ishikawa and Kiyomoto’s results. Further research is suggested to gain more insights on cultural differences in wayfinding. This could also be used in assessing how people orient themselves in space and how they normally refer to spatial models in reaching a specific destination.

This study posed the following hypotheses: 1) Men and women have difficulty following wayfinding instructions in a shifting frame of reference, but more so in the absolute frame; 2) Men perform better than women in outdoor wayfinding following verbal instructions in absolute directions; and 3) Women mostly have difficulty following absolute instructions rather than relative frame of reference.

The remainder of this paper is structured as follows: Section 2 gives an overview of related work regarding different reference frames and gender differences in wayfinding. In Section 3, we describe the methodology of our experiment. Section 4 gives the results with respect to the different reference frames and gender differences and section 5 discusses the results. The conclusions are drawn in section 6.

## 2 Related Work

Levinson (1996) described three different frames of reference: intrinsic, relative, and absolute. In the intrinsic reference frame, the orientation is defined with respect to the reference object; in the relative reference frame, orientation is defined with respect to the viewer; and in the absolute reference frame, orientation is defined with respect to fixed bearings such as cardinal directions.

Wayfinding directions are usually given in either relative or absolute frame of reference. In the following navigation task, people’s preferences vary on which is easier to follow. Several factors such as the time spent and the number of stops are taken into account while following directions.

Golledge et al. (1992) emphasized the need to understand how people acquire knowledge of the environment. Route learning has captured interest of several researchers from various disciplines, mostly in geography. According to Golledge et al, there is superiority of survey learning in unfamiliar environment at varying geographic background with gender differences. Lawton (2001) looked at how the geography of the place may affect how people would give directions such as the case of the Midwest/West region in the US whose inhabitants prefer giving cardinal directions, which might be attributed to their grid-like pattern road network.

Lovelace and Montello (1999) investigated various ways of assessing the quality of route directions through the inclusion of landmarks, turns, segments, and descriptive information. These are considered helpful measures to guide people in any wayfinding task.

Researchers have also noted cultural differences; for instance, Japanese speakers prefer relative frame of reference (Ishikawa and Kiyomoto, 2008). Ishikawa and Kiyomoto looked at how Japanese students fared when there is a shift from relative to absolute direction or vice versa. Also of equal interest are other ethnic groups such as Tenejapan Tzeltal that use only absolute directions while some Mayan cultures such as the Mopan prefers an intrinsic frame of reference (Levinson, 1996).

Several studies have been conducted regarding how men and women use their spatial abilities in navigating. Many experiments aimed to identify how gender or sex differences affect such an activity. Collucia and Louse's (2004) review on gender differences in spatial orientation revealed mixed results of spatial differences. However, it mostly showed the rarity of female superiority in many spatial tasks, attributable to biological explanations and environmental factors. According to Collucia and Louse, gender differences in terms of spatial orientation may be explained through evolutionistic approach, individual strategies and personality factors. Ward (1986) showed that people mostly rely on listing landmarks and turns while giving directions whereby men would use more absolute indicators than women. Although many studies showed similar result, Weiss et al. (2003) regarded the concept of spatial ability and spatial cognition as vague.

It is often considered a stereotype that women have more difficulty in any wayfinding task than men (O'Laughlin and Brubaker, 1998). There is a tendency for women to even think that they have a poor sense of direction and they sometimes cannot follow direction, especially in an absolute frame of reference. However, the results are diverse, with some saying that men are better than women while others say there is no gender difference. Eals and Silverman (1994) highlighted the fact that there is a female advantage in recalling spatial objects. Montello et al (1999) further emphasized the superiority of women in object location and that they make fewer mistakes in recalling landmarks from their campus route experiment. Men, on the other hand, showed better spatial ability by using metric distances and cardinal directions when thinking of environmental space. Montello et al. pointed out that it is wrong to assume that males are generally better than females in terms of spatial abilities because they vary at different levels. Kim et al (2007) showed a similar result whereby female subjects responded faster in a 2-D matrix navigation task than males when landmark instructions were provided. The differences is quite interesting as it follows the idea of women being more confident in relative direction-related tasks while men are more on absolute directions. However, Iachini et al (2005) found no differences between men and women in object recognition and in recalling the spatial layout of a place.

