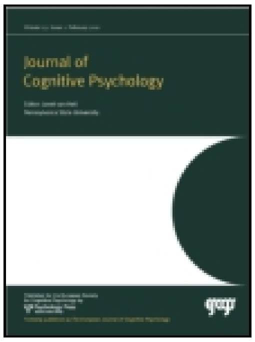

Journal of Cognitive Psychology

ISSN: 2044-5911 (Print) 2044-592X (Online) Journal homepage: http://www.tandfonline.com/loi/pecp21

Spatial text processing in relation to spatial abilities and spatial styles

Francesca Pazzaglia & Chiara Meneghetti

To cite this article: Francesca Pazzaglia & Chiara Meneghetti (2012) Spatial text processing in relation to spatial abilities and spatial styles, Journal of Cognitive Psychology, 24:8, 972-980, DOI: 10.1080/20445911.2012.725716

To link to this article: https://doi.org/10.1080/20445911.2012.725716

Published online: 23 Oct 2012.

JOURNAL OF COGNITIVE PSYCHOLOGY, 2012, 24 (8), 972–980

Psychology Press
Taylor & Francis Group

Spatial text processing in relation to spatial abilities and spatial styles

Francesca Pazzaglia and Chiara Meneghetti

Department of General Psychology, University of Padua, Padua, Italy

The present study examined how people's spatial abilities and spatial preferences for representing environmental information influence the ways in which they represent information from spatial descriptions. Spatial individual differences can have a central role in sustaining the mental representation deriving from survey and route descriptions. A group of 48 undergraduates listened to survey and route spatial descriptions and performed a sentence verification task on their content. They were then administered two spatial tasks, the Mental Rotation Test (MRT) and the Minnesota Paper Form Board (MPFB), plus a self-rating scale on sense of direction and spatial representation. The results showed that spatial abilities influenced the recall of survey and route texts differently. The MPFB and the MRT positively predicted the accuracy of answers on the survey text, which was negatively predicted by a preference for a route representation. Preference for a survey representation was positively associated with the accuracy of answers on the route text. Taken together, these results support the existence of a relationship between spatial abilities, spatial styles, and the processing of spatial language that depends on whether a route or a survey perspective is adopted.

Keywords: Spatial descriptions; Spatial abilities; Spatial styles.

People acquire knowledge on an environment by representing it in various ways. One of the main models for organising the development of spatial knowledge was theorised by Siegel and White (1975), who postulated a gradual acquisition of spatial information which begins with the formation of a landmark representation (in which salient landmarks are represented isolated from the surroundings), followed by the formation of a route representation (in which salient landmarks are correlated with one another and in relation to paths), and ultimately arriving at the finest level, a survey representation (in which the environment is represented like a map, including distance and directional relationships between landmarks). This model is supported by studies showing that increasing levels of familiarity with an environment help individuals to develop more allocentric knowledge (Bryant, 1982; Iachini, Ruotolo, & Ruggiero, 2009; Nori & Piccardi, 2010).

Familiarity with an environment does not necessarily rely on a survey representation, however, as Montello explained (1998), using a model in which spatial knowledge—including the survey representation—is acquired in a continuous process (not step by step as suggested by Siegel & White, 1975). In fact, Ishikawa and Montello (2006) showed that a metric knowledge of a layout, without any accurate ordinal knowledge, can be acquired immediately after an individual's first exposure to a new place. It should be noted, however, that these results are liable to a considerable interindividual variability: individuals with a good sense of direction developed survey knowledge more easily at an early stage (see also Burgess,

Correspondence should be addressed to Francesca Pazzaglia, Department of General Psychology, University of Padua, Via Venezia, 8, Padua 35131, Italy. E-mail: francesca.pazzaglia@unipd.it

http://www.psypress.com/ecp http://dx.doi.org/10.1080/20445911.2012.725716

2006, for a review of allocentric and egocentric knowledge).

