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Besides navigation accuracy: Gender differences in strategy selection and level of spatial confidence

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ABSTRACT

A virtual version of the reorientation task was employed to test new behavioral measures of navigation strategies and spatial confidence within a gender-fair assessment approach. The results demonstrated that, from a behavioral point of view, women had lower level of spatial confidence than men regardless of level of accuracy. Moreover, the way men and women selected spatial strategies depended on the arrangement of spatial cues within the environment. In other terms women relied on landmarks under specific conditions compatible with an adaptive combination/associative model of spatial orientation. Finally, the present study emphasized the importance to assess gender differences taking into account specific affective variables and information selection processing, beyond accuracy.

1. Introduction

Spatial orientation is one of the most critical skills in which sex differences, favoring males, are largely documented in all mobile creatures (e.g. Saucier, Shultz, Keller, Cook, & Binsted, 2008; Barkley & Jacobs, 2007; Forcano, Santamaria, Mackintosh, & Chamizo, 2009; Sovrano, Bisazza, & Vallortigara, 2003; Astur, Ortiz, & Sutherland, 1998; Gyselinck, Picucci, Nicolas, & Piolino, 2006). Nevertheless, human research reveals a more nuanced pattern of results than a simple claim of a male superiority. In fact, gender differences in orientation tasks show a large variability (for a review Coluccia & Louse, 2004) that might reflect the multi-component nature of spatial performance (e.g. Wolber & Hagarty, 2010; Botella, Peña, Contreras, Shih, & Santacreu, 2009). Three different cognitive factors might contribute to clarify various aspects of gender differences in spatial orientation, that is, the ability (e.g. Astur et al., 1998; Miller & Santoni, 1986), the strategies adopted to solve the task (e.g. Sandstrom, Kaufman, & Huettel, 1998) and the affective components, i.e. self-confidence (e.g. Bryant, 1991). In particular, the *ability* can be referred as the level of achievement reached by men and women in solving the task and specifies "who is the best at". It is often evaluated in terms of accuracy by measuring variables such as time taken, path lengths, number of wrong directions, number of correct answers.

Spatial strategy, on the other hand, is referred to a quite stable proneness to adopt more readily a class of spatial information or a model of spatial reasoning in order to solve a task (e.g. Cooper & Mumaw, 1985). It regards "how individuals solve a task" and does not imply by itself the concept of achievement (Bosco, Longoni, & Vecchi, 2004; Lawton, 1994, 1996; Sandstrom et al., 1998; Saucier, Green, Leason, & MacFadden, 2002). Converging data, within strategy selection topic, reveal that men and women rely on different spatial cues when navigating (such as) a) *geometric* and *feature*, b) *directional* and *positional* and c) *holistic/configurational* and *analytic/landmark* respectively (e.g. Sandstrom et al., 1998; Barkley & Gabriel, 2007; Glück & Fitting, 2003; Ruggiero, Sergi, & Iachini, 2008; Coluccia, Bosco, & Brandimonte, 2007; Ward, Newcombe, & Overton, 1986). Nevertheless, following the *adaptive combination model*, factors such as *cue salience*, *encoding certainty* and *cue validity* might affect gender differences more than cue type *per se* (Kelly, McNamara, Bodenheimer, Carr, & Rieser, 2009; Kelly & Bischof, 2005; Learmonth, Newcombe, Sheridan, & Jones, 2008; Ratliff & Newcombe, 2008).

Level of spatial confidence also might affect gender differences in spatial performance as it plays a role in determining the emotional appraisal in approaching orientation task (e.g. Moè & Pazzaglia, 2006; Parsons, Adler, & Kaczala, 1982; Schmitz, 1997). Self-confidence usually refers to the beliefs that people have about their own capacities in any kind of tasks. It strongly derives from social expectation, gender beliefs, personal and vicarious experiences (Hackett & Betz, 1981). A strong impact of level of spatial confidence has been showed in both psychometric and navigation assessment (e.g. Bryant, 1991; Cooke-Simpson & Voyer, 2007; Moè & Pazzaglia, 2006; Wraga, Duncan, Jacobs, Helt, & Church, 2006). One common use of level of confidence assumes that it reflects

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memory strength. However previous studies, in different domains, have shown behavioral dissociations between confidence and accuracy (Busey, Tunnicliff, Loftus, & Loftus, 2000; Chua, Schacter, Rand-Giovannetti, & Sperling, 2006), suggesting that they may not be based on entirely the same information. With regard to spatial performance, Parsons et al (1982) demonstrated that women showed lower levels of confidence in their ability to solve spatial tasks even when they perform as well as men (e.g. O'Laughlin & Brubaker, 1998; Beyer & Bowden, 1997).