There is male advantage in angular judgment and travel distance elimination (Holding and Holding, 1988). It shows that most women tend to show bias towards underestimation and that they were guessing in some spatial tasks. In a neuropsychological test conducted, they found out that men are better on visual-spatial tasks such as spatial orientation, mechanical abilities and mathematics while women outperformed men on most verbal tests (Weiss, et al, 2003). Although, there is a decreasing gender difference in mental rotations test over time (Masters and Sanders, 1993; Colom, et al., 1999).

Scholl et al. (2000) showed that men are better in orientation strategy (which refers to cardinal directions) while women use route strategy referring mostly to landmarks. The authors observed that women prefer route strategies when asking for directions and tracking the distances when going through the routes in an unfamiliar environment, while men use cardinal directions more often for orientation. In the study of Silverman and Choi (2006), results revealed that men outperformed women in dynamic navigation following Euclidean instructions. Women mostly use topographical over Euclidean navigational strategies. Schmitz (1997) studied how gender played a role on some German students in wayfinding in a three-dimensional maze. The results showed that girls developed higher anxiety and fear than boys when going through the maze. It also turned out that those subjects who were slow in the experiment and scored high in anxiety and fear tend to recall more landmarks than those who were less nervous. Women usually tend to experience higher spatial anxiety over men (Lawton, 1994), which also appeared in a cross cultural study between Hungarians and Americans (Lawton and Kallai, 2001).

There are an increasing number of studies showing no gender differences in spatial cognition specifically in learning a spatial skill. Spence et al. (2009) trained selected participants in learning a new video game. Such training method proved that women could equally acquire a basic spatial skill like men. Hund and Minarik (2006) stated in their study that men and women showed they were both fast and accurate when navigating based on cardinal directions than in landmark directions.

### **3 Outdoor Wayfinding Experiment: Method**

#### **3.1 Participants**

Twenty-four German students in the undergraduate and graduate levels unfamiliar to the study area participated in the experiment. The group was composed of 12 men and 12 women who were not compensated for participating. The age range was 19 to 30 years old with mean age of 23.88 years. The participants were all geosciences students except for one political science student.

#### **3.2 Study Area**

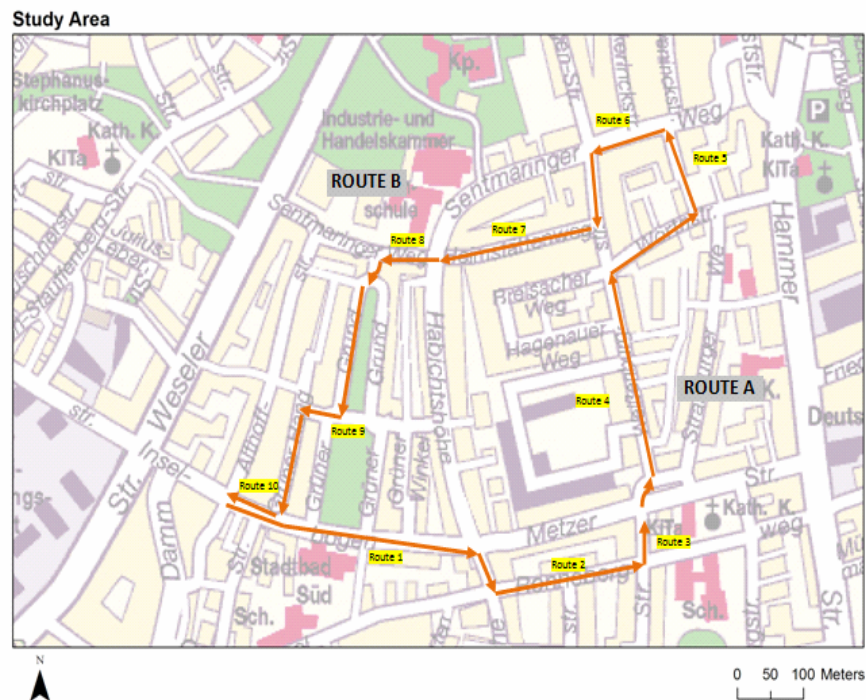
The study site was a residential area in Münster, Germany, which was purposely chosen because of its unfamiliarity to the participants (see Fig.1). Route lengths and number of turns were taken into consideration in choosing a study area, comparable to that of Ishikawa and Kiyomoto's experiment.

