Spatial mental representations derived from spatial descriptions: The predicting and mediating roles of spatial preferences, strategies, and abilities

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The aim of this research was to investigate how spatial self-assessments and spatial cognitive abilities jointly influence the construction of mental representations derived from spatial descriptions. Two studies were conducted using the path models approach to test to what extent spatial self-assessments (Study 1, 194 participants) and the combination of the latter with spatial abilities (Study 2, 206 participants) can be modelled to predict memory for spatial descriptions. In both studies, we recorded spatial representation preferences (distinguishing between survey, route, and landmark-focused mode) and self-reported strategies used to memorize descriptions (distinguishing between survey, route, and verbal strategies); in Study 2, we also measured spatial abilities by testing mental rotation (MR) and visuo-spatial working memory (VSWM). Participants listened to spatial descriptions and then completed recall tasks. In both studies, the final path models showed that spatial preferences influenced spatial recall through the mediation of congruent strategies: that is a survey (route) preference influenced spatial recall mediated by a survey (route) strategy. MR predicted spatial recall, mediated by both VSWM and survey strategy (Study 2). Overall, these findings indicate that spatial preferences (particularly for a survey mode) in association with spatial abilities effectively concur to help form mental representations derived from spatial descriptions.

Acquiring knowledge of an environment is an important everyday activity. Although our surroundings can be learned directly by exploring and indirectly by using maps and virtual navigation systems, a commonly used source is spatial language. This is the case, for example, when a person unfamiliar with a town reads the description of a route in a guidebook, explaining how to get from the station to the museum, or the path to follow when visiting a nature park. To reach their destination people build a mental spatial representation. It is widely accepted that the mental model they create is an internal representation of the world analogous to the structure of the corresponding state of affairs in the outside world (Johnson-Laird, 1983). This internal representation preserves the physical properties of space, that is relationships between objects (Perrig & Kintsch, 1985; Taylor & Tversky, 1992) and information about distances (Morrow, Stine-Morrow, Leirer, Andrassy, & Kahn, 1997; Rinck, Hahnel, Bower, & Glowalla, 1997).

Although analyses on mental representations derived from visual (see Montello, Waller, Hegarty, & Richardson, 2004; for a review) and verbal (see Gyselinck & Meneghetti, 2011;
Spatial preferences represent two different lines of research—the former related more to spatial cognition and the latter to mental model studies. Researchers agree that both types of representation have spatial properties, that is, they are an internal representation of the structure of the environment (Wolbers & Hegarty, 2010). One commonly posed relevant question in spatial domain studies analysing how environments are represented (whatever the type of input considered) is how to analyse individual determinants. Among various factors producing inter-variability in environment learning—such as familiarity (Iachini, Ruotolo, & Ruggiero, 2009; Nori & Piccardi, 2010; Thorndyke & Hayes-Roth, 1982), gender (Coluccia & Iouse, 2004; Cornoldi & Vecchi, 2003; Lawton, 2010)—spatial skills have an important role (as shown by Allen, Kirasic, Dobson, Long, & Beck, 1996; Hegarty, Montello, Richardson, Ishikawa, & Lovelace, 2006). On the other hand, the influence of individual spatial competences in representing the environment, especially when the information is acquired from descriptions, remains rather less well explored. It is important to bridge this gap to see how people can be helped to form a better mental representation of an environment. The novel intent of the studies described here was therefore to analyse the contribution of individual spatial factors in influencing mental representations derived from environment descriptions, particularly considering the following: (1) subjectively reported spatial preferences and strategies; and (2) objectively examined spatial abilities.

**Spatial preferences, strategies and spatial learning**

Spatial preferences are self-reported ways in which people mentally represent an environment to orient themselves therein, also termed orientation strategies (Lawton, 1994, 1996), spatial representation (Pazzaglia & De Beni, 2001; Pazzaglia, Cornoldi, & De Beni, 2000) or spatial cognitive styles (Nori & Giusberti, 2003). These individual preferences are generally distinguished into survey and route modes (Lawton, 1994; O’Keefe & Nadel, 1978; Russell & Ward, 1982). People who opt for the route mode prefer to represent the environment as sequences of actions and landmark locations relative to their own position (from the person’s point of view). Those who opt for the survey mode prefer to represent the environment by integrating information on landmark positions and their relationships (irrespective of the person’s point of view) using global references such as cardinal points.

Survey and route preferences are identified by means of questionnaires (e.g., Lawton, 1994; Pazzaglia et al., 2000), in which respondents rate how they represent the environment and orient themselves in common real-life situations (e.g., in an unfamiliar city or a natural outdoor environment). Lawton (1994) empirically confirmed that survey and route preferences are two distinct factors, and Pazzaglia et al. (2000) added a non-spatial mode, called landmark-focused preference (which differs from the survey and route modes), to indicate a preference for representing the environment by focusing on landmarks as particular patterns of perceptual events.

Numerous studies have shown that these spatial preferences have a marked impact on spatial learning. In particular, the survey mode (which has been analysed more than the route mode) emerges as an effective spatial mode that positively influences spatial task performance. Studies using the individual differences approach have shown that individuals who prefer the survey mode (generally compared with people focusing on landmarks or disinclined to use the survey) performed better in spatial tasks, such as pointing tasks after map learning (Pazzaglia & De Beni, 2001, 2006), and giving left or right directions on a map (Meneghetti, Pazzaglia, & De Beni, 2011). A survey preference does
not always coincide with the best spatial performance, however, when it comes to navigating in an irregular outdoor environment (Denis, Pazzaglia, Cornoldi, & Bertolo, 1999), or way-finding on the strength of verbal instructions (Pazzaglia & De Beni, 2001).

The influence of spatial preferences on the recall of environment descriptions has recently attracted some interest. A study by Meneghetti, Pazzaglia, et al., 2011 showed that, after learning descriptions from a route perspective (expressing information from a person’s point of view) and a survey one (expressing information from a bird’s-eye view), individuals with a strong survey preference fared better in answering questions testing spatial relations between landmarks from both a route and a survey perspective. These findings indicate that the mental representations formed from spatial descriptions by individuals with a marked survey preference are flexible and can be ‘seen’ from different points of view (see also Pazzaglia & Taylor, 2007 for similar results found after virtual explorations).

