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Direction Giving and Following in the Service of Wayfinding in a Complex Indoor Environment

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Abstract

We examined how sense of direction, descriptive feature content, and gender relate to direction giving and following during wayfinding in a complex indoor environment. In Experiment 1, participants provided directions to destinations. Participants with a good sense of direction provided more distances, marginally more correct descriptions, and marginally fewer straight references than those with a poor sense of direction. In Experiment 2, participants rated the effectiveness of these directions. Directions that were rated highly contained more descriptive features than did directions that were rated less highly. In open-ended responses, positive mentions of landmarks and negative mentions of cardinal descriptors were frequent. In Experiment 3, participants navigated faster when following the worst-rated directions than when following the best-rated directions.

Keywords: wayfinding, sense of direction, direction giving, direction following

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Finding our way through the environment is essential to human functioning. Often, people give and follow directions to facilitate wayfinding. For example, a college freshman may ask another student or a university staff member how to get to a classroom or office in a campus building. It is no surprise that spatial skills and strategies differ across individuals (e.g., Hegarty, Montello, Richardson, Ishikawa, & Lovelace, 2006; Kato & Takeuchi, 2003; Lawton, 1996; Prestopnik & Roskos-Ewoldsen, 2000). However, surprisingly little research has examined how these differences affect wayfinding involving direction giving and following in everyday environments. The primary goal of this study was to examine the processes involved in giving and following directions in the service of wayfinding in a complex indoor environment. In particular, we sought to specify how descriptive features, sense of direction, wayfinding strategies, and gender are related to direction giving and following for wayfindng in a university building.

Descriptive Features in Wayfinding Directions

People provide a variety of details when giving directions for wayfinding, including landmarks, cardinal directions, street names, distances, and turn descriptions (Golding, Graesser, & Hauselt, 1996; Hund, Haney, & Seanor, 2008; Mark & Gould, 1995; Ward, Newcombe, & Overton, 1986; Wright, Lickorish, Hull, & Ummelen, 1995). Individual differences in wayfinding details are widespread, with some people providing only the basic details, whereas others provide elaborate descriptions (Devlin, 2003). For instance, Denis, Pazzaglia, Cornoldi, and Bertolo (1999) found substantial differences in the length and amount of landmark information given when participants described three different routes in Venice.

Given this variability, an important question is what factors impact the effectiveness of wayfinding directions. One important consideration is the features of the directions themselves. Allen (1997) describes these features in terms of environmental features (i.e., landmarks, pathways, choice points), delimiters (i.e., distance, cardinal direction, left-right), verbs of movement (i.e., turn, go, continue), and state-of-being verbs (i.e., you will *be* on x street, the destination *is* across from y). Some of these features are more preferred in route directions than others. For instance, Lovelace, Hegarty, and Montello (1999) asked participants to provide directions for familiar and unfamiliar routes. In general, landmark mentions correlated with route quality for both familiar and unfamiliar routes, indicating that higher quality routes contained more landmarks. Moreover, longer route descriptions received higher ratings because they were more complete. Furthermore, Denis et al. (1999) found that directions deemed high in quality were clear and complete, with an adequate number of landmarks, but with no redundancy or uncertainty. Poor-quality descriptions, on the other hand, were unclear, incomplete, or redundant (see also Devlin, 2003). Hund et al. (2008) asked participants to respond to an open-ended question about their preferences regarding wayfinding directions. Positive mentions of landmark and left-right information and negative mentions of cardinal directions were common, further supporting landmark preferences overall.

In addition to assessing direction giving, it is important to specify direction following processes. For instance, Allen (2000) found that participants follow directions with landmarks at choice points with fewer errors than those with landmarks at non-choice points. Furthermore, directions containing landmarks led to fewer wayfinding errors than descriptions containing cardinal directions and distance information. Nonetheless, research findings regarding how effectively participants follow highly-rated or poorly-rated wayfinding directions are inconsistent

(Denis et al., 1999; Honda & Nihei, 2004; Hund et al., 2008). In Denis et al.'s (1999) study, participants were asked to provide descriptions of three routes in Venice. These descriptions were compiled so that a new group of participants could rate their quality in navigational assistance on a seven-point scale. The highest and lowest rated descriptions then were included in a third experiment where participants were asked to follow the descriptions to the best of their ability. Participants navigated with fewer errors when following highly rated directions in comparison to poorly rated directions (see Lovelace et al., 1999 for similar ideas).

In contrast, other research has shown that worst-rated directions facilitate faster wayfinding than best-rated directions. Hund et al. (2008) employed a similar methodology to Denis et al. (1999), except they had participants give descriptions of six routes in a model town. When participants followed the best- and worst-rated descriptions through the model town, they navigated faster following the worst rated directions. Why might this have been the case? It is possible that people navigated more quickly when following the worst-rated descriptions because these worst-rated descriptions were concise and to the point, which led to better wayfinding than the overly elaborate, specific best-rated descriptions. These inconsistencies across studies show that this area of research needs to be explored further. Moreover, it would be helpful to clarify what role environmental scale plays in these inconsistencies.

Many different types of environments have been used to understand wayfinding processes, including virtual, model, indoor, and outdoor environments that differ in scale and mode of learning. For example, Hegarty et al. (2006) compared three different types of environments for wayfinding: a desktop virtual environment, walking two floors of a campus building, and watching a videotaped route through the building. Participants were made aware of certain landmarks on the route they learned and were asked to make distance and directional judgments between landmarks and to draw a sketch of the route including the landmarks. Although performance on direct learning measures differed from performance on measures derived from video or virtual learning, there were important relations among performance across domains. In particular, abilities related to small-scale space (e.g., embedded figures, mental rotation, spatial working memory, and perspective taking measures) were predictive of environmental learning, particularly learning through media. The authors therefore conclude that small- and large-scale spatial abilities rely on similar, but not identical, processes.

In both Hund and Minarik (2006) and Hund et al. (2008), a table-top model town was used to assess wayfinding. Hund and Minarik (2006) found that cardinal descriptors led to higher wayfinding efficiency. Similarly, the worst-rated descriptions that led to better wayfinding performance (noted above) contained more cardinal descriptions than the best-rated descriptions (Hund et al., 2008). This pattern of results differs from the results of other studies that used larger, everyday environments (Denis et al., 1999; Saucier, Green, Leason, MacFadden, Bell, & Elias, 2002). Perhaps these variations are due in part to differences in interacting with small- and large-scale environments. In the model town, the environment was experienced via a survey perspective, perhaps rendering cardinal descriptions efficient for wayfinding. Furthermore, the entire environment was visible throughout the task, which reduced memory demands relative to everyday wayfinding in large-scale environments that involve ground-level views in which only part of the route is visible at any given moment. Although Hund et al. (2008) noted similarities in direction giving when conducting a direct comparison of small- and large-scale environments, potential similarities and differences between environments when following directions in the service of wayfinding need to be explored further.

