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The role of visuospatial and verbal abilities, styles and strategies in predicting visuospatial description accuracy

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ABSTRACT

The aim of the present study was to analyze how visuospatial and verbal abilities, styles and strategies predict and mediate the recall of visuospatial descriptions. A group of 198 participants read short visuospatial and abstract descriptions, and then answered multiple-choice questions and reported the strategies (imagery vs repetition) used to memorize the content. Participants' verbal and spatial abilities, and cognitive styles (distinguishing between visual, spatial and verbal styles) were also assessed. The results of the path analysis showed that there was a direct influence of verbal competence (reading comprehension) on description recall accuracy in both visuospatial and abstract texts; the influence of visuospatial competence (including spatial visualization and visual style) on recall accuracy was limited to the visuospatial description and was mediated by the use of an imagery strategy. Overall, these findings indicate that visuospatial ability, visual style, and imagery strategy jointly influence the accuracy of visuospatial description recall.

1. Introduction

Every day, people frequently acquire visuospatial information from verbal input, when they read descriptions of geographical layouts, such as paths through places in a tourist guide. Spatial descriptions verbally convey information that can be mentally visualized by readers/listeners. Individuals are known to represent visuospatial information drawn from descriptions by constructing mental models, i.e. internal representations that resemble the structure of the corresponding state of affairs in the outside world (Johnson-Laird, 1983; Perrig & Kintsch, 1985; Taylor & Tversky, 1992). Several studies have shown that mental representations derived from spatial descriptions can have different final features (see Pazzaglia, Gyselinck, Cornoldi, & De Beni, 2012 for a review) attributable to various factors. Among these factors, cognitive style, visuospatial ability, and a preference for using certain strategies may have an important role in influencing the final characteristics of the mental representation. No research to date has thoroughly analyzed the combined influence of such individual factors on the learning of spatial descriptions.

Visuospatial competence, involving the ability to generate, retain and transform abstract visual images (Lohman, 1979), can be divided into different sub-competences (e.g. Linn & Petersen, 1985; Uttal et al., 2013), including spatial visualization, or the ability to perform multistep manipulations of complex spatial information (measured, for instance, using the Minnesota Paper Form Board [MPFB]; Likert & Quasha, 1941) – and mental rotation, or the ability to mentally rotate two- or three-dimensional stimuli (measured, for instance, with the Mental Rotations Test [MRT]; Vandenberg & Kuse, 1978). These two subcompetences have a key role in influencing the representation of spatial information (Hegarty, Montello, Richardson, Ishikawa, & Lovelace, 2006; Hegarty & Waller, 2006 for a review), even when it is conveyed using spatial descriptions (see Gyselinck & Meneghetti, 2011; Pazzaglia et al., 2012, for reviews).

Cognitive styles and strategies may also influence information processing. Cognitive styles are generally defined as referred modes of cognitive functioning when acquiring and processing information (Ausburn & Ausburn, 1978; Messick, 1976). Among the various classifications of cognitive styles (for a review see Kozhevnikov, 2007), one of the most popular distinguishes between visual and verbal styles (Paivio, 1971), described as a preference for using visual strategies (the visualizer's style) or verbal strategies (the verbalizer's style) when performing cognitive tasks; these two styles are sometimes conceived as lying at opposite ends of the same dimension (Richardson, 1977). Further studies, conducted mainly by Kozhevnikov and colleagues (e.g. Blajenkova, Kozhevnikov, & Motes, 2006; Kozhevnikov, Blajenkova, & Becker, 2010; Kozhevnikov, Kosslyn, & Shepard, 2005) have led to a new conceptualization of the visualizer's style, distinguishing between spatial and object visualizers: spatial visualizers are people who prefer to manipulate schematic, spatially organized images, while object

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visualizers prefer to work with static images, paying attention to pictorial stimuli such as shape, size and color. Although there is evidence of these distinctions between verbalizers and visualizers (and between spatial and object visualizers) being supported by different neurological activation patterns, as seen in studies on brain lesions (Kraemer, Rosenberg, & Thompson-Schill, 2009; Motes, Malach, & Kozhevnikov, 2008; Oliveri et al., 2012), a distinctive influence of these cognitive styles on cognitive task performance has not been consistently identified (i.e. the relation between cognitive style and performance was confirmed in some cases [Mayer & Massa, 2003; Thomas & McKay, 2010], but not in others [Kollöffel, 2012; Massa & Mayer, 2006]). The conceptualization of a preference for object or spatial visualization seems to produce more consistent results: individuals with a spatial preference perform better in spatial tasks like the MRT (e.g. Blazhenkova & Kozhevnikov, 2009; Kozhevnikov et al., 2010) and spatial environment tasks (such as map learning; Pazzaglia & Moè, 2013), while those with an object or verbal preference perform better in visual and verbal tasks, respectively (e.g. Blazhenkova & Kozhevnikov, 2009).

Taken together, these studies indicate that visual (object and spatial) and verbal cognitive styles can be important in influencing an individual's approach to learning material, though no evidence has been obtained as yet on their role when spatial descriptions are learned. Spatial descriptions are characterized by a verbal format and visuospatial content, so they can be encoded and retained using verbal, visual and spatial strategies, and exploiting verbal and visuospatial abilities. It thus seemed of considerable potential interest to investigate whether, and to what extent the representation of spatial descriptions is influenced by an individual's visual (object), spatial and verbal cognitive styles, and how they combine with the individual's cognitive abilities and the strategies he/she uses to process a text in influencing the accuracy of the resulting spatial representation.

