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SHORT PAPER

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Orienteering: What relation with visuospatial abilities, wayfinding attitudes, and environment learning?

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Abstract

Orienteering is a sport that involves navigating. As navigation skills relate to individual visuospatial factors, it is worth examining whether practicing orienteering is associated with people's visuospatial abilities and wayfinding attitudes. A sample of 51 participants comprising three groups of 17 individuals with different orienteering expertise (experts, beginners, and controls—people that do not practice sport) completed visuospatial cognitive tasks and wayfinding attitude questionnaires, and were assessed on their everyday spatial habits and map learning. Results of Bayesian analysis showed that experts scored higher than controls in most visuospatial tasks, reported more positive wayfinding attitudes (sense of direction, knowledge of cardinal points, everyday map use), and learned better from maps. Beginners generally performed better than controls and less well than experts did. These results show that orienteering relates with individual visuospatial abilities, attitudes, spatial habits, and spatial learning. They are discussed within the frame of motor activities and spatial cognition.

KEYWORDS
mental maps, navigation, orienteering, visuospatial abilities, wayfinding attitudes

1 | INTRODUCTION

1.1 | Wayfinding and orienteering

Navigation is a complex skill (Wolbers & Hegarty, 2010) with a locomotion component (involving body movements coordinated with local and proximal surroundings) and a wayfinding component (which entails goal-directed and planned movement through the environment). Wayfinding can involve several tasks, one being path search (Wiener et al., 2009): moving toward a target at an only approximately known location through an unfamiliar environment, with no prior knowledge of the space in between. Reaching this target by the shortest route is even more complicated. This is a wayfinding task involved in orienteering. Orienteering is a sport that combines running with wayfinding and in which path search has a fundamental role. Using only compasses and highly detailed maps, orienteers run as fast as possible to a series of control points circled on their maps, and identified on the ground with flags. Importantly, no route between control points is specified and orienteers have no prior knowledge of the environment. To win, they must both run the fastest and find the shortest route.

1.2 | Domain-specific and general aspects of orienteering

Studies on orienteers have examined both the specific and the general aspects of orienteering. Studies on domain-specific skills investigated how orienteers move and locate themselves in the environment (Mottet & Saury, 2013), or how and where they focus their attention during races (Eccles et al., 2002; Mottet et al., 2016) to circumvent information-processing limitations (Eccles, 2006). The results showed that how orienteers locate themselves while navigating is related to races' phases and time pressures (Mottet et al., 2016; Mottet & Saury, 2013), and that experts are able to fold and use a map efficiently to anticipate features of the terrain, and memorize a simplified representation of the environment to overcome processing limitations. The authors argued that orienteers' stronger cognitive abilities might stem from their developing specific field strategies (Eccles, 2008; Eccles et al., 2002, 2006).

Concerning relations between practicing sports and general abilities, it has been demonstrated that athletes' cognitive abilities are superior to those of non-athletes, in terms of processing speed, attention, visuo-perception, and executive functions, with small-medium effects sizes (Chang & Etnier, 2015; Etnier et al., 1997; Scharfen & Memmert, 2019; Voss et al., 2010 for reviews and meta-analyses). There is evidence of this in orienteers too, though studies have focused mainly on attention and perception (measured with laboratory tasks; Cereatti et al., 2009; Commons-Miller & Commons, 2003; Pesce et al., 2007; Zach et al., 2015). Orienteers rely heavily on wayfinding experience, and this enables us to consider other, more general aspects, such as small-scale visuospatial abilities, large-scale environment learning abilities, and wayfinding attitudes.

Visuospatial abilities are small-scale abilities needed to generate, retain, and transform abstract visual images (Lohman, 1988) generally measured with paper and pencil tasks. They include distinct factors like spatial visualization (the ability to manage spatial stimuli) or rotation, be it object-based (mental rotation) or subject-based (perspective taking, or mentally turning oneself in relation to the environment) (Uttal et al., 2013). Visuospatial abilities have been consistently related to large-scale abilities like environment learning (Hegarty et al., 2006). On the other hand, wayfinding attitudes are generally assessed using self-report questionnaires, referring to perceived sense of direction (Pazzaglia & Meneghetti, 2017), spatial anxiety (Lawton, 1994), pleasure in exploring places (Meneghetti et al., 2014), and preferred type of environment representation (Pazzaglia & Meneghetti, 2017). Wayfinding attitudes have also been found related to visuospatial abilities and environment learning (Hegarty et al., 2006; Pazzaglia et al., 2018).