Sense of Direction

Sense of direction, which is “an awareness of orientation or location” (Kozlowski & Bryant, 1977, pp. 178), is related to wayfinding ability. Those with a good sense of direction know their location in relation to their surroundings, which may lead to better wayfinding ability. For example, Prestopnik and Roskos-Ewoldsen (2000) asked participants to complete a sense of direction questionnaire and an exercise to indicate the direction of different starting points from each ending destination. As expected, those with a better sense of direction showed higher accuracy than those with a worse sense of direction. Similarly, Kato and Takeuchi (2003) guided female participants through a route and then asked them to make their way through the route by themselves. Those with a good sense of direction showed better wayfinding performance than those with a poor sense of direction. Hegarty et al. (2002) developed the self-report, 15-item Santa Barbara Sense of Direction Scale to assess the impact of sense of direction on a variety of spatial skills. This scale includes items such as, “I tend to think of my environment in terms of cardinal directions” and “I don’t have a very good ‘mental map’ of my environment.” As expected, higher scores on the questionnaire correlated with more accuracy when pointing to unseen landmarks and when pointing to the starting point of a path followed during wayfinding. According to the authors, their comprehensive scale provides details about sense of direction in a variety of contexts, including wayfinding, remaining oriented in an environment, learning layouts, using maps, and giving and following directions (see also Hegarty et al., 2006).

Sense of direction also can be measured using behavioral tasks. For example, Kozlowski and Bryant (1977) asked participants to indicate the direction of five unseen buildings on the circumference of a small circle. Accuracy on this task related to self-report sense of direction and accuracy on another wayfinding task where participants indicated on a map the direction of two nearby cities and northward heading. Moreover, Hund and Nazarczuk (2009) used a similar process to have participants indicate the direction of five locations in the basement of a campus building and five locations on campus. Participants with larger errors on this behavioral sense of direction task exhibited more wayfinding errors and took longer when navigating in the basement in a campus building than participants with smaller sense of direction errors, showing that this measure of sense of direction is related to wayfinding. However, behavioral task performance unexpectedly did not correlate with self-reported sense of direction. More research is needed to assess the validity of these two measures and their relation to wayfinding ability.

Wayfinding Strategies and Anxiety

Wayfinding strategies also are related to wayfinding efficiency. According to Lawton and Kallai (2002), there are two main types of wayfinding strategies: orientation strategies and route strategies (see also Taylor & Tversky, 1996). Orientation strategies involve keeping track of global reference points, such as cardinal directions or global reference frames, (e.g., "I keep track of the direction in which I am going" and "I keep track of where I am in relation to a reference point"). Route strategies involve keeping track of step-by-step routes, vistas, or landmarks (e.g., "I ask for directions telling me whether to turn right or left at particular landmarks"). These strategies have been found to relate to various aspects of wayfinding performance. For instance, Lawton (1996) assessed how these strategies related to results from a behavioral sense of direction task by having participants point to four landmarks on a floor of an academic building from an unfamiliar location. As reliance on orientation strategies increased, pointing accuracy to these locations also increased. However, use of route strategies was unrelated to pointing error. These results indicate a strong relation between orientation strategy preference and sense of direction.

Preference for particular strategies also relates to wayfinding performance for certain types of directions. For example, Hund and Minarik (2006) found that preference for orientation strategies was related to better wayfinding performance using cardinal directions in a model town and better wayfinding performance overall, whereas preference for route strategies was related to better performance using landmark directions. Hund et al. (2008) also found that reliance on route strategies was related to fewer errors on a similar wayfinding task. Not all studies, though, have found specific wayfinding strategies to be an indicator of wayfinding performance. Prestopnik and Roskos-Ewoldsen (2000) used a wayfinding task that contained both survey and route sections, and they predicted that those who used route strategies would be faster at following routes shown on a computer from one area of a campus to another, whereas those who used orientation strategies would be faster at the task at the end where they needed to determine the direction of the starting location. However, no differences were found. These studies show that wayfinding strategies are related to wayfinding performance, although the extent of that relation needs to be examined further.

People report varying degrees of anxiety about wayfinding, and high anxiety levels can negatively affect wayfinding performance. For instance, people may feel anxious about following directions or navigating in unfamiliar environments (Lawton & Kallai, 2002). In the Lawton (1996) study discussed above, wayfinding anxiety was linked to larger pointing errors. Similarly, Hund and Minarik (2006) found that as anxiety levels increased, navigation errors moderately increased. Again, however, not all studies have found that anxiety relates to wayfinding performance. For example, Saucier et al. (2002) examined the relation between spatial anxiety and wayfinding speed and accuracy when following directions on campus. Contrary to predictions, spatial anxiety was unrelated to navigation efficiency. Thus, evidence concerning the relations among wayfinding strategies, anxiety, and everyday navigation performance is mixed, perhaps reflecting the intricacies of these relations and the potential impact of additional factors, such as gender.

Gender

Although colloquial accounts of gender differences in wayfinding are widespread, gender differences in wayfinding research have been inconsistent and mostly pertain to preferences instead of performance (Honda & Nihei, 2004; Hund & Minarik, 2006; Hund et al., 2008; Lawton & Kallai, 2002; Saucier et al., 2002). For instance, when Lawton and Kallai (2002) asked participants whether they preferred either route strategies or survey strategies, they found that men preferred orientation strategies whereas women preferred route strategies. Moreover, women reported more wayfinding anxiety compared to men. Other studies have replicated these gender differences in strategy preferences (Hund & Minarik, 2006; Hund et al., 2008; Saucier et al., 2002) and in spatial anxiety (Honda & Nihei, 2004; Lawton & Kallai, 2002, but see Hund & Minarik, 2006 for an exception). Moreover, one recent comprehensive study found that men outperformed women on survey tasks, whereas women outperformed men on route tasks. Women did better than did men when remembering the locations of objects, and men did better than did women when learning a new environment by traveling through it (Montello, Lovelace, Golledge, & Self, 1999).

Gender differences sometimes are evident in people's wayfinding behavior. For instance, the type of information provided in directions differs by gender. Cherney, Brabec, and Runco (2008) asked participants to write directions from two campus locations. Men provided more cardinal descriptions than did women, whereas women provided more landmark information than did men (see also Ward et al., 1986; see Devlin, 2003 for an exception). Furthermore, men typically perform better following cardinal directions, whereas women perform better following directions with landmarks (Saucier et al., 2002). Perhaps these findings are related to strategy preference because they coincide with the wayfinding strategy favored by each gender. They also suggest the similar gender differences are found when giving and following wayfinding directions, although not all studies have found such differences (e.g., Hund & Minarik, 2006). Additional findings suggest that women have a harder time following poorly written directions and demonstrate more hesitation than do men (Honda & Nihei, 2004). Women also make more wayfinding errors (Devlin & Bernstein, 1995; Prestopnik & Roskos-Ewoldsen, 2000; Saucier et al., 2002). More generally, robust gender differences in spatial performance tasks such as mental rotation have consistently shown that men are faster and more accurate than are women (Pazzaglia & DeBeni, 2001; Saucier et al., 2002).

