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Gender Differences in Acquisition of Environmental Knowledge Related to Wayfinding Behavior, Spatial Anxiety and Self-Estimated Environmental Competencies

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This study investigated gender differences in wayfinding and representation of an unfamiliar building. Thirty-two white German adults (undergraduates, graduates, academic staff, carpenters, social workers) carried out three wayfinding runs, each followed by a representation task either of drawing a map or of writing a description of the environment. Self-estimation of spatial anxiety and environmental competencies was assessed before the task. Men recalled more route directions in maps and descriptions than women. Independent from element quantity, women preferred landmarks to route directions under both conditions. Men preferred mixed representations with similar proportions of landmarks and route directions in their first and second representation and showed a weak landmark preference only in the last representation. Route direction preferences related to higher speed in wayfinding (more men) and higher self-estimation of wayfinding competence. Landmark preferences related, in women only, to higher self-estimated levels of spatial anxiety. Speed in wayfinding, self-estimation of competencies, and spatial anxiety overlapped predictability of gender on differences in environmental representation.

Environmental research theory distinguishes between two types of environmental knowledge: route knowledge and configurational knowledge (e.g., Evans, 1980; Golledge, 1987). *Route knowledge* includes important landmarks in the environment, the routes connecting them and the order of route turns (relational directions such as right, left, straight ahead) in wayfinding.

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Configurational knowledge refers to a more "global" representation of the environment according to an Euclidean reference system. Cardinal directions and metric distances serve as coordinates to map spatial relationships among distinctive locations within a network of routes (Gärling, Lindberg, Carreiras, & Böök, 1986).

There has been much discussion about the developmental course of environmental knowledge, both ontogenetically and microgenetically. Siegel and White (1975) proposed that environmental learning and development follow a series of stages from landmark knowledge to route knowledge and finally to survey (i.e., configurational) knowledge. Whereas the results of some studies support this model (Cohen & Schuepfer, 1980; Evans, 1980; Evans, Marrero, & Butler, 1981), other studies show that route knowledge can be acquired prior to landmark knowledge (Gärling, Böök, Lindberg, & Nilsson, 1981) or even without landmarks at all (Allen, 1988). Moreover, survey knowledge can already be acquired during the initial period of an environmental learning task (Holding & Holding, 1989; Montello & Pick, 1993).

This controversy led to the assumption that different information processing systems, rather than one general mechanism, underlie environmental learning. The current question of environmental research is how these processes interact or may be referred to alternatively by different subjects and under different conditions. For example, a mapping task allows a person to collect information simultaneously about an environment and thus probably facilitates the acquisition of configurational knowledge, such as metric distances and cardinal directions (Evans & Pezdek, 1980). In a wayfinding task, environmental information is available only step by step through traveling and a person may focus on memorizing the sequence of route directions and landmarks (Galea & Kimura, 1993; Ward, Newcombe, & Overton, 1986). This example refers to at least two different information processing systems (simultaneously and sequentially) and two different strategies in environmental learning (configurational and route strategy). Even within the route strategy, a set of substrategies reflects different relationships between landmarks and route directions (Anooshian, 1996). To give a route instruction, a person may refer only to a landmark as in "go to the big building," add relational directions as in "turn left at the bridge," or may only use route directions such as "first turn right, then turn left" (Pick, Montello, & Somerville, 1988). Configurational information can be used instead of landmarks and route directions such as "go 3 miles north" instead of "turn left at the church" (Ward *et al.*, 1986). Preferences for one strategy over the other may help explain the variety in quantity and quality of competencies in wayfinding and environmental knowledge.

This study investigated gender differences in preferred strategies on wayfinding and the acquisition of environmental knowledge. Past research comparing maps and/or route instructions produced by women or men has shown mixed results. Female students recalled more landmarks in route descriptions following a mapping task (Miller & Santoni, 1986), and more landmarks and fewer routes in drawn maps of a familiar campus area compared to men (McGuiness & Sparks, 1983). Galea and Kimura (1993) found that male undergraduates outperformed women in route learning from a novel map, whereas women outperformed men in landmark recall. This female advantage could not be attributed to a superior visual-item memory. In contrast, Ward *et al.* (1986) did not find gender differences in the number of landmarks in route instructions, but male college students referred to more cardinal directions and mileage estimations than did women.

Contradictory results have also been reported in terms of the accuracy of configurational knowledge. Female students' maps of their campus area were more accurate in interbuilding distances, whereas male students' maps showed a higher position accuracy of building arrangement (McGuinness & Sparks, 1983). Some studies have found a male advantage in directional accuracy (Galea & Kimura, 1993; Holding & Holding, 1989; Lawton, 1996; Lawton, Charleston, & Zieles, 1996; Miller & Santoni, 1986). Other studies could not confirm gender differences in pointing accuracy (Golledge, Ruggles, Pellegrino, & Gale, 1993; Montello & Pick, 1993; Sadalla & Montello, 1989) or in distance accuracy between campus buildings (Kirasic, Allen, & Siegel, 1984). Golledge, Dougherty, and Bell (1995) found that female and male students performed equally in estimating distances and directions to landmarks both after a computer-simulated travel through and a mapping of an unfamiliar route system.