This latter point introduces one of the questions of major interest in spatial cognition studies and approaches the issue discussed here, i.e., to what extent mental representation is modulated by individual spatial differences. Some people do not develop a survey representation, irrespective of their exposure to an environment (Ishikawa & Montello, 2006) and this depends, to some degree at least, on individuals' preferences for representing an environment, i.e., their cognitive styles. Cognitive styles of spatial representation are stable preferences self-expressed by individuals when they focus on specific environmental information. These styles are generally identified by means of questionnaires (e.g., Bryant, 1982; Hegarty, Richardson, & Montello, Lovelace, & Subbiah, 2002; Kozlowski & Bryant, 1977; Lawton, 1994; Münzer & Hölscher, 2011; Pazzaglia, Cornoldi, & De Beni, 2000). In particular, Pazzaglia et al. (2000) distinguished between three types of preference as: landmark-focused (representing single landmarks), route (representing landmarks and the paths connecting them), and survey (representing the environment as a map).

A number of studies have shown that differences in cognitive styles of spatial representation help to explain how the same environment may be learnt differently (Denis, Pazzaglia, Cornoldi, & Bertolo, 1999; Nori & Giusberti, 2003; Nori & Piccardi, 2010; Pazzaglia et al., 2000; Pazzaglia & De Beni, 2001, 2006; Pazzaglia & Taylor, 2007; Piccardi et al., 2011). The style people use to represent spaces relates to their way-finding ability and their performance in environmental tasks (Denis et al., 1999; Pazzaglia & De Beni, 2001, 2006; Pazzaglia & Taylor, 2007). For example, higher survey preference (when people say they create a mental map of an environment) is related to tasks typically requiring accurate survey representation, e.g., pointing to unseen locations (Lawton, 1996), judging directions after navigation and map inspection (Pazzaglia & De Beni, 2006; Pazzaglia & Taylor, 2007). Pazzaglia and Taylor (2007) found, for instance, that people with a strong survey preference after learning an environment by navigation or map inspection make few navigation errors.

A preference for the survey mode also is related to people's spatial skills (Nori & Giusberti, 2003; Pazzaglia & De Beni, 2001). Spatial ability—differently from spatial preference—concerns the ability to generate, retain, and transform abstract visual images (Lohman, 1979), and it is tested using objective tasks. Concerning the relationship between spatial preference and spatial abilities, Pazzaglia and De Beni (2001) found that individuals with a preference for the survey mode performed better than individuals with a preference for the landmark-focused mode in the Mental Rotation Test (MRT; Vandenberg & Kuse, 1978), which assesses mental rotation ability, while they did not differ in their performance with the Minnesota Paper Form Board (MPFB; Likert & Quasha, 1941), which assesses the spatial visualisation ability. Mental rotation and spatial visualisation are two spatial factors (frequently tested using the MRT and MPFB, respectively; Linn & Petersen, 1985) that are often considered in spatial cognition studies (e.g., Allen, Kirasic, Dobson, Long, & Beck, 1996).

Findings on the relationship between survey preference and MRT have shown that the preference for forming a global mental image of an environment is associated with the ability to perform mental rotations, which can only be done efficiently by using a global mental rotation strategy (Shepard & Metzler, 1971). This supports the idea that spatial abilities and spatial strategies work together to cope efficiently with environment learning (Hegarty, Montello, Richardson, Ishikawa, & Lovelace, 2006).

The present study takes a novel approach to investigating how spatial preferences and spatial abilities (mental rotation, as measured by the MRT, and spatial visualisation, as measured with the MPFB) simultaneously influence spatial text processing. Spatial cognition studies frequently test environment learning using visual inputs (maps or navigation tasks, e.g., Allen et al., 1996; Pazzaglia & Taylor, 2007). This study was designed to analyse the relationship between spatial competence (i.e., spatial abilities and spatial preferences) and descriptions of an environment, i.e., it takes an approach that comes midway between spatial cognition and mental model studies. It is generally accepted that mental models constructed from descriptions of a given environment have similar spatial features to those of the environment concerned (Chabanne, Péruch, Denis, & Thinus-Blanc, 2003–2004; Johnson-Laird, 1983; van Djik & Kintsch, 1983). Visuospatial abilities are also known to be related with spatial text recall, in terms of both mental rotation (using the MRT; Meneghetti, Gyselinck, Pazzaglia, & De Beni, 2009) and spatial visualisation (using the MPFB; Bosco, Filomena, Sardone, Scalisi, & Longoni, 1996; Denis, 2008; de Vega, 1994). On the other hand, no studies have investigated the combined influence of spatial abilities (i.e., mental rotation and spatial visualisation) and spatial preferences on spatial text recall (i.e., whether high scores in spatial tasks and spatial preferences enhance spatial text recall).