Another self-reported individual modality capable of influencing the recall of spatial descriptions (also taken into account in this study) is the specific use of imagery strategies to process spatial content. People hearing or reading route directions, for instance, can use mental images, imagining themselves moving along the route or mentally representing the layout of the elements described. These images help them to construct a good mental representation of the environment described (e.g., de Vega, Cocude, Denis, Rodrigo, & Zimmer, 2001), and facilitate the processing of visuo-spatial descriptions (e.g., De Beni & Moë, 2003). Studies have shown that individuals specifically instructed to use mental images to learn spatial descriptions have a better spatial recall than those told to use a repetition strategy (Gyselinck, De Beni, Pazzaglia, Meneghetti, & Mondoloni, 2007; Gyselinck, Meneghetti, Pazzaglia, & De Beni, 2009). In another study, Meneghetti, De Beni, Gyselinck, and Pazzaglia (2011) found that individuals spontaneously reported using different spatial strategies to memorize spatial descriptions, that is they imagined moving along a path (route strategy) or formed a mental map (survey strategy), rather than rely on mentally repeating the text content (verbal strategy). All these studies show that imagery strategies are used spontaneously by individuals and improve their spatial recall when individuals are specifically instructed on their use.

In short, while previous studies have demonstrated the important role of self-reported spatial preferences and imagery strategies in influencing mental representations derived from spatial descriptions, little is known about how their combined influence on such mental representations. This question is specifically approached in Study 1.

Visuo-spatial abilities and spatial learning

Spatial ability is a cognitive skill used to generate, retain, and transform abstract visual images (Lohman, 1979). It is positively associated with environment learning (e.g., Allen et al., 1996; Fields & Shelton, 2006; Hegarty et al., 2006), even when the environment is conveyed by means of spatial descriptions. Previous studies using the individual differences approach have shown that, after learning spatial descriptions, individuals with good spatial abilities are more accurate in spatial recall tasks (Bosco, Filomena, Sardone, Scalisi, & Longoni, 1996; Meneghetti, Gyselinck, Pazzaglia, & De Beni, 2009; Pazzaglia, 2008; Pazzaglia & Cornoldi, 1999). Spatial ability is tested using objective spatial tasks, and one such ability that is frequently tested is mental rotation (MR, using the Mental Rotations Test [MRT]; Vandenberg & Kuse, 1978), that is the ability to mentally rotate two- or three-dimensional stimuli, which has proved important in environment learning (Fields & Shelton, 2006) also using descriptions (Meneghetti et al., 2009; Pazzaglia, 2008).
Another cognitive ability frequently investigated in relation to spatial description processing is working memory (WM), a temporary cognitive function involved in processing information. In particular, the WM system devoted to processing visuo-spatial information, that is the visuo-spatial working memory (VSWM), has a major role in processing spatial descriptions. It has been amply demonstrated that when a spatial description (called the primary task) is heard while performing another (secondary) spatial task loading VSWM, recall of the spatial description deteriorates, confirming the VSWM’s involvement in processing spatial descriptions (for more details, see De Beni, Pazzaglia, Gyselinck, & Meneghetti, 2005; Meneghetti, De Beni, Gyselinck, et al., 2011; Pazzaglia, De Beni, & Meneghetti, 2007). One way to record individual differences in VSWM is to measure spatial span with the Corsi blocks task (Corsi, 1972), which involves processing and retaining a sequence of blocks in forward and backward order. It has been demonstrated that individuals with a high spatial span are better at recalling spatial descriptions (Gyselinck et al., 2007; Pazzaglia & Cornoldi, 1999).

MR and VSWM abilities are related to one another. This has been shown by individual differences studies in which good MR performers had higher scores in the Corsi task and were better able to handle two spatial tasks simultaneously, that is listening to a spatial description while performing a secondary spatial task loading the VSWM (Meneghetti, De Beni, Gyselinck, & Pazzaglia, 2013; Meneghetti et al., 2009); and confirmed by analyses at a continuous level in which MR affected spatial recall mediated by the VSWM (Meneghetti, De Beni, Pazzaglia, & Gyselinck, 2011).

To sum up, the above studies have shown that spatial abilities – and especially MR and VSWM (considered in this study) – strongly influence spatial representations formed from environment descriptions. How these spatial abilities combine with spatial self-assessments in influencing the learning of spatial descriptions has yet to be explored, however, and is the question specifically approached in Study 2.

Spatial preferences, strategies, visuo-spatial abilities, and spatial learning
A literature review generated some evidence that spatial abilities (focusing on MR or VSWM) are related with spatial preferences and strategies (analysing the survey or route preferences, or the spatial strategies used) in influencing environment learning.

Studies on the relationship between spatial preferences and spatial MR ability showed that these two aspects are related: individuals with a strong survey preference did better in MRT, suggesting that global-based processes are involved in both tasks (Meneghetti, Pazzaglia, et al., 2011; see also Pazzaglia & De Beni, 2001, 2006). How spatial abilities and spatial preferences jointly influence environment learning has been less well explored, however. Hegarty et al. (2006) used structural equation models (SEM) to show that both spatial abilities (a latent factor also comprising MR) and spatial self-assessments (identified using the Santa Barbara Sense of Direction scale, (Hegarty, Richardson, Montello, Lovelace, & Subbiah, 2002)) simultaneously had a positive influence on environment learning from visual input (navigation or virtual exploration). As for learning spatial descriptions, Pazzaglia and Meneghetti (2012) recently showed that both spatial abilities (measured with the MRT and the Minnesota Paper Form Board [MPFB]; Likert & Quasha, 1941) and survey and route preferences positively predict spatial recall.

Spatial preferences relate not only to MR but also to VSWM. Baldwin and Reagan (2009) showed that individuals who reported having a good sense of direction performed better in virtual environment learning than those who did not, but the advantage of the
former over the latter diminished when they had to perform a secondary spatial task loading the VSWM at the same time.

The relationship between the self-reported use of spatial strategies to memorize spatial descriptions and spatial abilities (MR and VSWM capacity) has been less thoroughly explored. Nevertheless, some evidence of imagery strategies being related to VSWM and MR comes from the fact that the use of spatial strategies to memorize spatial descriptions declines when a spatial task loading the VSWM is being performed (Meneghetti, De Beni, Gyselinck, et al., 2011), and their use is greater in individuals with better MR skills (Meneghetti et al., 2013).