Overall, these results show gender differences in route knowledge (i.e., a male advantage in both route learning and route recalling compared with a female advantage in landmark recalling), whereas differences in the accuracy of configurational knowledge are not consistent. Additional results of these studies reveal some interesting aspects. The male advantage in route number on campus maps under free-recall condition (McGuinness & Sparks, 1983) vanished after all participants had been prompted to exclusively draw the routes between three particular buildings. The male advantage of reporting more cardinal directions in route instructions (Ward *et al.*, 1986) diminished after all participants had been prompted to use cardinal directions. Differences in angular errors between particular buildings on campus maps—some favoring men, others favoring women—could be related to gender differences in the frequency of visiting these locations (Kirasic *et al.*, 1984). Miller and Santoni (1986), who found a male advantage in directional accuracy and a female advantage in landmark recall, reexamined accuracy scores with landmark scores entered as covariates. Gender differences in accuracy were then no longer significant.

In conclusion, gender differences in environmental knowledge may be related to "stylistic preferences" in the use of different environmental strategies rather than to different competencies (Ward *et al.*, 1986). Women prefer a more landmark-based strategy, whereas men prefer a more configurational (Euclidean) strategy (Galea & Kimura, 1993). These assumptions are supported by studies conducted by Lawton (1994, 1996), who assessed the self-reported use of wayfinding strategies. She categorized orientation strategy (reference to metric distances and cardinal directions; i.e., configurational knowledge) against route strategy (reference to landmarks and route directions). In general, men reported a higher use of the orientation strategy, whereas more women preferred to rely on the route strategy. The preferred use of the orientation strategy related to a male advantage in pointing accuracy (Lawton, 1996) and to better results in a task of spatial perception (Lawton, 1994).

If gender differences in environmental knowledge are based in part on gender-related differences in preferred environmental strategies, we have to take a serious look at external and internal mediators that relate to such strategies. First, different task conditions have to be considered in environmental knowledge acquisition and externalization (for reviews see Bryant, 1984; Kitchin, 1996a; Montello, 1991). A drawn map presents information simultaneously, whereas a route instruction can give information only sequentially. Prompting the participants to a certain performance criterion (e.g., route recall, the use of cardinality) may shift recall preferences in externalization (McGuinness & Sparks, 1983; Ward *et al.*, 1986).

Second, a variety of internal mediators probably influence strategies in environmental learning (for reviews see Blades, 1991; Evans, 1980; Golledge, 1987). Kitchin (1996b) combined theories from the 1970s to the present in a conceptual schema of environment–behavior interaction. This conception emphasizes the importance of the individual as an actor within the environment rather than as a passive receiver of environmental information. Against the background of a dynamic memory system, the actor selects and filters environmental information before it is stored in his or her memory. These decision-making processes are guided by previously stored information in association with their emotional context (e.g., anxiety vs. security in wayfinding, pleasantness vs. unpleasantness of locations). Thus, emotionally biased experiences acquired through real-world activities work as anticipatory schemata in the use of environmental learning strategies.

Although several authors point out the importance of affective disposition in environmental behavior (Amedeo, 1993; Anooshian & Siegel, 1985; Kitchin, 1996b; Küller, 1991; Russel & Snodgrass, 1987), only a few studies have investigated such relationships in detail. Kozlowski and Bryant (1977) found that pointing accuracy was positively associated with a self-reported "sense of direction," which itself related negatively to spatial anxiety ("worry about becoming lost"). Pleasantness or unpleasantness of locations affected the accuracy of distance estimation between them (Herman, Miller, & Shiraki, 1987; Smith, 1984). As to gender differences, LaGrone (1969) reported that women more often feel disoriented with regard to their "sense of direction" than men. Bryant (1982) also found that men, in general, reported a better "sense of direction," whereas women scored higher levels of "worry about becoming lost." Lawton's environmental questionnaire revealed higher levels of spatial anxiety for women compared with men. Spatial anxiety related negatively to the use of the orientation strategy and to pointing accuracy (Lawton, 1996).

Schmitz (1995, 1997) investigated relationships among anxiety, wayfinding behavior, and the acquisition of environmental knowledge in adolescence. Students, ages 10 to 17, who rated themselves as having higher levels of anxiety, conducted wayfinding in an unfamiliar environment (a three-dimensional maze) more slowly than less anxious ones. Highly anxious participants also tended to use a higher proportion of landmarks compared with route directions in maps and descriptions of this environment. Girls, in general, scored higher levels of anxiety, showed less speed in wayfinding, and recalled a higher percentage of landmarks against route directions compared with boys. These results indicate that spatial anxiety not only relates to self-reported strategy use (as Lawton showed) but also to real-world wayfinding behavior (anxiety—speed in wayfinding) and to the acquisition of environmental knowledge (anxiety—landmark preference).

This study used a similar approach to Schmitz (1995, 1997) in examining gender differences in adults' use of route strategy. This investigation focused on how preferences for landmarks against route directions are related to wayfinding behavior and self-evaluation of spatial anxiety and environmental competencies. Participants had to find a route in an unknown building three times and were asked to recall the acquired environmental knowledge after each wayfinding run. No performance criteria were given before or during the task to avoid any prompting. Two recall conditions, either in drawing or in writing, were chosen to evaluate effects of different externalization techniques. Self-estimated spatial anxiety and environmental competencies were assessed in a questionnaire prior to the wayfinding task.

METHOD

Participants

A total of 32 white German adults, 17 women (mean age 30.8, $SD = 4.4$) and 15 men (mean age 30.3, $SD = 3.9$) participated in this study. All were unfamiliar with the building in which the wayfinding task took place. Undergraduates, graduates, and members of the academic staff working in other parts of the university, as well as professions such as carpentry or social work, made up both female and male subgroups. The participants were told (a) that the study aimed to reveal individual strategies in environmental learning, (b) that no "best strategy" existed and that every personal strategy had its own pros and cons, and (c) that there was no performance criterion in this task.

