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Travel planning in men and women. Who is better?

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Abstract

Gender differences are often reported in spatial abilities, most of the times favouring men. Even during wayfinding, which requires planning and decision-making, such as choosing roads to take or shortcuts, men are in general better and faster than women. Although different interpretations have been proposed to explain men's advantage in navigation, no study has explored the possibility that it could be due to men's better travel planning ability. This latter has been recently identified as a distinct kind of planning that allows implementing an efficient navigational strategy in accordance with the environmental features. Therefore, the present study was aimed at investigating gender differences in travel planning ability. We compared men and women in performing the Key Search Task that requires to implement a strategy to search for a lost object in a wide imagined space. Results showed that men outperform women in both the overall performance and in some specific indexes of the total score. Men had a better travel planning ability with respect to women, outperforming women in configuring the planned strategy and choosing the best point to enter the imagined field. Therefore, men seem to plan the best navigational strategy and appear more cognitively flexible than women in adapting the strategy at the environmental features. The two genders did not differ in the time spent to solve the task. This finding suggests that differences in travel planning skills can contribute in explaining gender differences in wayfinding and spatial orientation.

Keywords Travel planning · Navigational planning · Sex differences · Spatial navigation · Spatial orientation · Spatial planning

Introduction

Gender differences in spatial cognition have been widely studied (e.g., Lawton, 2010; Palmiero, Nori, Rogolino, D'Amico, & Piccardi, 2016; Levine, Foley, Lourenco, Ehrlich, & Ratliff, 2016; Munion, Stefanucci, Rovira, Squire, & Hendricks, 2019). Men outperform women in many tasks, especially in spatial perception, mental rotation (Montello, Lovelace, Golledge, & Self, 1999; Voyer, Voyer, & Bryden, 1995), and visuo-spatial working memory (Piccardi et al., 2019; Voyer, Voyer, & Saint-Aubin, 2017). On the other hand, women perform better than men in object location memory (Lawton, 2010), in verbal episodic memory (Herlitz & Rehnman, 2008), in remembering to do an event-based task (e.g., prompted by an external event) and when the task required a physical response modality (Palermo et al., 2016).

Gender is also one of the many internal factors that influence the ability to orient oneself in the environment (e.g., Lopez, Postma, & Bosco, 2020; Causse, Chua, & Rémy, 2019; Nori, Grandicelli, & Giusberti, 2009; Nori et al., 2018; León, Tascón, & Cimadevilla, 2016; Lawton, 2010; Montello & Sas, 2006). Specifically, if compared to women, men are better at reading maps, mentally transforming environmental information, and estimating distances (e.g., Lawton, 2010). Generally speaking, wayfinding requires a goal to reach, which is located beyond the local surround. This implies the involvement of decision-making and problem-solving skills, such as choosing the roads to take, creating shortcuts, as well as scheduling trips (Montello, 2005). During wayfinding, men take significantly more shortcuts (Boone, Gong, & Hegarty, 2018; Boone, Maghen, & Hegarty, 2019), commit fewer errors and take less time to find the exit of a maze (Moffat, Hampson, & Hatzipantelis, 1998; Sandstrom, Kaufman, & Huettel, 1998) even when asked to find the best route to reach a destination passing on a series of

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sub-goals on a computer screen (e.g., The Map task; Basso & Bisiacchi, 1999; Cazzato, Basso, Cutini, & Bisiacchi, 2010). Several interpretations have been proposed to explain this advantage. Men seem to acquire more quickly high-order spatial knowledge of the environment that is crucial to choose the best strategy to reach a goal (Boone et al., 2019). Men and women pay attention to different environmental features and cues while navigating, such as eliciting different strategies to spatial orient through the world. Men seem to rely on global reference points and configurational or "survey strategies". Women, indeed, show the use of landmarks (environmental objects that people use as reference points, Nico et al., 2008) and procedural "route strategies" on how to get from one place to another (Galea & Kimura, 1993; Lawton, 1994; Lawton, 1996; Lawton, Charleston, & Zieles, 1996; O'Laughlin & Brubaker, 1998). This also means that women prefer using an egocentric strategy (that relies on body-to-object spatial relations) (Chen, Chang, & Chang, 2009) and men prefer using an allocentric strategy (that relies on object-to-object spatial relations) (Lawton, 2010). However, another possible explanation for the gender difference in wayfinding is that men and women differ in their ability to plan the best sequence of actions to reach a goal, that is, travel planning: a specific skill recently distinguished from other forms of planning (Bocchi et al., 2020).