Summarizing the above-mentioned studies showed that individual spatial factors with a relevant role in environment learning include: (1) spatial self-assessments on environment orientation preferences (Meneghetti, Pazzaglia, et al., 2011; Pazzaglia & Meneghetti, 2012) and imagery strategies (Gyselinck et al., 2007, 2009; Meneghetti, De Beni, Gyselinck, et al., 2011); and (2) spatial abilities such as MR (Meneghetti et al., 2009, 2013) and VSWM (Pazzaglia & Cornoldi, 1999). Although some of these factors were considered concomitantly in previous studies (spatial ability vs. spatial preference, Pazzaglia & De Beni, 2006; Pazzaglia & Meneghetti, 2012; spatial ability vs. WM, Meneghetti et al., 2009; imagery strategy vs. WM, Gyselinck et al., 2007, 2009; spatial ability vs. imagery strategy vs. WM, Meneghetti, De Beni, Gyselinck, et al., 2011; Meneghetti et al., 2013; spatial orientation vs. WM, Baldwin & Reagan, 2009), the combined role of all these variables in influencing spatial description learning remains to be clarified. In particular, little is known about how spatial or non-spatial preferences and strategies co-operate (and this is the aim of our Study 1), or how such self-reported preferences or strategies relate to spatial cognitive abilities (such as MR and VWM) in forming mental representations from environment descriptions.

**Aims**

The aims of this research were to investigate how:

1. Self-reported environment orientation preferences (distinguishing between survey-, route- or landmark-focused modes) and strategies used to memorize spatial content (classified as survey, route and verbal strategies) predict mental representations obtained from spatial descriptions (Study 1).

2. Self-reported assessments (preferences and strategies) in combination with spatial cognitive abilities (MR and VWM) efficiently predict spatial recall (Study 2).

Study 1 focused on how self-reported preferences and strategies can be modelled to influence spatial description recall; Study 2 also combined self-reported measures with objective spatial measures. For both studies, a large sample was administered two self-reporting tools, the Sense of Direction and Spatial Representation Scale (SDSR Scale; Pazzaglia et al., 2000) and a questionnaire recording the strategies used to memorize environmental descriptions (Meneghetti, De Beni, Gyselinck, et al., 2011). In addition, participants in Study 2 completed two spatial tasks, that is the MRT and a Corsi blocks task (Corsi, 1972) measuring their MR and VSWM abilities, respectively. Participants were first administered spatial measures (the SDSR in both studies, and the MRT and Corsi task in Study 2); then they listened to spatial descriptions from a route perspective, and they answered the imagery strategy questionnaire and completed the recall tasks, that is map drawing and a verification task. Although the last two tasks are frequently both used to measure the goodness of mental representations derived from spatial descriptions, some previous studies have shown that map drawing, a task in which participants graphically
reproduce the position of landmarks in a layout (Gyselinck et al., 2009; Meneghetti et al., 2009), generates clearer findings. Our analyses on the relationship between spatial variables using the path model approach will therefore be based mainly on map-drawing accuracy.

In Study 1, path models were used to test the predictive role of spatial or non-spatial preferences and the mediating role of spatial/non-spatial strategies in spatial text recall (map drawing). Spatial preferences were considered *a priori* factors because they represent the usual approach to acquiring knowledge of an environment, and the strategies were considered as mediators because they indicate how spatial descriptions (the final variable of interest) can be memorized.

Starting from the assumption that spatial recall might be influenced both by spatial preferences (as suggested by Meneghetti, Pazzaglia, *et al.*, 2011; Pazzaglia & Meneghetti, 2012) and by spatial strategies (as suggested by Meneghetti, De Beni, Gyselinck, *et al.*, 2011), in Study 1 we tested whether spatial preferences have a direct effect on spatial recall (direct effect hypothesis), or whether their influence is mediated mainly by the spatial strategies used to recall spatial descriptions (mediation hypothesis), investigating whether people’s spatial preferences were associated with the use of strategies based on similar reference frames (i.e., a survey preference associated with the use of a survey strategy, and a route preference with the use of a route strategy).

We also looked into whether spatial recall might be directly influenced by a landmark-focused preference or indirectly mediated by the use of a verbal strategy, and how these non-spatial factors are related to the spatial factor, given that no evidence had hitherto been collected on this issue.

**STUDY 1**

**Method**

**Participants**
A total of 194 undergraduates (64 male participants, 130 female participants) from the University of Padua (mean age 21.59 years) took part in the study.

**Material**

*Visuo-spatial self-assessment measures*
Sense of Direction and Spatial Representation Scale (SDSR; Pazzaglia *et al.*, 2000). This comprises 11 items measuring a total of five factors: two of them measure general sense of direction and knowledge and use of cardinal points, while three specifically measure spatial or non-spatial preferences, that is the tendency to orient oneself in different environments by remembering routes that connect one place to another (route preference), or by creating a mental map of the environment (survey preference), or by identifying landmarks (landmark-focused preference). Scores are given on a Likert scale (from 1 = *not at all* to 5 = *very much*), with a reliability of .75 (see Pazzaglia *et al.*, 2000; Pazzaglia & De Beni, 2001, for more details).

Strategy questionnaire (Meneghetti, De Beni, Gyselinck, *et al.*, 2011). This consists of a list of three strategies: (1) route (‘I imagined moving along a path’); (2) Survey (‘I created a mental map’); and (3) Verbal (‘I repeated the text content’). Answers are given on a Likert scale indicating the extent to which a given strategy was used, from 1 (*very little*) to 7 (*a great deal*).
Spatial descriptions and recall measures

Spatial descriptions. Three spatial descriptions worded from a route perspective were used (from Meneghetti et al., 2009, 2013), describing three fictitious outdoor environments. In all cases, the various landmarks are described from a person’s point of view, using terms such as ‘left’, ‘right’, etc. All descriptions contained 12 sentences describing 14 landmarks and were of similar length (in the Italian versions: Holiday Farm 320 words, Nature Park 317, Tourist Centre 312), and they were equally well recalled.

Verification test. Fourteen sentences of similar length (with a mean 30 syllables in each sentence), half of them true and the other half false, were used for each text (see Meneghetti et al., 2013). Spatial sentences tested spatial relationships between landmarks from a person’s viewpoint and from a map view ($\alpha = .78$).