#### **3.3 Procedure**

Snowball sampling method was used in gathering participants. The participants were divided into Group A-R (Absolute-Relative) and Group R-A (Relative-Absolute), each group with equal distribution of men and women. The A-R group walked the first set of five routes (Route A) in absolute directions and then shifted to relative directions on the second set of route segment (Route B). The R-A group, on the other

hand, walked Route A given in relative directions first and then shifted to absolute directions in Route B.

Before the participants started the experiment, they were asked to fill out the Santa Barbara Sense of Direction Scale Questionnaire which consists of 15 questions, which were then used in correlating to each individual's performance in the wayfinding task. Seven questions were stated in a positive statement such as: "My "sense of direction" is very good," while eight questions were negatively phrased, i.e.: "I don't remember routes very well while riding as a passenger in a car." The questionnaire was used to examine the spatial and navigational abilities, preferences and experiences of each individual.



**Fig. 1.** The study area with the 10 routes. Route A comprises 1-5 routes while Route B is composed of routes 6-10.

The entire procedure was explained to the participants, which includes taking the video while conducting the experiment. The cardinal directions were explained. Before proceeding to the starting point, each participant was asked to point where north is. The participant was then led to the starting point where the first task was given. The participant was followed by the experimenter without making any conversation. Whenever the participant take the wrong route, the experimenter leads him/her to the right direction once s/he takes twice the expected time to travel the entire route. This was also used in gauging the off-route distance they travelled which doubled the actual distance of the route. The whole wayfinding experiment was videotaped to record

the time spent, deviations of the route and the number of stops made. Spending 15 seconds or longer on a particular spot counts as one stop.

### 3.4 Verbal Route Instructions

Each route had a distance which ranged between 62-400 meters long. The entire route was 2.3 km. A participant had to find a specific goal before proceeding to the next route. For relative reference frame, egocentric representations were used for directions. For the absolute part, cardinal directions and distances in meters were used. The same landmarks as sub-goals were used for both absolute and relative frames of reference for each route.

In the verbal route directions, the participant was given an 11x15 cm instruction card where the routes were described in either relative or absolute frame. An example of a relative route instruction is Route 3 written as: “Turn left from the pharmacy and walk straight. You see the Ulf Import driving school to your right. Cross the street, you see the Haus Niemann restaurant **[goal]** to your left. You see Johanniter-Akademie guest house in front of you. You also see Schlecker store and a church to your right.” (Translated from German<sup>1</sup>).

The absolute instruction version of the same route reads, “Walk 70 meters north. You see the Ulf Import driving school to the east. Cross the east-west running road, you see a Haus Niemann restaurant **[goal]** to the west. You see Johanniter-Akademie guest house to the north. You also see Schlecker store to the east and a church to the ESE.” (Translated from German<sup>2</sup>).

## 4 Results

### 4.1 Groups A-R and R-A on Switching Frame of Reference

The results were analyzed in SPSS using Mixed ANOVA with the Route sets (Route A and Route B) as within-subject factor and the Group (Absolute-Relative and Relative-Absolute) as between-subject factor.

#### 4.1.1 Number of Stops

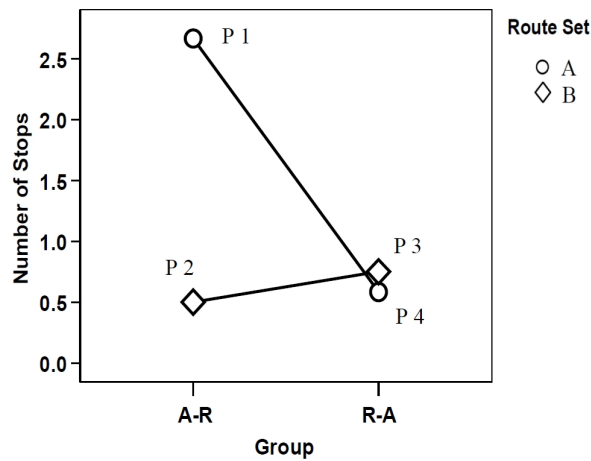
A mixed ANOVA showed that the main effect of Group was significant,  $F(1, 22) = 4.25$ ,  $p = 0.05$ . Hence, there was a significant difference with the number of stops each group made. There was a significant effect of Route set (stops) and Route set (stops) x