In regards to sense of direction, Hund and Nazarczuk (2009) did not find any gender differences in a behavioral sense of direction pointing task, although women did report a lower sense of direction in a self-report measure. Sex differences in self-report sense of direction measures also have been reported elsewhere (Bryant, 1982; Hegarty et al., 2006). These findings suggest that systematic investigations of gender (along with other factors) may help clarify the sources of variation in wayfinding preference and behavior.

Current Study

The overall goal of this study was to examine how the types of descriptive features contained in wayfinding descriptions, sense of direction, wayfinding strategies, and gender relate to wayfinding in an everyday, indoor environment. The goal of Experiment 1 was to specify how sense of direction, wayfinding strategies, anxiety, and gender relate to the descriptive features provided when giving wayfinding directions. Participants were asked to provide directions from various starting locations to destinations in the basement of a campus building. We expected that people with a good sense of direction would provide more correct descriptions than those with a poor sense of direction. Furthermore, we predicted that as preference for orientation strategies increased, provision of cardinal descriptors also would increase, whereas as preference for route strategies increased, provision of landmark and left-right descriptors also would increase. In addition, we predicted that women would indicate higher route strategy preferences and spatial anxiety than would men, and that men would indicate higher orientation strategy preferences than would women. Experiments 2 and 3 assessed recipients' responses to the wayfinding directions obtained in the first experiment to provide a more complete understanding of wayfinding.

EXPERIMENT 1

Method

Participants

Participants were 36 male and 39 female students from a large, public Midwestern university who received credit in their psychology courses. Ages ranged from 18 to 31 years, with a mean age of 19.75 years. Data from one additional participant were excluded from all analyses because of experimenter error.

Materials

Wayfinding anxiety scale. The 8-item Wayfinding Anxiety Scale (Lawton, 1994) was used to assess anxiety related to wayfinding. Participants responded using a 5-point scale indicating the level of anxiety they would experience in a variety of wayfinding situations, including, "Finding your way out of a complex arrangement of offices that you have visited for the first time." Results were summed, with higher scores indicating greater anxiety. This scale has acceptable psychometric properties (Cronbach's alpha reported in Lawton, 1994 is .80, Cronbach's alpha for the present data is .75).

Wayfinding strategy scale. The 17-item Wayfinding Strategy Scale (Lawton & Kallai, 2002) also was included. Participants used a 5-point scale to specify how often they used each strategy. Based on standard scoring criteria, the strategies were categorized into two groups: orientation strategies and route strategies. Orientation strategies involve keeping track of global reference points, such as cardinal directions, (e.g., "I keep track of the direction in which I am going" and "I keep track of where I am in relation to a reference point"). Route strategies involve keeping track of step-by-step routes, vistas, or landmarks (e.g., "I ask for directions telling me whether to turn right or left at particular landmarks"). Scores for each subscale were summed, so higher scores indicated stronger preferences for the specific wayfinding strategies. These subscales have acceptable psychometric properties (Cronbach's alphas reported in Lawton & Kallai, 1994 are .79 for the orientation subscale and .70 for the route subscale, Cronbach's alphas for the present data are .77 for the orientation subscale and .70 for the route subscale).

Sense of direction. Sense of direction was measured by asking participants to indicate direction estimates for 10 landmark locations (i.e., 5 salient locations in the basement, such as the elevators, and 5 salient buildings on campus, such as the library) using sheets of paper that included a printed outline of a circle with a dot indicating their current location and an arrow indicating their facing direction (Hegarty et al., 2006; Hund & Nazarczuk, 2009; Kozlowski & Bryant, 1977; Lawton, Charleston, & Zieles, 1996; Sholl, Acacio, Makar, & Leon, 2000). Participants had no visual access to any of the landmarks. Furthermore, they also completed a two-question self-report Sense of Direction Scale to assess sense of direction (Hund & Nazarczuk, 2009; Kozlowski & Bryant, 1977; Pazzaglia & DeBeni, 2001). The questions included, “Do you think you have a good sense of direction?” and, “Are you considered by your family or friends to have a good sense of direction?” Participants responded using a 5-point scale varying from “not at all” to “very much.” Test-retest reliability averaged .93 when participants reported their sense of direction in sessions separated by 2 weeks to 3 months (Kozlowski & Bryant, 1977). In the present study, the scale again evinced acceptable psychometric properties (Cronbach’s alpha for the present data is .90).

Environmental familiarity and demographic information. Two items measured participants’ familiarity with the campus building used in the study (Hund & Nazarczuk, 2009). These probed overall familiarity and how often participants visit the basement of the building during a typical week. Participants also completed a brief demographic information form.

Design and Procedure

Participants were asked to write directions to get from a starting location to a destination for each of six trials. Trial order was counterbalanced across participants. For each trial, participants were asked to choose one possible route to get from the starting location to its destination and to describe the route as they would in everyday life. If participants were unsure of any locations or directions, they were told that they could indicate so. Two sets of inquiries (Set A and Set B) were created using locations in the basement of a large campus building. The starting locations and destinations in Set A were the teaching assistant desks and the vending machines, the windows overlooking the plaza and the computer classroom, and the research classroom suite and the elevators. Starting locations and destinations in Set B included the computer classroom and the TA desks, the vending machines and the research classroom suite, and the elevators and the windows overlooking the plaza.[1] Space for written wayfinding directions was provided below each starting and ending location. After finishing all six trials, participants completed the self-report measures and the sense of direction exercise.

Coding and Measures

Descriptive features. Researchers coded the frequency with which participants mentioned seven descriptive features: cardinal directions (i.e., north, south, east, west), landmarks (i.e., any named landmark along the paths such as the sliding doors or bathrooms), left or right, distances (i.e., feet or steps), number, straight (i.e., “go straight”), and miscellaneous information. These frequencies were converted to proportions relative to the total frequency of descriptive features.

Direction accuracy. For each trial, researchers determined whether the directions successfully or unsuccessfully led from the starting location to the destination, or whether the participants opted to write “I don’t know.” Two coders independently assessed the directions provided by 15 randomly selected participants (20% of the sample) to assess overall reliability. They agreed exactly on 247 out of 300 categorical judgments concerning descriptive features and accuracy (82.33% exact agreement), indicating a reasonably high level of inter-rater reliability.

Sense of direction. Participants’ direction estimates of landmarks on the circle-pointing task were recorded by calculating the angular error in degrees. Angular error for each location was determined by using the absolute value of the difference between the correct position and the estimated position of the location, which was measured by a protractor (Hund & Nazarczuk, 2009; Wang & Spelke, 2000). Angular errors were averaged across all ten locations, providing a global measure of sense of direction. Average estimates greater than one standard deviation above the mean were omitted from analysis, eliminating data from 18 participants (10 women, 8 men) for the subset of analyses involving this measure.[2] Two coders independently assessed angular responses in the sense of direction exercise for 25 randomly selected participants (33%

of the sample). They agreed within two degrees on 228 out of 250 (91.20%) location estimations, indicating a high level of inter-rater reliability.