Materials

Route System

The wayfinding task was carried out on the second floor of the biological institute at Marburg University (Figure 1). Three main corridors connect three staircases (A, D, C) and meet at a T-crosspoint. The staircases and corridors are separated from each other by walls with no visual connection between them. Staircases C and D both have two exits to opposite corridors that lead to the main corridor; staircase A has only one exit. Every main corridor follows a series of right-angle turns making only short route segments visible from any one point. Several right-angle corridors branch off the main route ending at closed doors. To most of the visitors, this corridor system gives the impression of a maze because a person has to pass an endless number of similar corridors when searching for a particular room. Yet, some landmarks serve as wayfinding aids: some old cupboards, a couple of chairs with a table, refrigerators and garbage bins at particular route turns, and posters on the walls and doors. All Exit signs were covered during the wayfinding task.

Recall Conditions for Environmental Representation

Half of the participants were asked to draw maps on a sheet of paper (30 × 42 cm), including the outlines of the building and the three staircases, A, D, and C. The other half had to write down descriptions of the explored floor on a lined sheet of paper.

Questionnaire

A questionnaire was developed to assess the participants' self-estimation of spatial anxiety and environmental competencies. Ratings on origi-

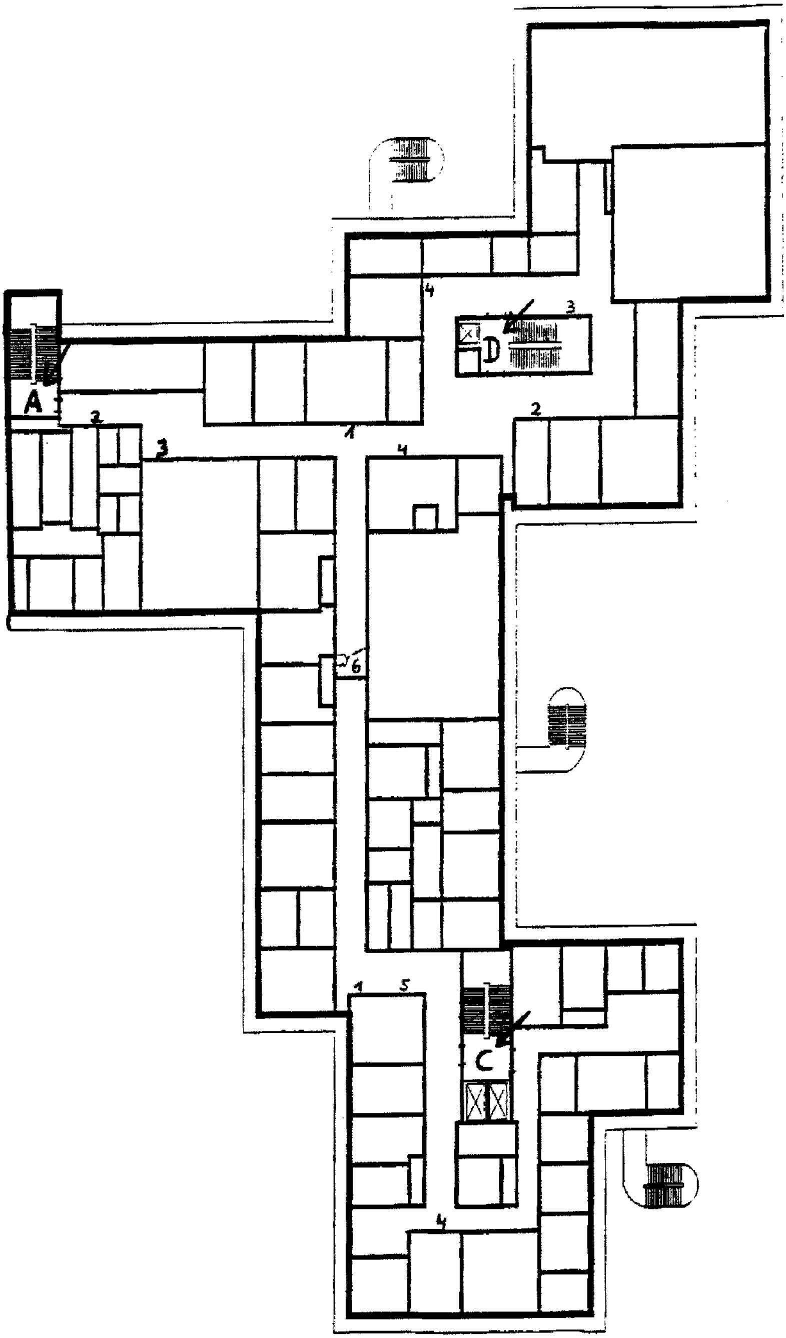

Fig. 1. A ground floor plan of the route system: A, D, C = staircases, 1 = garbage bins, 2 = cupboards, 3 = tables and chairs, 4 = refrigerators, 5 = shelves, 6 = door in the corridor.

nally 11 items were given on a 4-point scale ranging from "nearly never" (1) to "nearly always" (4). One item did not distinguish between two factors of environmental competencies and was therefore excluded from further analyses. The remaining items are shown in Table I. The Cronbach alpha coefficient was .80 for spatial anxiety (four items), .66 for wayfinding competence (three items), and .73 for configurational competence (three items). To differentiate between spatial anxiety and other aspects of anxiety, a standardized scale used to assess test anxiety (seven items) was included from the German version of the Work and Family Organization Test (Spence & Helmreich, 1978).