<sup>1</sup> The original instructions in German read as follows “Bitte biegen Sie an der Apotheke links ab und laufen geradeaus. Sie sehen die Ulf Import Fahrschule zu Ihrer Rechten. Überqueren Sie eine Straße. Zu Ihrer Linken sehen Sie das Restaurant Haus Niemann **[Ziel]**. Vor Ihnen sehen Sie die Johanniter Akademie Gästehaus. Außerdem sehen Sie eine Kirche und einen Schlecker Supermarkt zu Ihrer Rechten.“

<sup>2</sup> The original German instructions read as follows: “Bitte laufen Sie 70 Meter in Richtung Norden. Sie sehen die Ulf Import Fahrschule im Osten. Überqueren Sie nun eine Ost-West verlaufende Straße. Sie sehen das Restaurant Haus Niemann **[Ziel]** im Westen. Sie sehen die Johanniter Akademie Gästehaus im Norden. Außerdem sehen Sie eine Kirche im OSO und einen Schlecker Supermarkt im Osten.“

Group interaction with  $F(1, 22) = 7.615$ ,  $p < 0.05$  and  $F(1, 22) = 10.36$ ,  $p < 0.01$ , respectively. This means that participants made more stops on one set of five routes which was the absolute frame of reference. The number of stops made by the A-R group in the absolute direction is (on average per participant) 2.7, but only 0.5 in the relative frame. The RA group, on the other hand, made 0.6 stops in the relative and 0.8 in the absolute frame of reference.

Fig. 2 shows the plotted result for A-R group, indicating that the participants made more stops in the first set of routes following absolute instructions, with the number of stops decreasing significantly in the second set with relative instructions (from point P1 to P2). For RA group, there is a minimal increase of the number of stops in the second set of routes in terms of the absolute directions (from point P4 to P3 in Fig. 2).



**Fig. 2.** The plotted graph shows the number of stops for A-R and R-A groups. P1 represents Route A (absolute) and P2 Route B (relative) for group A-R. P3 represents Route B (absolute) and P4 represents Route A (relative) for group R-A.

#### 4.1.2 Number of Deviations

All deviations off the route were recorded in each route. Also, the off-route distances were taken into account to determine how far each participant deviated from a particular route. Similar to the number of stops, mixed ANOVA was used for analysis. It showed an equal number of deviations for both R-A and A-R group wherein each group had 12 deviations in the entire experiment.

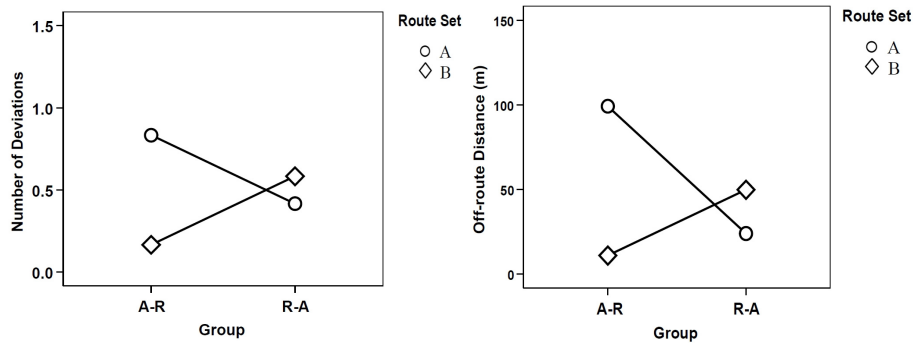
The main effect of route set was not significant  $F(1, 22) = 1.165$ ,  $p > 0.05$ . The number of deviations for the A-R group following absolute directions was (on average per participant) 0.8 and only 0.2 deviations in the relative frame. The R-A group participants made 0.4 deviations in the relative direction and 0.6 deviations in the absolute frame.