Results

One goal of this study was to investigate how sense of direction impacted what descriptors people provide when giving wayfinding directions involving one floor of a complex university building. To address this issue, independent samples *t*-tests were used to analyze accuracy and descriptive feature proportions among those with high and low senses of direction. A median split was used to divide men and women into good and poor sense of direction groups using the self-report measure (Median for women = 2.5, Median for men = 3.25). As expected, those with a good sense of direction provided correct directions marginally more often than those with a poor sense of direction, $t\ (73) = -1.87$, $p = .066$. Furthermore, those with a good sense of direction provided significantly more distance information, $t\ (73) = -2.85$, $p < .01$, and marginally less straight information, $t\ (73) = 1.69$, $p = .095$, than those with a poor sense of direction. Analyses focusing on the proportion of cardinal directions, landmarks, left-right, number, and miscellaneous revealed that there were no significant differences between good and poor sense of direction groups, all $|t|$s < 1.32, *p*s > .19 (see Table 1).

Another goal was to examine the relation between wayfinding strategies, anxiety, sense of direction, and descriptors provided. Correlational analyses revealed that as orientation strategy preference increased, proportion of cardinal directions also increased, $r\ (73) = .25$, $p < .05$, consistent with theoretical accounts focusing on orientation/survey strategies (Lawton, 1996; Lawton & Kallai, 2002; Shelton & McNamara, 2004; Siegel & White, 1975; Taylor & Tversky, 1996; Thorndyke & Hayes-Roth, 1982). Route strategy preference did not correlate significantly with any descriptor proportion measures, *r*s (73) < .16, *p*s > .15. Interestingly, spatial anxiety correlated with proportion of mention of landmarks, r (73) = .31, $p < .01$, left-right, r (73) = .52, $p < .001$, and number, r (73) = .31, $p < .01$ (see Table 2).

Correlational analyses further revealed that self-reported sense of direction was correlated with errors on the sense of direction exercise, r (55) = -.30, $p < .01$, orientation strategies, r (73) = .50, $p < .001$, distance proportion, r (73) = .32, $p < .01$, and straight proportion, r (73) = -.26, $p < .05$. The significant correlation between self-reported and behavioral measures of sense of direction is important for further establishing the validity of the measures. Moreover, as sense of direction increased, preference for orientation strategies and proportional frequency of mentioning distance increased, and proportional frequency of mentioning straight decreased. Finally, errors in the sense of direction exercise correlated with proportion of correct responding, r (73) = -.29, $p < .05$, indicating that correct responding decreased as direction errors increased (see Table 2).

Analyses of gender differences in strategies, anxiety, and sense of direction revealed that women (M = 24.67, SD = 3.72) preferred route strategies more than did men (M = 22.83, SD = 3.65), t (73) = 2.15, $p < .05$. Women (M = 2.87, SD = 1.24) also reported poorer sense of direction than did men (M = 3.49, SD = 1.22), t (73) = -2.16, $p < .05$. Other analyses yielded non-significant results. For the sense of direction exercise, women (M = 57.20, SD = 21.71) and men (M = 50.26, SD = 22.21) exhibited similarly large errors, t (55) = 1.19, p = .24. Women (M = 82.10, SD = 48.62) reported similar levels of spatial anxiety relative to men (M = 80.56, SD = 45.80), t (73) = .14, p = .89. In regards to orientation wayfinding strategies, men (M = 28.14, SD = 7.64) and women (M = 25.54, SD = 6.34) reported similar preferences, t (73) = -1.61, p = .11. Moreover, analyses of gender differences in descriptive features included in wayfinding directions revealed that men provided more cardinal descriptors (M = .06, SD = .11), t (73) = -

2.09, $p < .05$, and more miscellaneous descriptors ($M = .07$, $SD = .11$), $t\ (73) = -2.02$, $p < .05$, than did women (Cardinal: $M = .02$, $SD = .05$; Miscellaneous: $M = .03$, $SD = .06$).

Discussion

One goal of this study was to investigate how sense of direction impacted the descriptors provided when people provided wayfinding directions involving a complex indoor environment (i.e., one floor of a large university building). As predicted, people with a good sense of direction provided correct directions marginally more often than people with a poor sense of direction. Moreover, people with a good sense of direction reported more distances than people with a poor sense of direction, using statements such as "a few feet down" or "to the end of the hall" to provide detailed wayfinding descriptions. In contrast, people with a poor sense of direction reported marginally more references to going straight than people with a good sense of direction. The proportion of mention of the other descriptor types (i.e., cardinal, landmark, left-right, number, miscellaneous) did not differ for the two sense of direction groups.

Another goal of the experiment was to specify the relation between wayfinding strategies, spatial anxiety, sense of direction, and wayfinding descriptors. As expected, as preference for orientation strategies increased, proportion of cardinal directions in wayfinding descriptions also increased, indicating consistency between survey strategy preference and survey descriptor provision (Lawton, 1996; Lawton & Kallai, 2002; Taylor & Tversky, 1996; Thorndyke & Hayes-Roth, 1982). Surprisingly, the proportional inclusion of left-right and landmark descriptors did not increase with route orientation preference despite the use of landmarks in route strategies. Nonetheless, these findings provide preliminary support for the notion that wayfinding strategies are related to the descriptive details people provide when giving wayfinding directions.

The present results also revealed that as anxiety increased, the proportional inclusion of landmarks, left-right descriptors, and numbers in wayfinding directions also increased. Although this finding was unexpected and causal statements regarding the locus of the relation are not warranted, it is possible that people with higher spatial anxiety levels provided more descriptive features to ensure that more information was at hand to ease their wayfinding anxieties. It is interesting to note that the particular features included generally are consistent with a route perspective, indicating a potential link between route strategies and spatial anxiety. Future research is needed to provide details about the locus of spatial anxiety, as well as its relation to wayfinding strategies and outcomes.

Importantly, this project revealed a robust relation between self-reported and behavioral measures of sense of direction, at least for participants exhibiting moderate errors in locating landmarks (see Footnote 2 for details). Past research has yielded mixed results in this regard (Hund & Nazarczuk, 2009; Kozlowski & Bryant, 1977), so this finding is important for continued establishment of the validity of the two measures (see Hegarty et al., 2002 for similar findings). Moreover, as sense of direction increased, preference for orientation strategies and proportional mentioning of distance increased, and proportional mentioning of straight decreased. This tight link between sense of direction, orientation strategies, and "orientation" descriptors is interesting and has the potential to shed light on the nature of these concepts. For instance, it makes sense that orientation strategies and sense of direction would be tightly linked because both rely on one's ability and/or preference for keeping track of one's location in a broad environmental framework. Finally, the present results indicated that as errors in the sense of direction exercise increased, frequency of correct responding decreased. This relation again illustrates the tight link between sense of direction and wayfinding, this time highlighting the "costs" associated with poor sense of direction (e.g., less accurate wayfinding).