Procedure

The participants were tested individually. First each participant was asked to complete the questionnaire in a room on the ground floor of the building. The participant was then told that he or she would now be taken to another part of the building to carry out a wayfinding task. A walk-a-meter was adjusted to the individual's length of stride and the experimenter led the participant up staircase D to the second floor. On the staircase, the participant was instructed to find exit C on this floor and was ensured that he or she could take as much time as needed. The experimenter followed

Table I. Items[a] and Factor Loadings[b] in Scales of Questionnaire

Item	Factor 1	Factor 2	Factor 3
Spatial Anxiety			
I am afraid of losing my orientation outside.	.89	−.16	−.09
I am afraid of getting lost in an unknown city.	.84	−.24	−.07
In an unknown environment, I prefer to walk in a group rather than to walk alone.	.78	−.09	−.22
When I get lost on a walk, I get nervous.	.73	.25	−.22
Wayfinding competence			
When someone gives me a route instruction, I will find my destination easily.	−.06	.78	−.04
When I give others a route instruction, they will find their destination easily.	.01	.77	−.21
I will find my way well even in an unfamiliar city.	−.14	.68	.47
Configurational competence			
I am good at estimating distances.	−.18	.06	.82
I have problems in estimating distances between two places.[c]	−.28	.05	.78
I am bad at reading maps.[c]	−.04	.32	.78

[a]The items are translated from the German version of the questionnaire.
[b]Factor analysis was conducted on responses of 74 participants (see text).
[c]These items were reverse coded.

the participant recording the route on a floor plan. When the participant reached exit C, he or she was led to the staircase and the walk-a-meter data (time, meter) were added to the protocol out of the participant's view. Now the participant had to find exit A starting from C. Data recording was performed as before. The final section of this first run was to return to exit D starting from A. The participant was then led back to the ground floor room and was asked for a representation of the upper floor. So as not to prompt the participants to use other strategies in wayfinding and knowledge acquisition than spontaneously opted for, the information about the externalization task was first given after the wayfinding run. Participants were randomly assigned either to draw a map or to write a description (recall condition). Participants asking whether they had to refer to corridor segments/route turns or to distinctive landmarks were told to state the importance of these cues for their personal wayfinding performance. The second wayfinding run was conducted from exit A via C to D, followed by a second representation (same recall condition for each participant as before). The third run led from exit C via A to D, followed by a third representation.

Data Analysis

Wayfinding Measures

Errors were coded from the experimenter's protocol as every incorrect choice at the crosspoint, at a route turn or junction. For each run, sum of errors in its three sections were computed (e.g., for the first run: errors on the way from [D to C] + [C to A] + [A to D]). The average speed per run was calculated as total distance in meters per total time in this run. This was done instead of computing the average speed in the three sections of one run because section A $\Leftrightarrow$ D was shorter than the others. This section was often walked through with higher speed. Thus, the computing of average speed in the three sections would distort the average speed per run to the higher value for the shorter section. In addition, initial speed was calculated for the first section of the first run (from exit D to C). This was done because some of the participants, starting from D, first went to exit A in search of exit C, thus acquiring useful information for the second section of the run. Thus, only the parameter initial speed reflected wayfinding behavior in a completely unknown environment.

Environmental Representation

Maps and descriptions were scored by two raters for the following four categories:

- *Landmarks*—each drawn or recalled feature (e.g., cupboards, garbage bins, refrigerators, chairs, tables, shelves) and each specified door, window, or poster on corridor walls
- *Route Directions*—each drawn route turn and additional indication such as "right" and "left" in the maps and each described direction (e.g., right, left, straight ahead, way back, turn round)
- *Distances*—each recall of a metric distance
- *Configurational cues*—each reference to the relation between the exits, corridors, and the building configuration (e.g., "exits A and D vertically on line with exit C," "A and D are in the upper part of the building and C is in the lower part"); none of the participants mentioned cardinal directions that could also have been included in this category.

According to Galea and Kimura (1993) and Ward *et al.* (1986) landmarks and route directions in environmental representation reflect an externalization of route knowledge, whereas metric distances and configurational cues reflect an externalization of configurational knowledge. In this study, only two men used metric distances and only seven women and four men mentioned a configurational cue (and then, in only one or two of their representations). Therefore, the two configurational categories were dropped from further analysis. Scorer agreement (Pearson correlation) was .91, .94, and .93 for the number of landmarks in the three representations and .95, .97, and .98 for the number of route directions.

RESULTS

Questionnaire Scales

The small sample size in this study ($N = 32$) did not allow the use of factor analyses to check the questionnaire for scale development. However, because the same questionnaire was used in another wayfinding task with adults (Neidhardt, 1997), additional data on 42 participants were available. A principle components analysis, with oblique rotation, was conducted on the responses to the 11 items now including a total of $N = 74$. This analysis extracted three factors with Eigenvalues greater than 1.00 corresponding to the scales of self-estimated spatial anxiety, wayfinding, and configurational competence. The factor loadings for the 10 items that distinguished between the three scales are shown in Table I.

Participants in this study also had to rate self-estimation on a standardized scale of test anxiety. The correlation between spatial anxiety and test anxiety was not significant, $r(32) = .28$, $p = .11$. Thus, the two scales reflect different aspects of anxiety. The lack of correlation between test anxiety and either self-estimated wayfinding competence, $r(32) = -.03$, $p = .86$, or self-estimated configurational competence, $r(32) = -.08$, $p = .64$, indicates that the competence scales differ clearly from test anxiety.