Fig. 3 shows that A-R group had many deviations when they began the route following the absolute frame instructions (Route A) and fewer deviations when it shifted

to relative directions (Route B). Participants of the R-A group, on the other hand, made less deviations in the relative frame (Route A) but more deviations when the absolute direction (Route B) was given.

#### 4.1.3 Off-Route Distances

There is a significant effect of off-route distance and group interaction,  $F(1, 22) = 4.96$ ,  $p < 0.05$ . For A-R group in the absolute frame, participants travelled 99 m (on average per participant), but in the relative frame, they only went off-route for 11 m. The R-A group, on the other hand, traveled 24 m off-route in the relative frame while 50 m in the absolute direction.



**Fig. 3.** The plotted graph shows the number of deviations and off-route distance of A-R and R-A groups. Both figures show a decrease of number of deviations and off-route distance for the A-R group when shifting to the relative reference frame on route B. In the R-A group we can see an increase in number of deviations and off-route distance for the R-A group when shifting to the absolute reference frame on route B.

#### 4.1.4 Travel Time and Walking Speed

The Mixed ANOVA shows that the main effect of route set was significant as well as the route set for travel time and group interaction,  $F(1, 22) = 47.65$ ,  $p < 0.001$  and  $F(1, 22) = 15.52$ ,  $p < 0.01$ , respectively. Hence, this means that there are differences in the travel time in the route set of both absolute and relative frames. For A-R group, participant's travel time (on average per participant) was 26min on route A with the absolute directions and 15 min on route B with the relative directions. For R-A group, the participant's travel time was 20 min on route A with relative directions and 17 min on route B with absolute directions.

The walking speed was recorded in terms of steps per minute of each participant in every route. It was averaged for both Route A and Route B to examine whether there has been a change in their speed. It showed that there is no significant effect in terms of walking speed for both groups,  $F(1, 22) = 2.78$ ,  $p > 0.05$ . This means that participants maintained their normal walking speed even when a shift to another frame of reference was given.



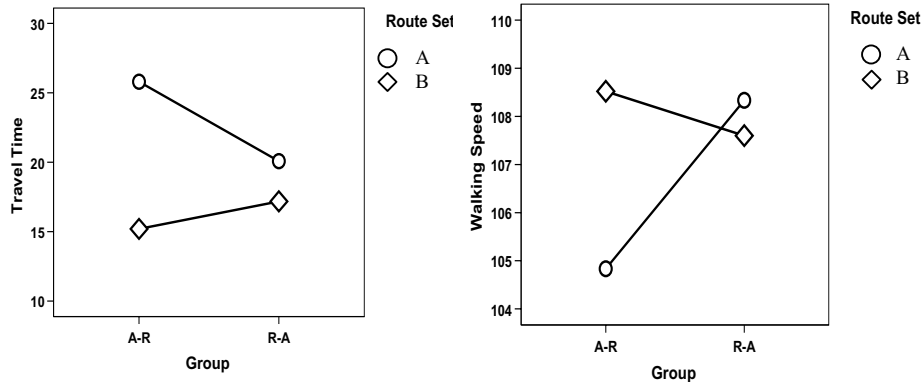


Fig. 4. Travel time and walking speed for A-R and R-A groups

## 4.2 Men and Women's Performance on the Frames of Reference

Mixed ANOVA was also used in analyzing gender performance in outdoor wayfinding with the Frame of Reference set (Absolute and Relative) as the within-subject factor and the Gender (Men and Women) as the between-subject factor.

### 4.2.1 Number of Stops

The main effect of frame of reference set was significant,  $F(1, 22) = 7.42$ ,  $p < 0.01$ , showing a significant difference on how men and women perform in absolute and relative frame of references. Fig. 5 shows that there were fewer stops in the relative directions made by both gender, and men made more stops than women.

The number of stops made by women in absolute and relative frames of reference is on average per person 1.5 and 0.3, respectively. Men meanwhile, made 1.9 stops following absolute directions and 0.8 with relative directions.