The wayfinding literature contains multiple accounts of robust gender differences in wayfinding strategies and efficiency (Hund et al., 2008; Hund & Minarik, 2006; Lawton & Kallai, 2002; Saucier et al., 2002). Consistent with these previous accounts, the present findings revealed gender differences in wayfinding strategy preference. That is, women preferred route strategies more than did men, consistent with previous research (Hund et al., 2008; Lawton & Kallai, 2002). However, inconsistent with those studies, no gender differences were found in regards to orientation strategies. It is interesting that our findings yielded differences in route, rather than orientation, strategies, because previous findings have suggested that men's higher preference for orientation strategies relative to women is the more robust of the two patterns (Devlin & Bernstein, 1995, 1997; Montello et al., 1999). Consistent with previous literature, women reported lower sense of direction than did men, although they exhibited similar errors on the sense of direction exercise (Hund & Nazarczuk, 2009). Additional theoretical and empirical work is needed to determine the nature and locus of gender differences across tasks.

The goal of the final two experiments was to add to our understanding of wayfinding processes by assessing people's responses to the wayfinding directions provided in the first experiment. In Experiment 2, a new group of participants read sets of descriptions (provided in Experiment 1) of particular routes through the basement of our university building. They were asked to rate each route description based on its effectiveness for aiding wayfinding using a 7-point scale. Given previous demonstrations of people's preference for wayfinding directions using a route perspective (Denis et al., 1999; Hund et al., 2008), we expected that highly-rated descriptions would include left-right turns and landmark references. In contrast, we predicted that descriptions rated as less effective would include cardinal directions. We also assessed participants' open-ended responses regarding wayfinding descriptor preferences, expecting that they would mention landmarks and left-right details positively and cardinal descriptors negatively (see also Hund et al., 2008).

EXPERIMENT 2

Method

Participants

Participants were 46 male and 44 female college students. The mean age was 19.78 years, with the ages ranging from 18 to 30 years. Participants were recruited and compensated in the same manner as in the previous experiment.

Materials

The same set of six starting locations and destinations were used as in Experiment 1. A packet containing 42 or 48 descriptions (7 or 8 different descriptions of the 6 starting location to destination descriptions) was used to elicit effectiveness ratings on a 7-point scale (Dennis et al., 1999; Hund et al., 2008). The specific instructions were the following: "Your task is to rate the effectiveness of the following descriptions, which provide directions for getting from place to place in the basement of DeGarmo Hall. Some of the descriptions may be excellent, whereas others may be difficult to interpret. Please rate each description on a seven-point scale. A score of 7 should be given to excellent descriptions that enable you to follow the directions and reach the goal without error or hesitation. A score of 1 should be given to very poor descriptions that do not allow you to easily reach the goal." Participants were randomly assigned to 1 of 10 groups, with each group rating a subset of the directions provided for each of the six trials in Experiment 1.[3] The same way-finding anxiety, wayfinding strategy, and environmental familiarity self-report measures and sense of direction exercise from Experiment 1 also were included.

Design and Procedure

Participants were asked to rate each wayfinding direction based on effectiveness. Then, they completed an open-ended question about the factors that influenced their ratings of the descriptions. The frequency of positive and negative mentions of cardinal directions, distances, left-right, and landmarks were coded. Participants then completed the self-report measures and the sense of direction exercise.

Coding and Measures

Coding for the sense of direction exercise was identical to that used in Experiment 1. Data from 15 participants (7 women, 8 men) whose mean error was greater than one standard deviation above the mean were omitted from analyses involving this measure. To assess inter-rater reliability, two coders independently assessed angular responses in the sense of direction exercise for 22 randomly selected participants (24% of the sample). They agreed within two degrees on 219 out of 220 (99.5%) location estimations, indicating a very high level of inter-rater reliability.

Results

The primary goal of this study was to specify the descriptive wayfinding features contained in effective and ineffective route descriptions. We compared the proportional mention of each feature in routes that received above-median ratings (i.e., the effective descriptions) and below median ratings (i.e., the ineffective descriptions) using independent samples *t*-tests (Hund et al., 2008). The best-rated route directions included more cardinal features, t (448) = -4.85, $p <$ .001, more landmarks, t (448) = -17.46, $p < .001$, more left-right information, t (448) = -19.55, p

$< .001$, more distance information, t (448) = -3.95, $p < .001$, more number information, t (448) = -5.71, $p < .001$, more "go straight" information, t (448) = -5.50, $p < .001$, and more miscellaneous information, t (448) = -6.44, $p < .001$, than the worst-rated route directions (see Table 3).

In participants' open-ended responses regarding wayfinding preference, positive mentions of landmarks were very frequent (see Table 4). Positive mentions of cardinal, landmark, left-right, distance, and straight descriptors differed significantly from a uniform distribution, Chi^2 (6, N = 90) = 87.67, $p < .01$, confirming that positive mentions of landmark and (to a lesser extent) left-right details were frequent. In contrast, negative mentions of cardinal descriptors were frequent (see Table 4). Negative mentions of the different types of descriptors also differed from a uniform distribution, Chi^2 (6, N = 90) = 66.20, $p < .01$, confirming that negative mentions of cardinal descriptors were very frequent.

Another goal was to assess gender differences in strategies, anxiety, and sense of direction. As expected, the present findings revealed robust gender differences. In particular, women reported significantly higher spatial anxiety than did men, t (88) = 3.03, $p < .01$. In regards to wayfinding strategies, men (M = 29.04, SD = 7.44) preferred orientation strategies more than did women (M = 25.86, SD = 6.78), t (88) = -2.12, $p < .05$, whereas women (M = 24.41, SD = 3.30) preferred route strategies more than did men (M = 22.70, SD = 4.18), t (88) = 2.15, $p < .05$. Women (M = 2.76, SD = 1.20) also reported poorer sense of direction than did men (M = 3.47, SD = 1.25), t (88) = -2.73, $p < .01$. On the sense of direction exercise, women (M = 75.70, SD = 31.22) exhibited larger errors than did men (M = 57.16, SD = 24.63), t (75) = 2.86, $p < .01$.

Discussion

Wayfinding descriptions receiving high effectiveness ratings contained more left-right and landmark descriptors than descriptions receiving lower ratings. These preferences were further supported by numerous positive mentions of landmarks, as well as left-right descriptors, in open-ended responses. These results are consistent with findings from the first experiment and from the broader literature suggesting that wayfinding descriptions adopting a route perspective (i.e., providing a mental tour of the route to be followed) often are preferable to descriptions adopting a survey perspective (e.g. Hund et al., 2008; Levelt, 1982; Linde & Labov, 1975; Shanon, 1984; Taylor & Tversky, 1996; see also Montello et al., 1999).