Map drawing. A blank sheet of white paper was used to draw a map.

Procedure
Participants were tested individually in a single session (taking around 45 min) organized as follows: first participants completed the SDSR questionnaire; then they heard one of the three descriptions (assigned to one of the six possible combinations of the different types of text) using an MP3 player with headphones; they completed the strategy questionnaire, assessing how much use they had made of each strategy on the Likert scale; then they performed the verification test and drew a map. In the verification test, the E-prime program was used to present the questions in random order on a laptop screen; the sentences remained on the screen until participants had pressed one of the two keys (indicating true and false). Finally, participants drew a map on a sheet of paper to graphically represent the landmarks and their positions.

Results

Scoring
For the verification test, the number of correct answers was counted. For the map-drawing task, a standard procedure was followed (Meneghetti, De Beni, Gyselinck, et al., 2011; Meneghetti et al., 2013): the experimenter corrected each drawing awarding one point for each correctly positioned landmark (i.e., when the landmark was located in the right position preserving the right relationship with others nearby). At the same time, another judge informed about the scoring procedure, – but not about the experimental aims – also corrected the drawings. The scores (maximum 14) were correlated and found strongly associated ($r = .98, p \leq .001$) and subsequent analyses were conducted on the scores awarded by the experimenter.

Descriptive statistics and correlations
Table 1 shows the descriptive statistics for each measure considered and the correlations between the scores.
Model estimation

Path analysis models (i.e., SEM using the observed variables) were computed using the LISREL 8.7 statistical package (Jöreskog & Sörbom, 1996). The observed data indicated a non-significant departure from normality, as shown by Mardia’s measure of kurtosis (MK), which was 1.06 ($1.96 < z < 1.96$; Mardia, 1970). The following fit indices (Jöreskog & Sörbom, 1993) were considered to test the goodness of the model: the root-mean-square error of approximation ($RMSEA$, below .05), the non-normed fit index ($NNFI$, above .97), the comparative fit index ($CFI$, above .97), and a non-significant chi-square (as recommended by Schreiber, Stage, King, Nora, & Barlow, 2006; Schermelleh-Engel, Moosbrugger, & Müller, 2003).

For Study 1, the independent variables were the route, survey, and landmark-focused preferences, while the mediators were the survey, route, and verbal strategies. The models were run considering map-drawing accuracy as the dependent variable, because it was taken to be a representative measure of spatial recall (Meneghetti, De Beni, Gyselinck, et al., 2011; Meneghetti et al., 2013).

The analysis started with a full model, which involved all possible relationships between the predictors, mediators, and dependent variable: the fit was good, $\chi^2(5) = 1.33, p = .93$, $NNFI = 1.14, CFI = 1.00, RMSEA = .0001$, but numerous relationships between variables were not significant. Further models were run, eliminating these insignificant relationships one at a time, starting with the lower values of $\beta$.

The final path model included only the significant relationships between the variables (see Figure 1); it confirmed good fit indices, $NNFI = 1.03, CFI = 1, RMSEA = .0001$, and the chi-square was not significant, $\chi^2(13) = 10.92, p = .63$. This model explained 18% of the variance ($R^2 = .18$).

We found significant positive direct relationships between: survey preference and survey strategy; route preference and route strategy; landmark-focused preference and verbal strategy; survey strategy and map-drawing; route strategy and map drawing.

Table 1. Study 1: Means and standard deviations (in brackets) of visuo-spatial measures considered for the path models and correlations between variables

<table>
<thead>
<tr>
<th>Measures</th>
<th>$M$ (SD)</th>
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<tr>
<td>Spatial/ non-spatial preferences</td>
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<tr>
<td>1. Route preference</td>
<td>6.59 (1.43)</td>
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<td>2. Survey preference</td>
<td>5.29 (1.94)</td>
<td>.20**</td>
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<td>3. Landmark-focused preference</td>
<td>7.45 (1.52)</td>
<td>.30**</td>
<td>.06</td>
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<tr>
<td>Strategies used to memorize descriptions</td>
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<td>4. Route strategy: ‘I imagined moving along a path’</td>
<td>5.51 (1.41)</td>
<td></td>
<td>.19**</td>
<td>.02</td>
<td>.15*</td>
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<tr>
<td>5. Survey strategy: ‘I created a mental map’</td>
<td>4.15 (1.48)</td>
<td></td>
<td>.04</td>
<td>.31**</td>
<td>−.20**</td>
<td>.10</td>
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<tr>
<td>6. Verbal strategy: ‘I repeated the text content’</td>
<td>3.80 (1.45)</td>
<td></td>
<td>−.04</td>
<td>−.09</td>
<td>.17*</td>
<td>−.14*</td>
<td>−.10</td>
</tr>
<tr>
<td>Spatial recall</td>
<td>7.61 (4.59)</td>
<td>.05</td>
<td>.01</td>
<td>−.12</td>
<td>.28**</td>
<td>.28**</td>
<td>−.26**</td>
</tr>
</tbody>
</table>

Note. *$p \leq .05$; **$p \leq .01$. 

Model estimation

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We found significant positive direct relationships between: survey preference and survey strategy; route preference and route strategy; landmark-focused preference and verbal strategy; survey strategy and map-drawing; route strategy and map drawing.
Negative direct relationships were found between: landmark-focused preference and survey strategy; verbal strategy and map drawing (see Figure 1 for the corresponding $b$ values). The significant indirect relationships were: survey preference and map drawing, route preference and map drawing, and landmark-focused preference and map drawing (see Table 3 for the corresponding $b$ and $z$ values).

**Discussion**

Study 1 investigated for the first time how spatial or non-spatial preferences and spatial or non-spatial strategies used to memorize spatial descriptions influence the accuracy of spatial description recall. The results of the final path model confirmed the mediation hypothesis for all predictors. Spatial preferences influenced spatial recall, mediated by the specific use of strategies relying on the same reference frame. Thus, route preference positively affected spatial recall mediated by the use of a route strategy; and survey preference positively influenced spatial recall mediated by the use of a survey strategy. It is worth noting that a landmark-focused preference negatively influenced the use of a verbal strategy, which in turn negatively influenced spatial recall.

**Figure 1.** Study 1: Standardized solutions in the final path model. Note. $*p \leq .05, **p \leq .01, ***p \leq .001$.