Travel planning is specifically involved in navigational situations, for instance when it is necessary to build an efficient strategy to reach an environmental goal. It implies to mentally evaluating and selecting the best solution for reaching the goal, among many imagined alternative actions (Arleo & Rondi-Reig, 2007; Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005), as well as finding an alternative route when the road we usually take is interrupted. Undoubtedly, travel planning is closely linked to the environmental context in which navigation takes place (Bocchi, Carrieri, Lancia, Quaresima, & Piccardi, 2017). As spatial orientation, even travel planning may be influenced by both internal and external factors (Gärling, Böök, & Lindberg, 1986; Kitchin, 1994; Nori & Giusberti, 2006; Piccardi, Iaria, Bianchini, Zompanti, & Guariglia, 2011). Among external factors, the spatial layout (environmental size, the number of possible destinations and routes) and the degree of landmark differentiation can drive the type of strategy to adopt. When the environmental layout is simple, individuals maintain more easily the direction and have more chances to choose the right route (Evans, Skorpanich, Gärling, Bryant, & Bresolin, 1984; Gärling et al., 1986). Similarly, individuals show better wayfinding skills when environmental features are easily distinguishable by size, shape, or architectural style (Evans et al., 1984). Among internal factors, instead, environmental knowledge (Piccardi et al., 2019), spatial cognitive style (Bocchi et al., 2018; Bocchi, Palmiero, Nori, Verde, & Piccardi, 2019) and skills (i.e., mental imagery, cognitive flexibility, mental rotation, visuo-spatial working memory) that are strictly related to spatial ability (Bocchi et al., 2017; Piccardi, Bocchi, Palmiero, Verde, & Nori, 2017; Sharma, Chandra, Singh, & Mittal, 2016; Byrne, Becker, & Burgess, 2007; Schacter, Addis, & Buckner, 2007; Schacter, Benoit, & Szpunar, 2017; Meneghetti et al., 2016; Pazzaglia & De Beni, 2006; Pazzaglia, Meneghetti, & Ronconi, 2018; Lopez, Caffò, & Bosco, 2019; Lopez et al., 2020; Coluccia & Louse, 2004; Picucci, Caffò, & Bosco, 2011).

Therefore, the present study was aimed at investigating for the first time if men and women show different travel planning skills, that is, differences in the specific ability that allows to implement the best sequence of actions to a goal. Indeed, although many studies have addressed gender issue in spatial navigation, no study so far suggested that these differences could be due to travel planning as a particular ability. After all, a good travel planning may be predictive of the positive outcome in quickly reaching the goal, while on the contrary, being unable to plan the correct sequence of navigational actions can cause a waste of time or get us lost without reaching the goal at all. Indeed, good travelers are those who can implement good navigation strategies (Liben, Myers, & Christensen, 2010; Bocchi et al., 2019): Bocchi et al. (2019) showed that people with a survey spatial cognitive style (individuals that use a map-like representation of the environment to orient themselves and are considered proficient navigators), that are very efficient in finding an alternative shortcut to reach a final destination and creating an interconnected network among different paths without relying on the aid of landmarks (Nori & Piccardi, 2011), performed better the Key Search Task (KST).

The hypothesis was formulated as follows: men are better than women in travel planning, in terms of both strategy (the best sequence of actions to reach a goal) and time spent to implement it. To test this hypothesis, we used the KST (Wilson, Alderman, Burgess, Emslie, & Evans, 1996), an ecological test that requires to search a lost object (a set of keys) in a wide imagined space and that requires to plan and implement the strategy that fit the best with the environmental features.

Material and Methods

Participants

A statistical power analysis was performed for sample size estimation. Since no previous studies investigated gender differences in travel planning ability, we set the effect size as medium (0.30) using Cohen's (1988) criterion. With alpha =0.05 and power = 0.90, the projected sample size needed with this effect size (G Power 3.1) was approximately $N =$ 120 for the between group comparison.

One-hundred and twenty-six college students (mean age 25.72 ± 4.31 years; educational level: 13.26 ± 1.09 years) attending the Psychology course were recruited at L'Aquila University (L'Aquila, Italy). They accepted to participate in exchange for extra credits. Before taking part in the study, participants filled in a questionnaire by which they self-reported any previous/current neurological or psychiatric disorders. The inclusion criterion was no history of neurological/psychiatric diseases (including substance abuse or dependence). None of the participants was excluded. Participants were divided in two groups according to their gender: 65 Men (M) (mean age 25.75 ± 3.99; mean educational level 13.26 ± 1.29) and 61 women (F) (mean age: 25.68 ± 4.66; mean educational level: 13.27 ± 0.85). Age was comparable between the two groups [$F_{(1,124)} = 0.007$; $p = 0.933$] as well as educational level [$F_{(1,124)} = 0.008$; $p = 0.931$]. According to the Declaration of Helsinki, before the assessment and after a full explanation of the protocol in which the clear non-invasiveness of the study was reported, a written informed consent was obtained from all participants included in the study. The study was approved by the local Ethics Committee.