To shed light on this issue, we asked a large sample of participants to read short visuospatial and abstract (control) descriptions, and then answer multiple-choice questions. They were also administered the Verbalizer–Visualizer Questionnaire (VVQ; Richardson, 1977), and the Questionnaire on Visual and Verbal Strategies (QVVS; Antonietti & Giorgetti, 1993, 1998) to ascertain their visual and verbal cognitive styles. The VVQ is the best-known classical measure used to identify a propensity to use verbal or visual strategies in cognitive tasks, and it has been claimed that verbalizers and visualizers can be seen as occupying the opposite ends of the same dimension (Richardson, 1977). Although this alleged unidimensionality has been questioned (Antonietti & Giorgetti, 1998), the questionnaire is sensitive in detecting people's preference for a verbal or a visual cognitive style, which has proved to influence their verbal and visual task performance, respectively (Kirby, Moore, & Schofield, 1988), and been found associated with distinct patterns of neural activation (Kraemer et al., 2009). We administered the QVVS (Antonietti & Giorgetti, 1998) to further assess visualizer/verbalizer cognitive style because of the differences between the two tools: the QVVS records visual and verbal strategies as two separate factors (not as opposite ends of the same dimension, as in the VVQ), and generates two distinct (visual and verbal) scores (e.g. Antonietti & Giorgetti, 1998), which have been found associated with different brain damage profiles (e.g. Oliveri et al., 2012). Moreover, whereas the VVQ concerns the ability to apply a certain strategy, the QVVS indicates the habit of applying it, regardless of the individual's ability to do so effectively. We might therefore expect different outcomes from the two questionnaires, particularly concerning the relations with spatial tasks and accuracy of visuospatial descriptions.

The Object-Spatial Imagery Questionnaire (OSIQ; Blajenkova et al., 2006) was also administered as an up-to-date measure used in the cognitive style domain specifically to assess people's preferences for object or spatial visualization. Participants also completed a Reading Comprehension Task to measure their verbal abilities, and spatial visualization and mental rotation tasks (using the MPFB and the MRT, respectively) to assess their spatial skills.

Participants' self-reported use of imagery/repetition strategies to memorize the visuospatial and abstract texts was also recorded. An analysis of their strategy usage was included in the study because previous research had shown that using imagery strategies (spontaneously or after training) facilitates the construction of accurate mental representations derived from visuospatial descriptions (Meneghetti, De Beni, Gyselinck, & Pazzaglia, 2013; Meneghetti, Pazzaglia, & De Beni, 2011; Meneghetti, Ronconi, Pazzaglia, & De Beni, 2013).

The concomitant influence of all the variables considered on visuospatial and abstract (control) text recall accuracy was thus tested on a continuous level using a path analysis approach. As initial predictors, we considered: i) verbal and spatial cognitive abilities, for their impact on visuospatial text processing (e.g. Meneghetti, Gyselinck, Pazzaglia, & De Beni, 2009; Meneghetti et al., 2011); and ii) cognitive styles, assuming that visual (object or spatial) and verbal preferences influence how a material is processed (as suggested by some studies, e.g. Thomas & McKay, 2010; Kozhevnikov et al., 2010; Pazzaglia & Moè, 2013). As mediators, we considered the reportedly-applied visuospatial (imagery) and verbal (repetition) strategies because their use correlates specifically with accuracy of spatial description recall (as recently demonstrated in Meneghetti, De Beni et al., 2013; Meneghetti, Ronconi et al., 2013). We hypothesized that both spatial abilities and cognitive styles might influence the accuracy of visuospatial description recall, and we examined here (for the first time) to what extent the concomitant influence of both abilities and styles on visuospatial text recall accuracy was mediated by the reported use of imagery and verbal strategies.

At the same time, in addition to visuospatial competence, we also analyzed verbal ability (reading comprehension), verbal style (i.e. a preference for remembering words and sentences) and the use of repetition-based strategies in relation to visuospatial text recall accuracy. Visuospatial and verbal competences could both be involved – given the format used (description) and the spatial content – but if the role of content prevails, then certain visuospatial abilities and styles may have an elective role in supporting accurate mental representations derived from visuospatial descriptions.

For control purposes, we also tested the specific contribution of visuospatial and verbal abilities, styles and strategies to the accuracy of abstract description recall, assuming that verbal competences might be involved and that visuospatial competences might not (or might be only marginally involved) in accuracy of non-visuospatial description recall.

2. Method

2.1. Participants

A sample of 198 undergraduates (68 males and 130 females) attending the University of Padova (mean age 21.59 years) took part in the study.

2.2. Material

2.2.1. Descriptions and verification test

Two short descriptions were used, one visuospatial and one abstract. The visuospatial description concerned a path through an outdoor park, charting a course from the entrance to a waterfall, including two turns and encountering three landmarks (boulevard, bridge and pond) (55 words). The abstract description was an extract from a text written by the Greek philosopher Plato expounding on the concept of “idea” in relation to the maieutic method and the spirit (57 words). These visuospatial and abstract descriptions had previously been chosen from among 8 options (the other 6 descriptions concerned a landscape, forces in physics, moons, features of poems, peace and war, and the concept of “meaning”) because they were judged to have the highest levels of imagery or abstraction, respectively. Using a Likert scale from 1 to 7