Showing that spatial preferences (survey and route) positively influence spatial recall only when mediated by the use of a strategy based on the same frame of reference (survey and route, respectively), and that a landmark-focused preference negatively influences spatial recall mediated by a verbal strategy newly demonstrates how the relationship

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1 Analyses on the results of the verification test in Study 1 were conducted for control purposes. Correlations showed much the same significant relations as for map drawing (the correlations reported here refer to verification test accuracy with route strategy $r = .17$, survey strategy $r = .15$, $p \leq .05$; verbal strategy $r = -.23$, $p \leq .01$). The same path models procedure was used as for map drawing. Starting from Model 1 (involving all possible relations between variables), the final model showed good fit indices, $\text{NNFI} = 1.02$, $\text{CFI} = 1$, $\text{RMSEA} = .0001$, and the chi-square was not significant, $\chi^2 = 10.94$, $p = .93$. The significant direct and indirect relations were similar to those in the path model based on the map-drawing task. The standardized $\beta$ coefficients expressing the relationship between the verification test and the three strategies were significant (survey strategy $\beta = .17$, $p \leq .05$; route strategy $\beta = .14$, $p \leq .05$; verbal strategy $\beta = -.21$, $p \leq .001$). The indirect effects of the preferences on verification test accuracy (mediated by the strategies used) were all significant (survey preference – spatial recall $\beta = .06$, $p \leq .05$; route preference – spatial recall $\beta = .04$, $p \leq .05$; landmark-focused preference – spatial recall $\beta = -.08$, $p \leq .001$). The only difference with respect to the map-drawing path model lies in that a significant direct negative relationship emerged for the verification test and the survey preference ($\beta = -.16$, $p = .05$). The total effect of survey preference on spatial recall was not significant ($\beta = -.10$), but the indirect effect was ($\beta = .06$, $p \leq .05$). This result indicates that the survey preference alone had a negative influence on spatial accuracy, but when this preference was associated with the use of a survey strategy its effect was positive.
between self-reported preferences and strategies may be organized (as predictors and mediators, respectively) in influencing the recall of verbally conveyed spatial content.

Given the importance of spatial cognitive abilities in environment learning (Hegarty et al., 2006; Pazzaglia & Meneghetti, 2012), the aim of Study 2 was to add to our knowledge of how spatial or non-spatial preferences and strategies cooperate with spatial abilities in influencing the mental representation derived from environment descriptions.

STUDY 2

The aim of Study 2 was to explore how spatial preferences and strategies (distinguishing between survey and route modes) are associated with objective spatial abilities in influencing the spatial mental representation derived from spatial descriptions. MR and VSWM abilities were chosen for their relevant role in learning environment descriptions (Gyselinck et al., 2007, 2009; Meneghetti et al., 2009, 2013; Pazzaglia, 2008). A previous mediation model study by Meneghetti, De Beni, Pazzaglia, et al. (2011) showed that MR (measured with the MRT) affects spatial text recall directly and also mediated by VSWM (the latter measured with the backward version of the Corsi blocks task). This finding supports the idea that MR ability is an a priori spatial factor affecting spatial recall and its role is mediated by the WM component dedicated to processing temporary visuo-spatial information.

In Study 2, we newly combined the analysis of spatial cognitive abilities measured with objective tasks (testing MR and VSWM) with spatial self-assessments (specifically examined in Study 1), organizing the variables as followed: MRT performance was considered a predictor on the same level as individual spatial or non-spatial preferences, and VSWM and spatial or non-spatial strategies were considered as mediators. The VSWM was taken to be a first-level mediator to see whether it affects spatial recall not only directly (as already studied in Meneghetti, De Beni, Pazzaglia, et al., 2011) but also through the mediation of spatial strategies, as second-level mediators (given that a relationship between VSWM and specific use of strategies had already been found in Meneghetti, De Beni, Gyselinck, et al., 2011), which in turn would directly affect spatial recall.

We therefore sought to confirm the mediation hypothesis regarding the following: (1) preferences and spatial recall being mediated by the strategy used (as seen in Study 1); (2) MRT and spatial recall being mediated by VSWM (as seen by Meneghetti, De Beni, Pazzaglia, et al., 2011). In addition, we sought for the first time to identify (3) the direct and indirect relationships between spatial abilities (MR and VSWM), spatial or non-spatial preferences, strategies and spatial recall. In particular, we newly examined whether:

1. MR ability is mediated by the use of specific strategies. Given the nearness of MR ability and strategies based on extrinsic frames of reference (Meneghetti, Pazzaglia, et al., 2011; Pazzaglia & De Beni, 2001, 2006), it may be that the MR effect on spatial recall might be mediated by the use of a survey strategy.

2. VSWM mediates the relationship between spatial preferences and spatial strategies, given that VSWM is related both to spatial strategies (Meneghetti, De Beni, Gyselinck, et al, 2011) and to spatial preferences (Baldwin & Reagan, 2009).

Method

Participants

A total of 206 undergraduates (82 male participants, 124 female participants) from the University of Padua (mean age 22.21 years) took part in the study.
Materials

Visuo-spatial objective measures

Mental Rotation Test (MRT, Vandenberg & Kuse, 1978). This involves finding two of four figures (assembled cubes) that match a target figure, but in a rotated position (20 items, time limit 8 min).

VSWM task. The Corsi blocks task (Corsi, 1972) involves sets of blocks placed irregularly on a board being tapped by an experimenter in increasingly long sequences, and participants have to reproduce the sequence in forward or reverse order. The sequences increase from 2 to 9 blocks (and two sets are tapped for each length of sequence). The SDSR scale, strategy questionnaire, spatial descriptions, and recall tasks (verification test and map drawing) were the same as in Study 1.

Procedure

Participants were tested in a single session (lasting around 1 hr), starting with the spatial measures (presented in a balanced order), that is the MRT, Corsi blocks task (in forward and reverse order) and SDSR questionnaire. For the MRT, they read the instructions and had three practice items, and then they completed the task with a time limit of 8 min. For the Corsi blocks task, the experimenter tapped one block per second and participants had to reproduce the same sequence either forwards or backwards. When they failed to reproduce two sequences of a given length correctly, the task was abandoned.

Finally, participants listened to a spatial description twice, then they answered the strategy and verification test, and they drew a map, following the same procedure as in Study 1.