Procedure

The study was conducted in a quiet room where participants were assessed individually. They were asked to sit on a comfortable chair in front of the experimenter. They were informed about the procedure, signed the informed consent, gave the authorization to use their personal data and reported a brief medical history. Afterwards, participants underwent the KST.

Compliance with Ethical Standards

At the beginning of each experimental session, the experimenter gave and explained to the participants a leaflet with all the information regarding the aim, procedure, risks and advantages of the study. Participants were also informed about their rights and about the possibility to leave the study at any time they deemed it appropriate.

The KST

The Key Search Task (Wilson et al., 1996) is an easy-to-administer and ecological test. It is one of the subtests of the 'Behavioural Assessment of the Dysexecutive Syndrome' (BADS: Wilson et al., 1996), and it has been recently adopted to assess travel planning (Bocchi et al., 2017, 2019, 2020; Carrieri et al., 2018). It consists of an A4-sized piece of paper with the drawing of a 10×10 cm empty black square in the middle and a small black dot placed 5 cm below the centre of the base of the square (see Fig. 1). Participants were told to imagine that the square was a large field in which they had lost their keys. They were asked to draw a line (through with a marker), starting on the black dot (representing the starting point) to begin the searching of the keys. Participants were required to draw the path they would have followed for being sure to find the keys. They only knew that the lost keys were somewhere in the field, but they did not know exactly where.

According to the BADS handbook (Wilson et al., 1996), the KST is evaluated with a total score obtained by summing five different subscores: (1) EN—entry in the field: 3 points if the participant enters in the square within 10 mm from one of the two angles on the square basis, 2 points if the participant enters the squares from any point on the square basis (beyond 10 mm from the angle), 1 point if the participant enters the square from any other point; (2) EX—exit from the field: 3 points if the participant ends his/her pursue within 10 mm from any angle of the square, 2 points if the participant exit from the field in any point along the square basis, 1 point if the participant stops searching along any of the square sides beyond the 10 mm, 0 points if the participant does not end on the field perimeter or ends in any other point of the field. (3) CL—presence of a continuous line (pen stroke): 1 point if the participant does not rise the pen while tracking the route, or rises the pen but continues tracking from the interruption point as in a continuous line, 0 point if the participant raises the pen from the sheet and then continues tracking the route from a distant point, as if he/she 'jumped' from a point to another. (4) CO—searching a layout: 5 points if the participant searches the key using one of the efficient systematic configurations often used by people to search a lost object, 3 points if the participant uses a 'mixed' configuration resulting from using two or more different configurations together, 0 point if the participant does not use a systematic configuration. (5) FC—field coverage: regardless of the configuration used, 1 point if the participant clearly tries to search all over the field without leaving 'uncovered points', 0 point if the participant does not try to explore the field. The raw score was obtained summing the score reached by the participant in each variable (max 13) and represented the indicator of the KST performance. The time employed to complete the KST was also recorded.

Regarding inter-rater reliability of the KST, according to the handbook of the BADS (Wilson et al., 1996), which the KST is taken from, two different examiners assessed the performance at the subtests of the BADS, among these, the KST performance. Moreover, at the end of the test, the two examiners independently assessed the salient aspects of the KST. In addition, to ensure the coherence in the scoring of the patterns of KST, the scoring has been done again from a therapist of the Applied Psychology Unit Subject Panel. Results showed that the values of inter-rater reliability are very high (alpha: 0.88 to 1.00). Despite the complexity of the scoring of the KST, the value of inter-rater reliability is very high (alpha: 0.99).