We would expect performance in visuospatial tasks to predict text recall (as suggested by earlier studies, e.g., de Vega, 1994; Meneghetti et al., 2009). At the same time, people's spatial preferences might also predict their spatial text recall, as suggested by previous studies showing that survey representation correlates with the better learning of an environment acquired by means of visual inputs (e.g., Pazzaglia & De Beni, 2006; Pazzaglia & Taylor, 2007).

Another issue addressed by this paper is whether spatial abilities and spatial preferences have different effects depending on the spatial perspective used to describe the environment. Spatial descriptions can convey information in route and in survey perspective. Route descriptions represent a space from an egocentric standpoint and use an intrinsic reference frame; survey descriptions represent the space from an allocentric perspective and use an extrinsic reference frame, such as cardinal directions. Several past studies have suggested that mental models generated from route and survey spatial texts have different properties and rely on different visual and spatial memory systems (see Pazzaglia, Gyselinck, Cornoldi, & De Beni, 2012, for a review). Based on these previous findings, we expect spatial preferences and spatial abilities to have different roles in the processing of route and survey texts. Since MRT findings have been associated with the use of global strategies (Pazzaglia & De Beni, 2001), performance in mental rotation can predict the accuracy in survey descriptions. The MPFB may have a relevant role in spatial text recall too: since it involves arranging a number of parts of figures into a complete figure, performance in the MPFB task might be better able to predict the recall of survey texts representing landmark locations within a global area. We also assume that spatial preferences (for the survey or route, but not for the landmark-focused mode) might enhance route and survey text recall. Whether these preferences for the survey and route modes have different roles as a function of the perspective learnt is also explored: in particular, a strong preference for survey representation may underpin a better accuracy in both types of spatial text (as suggested previously by Pazzaglia & Taylor, 2007), whereas a preference for route representation may be specifically associated with the route perspective.

Participants in the present study listened to survey and route descriptions, and then completed a true/false sentence verification test, responding to filler as well as route and survey inferential sentences. They also completed the sense of direction and spatial representation scale (SDSR; Pazzaglia et al., 2000), the MRT, and the MPFB.

METHOD

Participants

A sample of 48 undergraduates (32 females) recruited at the University of Padova took part in the experiment ($M = 23.06$, $SD = 1.06$; range 22–25 years).

Materials

Spatial measures

Sense of direction and spatial representation scale (SDSR; Pazzaglia et al., 2000). The SDSR scale comprises 11 items grouped under five different factors: (1) general sense of direction; (2) knowledge and use of cardinal points; and (3), (4), (5) preference for survey, route, and landmark-focused representations, respectively (see examples in the Appendix). The reliability of the test for Factors 1–5, as measured by Cronbach's α, was .76, .75, .62, .48, and .59, respectively. For the present study, we used the scores obtained for Factor 3 (survey representation, Items 3c, 4a), considering individuals obtaining high (9 or more, $\geq 75^\circ$ percentile) and low (7 or less, $\leq 25^\circ$ percentile) scores for this factor.

Mental Rotation Test (MRT; Vandenberg & Kuse, 1978). The MRT measures mental rotation abilities. It consists of 20 items (3-D abstract objects), each comprising one target stimulus and four other stimuli, two of which are the same as the target but rotated. The task consists in identifying the two figures that match the target figure but in a rotated position. We allowed participants 8 minutes to complete the test (as suggested by Vandenberg & Kuse, 1978) and awarded 1 point if both figures were identified correctly (Cronbach's $\alpha = .83$).

TABLE 1
Descriptive statistics and correlations between variables

	M (SD)	*1*	*2*	*3*	*4*	*5*	*6*
1. Route text accuracy	10.35 (2.22)						
2. Survey text accuracy	10.52 (2.66)	.09					
3. Route preference	3.38 (0.83)	.09	−.31*				
4. Survey preference	2.97 (1.24)	.54**	.17	−.26			
5. Landmark-focused preference	3.84 (0.76)	.06	.05	−.03	−.21		
6. MPFB	20.52 (4.54)	−.07	.55**	−.04	.12	−.15	
7. MRT	8.77 (4.59)	.07	.44**	−.07	.38**	−.21	.33*

*$p < .05$, **$p < .01$.