Wayfinding Behavior

Figure 2 illustrates the mean number of errors and the average speed in three wayfinding runs for women and men. Chi-square measures were used to calculate effects of either gender or runs on the number of errors because these data did not meet the criterion for homogeneity of variance. Speed data were submitted to a repeated-measures MANOVA with gender

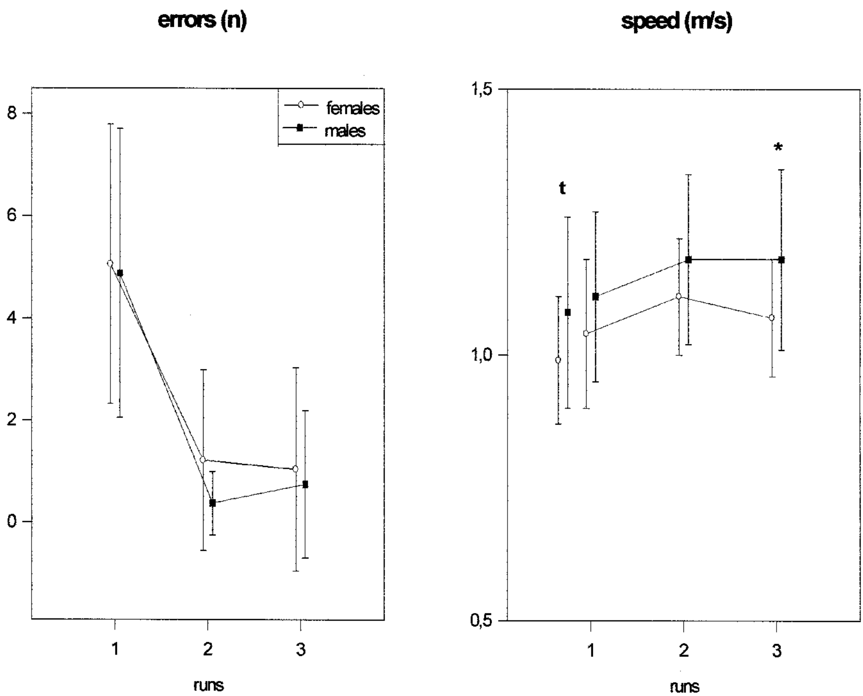

Fig. 2. Mean number of errors and average speed in three wayfinding runs for women ($n = 17$) and men ($n = 15$). Initial speed in the first section of run 1 (from exit D to C) is shown as a single data point. Standard deviation is presented in error bars, ${}^{t}p < .10$, $^{*}p < .05$.

as the between-subjects factor and successive runs as the within-subjects factor.

The analysis confirmed a significant decrease in errors, Friedman χ^2 (2, N = 32) = 42.76, $p < .001$, and a smaller but also significant increase in speed, $F(2, 56) = 5.42$, $p = .007$, $\eta = .14$, from runs 1 to 3. A main effect of gender was marginally significant for speed, $F(1, 28) = 3.95$, $p = .055$, $\eta = .11$, but only weak in effect size. Post hoc t tests confirmed a higher speed for men in the last run ($t = 2.25$, $p = .03$). In addition, men tended to walk faster in the first section of run 1 ("initial speed," represented by the solid datapoints in the plot of "speed," in Figure 2) than women ($t = 1.70$, $p < .10$). Analyses of errors revealed no significant effect of gender. There was no interaction between gender and runs for any of the wayfinding measures.

Although men's length of stride (mean 76.9 cm, $SD = 7.1$) was slightly longer than women's (mean 72.9 cm, $SD = 5.0$), neither the gender differences nor the correlation between length of stride and initial speed were significant. The initial speed related significantly to the speed in run 2, $r(32) = .55$, $p = .001$, and to the speed in run 3, $r(32) = .66$, $p < .001$. A significant correlation could also be established between speed in runs 2 and 3, $r(32) = .74$, $p < .001$. Thus, the higher a participant's initial speed the higher it was in the following runs and vice versa. There were no such interrelations for errors.

Environmental Representation

The scatterplots of three successive representations (Figure 3) show the number of landmarks and route directions for each participant. These variables were submitted to repeated-measures MANOVA with gender and recall condition (map or description) as the between-subjects factors and successive environmental representations as the within-subjects factor.

Quantitative Analysis

A significant effect of gender, $F(1, 28) = 6.48$, $p = .02$, $\eta = .19$, indicated that women, in general, recalled fewer route directions than men. The gender differences held for representation 1 (mean women = 4.2, SD = 5.3; mean men = 8.7, SD = 5.8; $t = 2.30$, $p = .03$) and representation 2 (mean women = 4.3, SD = 4.6; mean men = 8.3, SD = 4.9; $t = 2.38$, p = .02), but not for representation 3 (mean women = 5.6, SD = 6.3; mean men = 9.1, SD = 5.5; $t = 1.65$, $p = .11$). No gender differences were found