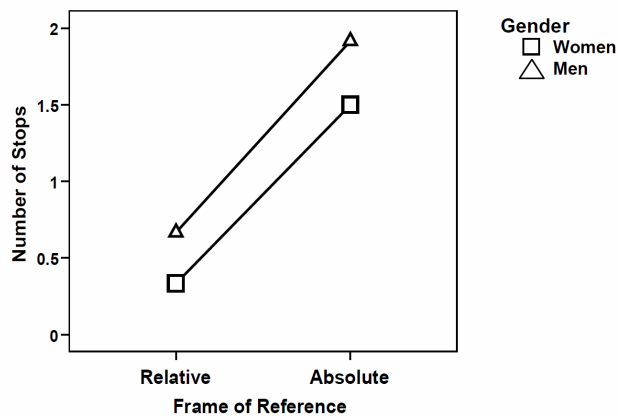


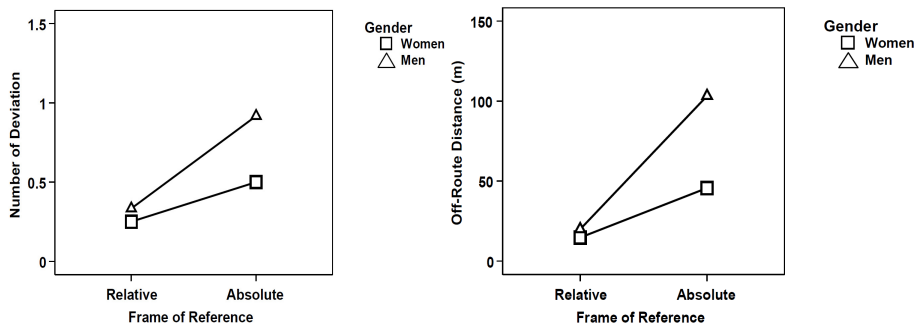
Fig. 5. The plotted graph shows the number of stops of men and women in absolute and relative frames of reference

#### 4.2.2 Number of Deviations

There was no significant effect of reference frame for gender,  $F(1,22) = 3.14$ ,  $p > 0.05$ . Although, it showed in the result that the absolute frame of reference was a bit difficult for participants to follow. Fig. 6 shows that there had been more deviations in the absolute as compared to the relative frame of reference. It also shows that men made more deviations than women. The number of deviations men incurred for the relative frame is 0.33 while in the absolute frame, they made 0.92 deviations. For women, they made 0.25 deviations in the relative frame and 0.5 deviations following the absolute direction.

#### 4.2.3 Off-Route Distances

In terms of the off-route distance, the main effect of frame of reference set was significant,  $F(1, 22) = 4.86$ ,  $p < 0.05$ . Both men and women walked longer off-route distances in the absolute frame of reference. However, as Fig. 6 shows, men walked longer distances when they went off-route in both frames of reference. Men walked on average 103m off-route following absolute directions and 20m off-route following relative directions. Women walked on average 46m off-route in absolute directions and 15m off-route following using relative directions.



**Fig. 6.** The plotted graph shows the number of deviations and off route distance of men and women made in absolute and relative frames of reference

#### 4.2.4 Travel Time and Walking Speed

For the time each group spent on the experiment, there was a significant effect of the frame of reference set,  $F(1,22) = 5.03$ ,  $p < 0.05$ , indicating that both men and women spent longer time following the absolute frame of reference. Women spent on average 21min with absolute and 18min with relative directions. Men spent on average 22min with absolute and 17min with relative directions.

There was likewise a significant effect of the frame of reference set in terms of walking speed,  $F(1,22) = 4.86$ ,  $p < 0.05$ . Both men and women walked faster in the relative frame than in the absolute. It was also observed that women's walking speed was slightly faster than that of men. This might be the effect of the changing weather condition wherein most women participated in the later part of the experiment when it started to snow. Walking speed of women was on average 108 (steps per minute) in the absolute and 111 in the relative reference frame and men's walking speed was 104 in absolute and 106 in relative reference frame.