Minnesota Paper Form Board (MPFB; Likert & Quasha, 1941). The MPFB measures spatial visualisation abilities. It consists of 32 items, each comprising one 2-D target figure and five sets of separated parts of figures. The task involves choosing the one set that can be combined into a figure corresponding to the target. We allowed participants 8 minutes (as suggested by Likert & Quasha, 1941) and awarded them 1 point for each correct response (Cronbach's $\alpha = .80$).

Reading Comprehension Task (RCT; Cornoldi, Rizzo, & Pra Baldi, 1991). The RCT involves reading an abstract text and answering 10 multiple-choice inferential questions. Each correct answer is awarded 1 point.

Experimental task

Spatial texts. Two fictitious outdoor environments (a zoo and a farm) were described from both a survey and a route perspective (Pazzaglia, Cornoldi, & Longoni, 1994), for a total of four descriptions. All the descriptions included eight landmarks and 21 sentences (14 spatial and seven nonspatial), and were of equal difficulty.

Sentence verification test. For each spatial text, there were 24 true/false questions of the same length; eight of them were filler sentences testing nonspatial information, and the other 16 were inferential sentences (eight route and eight survey), all requiring that the respondent judge the spatial relationships between landmarks that were not mentioned explicitly in the text.

Procedure

During individual sessions, each participant completed the MRT, the MPFB, and the RCT (this last test was limited to a subgroup of 18 participants) and then listened twice, without pause, to a tape-recording of one survey and one route description. Immediately after listening to each description, they completed a true/false sentence verification test. The descriptions were balanced between participants in terms of perspective and environment. During the test, the sentences were displayed on a computer screen in random order and participants had to press one of two keys to indicate whether the sentence was true or false (timing and accuracy were recorded).

RESULTS

Relationships between variables

Table 1 shows the descriptive statistics and correlations between the variables considered. Pearson's correlations showed that accuracy in referring to survey and route texts (given by the sum of the inferential survey and route questions[1]) correlated differently with measures of individual differences. Accuracy in the survey text correlated positively with the scores for the visuospatial tasks (MPFB and MRT) and negatively with the ratings on route preference; accuracy in the route text only correlated positively with a survey preference. The MRT and MPFB results correlated positively with one another, and a survey preference correlated positively with the MRT. No significant correlations emerged with the RCT.

[1] Since the correlations of both the route and the survey inferential questions in each spatial text with individual difference measures were similar, the scores for both types of question were pooled and the total score was considered in the analyses. The filler questions were not included in the total score because they revealed no significant correlations with individual difference measures and inferential questions.

Overall, these results suggest that accuracy in route and survey texts depends on different spatial abilities and spatial preferences.

Variables predicting spatial text accuracy

A hierarchical multiple regression was used to analyse the predictive influence of measures of individual visuospatial differences on the route and survey texts. The total accuracy of answers to inferential questions (both survey and route) was considered as the dependent variable. At a first step in the regression, the type of text (a dichotomous variable, i.e., 1 for the survey text and 0 for the route text) and measures of individual differences (at continuous level), i.e., MRT and MPFB scores, and survey and route preferences ratings, were inserted as independent variables (the landmark-focused preference was omitted because it did not correlate with the other measures considered). At a second step, the values corresponding to the interactions between the type of text and each measure of individual differences were considered as independent variables. The results showed a significant effect of the variables included at both the first step, $F(5, 95) = 3.77$, $p \leq .01$, and the second, $F(9, 95) = 7.10$, $p \leq .001$, accounting for 17% and 26% of the variance, respectively. In particular, at the first step (shown in Table 2), the MPFB, $\beta = .20$, $p = .05$, and survey preference, $\beta = .26$, $p = .02$, had significant effects, showing that text accuracy was predicted by higher scores in the MPFB and higher ratings for survey mode; at the second step, the significant interactions showed that the measures of individual differences were differently associated with the accuracy of survey and route texts. The Text $\times$ MRT, $\beta = .32$, $p = .02$, and Text $\times$ MPFB, $\beta = .41$, $p \leq .001$, interactions showed that higher MRT and MPFB scores were associated with a greater survey text accuracy; the Text $\times$ survey preference, $\beta = -.49$, $p \leq .001$, and Text $\times$ route preference, $\beta = -.38$, $p \leq .01$, interactions showed that a stronger survey preference was associated with a greater route text accuracy (route text $= 0$), whereas a stronger route preference was associated with a lower survey text accuracy (survey text $= 1$).