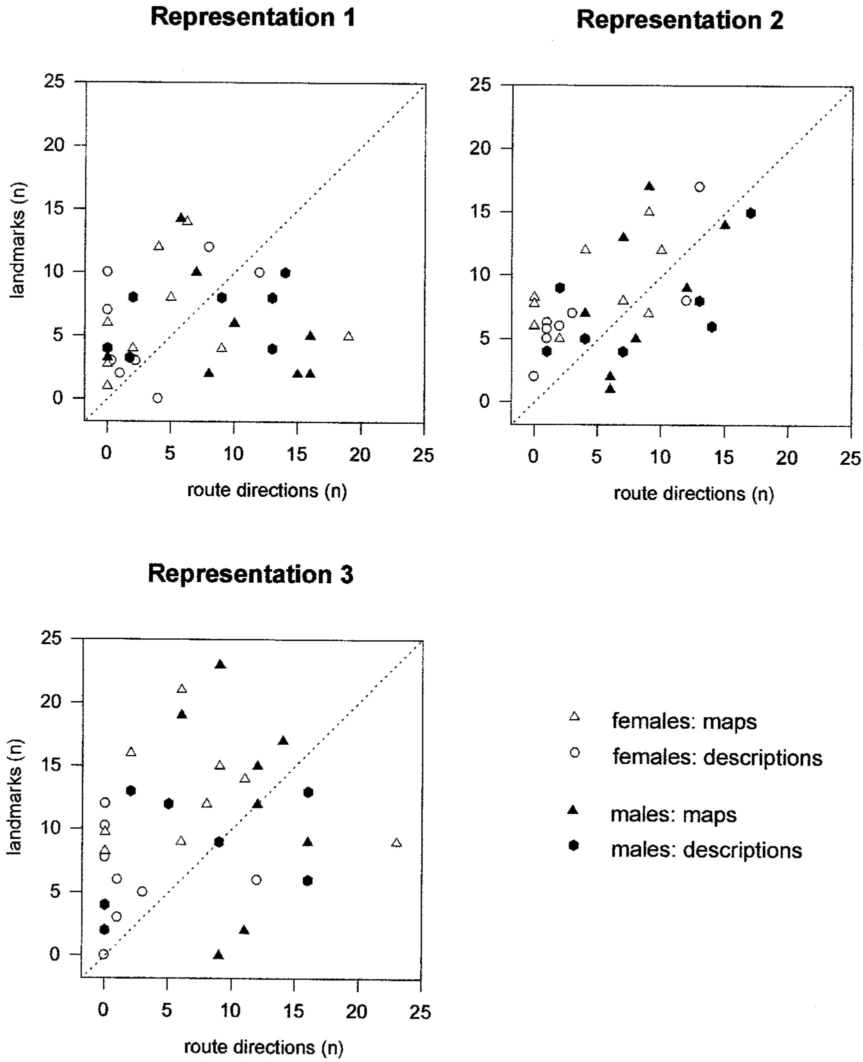

Fig. 3. Number of landmarks against route directions for women (n = 17) and men (n = 15) in individual representations (1 to 3) such as drawn maps or written descriptions.

in the number of landmarks, $F(1, 28) = .09, p = .76$, neither in representation 1 (mean women = 6.1, SD = 4.2; mean men = 5.9, SD = 3.6; t = .13, p = .90) nor in representation 2 (mean women = 8.1, SD = 3.8; mean men = 7.9, SD = 4.9; t = .12, p = .91) or in representation 3 (mean women = 9.8, SD = 4.8; mean men = 11.4, SD = 6.6; t = .78, p = .44). The analysis of landmark numbers yielded a significant increase from representations 1 to 3, $F(2, 56) = 18.80$, $p < .001$, $\eta = .40$, whereas the mean number of route directions did not increase significantly. The main effect of the recall condition was not significant and there were no interactions between gender and recall condition according to route directions, $F(1,28) = .02$, $p = .90$, and landmarks, $F(1.28) = .09$, $p = .76$. However, a significant interaction between recall condition and repeated representation was found, $F(2, 56) = 9.34$, $p < .001$, $\eta = .25$. Map-condition participants drew more landmarks ($t = 3.34$, $p = .002$) and more route directions ($t = 2.52$, $p = .02$) in their last map than description condition participants mentioned in their last description.

Analysis of Preferences

The analysis of element number does not reveal any information about recall preferences in representation independent of their quantity. Suppose there were some men who recalled many landmarks and route directions compared with some women who recalled only a high number of landmarks. The group average would reflect a similar number of landmarks for women and men but more route directions for men. In terms of recall preferences, however, the men preferred a mixed landmark/route direction representation, whereas the women preferred predominantly landmark maps. The breakdown of data in the scatterplots shows such relationships between landmarks and route directions for each participant's representation. Some participants clearly recalled more landmarks compared with route directions. Other participants gave mixed representations (datapoints along the dashed lines), and even others used predominantly route directions. Because gender differences in such preferences were a focus point of this study, a *preference score* (number of landmarks − number of route directions/number of landmarks + route directions) was calculated for each representation. The scores ranged between +1 and −1, with positive values indicating a preference for landmarks, negative values indicating a preference for route directions, and values around zero reflecting mixed representations. This preference score was then independent of the element quantity in the representation.

A repeated-measures MANOVA was computed for these scores with gender and recall condition (map or description) as the between-subjects factors and successive representations as the within-subjects factor. The mean preference scores in Table II are subdivided only for women and men because no significant main effect of condition, $F(1,28) = 1.01$, $p = .32$, and no interaction between gender and condition, $F = .34$, $p = .56$,

Table II. Preference Scores for Landmarks Against Route Directions[a] in Three Representations

		Women		Men			
		M	(SD)	M	(SD)	t	p (two tailed)
Representation	1	.36	(.61)	−.04	(.59)	1.86	0.07
	2	.48	(.40)	−.02	(.39)	3.58	0.001
	3	.40	(.51)	.19	(.50)	1.17	0.25

Note. Mean scores (M), standard deviations (SD) for women ($n = 17$) and men ($n = 15$).
[a]Positive scores reflect preferences for landmarks, negative scores reflect preferences for route directions, and scores around zero reflect no preferences.

were found. The analysis of variance yielded significant differences associated with gender, $F(1, 28) = 5.24$, $p = .03$, $\eta = .16$. Women, in general, preferred landmarks in all three representations, whereas men used similar amounts of landmarks and route directions in the first and second representation and showed weak landmark preferences only in their third representation. Thus, the smaller group average for women in number of route directions compared with men reflected individual preferences for landmarks and neglect of route direction information.