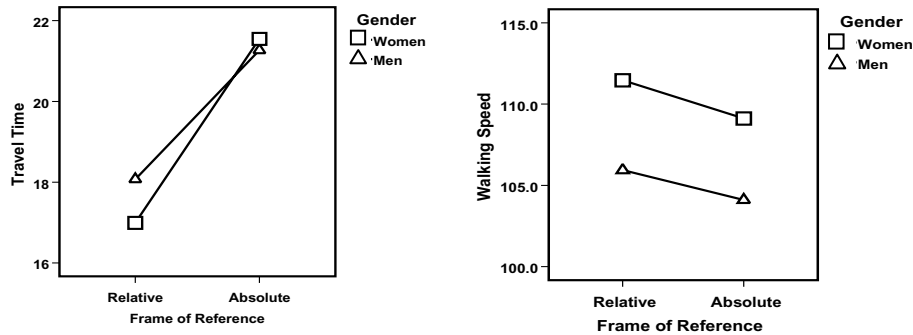


Fig. 7. Travel time and walking speed of men and women

#### 4.3 Correlation with the Sense of Direction Scale

The Santa Barbara Sense-of-Direction questionnaire is an indicator of how well the participant judged his/her spatial and navigational abilities, preferences, and experiences. The questions ranged from assessing how poor his/her memory is and how well s/he enjoys reading maps and giving directions.

The mean was calculated for each participant. The negative questions were translated into positively formed statements so that the high numbers mean that participants rated their own sense of direction (SOD) as good. The result was then correlated with the number of stops, deviations, and off-route distances.

Using a Pearson correlation measure, it showed that there was a negative correlation with the sense of direction scale and the three wayfinding performance measures in the first set of routes for absolute frame of reference. This means that participants with better SOD tend to make fewer stops, less deviations, and walked off the route less frequently. The result was, stops ( $r = -0.60$ ,  $p < 0.05$ ), deviations ( $r = -0.21$ ,  $p > 0.05$ ), and off-route ( $r = -0.02$ ,  $p > 0.05$ ). However, the correlation was only significant for the number of stops.

The correlation result of men and women revealed that there was a negative correlation for all the performance measures along with the SOD of women although not significant; stops ( $r = -0.47$ ,  $p > 0.05$ ), deviations ( $r = -0.31$ ,  $p > 0.05$ ), and off-route distance ( $r = -0.27$ ,  $p > 0.05$ ). However, for men, it was observed that there was only a negative correlation for the number of stops but a positive correlation for deviations and off-route distances; stops ( $r = -0.22$ ,  $p > 0.05$ ), deviations ( $r = 0.43$ ,  $p > 0.05$ ), and off-route ( $r = 0.29$ ,  $p > 0.05$ ). Also, the result did not show any significant effect on gender difference. A positive correlation means that those participants, who judged their SOD higher, tend to make more stops, more deviations, and make longer off-route distances.

## 5 Discussion

### 5.1 Shift and Comparison of Results to Ishikawa and Kiyomoto (2008)

The findings of this study showed that there are differences on how people perform outdoor wayfinding experiment depending on which frame of reference was used.

Generally, subjects performed better when instructions were given in a relative reference frame and there were more stops and deviations when instructions were given in absolute directions, particularly when participants started off with instructions in the absolute reference frame. When participants started with instructions in the relative reference frame, their performance got worse when shifting to the absolute reference frame. But the participants were still able to adapt to their non-preferred (absolute) frame of reference. In this experiment, it is observed that the A-R group participants found it difficult to follow absolute instructions first, considering the number of stops and deviations they made. When shifting to the preferred frame of reference, the relative reference frame, a notable improvement in their wayfinding performance was seen. In the R-A group, participants shifted from the preferred relative reference frame to the non-preferred, absolute frame of reference. In this group, the wayfinding performance was also better in relative than in absolute reference frame, but the differences was not as big as in the A-R group. The experiment showed that shifting to a non-preferred reference frame was not as difficult for the participants who started in the preferred frame of reference.

This research followed the methodology of Ishikawa and Kiyomoto (2008), examining how people adapt to switching frames of reference following verbal route instructions. Comparing the results to their study, it also shows that German speakers just like the Japanese, prefer relative frame of reference. In Table 1, both Japanese and German participants showed significant effects for the interaction of Route and Group in the number of stops, off-route distance, and travel time.

In terms of the walking speed, the same result was attained comparing with Ishikawa and Kiyomoto's experiment wherein there was no difference in the participant's speed even when the route instructions were changed. Participants were still able to maintain their normal walking speed when a shift of reference frame was made.