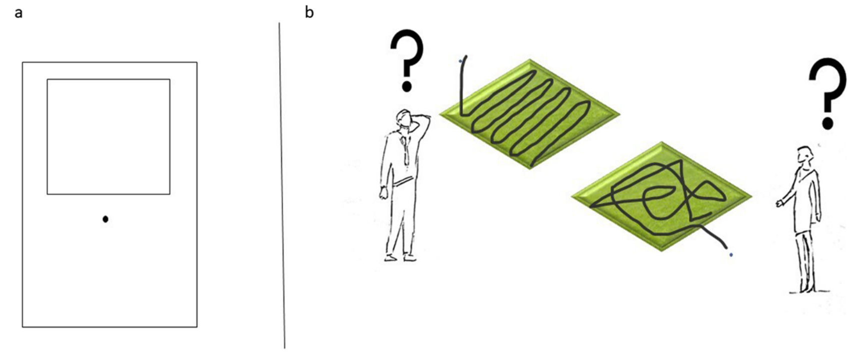

Fig. 1 **a** the Key Search Task: an A4 sheet of paper with a square of 10 × 10 cm and a dot below the square basis; **b** an example of how men and women perform the KST. While men implement an efficient strategy with a repetitive configuration, women showed no systematic configuration in their strategy

Statistical Analyses and Results

To investigate if the two groups (M: men and F: women) differed in the KST score and in the time spent to complete the KST, two separate one-way ANOVAs were carried out. In the first ANOVA, Group (M and F) was set as the between factor and total score of KST as the dependent variable. In the second ANOVA, Group (M and F) was set as the between factor and time of the KST as the dependent variable. The alpha level was set at 0.05.

Groups differed significantly for the KST total score [$F_{(1, 124)} = 10.291$; $p = 0.002$; partial $\eta2 = 0.409$]. Men had a significantly better performance compared to women. Regarding time to complete the KST no difference was found between groups [$F_{(1, 124)} = 0.18$; $p = 0.895$; partial $\eta2 = 0.842$]. Means and standard deviations of the KST score and the KST time are reported in Table 1.

To investigate if the two groups differed in a specific aspect of KST, [EN—entry in the field, EX—exit from the field, CL—presence of a continuous line, CO—searching of a layout (configuration), FC—field coverage], a MANOVA was carried out with Group (M, F) as the between factor and subscores of the KST (EN—entry in the field, EX—exit from the field, CL—presence of a continuous line, CO—searching of a layout/configuration, FC—field coverage) as the dependent variables.

The MANOVA analysis revealed a significant effect of the variable 'Group' [Lambda Wilks = 0.903, F (5, 120) = 2.571, $p = 0.030$; partial $\eta2 = 0.097$]. The Univariate ANOVA revealed that gender showed significant effects in: KST-EN [$F_{(1,\ 124)} = 7.784$, $p = 0.006$; partial $\eta2 = 0.059$], KST-CO [$F(1, 124) = 7.168$, $p = 0.008$; partial $\eta2 = 0.055$].

Table 1 Means and standard deviations of KST total score and KST time in male and female groups.

	Male $n=65$	Female $n=61$
KST total score	8.63 (3.60)	6.61 (3.48)
KST time	52.77 (39.66)	51.80 (42.17)

Discussion

The study investigated if women and men showed a different travel planning ability, that is, a different ability to implement the best strategy to solve a navigational task. Results showed that men outperformed women in the overall performance, but no gender difference was found in the time spent to complete the KST. Moreover, men performed better in some specific indexes of KST, that is, EN-entry and CO-configuration.

This latter is certainly the most complex score in KST and also the one that better reflects the characteristics of travel planning. Indeed, also configuration suffers from the environmental features: it is the index that represents the individual's skills to choose the strategy that best suits the environmental features. For this reason, the KST configuration index, like travel planning, is related to the cognitive flexibility of the person (Scott, 1962; Bocchi et al., 2017; Harris & Wolbers, 2014). The field in which is required to search for the lost key does not have any reference point, so the best way to search the key is using an organized searching strategy, with a repetitive layout (see fig. 1), which allows to explore all over the field while keeping track of the places already visited (Wilson et al., 1996). Respect to women, men appear more flexible in adapting their strategy to the navigational task. These results are also consistent with both Cazzato et al. (2010) and Bosco, Longoni, and Vecchi (2004), who found that men performed better than women since they were able to adapt their strategy according to the task requirements. Cazzato et al. (2010) also reported that men changed their strategy during the execution of the task more often if compared to women, who preferred to adopt a constant strategy. Similarly, Coluccia and Louse (2004) suggested that men performed better in spatial orientation because they spontaneously preferred more complete strategies and because they could swap easily their strategies, in line with the available information.