Some evidence has been produced on how orienteering relates to visuospatial abilities. As concerns small-scale visuospatial abilities, people with stronger mental rotation abilities were better in orienteering races (Malinowski, 2001), and that orienteers performed better in mental rotation tasks than non-practitioners (Schmidt et al., 2016). Orienteering training improved participants' spatial visualization performance, both object- and subject-based rotation (Roca-González et al., 2017), and their spatial working memory too (Notarnicola et al., 2012). This suggests a relation between orienteering and small-scale visuospatial abilities, but no systematic evidence has been collected to date.

Wayfinding attitudes have rarely been examined in relation to orienteering. To our knowledge, only Cornoldi et al. (2003) showed that orienteering experts have a stronger sense of direction (than non-practitioners or beginners), and reported higher survey (map-based) environment representations, while they did not differ on landmark and route representation modes.

These studies suggest that orienteering can relate to visuospatial abilities and wayfinding attitudes, but the matter deserves further investigation because the evidence only concerns visuospatial abilities, while wayfinding attitudes have rarely been considered. Also, although navigation (large-scale) is related to visuospatial abilities (small-scale) and wayfinding attitudes (Hegarty et al., 2006), no studies have examined whether successful orienteering (as a navigation-like experience) is related to better environment representations.

1.3 | Rationale and aim of the study

As the relation between orienteering (a navigation-based practice) and visuospatial abilities, and competences in general, has not been studied systematically, we compared expert orienteers, beginners, and non-orienteering controls on their visuospatial abilities; wayfinding attitudes; everyday spatial habits; and environment learning ability.

To this purpose, we administered a set of visuospatial tasks measuring rotation (object- and subject-based) and spatial visualization, and questionnaires measuring wayfinding attitudes (these measures have been chosen because they relate to environment learning; e.g. Hegarty et al., 2006). We also examined everyday spatial habits, such as map use, and getting lost frequency (Meneghetti et al., 2020), and environment learning from maps, assessing its representation properties with a pointing task (Levine, 1982).

We expected experts to perform better than controls in visuospatial tasks, with differences depending on the type of task because specific sports affect different visuospatial abilities (Voyer & Jansen, 2017). In particular, we expected differences in object-based mental rotation (Schmidt et al., 2016), and possibly also in perspective taking (subject-based rotation) and spatial visualization (Roca-González et al., 2017). Experts could have a stronger sense of direction, prefer a map to represent an environment, and use cardinal points (allocentrically based), but might not necessarily report higher self-to-object preferences (egocentrically based) (Cornoldi et al., 2003).

We newly examined whether more pleasure in exploring and less spatial anxiety better qualified orienteering experts since greater orientation and navigation abilities are associated with more functional spatial attitudes (He & Hegarty, 2020). We also explored whether orienteering expertise might affect every day spatial habits, such as using and learning from maps, given their important role in this sport. We compared orienteering beginners with experts and controls on the assumption that they would resemble the experts to some degree.

2 | METHOD

2.1 | Participants

The study sample consisted of 51 participants (32 males) equally divided into three groups of 17 experts (at least 8 years of practice),

TABLE 1 Participants' age, number (and gender), orienteering experience and education by group

	Experts	Beginners	Controls
Age	39.82 (16.69)	28.71 (14.89)	39.83 (8.24)
Numerosity (females)	17 (4)	17 (7)	17 (8)
Total competitions	498.52 (270.48)	71.29 (65.09)	0
Years of orienteering	20.58 (7.69)	3.64 (1.57)	0
Competitions per year	24.80 (9.39)	17.12 (13.10)	0
Years of education	14.82 (2.69)	14.12 (3.62)	15.53 (2.50)

beginners (up to 5 years of practice), and controls (non-practitioners who engaged only in physical activity for leisure and no more than 1.5 h a week). Experts and beginners were members of Veneto sections of the Italian Federation of Sport Orienteering (FISO). Participants in the control group were contacted personally by the experimenter. All participants live in the Veneto region, and volunteered (no incentives were offered) to participate in the study (approved by the Ethical Committee for Psychological Research at the University of Padova; No. 3169). Beginners and experts were similarly involved in official competitions, and all three groups had similar years of schooling (See Table 1 for details). Beginners were younger than experts or controls ($F = 3.70$, $p < .05$), and had a similar education level ($F = 0.95$, $p > .05$).

2.2 | Materials

2.2.1 | Individual difference measures

The visuospatial tasks and questionnaires on wayfinding attitudes have good psychometric properties ($\alpha = .70$–$.90$; De Beni et al., 2014).

2.2.2 | Visuospatial tasks

All measures have a 5-min time limit.