The preference scores in three successive representations were highly correlated (representations 1 and 2: $r(32) = .79$, $p < .001$; representations 1 and 3: $r(32) = .69$, $p < .001$; representations 2 and 3: $r(32) = .48$, $p < .01$). Participants who preferred landmarks in their first representation also did so in the following representations, whereas others showed a permanent preference for route directions or mixed representation through all trials.

Relationships Between Questionnaire Scales, Wayfinding Behavior, and Preferences in Environmental Representation

Correlation Analyses

Table III shows correlations between questionnaire and wayfinding measures on the one hand and preference scores in three successive representations on the other hand. A significant positive relationship between spatial anxiety and preference scores for women indicated that those who scored higher levels of spatial anxiety preferred landmarks in the three representations more than the less anxious ones. For men, negative correlations were not significant. Self-estimated wayfinding competence correlated negatively with the landmark preference scores in all representations, with significant values only for the female subgroup.

Initial speed (first section of run 1) was taken as a dependent variable

Table III. Spearman Rank Correlations (r) Between Questionnaire Measures, Initial Speed,[a] Errors in Wayfinding, and Preference Scores in Three Representations

		Preference Score in Representation		
		1	2	3
Spatial anxiety	Entire sample	.11	.15	−.01
	Women	.66**	.67**	.43[t]
	Men	−.41	−.25	−.51[t]
Wayfinding competence	Entire sample	−.52**	−.49**	−.52**
	Women	−.49*	−.50*	−.65**
	Men	−.28	−.29	−.27
Configurational competence	Entire sample	−.22	−.31[t]	−.07
	Women	−.33	−.37	−.23
	Men	.09	−.07	.18
Initial speed	Entire sample	−.47**	−.40*	−.29
	Women	−.39	−.44[t]	−.09
	Men	−.53	−.30	−.50[t]
Errors in run 1	Entire sample	−.12		
	Women	−.09		
	Men	−.18		
Errors in run 2	Entire sample		.42*	
	Women		.42[t]	
	Men		.17	
Errors in run 3	Entire sample			.11
	Women			.28
	Men			−.17

[a]Speed in the first section of run 1 (from exit D to C).
[t]$p < .10$, $*p < .05$, $**p < .01$.

for wayfinding behavior in a completely unknown environment. Furthermore, it reflected a permanent personal level of speed through the whole task because it related significantly to the speed in the following runs. A significant negative correlation was found between initial speed and the preference score in the first and second representation, indicating a higher preference for route directions with participants of higher speed. The number of errors in the second wayfinding run correlated positively with the preference for landmarks in the corresponding representation.

Regression Analyses

A series of multiple-regression analyses were carried out to determine how much of the variance in preference scores was accounted for independently by gender, questionnaire, and wayfinding measures. The preference score in the first representation was defined as the dependent variable. Only this first representation reflected unprompted personal preferences in following a wayfinding run in which the participants had not known yet what they had to do afterward. This preference score also held for permanent personal preferences due to its significant correlation to the scores in the following representations. Gender predicted only a small amount of variance on the preference score, $R^2 = .10$, $F(1, 30) = 3.48$, $p = .07$. The addition of self-estimated wayfinding competence (change in $R^2 = .16$) accounted for a significant change in variance, $F(2, 29) = 5.14$, $p = .01$, whereas the subsequent addition of self-estimated configurational competence and spatial anxiety had no further effect and were therefore excluded from analysis. The subsequent addition of initial speed (change in $R^2 = .11$) and errors in run 2 (change in $R^2 = .03$) increased the predictability of variance over gender and wayfinding competence, $R^2 = .40$, $F(4, 27) = 4.53$, $p = .006$. A final model of stepwise regression analysis showed that the preference score was independently predicted by initial speed ($\beta = -.38$, $t = 2.48$, $p = .02$) and wayfinding competence ($\beta = -.39$, $t = 2.55$, $p = .02$) but not significantly by gender or errors in run 2.

Because analysis had revealed opposite correlations between spatial anxiety and preference scores for the female (positive) and male (negative) subgroups (see Table III), an additional regression analysis was conducted separately for both groups with the preference score as the dependent variable and with initial speed, errors in run 2, spatial anxiety, and self-estimated wayfinding competence as the independent variables. For women, the combination of all four variables predicted the variance of the preference score significantly, $R^2 = .53$, $F(4, 12) = 3.42$, $p = .04$, with only spatial anxiety being independently predictive ($\beta = .60$, $t = 2.87$, $p = .01$). For men, only the combination of all four variables was marginally significant, $R^2 = .57$, $F(4, 10) = 3.33$, $p = .06$.

DISCUSSION

This study investigated gender differences in the use of landmarks and route directions in three environmental representations of an unfamiliar corridor system following three wayfinding tasks. Associations between wayfinding behavior, self-estimated spatial anxiety and competencies, and preferences in externalization of environmental knowledge were examined.

Most of the participants spontaneously referred to route knowledge in environmental representations of the previously explored building. They predominantly recalled information about the direction of route turns in the corridor system and the landmarks they passed. Few participants in this study mentioned a small number of metric distances or configurational cues. These results are consistent with findings from Ward *et al.* (1986), who found a predominance of route strategy over configurational strategy in spontaneous route instructions.