Results

Scoring

For the MRT, one point is awarded for each of the two figures correctly identified. For the Corsi task the final score corresponded to the number of blocks tapped in the longest correctly repeated sequence.

The verification test and map-drawing task were scored in the same way as in Study 1. The map-drawing scores awarded by two independent judges correlated closely ($r = .97$, $p \leq .001$) and subsequent analyses were conducted considering those awarded by the first judge (the experimenter).

Descriptive statistics and correlations

Table 2 shows the descriptive statistics for each measure and the correlations between the variables. The forward version of the Corsi task was omitted from the correlations and path models because it only correlated with the backward version of the same task ($r = .34$, $p \leq .05$).

Model estimation

The MK was 1.04 and did not depart significantly from normality ($-1.96 < z < 1.96$; Mardia, 1970).
### Table 2: Study 2: Means and standard deviations (in brackets) of visuo-spatial measures considered for the path models and correlations between variables

<table>
<thead>
<tr>
<th>Measures</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Spatial abilities</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. MRT</td>
<td>8.20</td>
<td>5.33</td>
<td>6.64</td>
<td>5.47</td>
<td>7.59</td>
<td>6.29</td>
<td>5.46</td>
<td>9.38</td>
</tr>
<tr>
<td>2. Corsi blocks task (backward version)</td>
<td>4.28</td>
<td>1.54</td>
<td>1.98</td>
<td>1.68</td>
<td>1.66</td>
<td>1.10</td>
<td>1.68</td>
<td>3.59</td>
</tr>
<tr>
<td><strong>Spatial/non-spatial preferences</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Route preference</td>
<td>0.9</td>
<td>0.2</td>
<td>0.7</td>
<td>0.1</td>
<td>0.07</td>
<td>0.07</td>
<td>0.05</td>
<td>0.01</td>
</tr>
<tr>
<td>4. Survey preference</td>
<td>0.11</td>
<td>0.11</td>
<td>0.21</td>
<td>0.27</td>
<td>0.27</td>
<td>0.07</td>
<td>0.21</td>
<td>0.29</td>
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<tr>
<td><strong>Strategies used to memorize descriptions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Landmark-focused preference</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.05</td>
<td>0.01</td>
</tr>
<tr>
<td>6. Route strategy: ‘I imagined moving along a path’</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.05</td>
<td>0.01</td>
</tr>
<tr>
<td>7. Survey strategy: ‘I created a mental map’</td>
<td>0.09</td>
<td>0.09</td>
<td>0.09</td>
<td>0.09</td>
<td>0.09</td>
<td>0.09</td>
<td>0.09</td>
<td>0.09</td>
</tr>
<tr>
<td>8. Verbal strategy: ‘I repeated the text content’</td>
<td>0.09</td>
<td>0.09</td>
<td>0.09</td>
<td>0.09</td>
<td>0.09</td>
<td>0.09</td>
<td>0.09</td>
<td>0.09</td>
</tr>
<tr>
<td><strong>Spatial recall</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Map-drawing accuracy</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.05</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Note: *p ≤ .05; **p ≤ .01.
The same path model procedure was used as in Study 1, except that objectively measured spatial abilities were added in Study 2, considering the MRT and the Corsi task (backward version) as a predictor and as a mediator, respectively. Here again, as in Study 1, we included the route, survey and landmark-focused preferences as predictors, and the survey, route, and verbal strategies as mediators; map drawing was the dependent variable considered. The path model thus included two mediators, VSWM and the strategies used. The VSWM should mediate the relationship between MR and spatial recall (as in Meneghetti, De Beni, Pazzaglia, et al., 2011) and it can also intervene in mediating between spatial preferences and strategies used. The strategies should mediate the relationship between spatial preferences and spatial recall (as in Study 1).

The analyses started with a full model, which considered all possible relationships between the predictors, mediators, and dependent variable, showing good fit indices $\chi^2(8) = .43$, $p = 1$, $NNFI = 1.22$, $CFI = 1.00$, $RMSEA = .0001$, but numerous relationships between variables were not significant. To arrive at the final model, a series of intermediate path models were run, removing the insignificant relationships between variables one at a time, starting with the lower $\beta$ values. The final path model included only the significant relationships between the variables (see Figure 2) and showed good fit indices, $NNFI = 1.12$, $CFI = 1$, $RMSEA = .0001$ and the chi-square was not significant, $\chi^2(18) = 5.96$, $p = 1$; it explained 25% of the variance ($R^2 = .25$). The final model showed the direct positive relationships between the MRT and the Corsi task; the MRT and map-drawing accuracy; survey preference and survey strategy; route preference and route strategy; the Corsi task and survey strategy; the Corsi task and map-drawing accuracy; survey strategy and map-drawing accuracy; route strategy and map-drawing accuracy. There was a direct negative relationship between landmark-focused preference and survey strategy (see the corresponding $\beta$ values in Figure 2). No significant relationships were found between verbal strategy and map drawing and the former variable was dropped in the final model.

A significant indirect relationship was found between route preference and map drawing, and a tendency between survey preference and map drawing, consistently with the results of Study 1. Finally, two significant indirect relationships emerged between the

**Figure 2.** Study 2: Standardized solutions in the final path model. Note. *$p \leq .05$, **$p \leq .01$, ***$p \leq .001$, †$p = .06$. 

[Diagram of the final path model]
**Table 3.** Significant indirect effects in Study 1 and Study 2

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Dependent variable</th>
<th>Study 1</th>
<th></th>
<th>Study 2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>B</td>
<td>z</td>
<td></td>
</tr>
<tr>
<td>Survey preference</td>
<td>Spatial recall</td>
<td>Survey strategy</td>
<td>.08</td>
<td>3.00***</td>
<td>.03</td>
</tr>
<tr>
<td>Route preference</td>
<td>Spatial recall</td>
<td>Route strategy</td>
<td>.04</td>
<td>2.00*</td>
<td>.05</td>
</tr>
<tr>
<td>Landmark-focused preference</td>
<td>Spatial recall</td>
<td>Verbal strategya</td>
<td>−.09</td>
<td>3.21***</td>
<td>−</td>
</tr>
<tr>
<td>Mental rotation test (MRT)b</td>
<td>Spatial recall</td>
<td>Corsi taskb, Survey strategy</td>
<td>−</td>
<td>−</td>
<td>.08</td>
</tr>
<tr>
<td>Mental rotation test (MRT)b</td>
<td>Survey strategy</td>
<td>Corsi taskb</td>
<td>−</td>
<td>−</td>
<td>.05</td>
</tr>
</tbody>
</table>

**Note.** *p ≤ .05; **p ≤ .01; ***p ≤ .001; †p = .06.

aThis variable was removed from the final model in Study 2 because the relationship with spatial recall was not significant.
bThese variables were not included in Study 1.