DISCUSSION AND CONCLUSIONS

The present study aimed to investigate the influence of spatial preferences (for survey and route modes) and spatial abilities (mental rotation and spatial visualisation) on spatial text comprehension. In particular, we analysed whether individual differences in spatial measures have a different impact on mental representations drawn from survey and route descriptions.

The literature on spatial cognition indicates that spatial abilities (particularly mental rotation and spatial visualisation, as measured in objective tasks) and spatial cognitive styles (such as a preference for a survey or a route representation, as measured using questionnaires) have an important role in learning environments from visual inputs (such as maps and navigation, e.g., Allen et al., 1996; Hegarty et al., 2006; Lawton, 1994; Pazzaglia & De Beni, 2001, 2006). On the other hand, no previous studies had analysed the combined role of spatial abilities and spatial

TABLE 2
Hierarchical multiple regression on accuracy of spatial texts

Step	*Predictors*	*ΔR^2*	*β^a*	*t*	*p-value*
1		.17			
	Text[b]		.03	< 1	.72
	MRT		.11	< 1	.34
	MPFB		.20	1.94	.05
	Survey preference		.26	2.41	.02
	Route preference		−.04	< 1	.67
2		.26			
	Text × MRT		.32	2.44	.02
	Text × MPFB		.41	3.34	≤ .001
	Text × Survey preference		−.49	−3.81	≤ .001
	Text × Route preference		−.38	−3.20	≤ .01
Total R^2		.43			

[a]Standardised coefficients. [b]Dichotomous variable: 1 survey text; 0 route text.

preferences when spatial information is conveyed in descriptions. We hypothesised that these spatial skills might have a different influence when spatial information is expressed from a route (i.e., person view) or from a survey perspective (i.e., map view).

The results of our hierarchical multiple regression confirmed that the role of these spatial competences changes as a function of the spatial perspective learnt. The accuracy of survey text was predicted by both types of spatial ability (measured by the MPFB and the MRT): the mental representation derived from survey text was underpinned by spatial visualisation and mental rotation. To mentally represent survey descriptions, listeners or readers construct a visual image, or map, and place landmarks in it. The quality of the resulting mental image relies on the ability to maintain/update it and the ability to handle/rotate it as a global configuration, hence the predictive value of the MPFB and MRT, respectively.

At the same time, self-reported measures consistently showed that survey text accuracy was negatively predicted by route preference. A strong inclination to represent information sequentially (i.e., landmark by landmark) from an egocentric standpoint interferes rather than helping with the construction of a mental representation as a global layout (needed to process survey descriptions).

A survey preference also had a significant role but, contrary to our expectations, it did not facilitate the representation of a survey description (no significant correlation emerged between survey preference and survey text accuracy), whereas a survey preference did correlate positively with route text accuracy, i.e., a stronger survey preference was associated with a more accurate performance in route description.

The results of the present study show that a marked survey preference helps to represent spatial information acquired by descriptions in route perspective, but the same does not apply to descriptions conveyed from a survey perspective. Previous studies found that a survey preference is involved in material visually encoded from a survey perspective, such as a map (Pazzaglia & De Beni, 2001) or a path explored from an aerial view (Pazzaglia & Taylor, 2007). The present study was the first to examine the relationship between survey preference and mental representations derived from spatial descriptions, and it generated different results from previous studies examining visual inputs. When information is transmitted verbally, a survey-mode representation is uninvolved in the listener's comprehension of survey descriptions, although it is related to the comprehension of route descriptions. When information is given from a survey perspective, anyone can probably construct a good survey representation, irrespective of their preferred cognitive style, but when they read a text that takes a route perspective, only individuals showing a survey preference succeed in creating a survey-focused representation from route text. On the other hand, a positive correlation emerged between survey preference and MRT (as found previously by Pazzaglia & De Beni, 2001, 2006) and this result also suggests that the relationship between survey preference and survey text accuracy might be mediated by MRT. The outcomes of the current study could, however, be partially attributable to the characteristics of the sample, which only included individuals with a high or low propensity to adopt a survey mode of representation. Other data will need to be collected in a larger sample population to see whether the relationships identified here between spatial preferences and spatial descriptions can be replicated.