Unexpectedly, wayfinding descriptions receiving high effectiveness ratings contained more cardinal directions than those receiving lower ratings. Open-ended responses, on the other hand, yielded numerous negative mentions of cardinal descriptors (see also Devlin, 2003). Although these open-ended responses are consistent with Hund et al. (2008), the negative mentions of cardinal directions do not coincide with the higher frequency of cardinal descriptors in the higher-rated directions. It is possible that wayfinding descriptions contained multiple, redundant pieces of information, such as noting a left/north turn. This is consistent with the higher inclusion of all information sources for best- as compared to worst-rated directions. Perhaps people sometimes prefer to have multiple sources of information available during wayfinding, even if it includes information about which they feel negatively (see Denis et al., 1999 for qualifications regarding this argument). Additional research is needed to assess the impact of redundant information, particularly focusing on the impact of cardinal descriptors alone or in concert with other wayfinding cues.

As expected, the present findings revealed robust gender differences consistent with those documented in the broader literature (Hund et al., 2008; Hund & Minarik, 2006; Lawton &

Kallai, 2002; Saucier et al., 2002). In particular, as in the first experiment, women reported lower sense of direction than did men, but they also exhibited larger errors on the sense of direction exercise than did men here. Furthermore, as in Experiment 1, women preferred route strategies more than did men. However, men showed a higher preference for orientation strategies than did women. Women also reported higher levels of anxiety than did men. Although it is not clear why the gender differences in this experiment were more robust than those reported in the first experiment, it is possible that the larger number participants included in Experiment 2 relative to Experiment 1 increased statistical power. Clearly, additional research is needed to clarify the locus of gender differences in wayfinding processes.

In addition to documenting features included in effective and ineffective wayfinding directions, the present findings were used to determine which route descriptions would be included in the experimental examination of wayfinding efficiency in Experiment 3. We selected the single best- and worst-rated correct route description for each starting location and destination (see below for details). These descriptions were used to guide a new set of participants who attempted to navigate through the basement of the campus building. We expected that participants would navigate more efficiently when following the best-rated directions than when following the worst-rated directions. That is, participants would be faster and make fewer errors when following more effective directions. Although worst-rated directions have led to faster wayfinding times and fewer errors when wayfinding in a model town (Hund et al., 2008), we expected that the present results would coincide with findings from Denis et al. (1999) and Honda and Nihei (2004), which indicated better wayfinding efficiency with highly-rated descriptions when wayfinding in large-scale environments.

EXPERIMENT 3

Method

Participants

Participants were 53 male and 49 female college students, ranging from 18 to 29 years (*M* = 20.0). Data from two additional participants were excluded from all analyses: one for whom English was not the native language and one who did not cooperate with instructions. Recruitment and compensation were handled in the same manner as in the previous experiments.

Materials

A subset of the best- and worst-rated routes generated in Experiment 2 was used in this experiment. Only descriptions that could accurately get participants from the starting location to the destination were included, and the highest- and lowest-rated description was selected for each route. Bound sets of note cards were created using the single best- and worst-rated correct descriptions for each of the six routes. Each note card contained one route segment. Participants were randomly assigned to follow one of two sets of directions, each containing 3 best-rated directions and 3 worst-rated directions (presented in a random order). Set A contained the worst-rated direction for the windows overlooking the plaza to the computer classroom, the best-rated direction for the computer classroom to the TA desks, the best-rated direction for the research classroom suite to the elevators, the worst-rated direction for the elevators to the windows overlooking the plaza, the best-rated direction for the vending machines to the research classroom suite, and the worst-rated direction for the TA desks to the vending machines. Set B included the opposite rating of each of these directions.[4] The best- and worst-rated directions contained similar numbers of route segments overall, $t\ (10) = -1.81$, $p = .10$ (Best: $M = 6.67$, $SE = .80$; Worst: $M = 5.00$, $SE = .45$). The same self-report measures and sense of direction exercise from the previous two experiments also were included.

Design and Procedure

Participants first completed the self-report measures. Next, they were asked to follow six sets of directions to navigate through the basement of the large campus building. Participants were shown which way was north, south, east and west, and they were told to follow the directions as accurately and quickly as they could. When the researcher said, “Go!” participants read the note cards one at a time and followed the directions by walking from the starting location to the destination. When participants reached the destination, they said, “Stop!” After following each of the six directions, participants completed the sense of direction exercise in an interior area of the basement where they had no visual access to any of the landmarks to be located.

Coding and Measures

The researcher recorded the time it took for participants to navigate each route along with any errors the participants made. Errors included backing up, turning the wrong way, taking an incorrect hallway, ending at an incorrect destination, stopping short or past a destination, and giving up on a route altogether (Hund et al., 2008; Hund & Nazarczuk, 2009). Note that the first three errors involved intervening travel, whereas the final three errors involved aspects of the destination. Wayfinding times were averaged (regardless of whether participants reached the destination without error) and errors were summed across the best-rated and worst rated routes.

Coding for the sense of direction exercise was identical to that used in the previous studies. Data from 26 participants (13 women, 13 men) whose mean error was greater than one standard deviation above the mean were omitted from analyses involving this measure. To assess inter-rater reliability, two coders independently assessed angular responses in the sense of direction exercise for 28 randomly selected participants (27% of the sample). They agreed within two degrees on 276 out of 280 (98.57%) location estimations, indicating a very high level of inter-rater reliability.

Results

The goal of this study was to examine how gender, direction type, and sense of direction affect wayfinding time and errors. A median split was used to divide the men and women into poor and good sense of direction groups using the self-report measure (Median for women = 3.0, Median for men = 3.5). Two Gender (men, women) x Direction Type (best-rated, worst-rated) x Sense of Direction (poor, good) mixed model Analyses of Variance (ANOVAs) analyzing wayfinding time and error were conducted.

Wayfinding time. Analysis of wayfinding time revealed no significant main effects of gender, $F(1, 98) = .20$, $p = .66$, or sense of direction, $F(1, 98) = .62$, $p = .43$. Wayfinding time did not differ for men ($M = 58.34$ s, $SE = 2.30$) and women ($M = 59.81$ s, $SE = 2.39$), or for good ($M = 57.77$ s, $SE = 2.38$) and poor sense of direction ($M = 60.38$ s, $SE = 2.41$). However, there was a significant main effect of direction type, $F(1, 98) = 5.05$, $p < .05$, indicating that participants navigated more slowly when following the best-rated directions ($M = 63.34$ s, $SD = 30.99$) than when following the than worst-rated directions ($M = 54.56$ s, $SD = 19.56$). All interactions failed to reach traditional significance levels.