MRT and map drawing, and between the MRT and survey strategy (see in Table 3 the corresponding β and z values).²

**Discussion**

The aim of Study 2 was to investigate how self-assessed spatial preferences for mentally representing the environment (survey vs. route vs. landmark-focused) and strategies reportedly used to memorize spatial descriptions (survey vs. route vs verbal) can be combined with spatial cognitive abilities (MR and VSWM) measured using objective tasks to predict the recall of environment descriptions. First, the final path model consistently confirmed that spatial preferences and spatial recall are mediated by the use of congruent spatial strategies, that is the relationship between spatial preferences and spatial recall was mediated by the use of strategies relying on the same reference frame (survey preference with survey strategy, or route preference with route strategy), as seen in Study 1, although the link between survey preference and survey strategy was weaker than in the former study. This result reinforces the importance of spatial self-assessments (preferences and strategies) in positively influencing spatial recall. Unlike the situation seen in Study 1, the relationship between landmark-focused preference, verbal strategy, and spatial recall was cancelled by the lack of any significant relationship between verbal strategy and spatial recall, while the negative relationship between landmark-focused preference and verbal strategy was preserved.

²Analyses on the verification test in Study 2 were carried out for control purposes. The correlations were significant as they were for the map-drawing task (verification test accuracy with MRT = .27, Corsi task = .29, route strategy r = .23, survey strategy r = .21; p ≤ .05 to p ≤ .01). The same path models procedure was used as for the map-drawing task. Starting from the Model 1 (involving all possible relationships between variables), the final model showed good fit indices, NNFI = 1.07, CFI = 1, RMSEA = .0001, with a chi-square that was not significant, χ² = 11.31, p = .88. The relationship was significant between verification test accuracy and strategies (survey β = .17; route β = .21, p ≤ .05), and between verification test accuracy and spatial abilities (MRT: β = .18; VSWM: β = .22, p ≤ .01), as in the analysis for the map-drawing task. The indirect relations (tracing the same pattern as for the map drawing results) were as follows: survey preference – spatial recall (β = .04, p = .05), route preference – spatial recall (β = .05, p ≤ .05), MRT – spatial recall (β = −.08, p ≤ .001); MRT – survey strategy (β = .05, p = .05). On the other hand, verbal strategy and spatial recall accuracy were not significantly related so this strategy was omitted from the model.
Second, the role of MR ability in predicting spatial recall was direct and mediated by VSTM fully in line with the findings of Meneghetti, De Beni, Pazzaglia, et al., 2011.

Third, the novel finding emerging from Study 2 is the relationship between spatial self-assessments (regarding preferences and strategies) and spatial abilities (in MR and VSTM) in predicting spatial recall. Our results showed that only survey preference and survey strategy correlate with these objectively measured spatial abilities (MR and VSTM). In particular, our final path model showed that the reported use of survey strategy mediated the effect of MR ability and VSTM on spatial recall (and VSTM in turn mediates the relationship between MR ability and survey strategy). The effect of MR ability on spatial recall was thus mediated by a cognitive ability (VSTM) and by the reported use of a spatial strategy based on an extrinsic frame of reference (the survey strategy), while the relationship between route preference and spatial recall was mediated by the route strategy without MR ability and VSTM being involved.

Conclusions
The aim of this research was to investigate how: (1) spatial self-assessments, distinguishing between individual preferences for mentally representing the environment and strategies reportedly used to memorize spatial content; and (2) visuo-spatial abilities (focusing on MR and VSTM) are involved in positively influencing the construction of mental representations from environment information conveyed by means of descriptions. The premises behind this research are that spatial (survey and route) preferences, imagery strategies (self-reported by means of questionnaires), MR ability, and VSTM (measured objectively) influence environment learning (e.g., Gyselinck et al., 2007, 2009; Meneghetti et al., 2009, 2013; Pazzaglia & Meneghetti, 2012). Although some of these individual competences have been found to work together (orientation strategy – VSTM, Baldwin & Reagan, 2009; spatial survey preference – MR ability; Pazzaglia & De Beni, 2001, 2006; MR ability – imagery strategy – VSTM, Meneghetti et al., 2009, 2013) in influencing environment learning from descriptions, there is a paucity of knowledge on how a number of individual spatial factors (spatial preferences, strategies and abilities) can be organized into a model to shed light on how they jointly influence environment description learning. First, we analysed whether self-assessments on people’s environment learning preferences (distinguishing between spatial [survey and route] and non-spatial [landmark focused] preferences) were a priori factors connected specifically with strategies reportedly used to memorize spatial content (again distinguishing between spatial and non-spatial), and whether these strategies influence the recall of spatial descriptions (Study 1). Having demonstrated that the pattern of self-reported preferences worked together with the strategies reportedly used, in Study 2 we tested how these self-assessments combine with spatial cognitive abilities in supporting environment learning.

The final path model of Study 1 (see Figure 1) showed that people’s spatial preferences for orienting themselves influence their recall of spatial descriptions only through the mediation of the spatial strategies they report using to recall spatial information. It emerged that an individual’s stronger preference for survey or route modes positively influenced their reported use of strategies based on the same reference frame (survey and route, respectively), and only these strategies directly influenced their spatial recall efficiency. This pattern of relationships between spatial preferences, spatial strategies, and recall of environment descriptions was fully confirmed in Study 2 as well, underscoring the importance of considering self-reported spatial preferences and
strategies as individual factors influencing how efficiently people can mentally represent an environment. In other words, individuals who prefer to represent information on an environment based on an extrinsic frame of reference (survey mode) are more inclined to form a mental map (survey strategy) when they encode environment descriptions, and this positively influences their recall of spatial descriptions. On the other hand, when people who prefer to represent the information based on an intrinsic frame of reference (route preference) encode spatial content, they are more likely to imagine walking along a path, locating landmarks from their own point of view (route strategy) and this, in turn, generates a good spatial recall performance.