On the whole, our finding show that spatial abilities have a crucial role in aiding the recall of spatial descriptions, which is a complex cognitive task. This corroborates past findings on the influence of cognitive functions, such as spatial abilities and/or spatial working memory, on spatial text recall (Brunyé & Taylor, 2008; De Beni, Pazzaglia, Gyselinck, & Meneghetti, 2005; Meneghetti et al., 2009), and adds the novel finding that this influence is more pronounced for survey texts than for route descriptions. Our results also shed more light on the relationships between spatial cognitive styles and spatial text processing, confirming that spatial preferences differently sustain the mental representation derived from route and survey texts, as suggested by previous studies. For example, Pazzaglia and Cornoldi (1999) and Pazzaglia, Meneghetti, De Beni, and Gyselinck (2010) showed that route text processing was disrupted more severely than survey text processing by a concurrent sequential spatial task (see also Deyzac, Logie, & Denis, 2006).

Another finding worth highlighting is that only spatial preferences (i.e., preferences for route and survey representations), but not a preference for landmark-focused representations, have a role in spatial text processing. Neither the correlation analyses nor the regression analyses identified any positive or negative influence of landmark-focused scores on accuracy in spatial text recall. It may be that people's preference for focusing on the visual properties of landmarks is more important when people actually navigate along a route (e.g., Denis et al., 1999). In our experiment, we gave information verbally and the texts contained few visual details. This issue might be better investigated by means of further studies on individual differences using texts enriched with visual information. Other studies could be conducted to clarify the profile of individuals with different spatial preferences, analysing their competence in visuospatial and verbal tasks, and in other everyday environment-related tasks.

It should be noted, however, that our results are based on the accuracy of answers in a verification test, which is a typical measure used in mental model studies to test comprehension skills (Taylor & Tversky, 1992). Accuracy in the verification test (measured as final output) might also express how spatial information is recalled. This is corroborated by studies showing that verification test correlated well with other typical recall measures (free recall and map drawing, e.g., Meneghetti, De Beni, Gyselinck, & Pazzaglia, 2011). Even if this measure well represents comprehension ability, it would be interesting to analyse whether our findings can be replicated with other measures typically used to test recall.

To sum up, the present study is the first to show that the involvement of spatial skills and spatial preferences changes, depending on the perspective adopted in spatial descriptions; survey text accuracy was positively predicted by mental rotation and spatial visualisation abilities, and negatively predicted by a preference for representing spatial information in route mode, whereas a preference for the survey mode was positively associated with route text recall.

Original manuscript received April 2012
Revised manuscript received July 2012
First published online October 2012

REFERENCES

Allen, G. L., Kirasic, K. C., Dobson, S. H., Long, R. G., & Beck, S. (1996). Predicting environmental learning from spatial abilities: An indirect route. *Intelligence*, *22*, 327–355.

Bosco, A., Filomena, S., Sardone, L., Scalisi, T. G., & Longoni, A. M. (1996). Spatial models derived from verbal descriptions of fictitious environments: The influence of study time and the individual differences in visuo-spatial ability. *Psychology Beitrage*, *38*, 451–464.

Brunyé, T. T., & Taylor, H. A. (2008). Extended experience benefits spatial mental model development with route but not survey descriptions. *Acta Psychologica*, *127*, 340–354.

Bryant, K. J. (1982). Personality correlates to sense of direction and geographical orientation. *Journal of Personality and Social Psychology*, *43*, 1318–1324.

Burgess, N. (2006). Spatial memory: How egocentric and allocentric combine. *Trends in Cognitive Sciences*, *10*, 551–557.

Chabanne, V., Péruch, P., Denis, M., & Thinus-Blanc, C. (2003–2004). Mental scanning of images constructed from visual experience or verbal descriptions: The impact of survey versus route perspective. *Imagination, Cognition and Personality*, *23*, 163–171.