Wayfinding errors. Analysis of wayfinding errors revealed no significant main effects. Wayfinding errors did not differ for men ($M = 6.31$, $SD = 3.86$) and women ($M = 6.72$, $SD= 5.96$), $F(1, 98) = 1.16$, $p = .28$, for best- ($M = 3.50$, $SD = 4.05$) and worst-rated directions ($M = 2.89$, $SD = 3.15$), $F(1, 98) = 2.72$, $p = .10$, or for good ($M = 6.08$, $SD = 4.49$) and poor sense of direction ($M = 7.20$, $SD = 5.72$), $F(1, 98) = .16$, $p = .69$. All interactions failed to reach traditional significance levels.

Correlations. Correlational analyses were used to determine relations between sense of direction and wayfinding efficiency measures. Self-reported sense of direction was correlated with spatial anxiety, r (100) = -.31, $p < .01$, orientation strategies, r (100) = .64, $p < .001$, route strategies, r (100) = -.23, $p < .05$, and wayfinding errors on the best-rated directions, r (100) = -.20, $p < .05$, indicating that orientation strategies increased and route strategies, anxiety, and wayfinding errors decreased as sense of direction increased. Spatial anxiety also correlated with orientation strategies, r (100) = -.22, $p < .05$, and with route strategies, r (100) = .32, $p < .01$, suggesting that orientation strategies decreased and route strategies increased as spatial anxiety increased. Moreover, wayfinding time was positively related to wayfinding errors for both the best-rated, r (100) = .74, $p < .001$, and worst-rated directions, r (100) = .66, $p < .001$, indicating that the pattern of results was not due to speed-accuracy trade offs. Finally, average time for the best-rated directions was negatively correlated with average time for the worst-rated directions, r (100) = -.21, $p < .05$, and total errors for the worst-rated directions, r (100) = -.24, $p < .05$ (see Table 5).

Gender differences. Analyses of gender revealed that women (M = 18.61, SD = 5.11) reported marginally higher spatial anxiety than did men (M = 16.89, SD = 4.67), t (100) = 1.78, p = .078. In regards to wayfinding strategies, men (M = 29.57, SD = 6.85) preferred orientation strategies more than did women (M = 24.53, SD = 6.67), t (100) = -3.76, $p < .001$, although women (M = 24.10, SD = 3.89) and men (M = 22.91, SD = 4.08) showed similar preferences for route strategies, t (100) = 1.51, p = .13. Women (M = 2.80, SD = 1.12) reported significantly lower sense of direction than did men (M = 3.32, SD = 1.09), t (100) = -2.40, $p < .05$, but women (M = 47.29, SD = 23.27) did not significantly differ from men (M = 40.45, SD = 19.12) with regards to errors on the sense of direction exercise, t (74) = 1.41, p = .16.

Discussion

The goal of this experiment was to investigate how wayfinding cues and sense of direction were related to wayfinding efficiency. People navigated more quickly when following the worst-rated directions than when following the best-rated directions. This speedy wayfinding relied, in part, on features of the route description participants were asked to follow. Nonetheless, additional factors, including overall travel speed, environmental obstacles (or lack thereof), and processing speed, undoubtedly played a role. Although the pattern of results may seem somewhat counterintuitive, it has been observed before, such as when participants navigated through a model town faster when following worst-rated directions than when following best-rated directions (Hund et al., 2008). Nonetheless, these findings are at odds with those from Denis et al. (1999), who found that people following best-rated directions navigated significantly faster than those following worst-rated directions. As noted in Hund et al. (2008), perhaps the worst-rated descriptions, although less detailed, were concise and to the point, which led to faster wayfinding than the intricate, precise best-rated descriptions. It is also possible that the indoor environment utilized here, though complex and large-scale, contributed to the pattern of findings being more similar to those using a table-top model town (Hund et al., 2008) than those using the city of Venice (Denis et al., 1999). Clearly, the complexity of the city far outpaced the complexity of the model or the university building. Future research should investigate this discrepancy between description ratings and wayfinding performance across a variety of environmental scales and complexities.

In regards to gender differences, wayfinding time and errors did not differ based on gender, consistent with previous reports (Hund et al., 2008). Analyses of wayfinding strategies and spatial anxiety, once again, revealed that women reported a lower sense of direction than did men, but made similar errors on the sense of direction exercise relative to men (i.e., consistent with Experiment 1). Women also reported marginally higher levels of spatial anxiety than did men. In terms of strategies, men preferred orientation strategies more than did women consistent with Experiment 2, but women did not prefer route strategies more than did men as in both of the previous two experiments. These inconsistencies between studies show that future research is needed to determine how gender and strategies are related.

We also found several significant correlations involving sense of direction. Self-reported sense of direction was related to errors on the best-rated directions, which shows that those who have a better sense of direction make fewer errors following the best directions. These findings confirm that sense of direction is related to wayfinding efficiency. Self-reported sense of direction also was related to anxiety, orientation strategies, and route strategies, such that anxiety and orientations strategies decreased and route strategies increased as sense of direction increased. Spatial anxiety also correlated with orientation and route strategies, indicating that orientation strategies decreased and route strategies increased as anxiety increased. These tight relations between spatial anxiety and route strategies and, conversely, between sense of direction and orientation strategies are similar to the findings from our early study and warrant further exploration.

GENERAL DISCUSSION

The overall goal of this project was to examine how descriptive features, sense of direction, wayfinding strategies, and gender are related to wayfinding in an everyday, indoor environment. The present findings show that, indeed, these factors are related to successful wayfinding. Most importantly, we found that sense of direction relates to wayfinding efficiency involving a complex indoor environment. Those who had a good sense of direction provided marginally more correct descriptions in Experiment 1 relative to those with a poor sense of direction. Moreover, participants with a good sense of direction used more distance information and marginally less “go straight” information than did participants with a poor sense of direction. When asked to follow directions for wayfinding in the third experiment, our findings revealed a link between sense of direction and wayfinding efficiency. In particular, as self-reported sense of direction increased, wayfinding errors when following the best-rated directions decreased. Together, these findings confirm that people who have a better sense of direction are more efficient during wayfinding.

Interestingly, the results followed more closely the patterns revealed in a previous set of studies using a model town (i.e., wayfinding times were slower for the best-rated routes than for the worst-rated routes, see Hund et al., 2008) than those using a city (Denis et al., 1999). Several factors could explain these discrepancies. For instance, perhaps different wayfinding behaviors are exhibited while following routes with different levels of complexity. Although our routes were in a complex building, the complexity of routes in an indoor environment may not compare to the complexities of routes outdoors in a city such as Venice. Even our most complex buildings (e.g., large hospitals, government buildings) are much smaller and less complicated than cities, by and large. This distinction points to the impact of complexity both of the routes themselves and of the overall environment. These important complexity issues deserve further study. Furthermore, it is possible that different cognitive processes could be used when wayfinding through large- and small-scale environments (Hegarty et al., 2006). These differences may be related both to divergent spatial perspectives and processing demands across environmental scales. Moreover, differences in how route directions were presented may have led to differences in memory demands that impact wayfinding. In particular, participants in Denis et al.’s (1999) study learned the route directions in their entirety at the beginning of each trial and then set off to find their way, leading to relatively high memory demands, particularly given the complexity of the city environment and routes to navigate. In contrast, participants in Hund et al.'s (2008) study experienced the route directions piece by piece in the midst of wayfinding (i.e., one segment at a time), leading to lower memory demands. These lower memory demands coupled with simpler routes and a simpler environment may have led, in part, to differences in wayfinding performance across studies. Clearly, these potential explanations deserve investigation in future research involving task spaces encompassing a variety of environmental scales.