Although these results are consistent with previous reports of environment description learning being positively related to (1) spatial preferences (using the individual differences approach based on selecting individuals with a high or low preference for survey mode (Meneghetti, Pazzaglia, et al., 2011), and on a continuous-level variables approach (Pazzaglia & Meneghetti, 2012); and (2) the specific use of strategies to memorize spatial descriptions (Meneghetti, De Beni, Gyselinck, et al., 2011), we showed here for the first time how preferences and strategies work together – respectively, as a priori and mediator factors – to cope efficiently with the learning of environment descriptions.

The role of a non-spatial preference and a verbal (repetition) strategy – investigated here for the first time – was less clear because the results obtained differed between the two studies. A non-spatial preference was found associated with the use of a verbal strategy, which negatively influenced the accuracy of spatial recall in Study 1, but not in Study 2. The lack of any relationship between verbal strategy and spatial recall in Study 2 may be attributable to the path model analysis including other spatial variables (i.e., spatial abilities), which may contribute to reducing the effect of non-spatial self-reported measures on spatial recall by emphasizing the importance of individual spatial competences in influencing environment learning.

In fact, the final path model of Study 2 (see Figure 2) showed that the contribution of spatial self-assessments cooperates with spatial abilities in explaining more of the variance in spatial recall performance (25%) than in Study 1 (18%).

The MRT performance predicted the recall of spatial descriptions both directly and mediated by VSWM (confirming a previous report from Meneghetti, De Beni, Pazzaglia, et al., 2011). At the same time, these spatial abilities were related to the preference and strategy use based on an extrinsic frame of reference (survey mode), but not to the other preferences and strategies: MR ability affected the recall of spatial descriptions mediated by the use of a survey strategy, which in turn is supported by VSWM. This means that high MR performers need support from their VSWM to apply a survey strategy, the use of which affords a positive influence on their recall of spatial descriptions. In such cases, when individuals with high MR abilities associated with a spatial preference based on an extrinsic frame of reference, that is the survey mode (as shown in Pazzaglia & De Beni, 2001, 2006), learn spatial descriptions from a route perspective (i.e., information presented from a person’s point of view, as they imagine walking along a path), they prefer to use a survey strategy. However, this strategy needs to be supported (mediated) by the VSWM system (i.e., it has to be operationalized in terms of the ability to process spatial sequences of blocks in reverse order).

Overall, the pattern of relationships between spatial variables confirms that spatial abilities and spatial self-assessments concur in efficiently approaching environment learning not only when the environment is acquired visually (e.g., by navigation, Hegarty et al., 2006) but also when environment information is conveyed using
descriptions (as in Pazzaglia & Meneghetti, 2012), though it is the survey mode (preference and strategy) that cooperates with spatial abilities (MR and VSWM) to memorize environment descriptions efficiently. While our results confirmed the relationship existing between MR, VSWM, imagery strategies and route descriptions (Meneghetti, De Beni, Pazzaglia, et al., 2011; Meneghetti et al., 2009, 2013), they also newly demonstrate that spatial self-assessments based on extrinsic reference frames (i.e., a preference for the survey mode for representing the environment) and MR ability are the initial (related) factors that affect spatial recall mediated by the VSWM and a survey strategy (i.e., basing the recall of spatial content on a map view). On a parallel level, a route preference positively influenced spatial recall without interacting with spatial abilities.

On the whole, our findings add to our understanding of the individual variables intervening in environment knowledge acquisition. Siegel and White (1975) postulated, for instance, that the final level of the way of mentally representing one’s knowledge of the environment is based on a map view (survey representation), followed by a route (from a person’s own point of view) and then by a landmark representation (based on knowledge of landmarks), but there is an inter-individual variability in how survey representations are formed that can be attributed, to some degree at least, to individual spatial differences (as suggested by Ishikawa & Montello, 2006). Our results show that, after encoding information from a person’s point of view (as in the case of spatial information being presented from a route perspective), individual spatial differences intervene on various levels to arrive at a mental representation that we tested using tasks based on a mainly extrinsic frame of reference (such as map drawing and the verification test to assess the relationships between landmarks from both a route and a survey perspective, which can be considered at the survey representation level of the Siegel & White model). People approach environment learning starting from their survey or route preferences (working in parallel, as shown by Lawton, 1994; and Pazzaglia et al., 2000) that enable them to apply strategies consistently, based on the same frame of reference, to memorize spatial content. In addition, a survey (but not a route) preference or strategy cooperates with spatial abilities (MR and VSWM), interacting with the latter in the role of predictor or mediator to efficiently approach the recall of spatial descriptions and thus generate a good spatial mental representation.

Although these new results show that spatial preferences and abilities concur in achieving a good mental representation derived from spatial descriptions, it will be interesting to see whether these individual spatial factors are similarly involved when descriptions are encoded using a survey perspective or environment knowledge is acquired from other sources (e.g., visual input or real exploration). Other spatial abilities based on an intrinsic reference frame (e.g., perspective-taking ability) found relevant to environment learning (Kozhevnikov & Hegarty, 2001; Kozhevnikov, Motes, Rasch, & Blajenkova, 2006) might contribute to explaining a part of the variability between individuals when spatial descriptions are used too.

In conclusion, the findings of Studies 1 and 2 consistently showed – for the first time – that individual preferences for both survey and route modes contribute to much the same extent to the efficient recall of spatial content expressed from a person’s point of view, mediated by the use of strategies based on the same reference frame. Study 2 additionally showed that VSWM and MR also interact with survey strategies to positively influence spatial recall, while the effect of a preference for the route mode on spatial recall using a route strategy persists without interacting with spatial abilities.
These results are relevant for their implications when it comes to clinical intervention and training programmes for populations whose visuo-spatial information processing is weak, such as older adults and non-verbal disabled children, who are vulnerable in learning new environments as seen in the elderly (Borella, Meneghetti, Pastore, and De Beni, under revision), and in non-verbal disabled children (Mammarella et al., 2009): improving their spatial abilities, being aware of (and possibly changing) their spatial preferences for orienting themselves, and teaching them spatial strategies for processing information may help to increase their ability to construct environment representations efficiently, possibly having a positive fallout on their well-being in their surroundings.

References


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