Cornoldi, C., Rizzo, A., & Pra Baldi, A. (1991). *Prove avanzate MT di comprensione della lettura [Advanced MT reading comprehension task]*. Firenze, Italy: Organizzazioni Speciali.

De Beni, R., Pazzaglia, F., Gyselinck, V., & Meneghetti, C. (2005). Visuospatial working memory and mental representation of spatial description. *European Journal of Cognitive Psychology*, *17*, 75–95.

Denis, M. (2008). Assessing the symbolic distance effect in mental images constructed from verbal descriptions: A study of individual differences in the mental comparison of distances. *Acta Psychologica*, *127*, 197–210.

Denis, M., Pazzaglia, F., Cornoldi, C., & Bertolo, L. (1999). Spatial discourse and navigation: An analysis of route directions in the city of Venice. *Applied Cognitive Psychology*, *13*, 145–174.

de Vega, M. (1994). Characters and their perspectives in narratives describing spatial environments. *Psychological Research/Psychologische Forschung*, *56*, 116–126.

Deyzac, E., Logie, R. H., & Denis, M. (2006). Visuospatial working memory and the processing of spatial descriptions. *British Journal of Psychology*, *97*, 217–243.

Hegarty, M., Montello, D., Richardson, A., Ishikawa, T., & Lovelace, K. (2006). Spatial abilities at different scales: Individual differences in aptitude-test performance and spatial-layout learning. *Intelligence*, *34*, 151–176.

Hegarty, M., Richardson, A. E., Montello, D. R., Lovelace, K., & Subbiah, I. (2002). Development of a self-report measure of environmental spatial ability. *Intelligence*, *30*, 425–447.

Iachini, T., Ruotolo, F., & Ruggiero, G. (2009). The effects of familiarity and gender on spatial representation. *Journal of Environmental Psychology*, *29*, 227–234.

Ishikawa, T., & Montello, D. R. (2006). Spatial knowledge acquisition from direct experience in the environment: Individual differences in the development of metric knowledge and the integration of separately learned places. *Cognitive Psychology*, *52*, 93–129.

Johnson-Laird, P. N. (1983). *Mental models: Towards a cognitive science of language, inference, and consciousness*. Cambridge, MA: Harvard University Press.

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

Lawton, C. A. (1994). Gender differences in way-finding strategies: Relationship to spatial ability and spatial anxiety. *Sex Roles*, *30*, 765–779.

Lawton, C. A. (1996). Strategies for indoor wayfinding: The role of orientation. *Journal of Environmental Psychology*, *16*, 137–145.

Likert, R., & Quasha, W. H. (1941). *Revised Minnesota Paper Form Board*. New York, NY: Psychological Corporation.

Linn, M. C., & Petersen, A. C. (1985). Emergence and characterization of sex differences in spatial ability: A meta-analysis. *Child Development*, *56*, 1479–1498.

Lohman, D. F. (1979). *Spatial ability: A review and reanalysis of the correlational literature* (Tech. Rep. No. 8). Stanford, CA: Stanford University School of Education.

Meneghetti, C., De Beni, R., Gyselinck, V., & Pazzaglia, F. (2011). Working memory involvement in spatial text processing: What advantages are gained from extended learning and visuo-spatial strategies? *British Journal of Psychology*, *102*, 499–518.

Meneghetti, C., Gyselinck, V., Pazzaglia, F., & De Beni, R. (2009). Individual differences in spatial text processing: High spatial ability can compensate for spatial working memory interference. *Learning and Individual Differences*, *19*, 577–589.

Montello, D. R. (1998). A new framework for understanding the acquisition of spatial knowledge in large-scale environments. In M. J. Egenhofer & R. G. Golledge (Eds.), *Spatial and temporal reasoning in geographic information systems* (pp. 143–154). New York, NY: Oxford University Press.

Münzer, S., & Hölscher, C. (2011). Entwicklung und Validierung eines Fragebogens zu räumlichen Strategien [Development and validation of self-report measure of spatial orientation]. *Diagnostica*, *57*, 111–125.

Nori, R., & Giusberti, F. (2003). Cognitive styles: Errors in directional judgments. *Perception*, *32*, 307–320.