Literature on gender differences has often focused on identifying who was more adept at solving a task (e.g. Hyde, 2005). According to this intent, highly taxing tasks (e.g. Vecchi & Girelli, 1998; Coluccia & Louse, 2004) have been frequently adopted. In these kinds of tasks, however, the specific contribution of factors affecting spatial performance (i.e. accuracy, strategies and levels of confidence) is hard to interpret. For instance, as task difficulty increases, spatial strategy selection impacts strongly the performance (e.g. Peña, Contreras, Shih, & Santacreu, 2008; McNamara & Scott, 2001). Moreover, when a task is perceived as particularly challenging, gender differences in spatial performance are strongly affected by the trust in its own skills (e.g. Moè & Pazzaglia, 2010). As a matter of facts, aiming to stress gender differences can also lead to disregard *gender-fair assessment* criteria. According to Willingham and Cole (1997), men and women should be tested on "what they are good at". Conceptualizing test fairness as a feature of test validity, the authors suggest a series of criteria that are: a) comparable opportunities for examinees to demonstrate relative proficiency, b) comparable exercises and scores and c) comparable treatment in interpreting the data (p. 359). Gender-fair assessment in virtual navigation tasks, for instance, is promoted whenever a) an adequate training with technological tools and environments is provided and b) instructions are adequately thought to be unbiased for both men and women (e.g. Cherney, 2008; Chilisa, 2000; Campbell & Greenberg, 1993). Moreover, Moè and Pazzaglia (2006) have suggested that gender stereotypes can be manipulated through the instructions overturning gender effect on spatial performance. On the contrary, underestimating gender-fair assessment criteria can lead to maintain social stereotypes (e.g. Cheryan & Bodenhausen, 2000; Schmader, 2002; Maass & Cadinu, 2003). In this view, some important assessment methods in gender research might pay little attention to these criteria developing tasks that differently tax genders. For instance, women have been demonstrated to be slower than men (e.g. Picucci et al., 2010; Cazzato, Basso, Cutini, & Bisiacchi, 2010; Banta Lavenex & Lavenex, 2010; Astur et al., 1998; Woolley et al., 2010), and to became more anxious when the time available is limited (Gavrielidou & Lamers, 2010; Kara, Hong, Chandra, Longborn, & Barkley, 2010). The performance in the widely used water-maze-like tasks (Astur et al., 1998; Morris, Garrud, Rawlins, & O'Keefe, 1982) is based specifically on the time spent and the path covered. As a consequence, the aforesaid systematic differences might threaten the equal opportunity to succeed in this kind of tasks.

The aims of the present study are manifold: a) to confirm the previous studies on substantially equal ability of men and women in the reorientation task, b) to evaluate the fairness of this kind of assessment procedure, and c) to promote two new behavioral measures: spatial strategy and self confidence. In particular, women are expected to adopt, if possible, a landmark strategy. According to the adaptive combination model (e.g. Kelly et al., 2009; Learmonth et al., 2008), they would follow this strategy essentially when landmark is considered as a stable benchmark. Men, on the other hand, would be less sensitive to the stability of landmark and would adopt spatial strategies in a more flexible manner (e.g. Castelli, Latini Corazzini, & Geminiani, 2008) showing to employ both landmark/feature and geometric strategies.

1.1. The experiment

The present study evaluates the contribution of the aforementioned components in spatial orientation performance adopting a gender-fair assessment. Reorientation paradigm (e.g. Hermer & Spelke, 1994, 1996) seems a suitable tool to reach this goal. It is a searching task allowing to assess the ability to use different sources of spatial information (i.e. geometrical, featural or both) after a disorientation procedure. The main assumption of this paradigm is that individuals and non-human animals can rely on two sources of information, i.e. information given by the shape of the environment and information given by the features (visual, auditory, olfactory, haptic cues), in order to reorient after being disoriented. A typical reorientation task, as described in Cheng (1986) and in Hermer and Spelke (1994, 1996) consists of: a) a learning phase, in which participants are free to navigate and explore an environment, and have to encode the location of a target stimulus (i.e. a source of food for rats, a toy for children, a distinctive object for adults), b) a disorientation phase, in which participants are blindfolded and rotated on themselves, thus perturbing their self reference system, and c) a testing phase, in which participants have to navigate the environment and find the hidden target previously shown. A virtual implementation of reorientation paradigm (VRP) already employed in Bosco, Picucci, Caffò, Lancioni, and Gyselinck (2008), Picucci, Caffò, and Bosco (2009), Picucci et al. (2010), Picucci and Bosco (2006) is adopted. To date, a direct comparison between real and virtual versions of reorientation paradigm is not available. Nonetheless, Picucci (2008, unpublished doctoral dissertation), trough a Goodness of Fit Analysis, demonstrated that Hermer and Spelke's results (1996) on the real version of the task were comparable with those obtained on VRP. As a matter of facts, the VRP is a virtual analogue of the original paradigm which allows to obtain a suitable experimental control on the procedure (Bosco et al., 2008; Picucci et al., 2010). It also allows a new methodology allowing to behaviorally specify/separate abilities from spatial strategies and level of self-confidence. This is particularly noticeable since usually self-report questionnaires have to be employed, in combination with experimental manipulations, to obtain an assessment of strategies and affective factors. Adopting these behavioral measures may prevent from biases commonly found in self-report questionnaire and favoring a more reliable assessment of components affecting spatial performances as they are actually expressed by participants during the task. In addition, the adoption of VRP may fill the lack of systematic studies on gender differences in this research paradigm (e.g. Cheng & Newcombe, 2005; see also Voyer, Postma, Brake, & Imperato-McGinley, 2007). The VRP seems suitable to ensure a gender-fair assessment providing the same starting condition for both men and women since a) participants did not have to recur to metric/coordinate information in order to locate the target (e.g. Iachini, Sergi, Ruggiero, & Gnisci, 2005), b) landmark was presented in a stable manner (e.g. Kelly & Bischof, 2008), and c) time and path did not influence the measuring of accuracy. Ability, strategies and level of spatial confidence were the main measures taken into account in the present study. In order to control for fairness, the performance was properly evaluated to show men and women were able to reach the excellence in a comparable manner. At the same time, path travelled and time taken are not considered as critical markers of spatial ability. As mentioned above, women are slower than men and become anxious in time limited tasks (e.g. Gavrielidou & Lamers, 2010; Picucci et al., 2010; Cazzato et al., 2010). In the present study, results on time and path are provided as variables supporting the internal validity of the paradigm and completing the sight on gender-related differences in this spatial navigation task (e.g. Glück & Fitting, 2003; Picucci et al., 2009). Accuracy was evaluated in terms of number of correct searching.