Several factors have been proposed to explain why men have more flexible strategies in spatial navigation, such as socio-cultural or biological ones (Coluccia & Louse, 2004; Lawton, 2010). Hormones manipulation affects spatial memory (Williams, Barnett, & Meck, 1990) such that a single administration of testosterone seems to improve visuo-spatial abilities in young women (Aleman, Bronk, Kessels, Koppeschaar, & Van Honk, 2004). Moreover, according to Annett (1992) women seem more disadvantaged than males in spatial ability because they have an advantage in the early development of the left hemisphere for language, while men show the opposite pattern. Men and women also undergo different life experiences, particularly regarding the spatial demands associated with the activities in which boys and girls participate (Baenninger & Newcombe, 1989). Men spent more time in activities that enhance the development of spatial skills (Lawton & Morrin, 1999), play more exploratory games, team sports, LEGO-construction (Goldberg & Lewis, 1969; Baenninger & Newcombe, 1989) and videogames (Barnett et al., 1997).

For what specifically attains travel planning ability, it must be considered that men seem to reach more easily high-order spatial knowledge that is fundamental to flexibly adapt to the environmental features, finding a shortcut and implementing a strategy (Boone et al., 2019; Coluccia & Louse, 2004). Indeed, high-order spatial knowledge, together with mental imagery, allows to better represent the environment and its features, that is, allow to form a more detailed cognitive map of the environment (Tolman, 1948) but also to manipulate and rotate it to easily find the destination (Palermo, Iaria, & Guariglia, 2008). Men are also field-independent more often than women, that is to say, they rely on an internal frame of reference in processing and organizing environmental information and are not susceptible to deceptive environmental cues (Boccia, Piccardi, D'Alessandro, Nori, & Guariglia, 2017). Also, as evidenced in previous studies (Bocchi et al., 2017; Piccardi, Bianchini, Zompanti, & Guariglia, 2008), the KST has a strong imaginative component, indeed to implement the right strategy it is necessary to imagine a wide field. So, it is likely that men are better than women in an imagined space without reference points. Indeed, it is known in literature that although landmarks generally play a key role in navigational tasks (Palmiero & Piccardi, 2017), women are more prone than men to orient themselves by using landmarks and to provide environmental directions enriched by details about landmarks' position along the route (Nori et al., 2009; Lawton, 2010; Piccardi et al., 2011; Tascòn, Boccia, Piccardi, & Cimadevilla, 2017). Differently, men are better than women in processing environmental metric properties and in building up a mental representation of the environment that allow them to correctly plan a navigational strategy. In line with this, men were also better than women in KST –EN, an index of the test in which the participant gets the maximum score when enters in the field within 10 mm from an angle of the square. This finding is explained by the evidence that men are more prone than women in processing geometrical configuration (layout) of the environment (e.g., Lawton, 2010).

Undoubtedly, the presence of gender differences in performing KST may depend on the requirements of the task itself. Indeed, it has been found that gender differences in spatial abilities may be explained by some components, such as the kind of environmental information available to the performer, and the reliability of environmental available cues, as well as the presence of time constrains and the possibility to choose flexible strategies (Doeller, King, & Burgess, 2008; Etchamendy & Bohbot, 2007; Foo, Warren, Duchon, & Tarr, 2005; Iaria, Petrides, Dagher, Pike, & Bohbot, 2003).

Regarding KST time, unlike from other studies (Bosco et al., 2004; Cazzato et al., 2010; Moffat et al., 1998), we did not find a gender difference in time spent to complete the KST. This was probably due to the fact that participants were not told to perform as quickly as they could, and no time limit was given. Moreover, the KST requires an execution time because the task requires not only to plan the strategy but also to draw it. So, it is possible that men spent their time implementing an accurate strategy, while women spent the same amount of time executing a disorganized strategy. Undoubtedly a future study should disambiguate this aspect taking separate time for the ideation and the execution phases, respectively. In the next future, it will be also interesting to investigate travel planning by using tests that allow to explore its different aspects. For instance, it would be helpful to include tests that require to directly move in a real environment and to use standard navigation tasks in order to provide evidence that travel planning is a predictor of navigation ability.

In conclusion, the present study showed the presence of gender differences in travel planning that could explain men' and women' different performances in navigational tasks. Indeed, despite no direct evidence is still available in more ecological settings, travel planning seems to affect positively the navigational performance (Bocchi et al., 2017, 2019). This is an interesting result that may disambiguate also some contrasting findings as well as to partially explain the wide variability between men and women in performing navigational tasks (e.g., Coluccia & Louse, 2004; Wolbers & Hegarty, 2010).

Code Availability not applicable.

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Data Availability The data contained and processed in this paper are available at the corresponding author upon request.

Declarations

Ethics Approval All procedures performed in this study were conducted in accordance with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Consent to Participate Informed consent was obtained from all individual participants included in the study.

Consent for Publication Not applicable.

Conflicts of Interest/Competing Interests The authors declare that they have no conflict of interest.

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