The present results yielded tight links between sense of direction, wayfinding strategies, and spatial anxiety. Consistent with other accounts (Hund & Nazarczuk, 2009; Lawton, 1996), better sense of direction was related to increasing preference for orientation strategies in both Experiments 1 and 3. Both sense of direction and orientation strategies are related to a reliance of global orientation, the capability to construct a survey model, and to keep track of one's current location in relation to the model (Hund & Nazarczuk, 2009). Furthermore, perhaps this global orientation that those with a better sense of direction demonstrate was useful in interpreting the specific best-rated descriptions in Experiment 3, leading to efficient wayfinding performance. In contrast, sense of direction and route strategies were negatively related in Experiment 3, indicating that increasing sense of direction was related to decreasing preference for route strategies. Moreover, sense of direction was negatively related to spatial anxiety, and spatial anxiety was positively related to route strategies and negatively related to orientation strategies in the third experiment. These findings point to a potential linkage between spatial anxiety and route strategies that contrasts with the tight linkage between sense of direction and orientation strategies. In fact, relations between spatial anxiety and inclusion of landmark and left-right descriptors and between orientation strategies and inclusion of cardinal descriptors, as well as similarities in patterns of gender differences, further strengthen these potential links. Although speculation regarding the locus of sense of direction, wayfinding strategies, and spatial anxiety relations is beyond the scope of this project, the tight links demonstrated here suggest that efforts to disentangle the antecedents and sequelae of these processes deserve theoretical and empirical attention.

Importantly, the findings from the first experiment provide support for the relation between self-report and behavioral measures of sense of direction. Previous research has yielded mixed results about the validity of the two measures, so these results help clarify the previous discrepencies (Hund & Nazarczuk, 2009; Kozlowski & Bryant, 1977; but see Hegarty et al., 2002 for similar convergence among self-report and behavioral measures). Moreover, women consistently reported lower sense of direction than did men, although they only exhibited larger errors on the behaviorial sense of direction exercise in Experiment 2. These findings confirm the importance of including behavioral and self-report measures in future investigations of wayfinding, as well as other spatial skills (see also Hegarty et al., 2006).

This study also provided interesting findings with regards to wayfinding strategies and gender. In the previous literature, men typically preferred orientation strategies, whereas women generally preferred route strategies (Hund & Minarik, 2006; Hund et al., 2008; Lawton & Kallai, 2002; Saucier et al., 2002). Women typically report more wayfinding anxiety than do men (Honda & Nihei, 2004; Lawton & Kallai, 2002). We found each of these results in two of the three experiments, showing a general consistency in the pattern of gender differences. However, our study did not yield any gender differences in wayfinding efficiency in Experiment 3, showing that although men and women may use different strategies to help get from place to place, they exhibit similar levels of wayfinding performance (see also Lawton et al., 1996).

The present findings have several important implications for everyday wayfinding, including industry settings where skillful wayfinding is required (e.g., law enforcement, transportation), as well as educational settings that foster skillful wayfinding (e.g., schools, museums) and everyday settings requiring wayfinding (e.g., shopping centers, hospitals, complex office buildings). Importantly, the complex indoor environment we employed is similar to many of these environments, suggesting that our results are of particular importance here. These findings also might be useful for individuals or training programs focusing on effective direction giving and following. Moreover, information about what descriptors led to the most effective wayfinding can be used to develop more effective GPS navigation systems and internet-based mapping/route planning services and informational kiosks, perhaps aiming to expand these services for complex indoor environments. In particular, directions rated as highly effective contained more descriptive features than did directions rated as less effective, and positive mentions of left-right details and landmarks were common, suggesting that wayfinders appreciate knowing that turns and landmarks are leftward or rightward. Interestingly, wayfinding efficiency patterns differed from effectiveness ratings, showing that future research is needed to confirm these conclusions.

Indeed, our findings point to several avenues for future research that would be beneficial for advancing our understanding of wayfinding processes. Future studies should evaluate the discrepancy between description ratings and wayfinding performance to help understand this difference. For example, having ratings done before and after people follow certain sets of directions could be the next step in identifying where the inconsistencies emerge. Furthermore, perhaps a direct analysis comparing different environments also would be beneficial in understanding environmental differences. Analyzing two different environments within the same study would help identify the differences between them without having to take into account experimental design differences across studies. Looking deeper into the reasons behind the gender differences in wayfinding also would be a viable research direction, such as specifying the locus of these differences, including examining the impact of gender roles and expectations.

In summary, the present findings reveal that descriptive features, sense of direction, strategies, and gender are related to successful direction giving and following for wayfinding in a complex indoor environment. These findings confirm that direction giving and following are dynamic processes that are dependent on complex interactions between many factors (for theoretical accounts, see Couclelis, 1996; Hill, 1987). Thus, they add to our growing understanding of competent wayfinding.

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Footnotes

[1] These starting locations and destinations were selected using several criteria. First, informal pilot work indicated that they were reasonably well-known locations. Moreover, an "ideal" route from each starting location to destination would require several turns, and the overall set of locations/routes encompassed most public areas of the basement.

[2] We acknowledge that elimination of data from 18 out of 75 participants (and 15 out of 90 participants in Experiment 2 and 26 out of 102 participants in Experiment 3) for analyses involving the sense of direction exercise raises caution about interpretations based on these findings. In particular, the present analyses exclude people who exhibited extremely large angular errors, which resulted in the exclusion of 17 to 25 percent of our sample for a small subset of analyses. Understanding the processes related to such large errors in reporting the angular locations of landmarks (including measurement issues and theoretical explication) is beyond the scope of this paper, but clearly represents an important avenue for future study.

[3] The descriptions were assigned to group randomly with the stipulation that all descriptions provided by the same participant were assigned to the same group. The difference in the number of descriptors each participant rated occurred because the overall number of descriptions per starting location and destination was not evenly divisible. That is, 75 descriptions of each route needed to be rated. We asked participants to rate 7 or 8 descriptions of each route to keep the task manageable so that across the 10 groups, all 75 descriptions were rated (i.e., 5 groups rated 7 descriptions for each route and 5 groups rated 8 descriptions for each route).

[4] The counterbalancing of route and rating (best- v. worst-rated) was included so that route was not confounded with rating type. We were not interested in particular routes, but

rather, how participants responded to the best- and worst-rated descriptions overall. This design allowed us to focus on this goal while avoiding the confound with route.