Gender differences in environmental strategies have been described as consisting of a male preference for the configurational strategy and a female preference for the route strategy (Galea & Kimura, 1993; Lawton, 1996; Ward *et al.*, 1986). The results of this study show that gender differences also appear in components of the route strategy when considered separately. In terms of recall preferences, independent of element quantity, more women showed a preference for landmarks in environmental representations and neglected route directions. Men, in general, did not recall fewer landmarks but in adding more route directions they gave mixed representations, including landmarks and route directions. Only in their last representation did men show a weak shift to landmark preferences. This shift may be due to an increase of recalled landmarks through repeated representations, whereas the number of route directions remained more or less constant. The gender differences were relatively weak in effect size. The breakdown of individual data showed a range of recall preferences with some women also preferring route directions and some men also preferring landmarks.

Although men, in general, showed a weak shift to landmark preferences toward the end of the task, individual preferences strongly related throughout the three representations. A participant's lasting preference for either a landmark-based, a mixed, or a directional-based strategy was laid down in the first representation and maintained through the following trials. Personal "stylistic preferences" in environmental representation, as first proposed by Ward *et al.* (1986), therefore seem to underlie knowledge externalization even if the element quantity increases with progressing experience (from representations 1 to 3). Only in drawn maps did the number of recalled elements increase until the end of the task, whereas participants who gave descriptions mentioned similar quantities in their second and third representation. Most of these participants wrote detailed descriptions of the upper floor in their second representation. When they had to write down the whole description again for a third time, some participants decided to refer partly to the former manuscript. As there were no effects of recall condition on the preferences for landmarks versus route directions, it may be assumed that the technique of externalization (drawn map or written description) relates to the quantity of representation rather than to preferred strategies.

Higher speed in wayfinding related to a predominance of recalled route directions against landmarks. As for recall preferences, correlation analysis confirmed permanent quicker or slower walkers through the whole task. A participant's initial speed in the first section of wayfinding (i.e., exploring the completely unfamiliar corridor system) related to his or her speed in all the following runs. Thus, quicker walkers seemed to rely predominantly on route directions, whereas slower walkers preferred landmarks as wayfinding aids. Women, in general, walked the unknown corridor system more slowly than men did. These effects did not relate to physiological parameters such as length of stride, but regression analysis showed that initial wayfinding speed overlapped the predictability of gender on preferences for route directions to landmarks. The results of this study could not explain why women and men differed in wayfinding speed and, associated with speed, showed different preferences in environmental representation. However, in a study with students, ages 10 to 17, higher levels of anxiety (more girls) related to slower speed in wayfinding and to landmark preferences, whereas higher speed (more boys) also related to route direction preferences (Schmitz, 1995, 1997). In this study with adults, spatial anxiety was also extracted as a strong predictor but only for women's landmark preferences; that is, more anxious women preferred landmarks against route directions more so than less anxious ones. In addition, participants who rated themselves as having higher levels of wayfinding competence before the task showed a predominance for route directions in comparison to those with a lower self-estimated competence.

However, we still do not know whether spatial anxiety, self-estimated wayfinding competence, and wayfinding speed relate to landmark or route direction preferences independently from each other or influence each other and then predict gender-related environmental preferences. Kitchin's (1996b) conceptual schema of environment–behavior interaction may help to explain some of these associations. He proposed that wayfinding activities as well as environmental knowledge acquisition are based on emotionally biased memory-processing systems. A participant discriminates and memorizes environmental information through real-world activities. This information is stored in long-term memory associated with its emotional context (e.g., success in wayfinding, worry about becoming lost). The subsequent selection of particular environmental cues for memory acquisition is guided by the previously stored information. The emotional state filter works as a mediator of these decision-making processes. A participant may then decide to use different environmental cues (e.g., route directions, landmarks) in environmental behavior. Kitchin's model also proposed that emotionally biased environmental learning starts with the beginning of real-world activities. Early environmental experience may therefore be one crucial factor that primes the memory-processing system to gender differences. From the age of 8 onward, boys show an extended home range (Matthews, 1986) and a higher complexity of home range activities (Schmitz, 1998) compared with girls. A more restricted early environmental experience leads to a higher score in spatial anxiety and a lower score in self-estimated wayfinding competencies (Schmitz, 1998). Boys recall more routes and route directions in maps of an unknown environment, whereas girls give greater emphasis to landmarks (Matthews, 1987; Schmitz, 1997). Thus, gender-related wayfinding behavior and preferences in environmental strategies develop at the latest in adolescence. Women and men possibly rely on such learned preferences, especially in exploring an unknown environment. Lawton (1994, 1996) found that more anxious adults (more women) reported stronger reliance on the route strategy compared with the configurational strategy (more men). The current results indicate that, within the route strategy, the preferred use of route directions seems to be still associated with self-estimated wayfinding competencies and higher wayfinding speed. Only for women does the representation of landmarks still relate predominantly to spatial anxiety.

Finally, there may be other mediators that have to be investigated to explain the variety of sometimes contradictory results on gender differences in environmental strategies. In this study, the participants' first experiences through wayfinding in the unknown environment were not standardized. There were participants who traveled the first run with no errors compared with others who made a lot of errors (wrong turns, going back some corridors and trying again). Thus, different participants initially gained different sets of information that may have influenced their wayfinding decisions as well as their acquisition of environmental knowledge. Those who made more errors in the middle of the wayfinding task (second wayfinding run) preferred landmarks in the following environmental representation. This may be a hint that error performance is also associated with landmark preferences. However, the strong reduction of errors from runs 1 to 2 did not show individual permanencies. Participants who made more errors in the first run did not make fewer or more errors in the second run compared with those who first traveled the corridors more or less correctly. Gender-related differences in errors failed to reach significance, and errors in run 2 could not predict preferences in environmental representation independently. To confirm possible associations between these parameters, additional studies have to be carried out by previously giving a guided tour through a more complex building (more error possibilities) for all participants.

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