**Table 1.** Comparison of German and Japanese Participants

Wayfinding Measures	German Participants	Japanese Participants (Ishikawa and Kiyomoto, 2008)
Number of Stops	sig. for Route x Group	sig. for Route x Group*
Deviations	not significant	sig. for Route x Group*
Off-route Distance	sig. for Route x Group	sig. for Route x Group*
Travel Time	sig. for Route x Group	sig. for Route x Group**
Walking Speed	not significant	not significant

\* Due to difficulties on Route 2, it was excluded in Ishikawa and Kiyomoto

\*\* only route B

Similarly to Ishikawa and Kiyomoto's results, the correlation between the SOD as assessed by the participants corresponding to their wayfinding performance was negative. This means that those who judged themselves having good SOD made less deviations, few stops and did not walk off the route frequently. However, the correlation in this study was only significant for the number of stops. In the case of off-route

distances, Ishikawa and Kiyomoto found a stronger negative correlation, while the present study showed very low negative correlation.

## 5.2 Gender Differences on the Frame of Reference

Recalling the hypotheses set in the study that (1) men perform better than women in outdoor wayfinding task where they had to follow verbal instructions in absolute directions and (2) women oftentimes have difficulty following absolute instructions compared with instructions in relative frame of reference; both hypotheses could not be verified in this study. The results even showed a tendency for women to perform better.

Based on the wayfinding performance measures set, the results showed that women made less stops, deviations and went off- route less frequently. However, the effect size of the gender differences is not big enough to show significant results with 24 subjects of this experiment. Studies stating that men usually perform better than women in many spatial activities especially in wayfinding (O’Laughlin and Brubaker, 1998; Lawton, 1994) could not be supported. In terms of the frame of reference, this experiment revealed that both genders perform significantly better with instructions in relative reference frame than with absolute reference frame. Several researchers have shown that men are better in following absolute frame of reference (Holding and Holding, 1988; Scholl et al, 2000; Silverman and Choi, 2006;). However, the experiment showed that women were able to follow absolute directions better than men following verbal instructions. An interesting observation is that when instruction shifted from relative to absolute frame of reference, the female participants did not make deviations. It was observed that women tend to adapt more easily to changing route instructions than men.

Holding and Holding (1998) stated in their study that women tend to show bias towards underestimation and that they were guessing in some spatial tasks, but in this research, women were able to estimate their distances by not walking longer off route as compared to men in this case, who tend to overestimate their distances when they went off the route.

In terms of the correlation of sense-of-direction report and wayfinding performance, the study did not reveal any significant correlations. The non-significant correlation indicated that women were able to evaluate their spatial skills better than men.

## 6 Conclusions and Future Work

This study presented interesting results on varying spatial abilities of men and women in wayfinding with different reference frames. This research contributes to existing literature on analyzing wayfinding and gender differences. The shifting frame of reference is seen as important to determine whether people follow navigational instructions in relative or absolute frame of reference more efficiently.

Our study showed that people perform significantly better in wayfinding if the route instructions are given in a relative reference frame compared to an absolute reference frame. This is independent of gender whereby men and women equally showed this significant preference for relative instructions.

Furthermore, we found a non-significant tendency that women outperform men in following relative and absolute directions. This contradicts to other studies which see women as poor in wayfinding task, particularly with cardinal directions. Our findings are based on several indicators to evaluate wayfinding performance. Women made fewer mistakes regarding the number of stops, deviations, and the off-route distance.

Analyzing the reference frame shift, we found that the overall performance increase of participants who started with an absolute and shifted to a relative reference frame was higher than the performance decrease of participants who started with a relative and shifted to an absolute reference frame. It seems to be easier to switch from a preferred to a non-preferred reference frame than starting with the non-preferred reference frame immediately. On the other hand, people who started with the non-preferred reference frame seem to feel more comfortable when switching to the preferred reference frame than when they started with it immediately.

While the experiment with a group of 24 participants showed significant effects with respect to the preferred reference frame, the gender effect was not significant. Future work needs to address this aspect and increase the sample size to test whether the female priority in number of stops, number of deviations and off-route distance is significant. Moreover, future work will examine the navigational ability of people across culture.

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