Nori, R., & Piccardi, L. (2010). Familiarity and spatial cognitive style: How important are they in spatial representation? In J. B. Thomas (Ed.), *Spatial memory: Visuospatial processes, cognitive performance and developmental effects* (pp. 123–144). New York, NY: Nova Publisher.

Pazzaglia, F., & Cornoldi, C. (1999). The role of distinct components of visuo-spatial working memory in the processing of texts. *Memory*, *7*, 19–41.

Pazzaglia, F., Cornoldi, C., & De Beni, R. (2000). Differenze individuali nella rappresentazione dello spazio: Presentazione di un questionario autovalutativo [Individual differences in spatial representation: An autovalutative questionnaire]. *Giornale Italiano di Psicologia*, *3*, 627–650.

Pazzaglia, F., Cornoldi, C., & Longoni, A. M. (1994). Limiti di memoria e specificità di rappresentazione nel ricordo di descrizioni spaziali "dall'alto" ed "entro il percorso" [Limits of memory and the specificity of representations in the memory of survey and route descriptions]. *Giornale Italiano di Psicologia*, *21*, 267–286.

Pazzaglia, F., & De Beni, R. (2001). Strategies of processing spatial information in survey and landmark-centred individuals. *European Journal of Cognitive Psychology*, *13*, 493–508.

Pazzaglia, F., & De Beni, R. (2006). Are people with high or low mental rotation abilities differently susceptible to the alignment effect? *Perception*, *35*, 369–383.

Pazzaglia, F., Gyselinck, V., Cornoldi, C., & De Beni, R. (2012). Individual differences in spatial text processing. In V. Gyselinck & F. Pazzaglia (Eds.), *From mental imagery to spatial cognition and language: Essays in honor of Michel Denis* (pp. 127–161). Hove, UK: Psychology Press.

Pazzaglia, F., Meneghetti, C., De Beni, R., & Gyselinck, V. (2010). Working memory components in survey and route spatial texts processing. *Cognitive Processing*, *11*, 359–369.

Pazzaglia, F., & Taylor, H. A. (2007). Perspective, instruction, and cognitive style in spatial representation of a virtual environment. *Spatial Cognition and Computation: An Interdisciplinary Journal*, *7*, 349–364.

Piccardi, L., Risetti, M., Nori, R., Tanzilli, A., Bernardi, L., & Guariglia, C. (2011). Perspective changing in primary and secondary learning: A gender difference study. *Learning and Individual Differences*, *21*, 114–118.

Shepard, R. N., & Metzler, J. (1971). Mental rotation of three dimensional objects. *Science*, *171*, 701–703.

Siegel, A. W., & White, S. H. (1975). The development of spatial representations of large-scale environments. In H. W. Reese (Ed.), *Advances in child development and behavior* (Vol. 10, pp. 9–55). New York, NY: Academic Press.

Taylor, H. A., & Tversky, B. (1992). Spatial mental models derived from survey and route descriptions. *Journal of Memory and Language*, *31*, 261–292.

Vandenberg, S. G., & Kuse, A. R. (1978). Mental rotation, a group test of three-dimensional spatial visualization. *Perceptual and Motor Skills*, *47*, 599–604.

Van Dijk, T. A., & Kintsch, W. (1983). *Strategies of discourse comprehension*. New York, NY: Academic Press.

APPENDIX A

Listed below are the two items in the SDSR scale (Pazzaglia et al., 2000) used to measure the preference for a survey, route, and landmark-focused spatial representation.

Item 3: Think about the way you orient yourself in different environments around you. Would you describe yourself as a person who orients him/herself by:

a. remembering routes that connect one place to another

1	2	3	4	5
(not at all)				(very much)

b. looking for well-known landmarks

1	2	3	4	5
(not at all)				(very much)

c. trying to create a mental map of the environment

1	2	3	4	5
(not at all)				(very much)

Item 4: Think of a city you have visited several times. Now, try to classify your representation of that city:

a. survey representation (i.e., map-like)

1	2	3	4	5
(not at all)				(very much)

b. route representation, based on memorised routes

1	2	3	4	5
(not at all)				(very much)

c. landmark-centred representation, based on memories of individual salient landmarks (such as monuments, buildings, crossroads, etc.)

1	2	3	4	5
(not at all)				(very much)