Short mental rotations test (sMRT, adapted from Vandenberg & Kuse, 1978; De Beni et al., 2014). This includes 10 items and involves finding two 3D objects out of four that match a target figure, but in a rotated position. One point is given for each item in which both the correct figures are identified (max: 10).

Short object perspective-taking task (sOPT, adapted from Kozhevnikov & Hegarty, 2001; De Beni et al., 2014). There are six items, each containing a set of objects displayed in a specific layout. Respondents must imagine being at one object, facing another, and pointing to a third, drawing the direction in a circle (from the center to the edge). The mean of the absolute angular error for each item was calculated (max: 180).

Short embedded figures test (sEFT, adapted from Oltman et al., 1971; De Beni et al., 2014). This includes 10 items, and respondents must identify simple shapes embedded in a more complex overall figure. One point is awarded for each correct answer (max: 10).

Short Minnesota Paper Form Board test (sMPFB, adapted from Quasha & Likert, 1937; De Beni et al., 2014). There are 16 items, each consisting of a simple 2D target object comprising separate parts and five options, or sets of parts. Respondents must decide which set of parts can make up the target object. One point is given for each correct answer (max: 16).

2.2.3 | Wayfinding attitude measures

Sense of direction and spatial representation scale (Pazzaglia & Meneghetti, 2017). It comprises 13 items on a 5-point Likert scale (1 = "not at all", 5 = "very much") measuring three factors: sense of direction—preference for survey mode (six items, max: 30), knowledge and use of cardinal points (three items, max: 15), route-landmark preference mode (four items, max: 20). The total for each scale is calculated.

Spatial anxiety scale (adapted by Lawton, 1994). This comprises eight items measuring the degree of anxiety felt in environmental situations, scored on a 7-point Likert scale (1 = "not at all", 7 = "very much") and a total score is calculated (max: 56).

Attitudes toward orientation tasks scale (De Beni et al., 2014). It comprises 10 items on a 7-point Likert scale (1 = "not at all", 7 = "very much"), with five items each for pleasure in exploring places and no pleasure in exploring places (preference for known environments). A total score is calculated as the sum of the items after reversing pleasure of known's scores (max: 70).

Everyday spatial habits scale (Meneghetti et al., 2020). It comprises five items on a 6-point Likert scale that assess the daily life orientation aids used (i.e., GPS, maps, and verbal instructions; three items) and the efficiency of respondents' moves (i.e., how often they get lost in familiar and unfamiliar environments; two items); each item is treated separately (max: 6).

2.2.4 | Environment learning: map and pointing tasks

Map. A scaled (1:200) city map (Meneghetti et al., 2011) was used, containing several interconnected roads and nine landmarks (named on the map alongside the corresponding images).

Pointing task. This consisted of written sentences asking respondents to imagine being at one landmark while facing another and pointing to a third, giving their answer by drawing a line outwards from the center of a circle. There were eight pointing trials in all, four aligned (from 0° to 45°) and four counteraligned (from 135° to 180°) with the observer's view. The mean of the absolute degrees of error was calculated.

2.3 | Procedure

Orienteers were tested individually at their own sports center, and controls were tested in a quiet room at a community center (e.g., library) during two 30- to 40-min sessions in the same week. In session 1, participants signed the consent form and completed the questionnaire on their demographics and sporting activities, then performed two visuospatial tasks and answered two wayfinding questionnaires. In session 2, they performed two visuospatial tasks, answered a wayfinding questionnaire, studied the map and completed the pointing task, and answered the questionnaire on everyday spatial habits. The order of administration of the visuospatial tasks and questionnaires was counterbalanced across participants and groups. For the visuospatial tasks, participants read the instructions (including time limits), completed the examples, and then worked on the tasks until they were stopped (after 5 min). For the questionnaires, they read the instructions, and then rated each sentence. After being asked to memorize all landmarks and their locations, they studied the map for up to 5 min, and then performed the pointing task (with items randomly presented).

3 | RESULTS

3.1 | Data analyses

A Bayesian approach was used for the analyses because it can better handle small sample sizes (McNeish, 2016) such as ours. The analyses were run using the *BayesFactor* package in R (Morey et al., 2018).

To examine the effect of group on the visuospatial tasks and questionnaires, we calculated for each variable the Bayes factor (BF) ratio between two models: a baseline regression model including gender and age as baseline predictors was considered. Gender and age were treated as covariates as they both have a role in the visuospatial domain (males and younger people perform better than females and older adults; Borella et al., 2014; Nazareth et al., 2019). Group was added as a third predictor in the full model.

For the pointing task we used the same procedure but, as it comprises aligned and counteraligned subtasks, we calculated the BF of four mixed effects models with participant as a random effect. The first included only gender and age as predictors (M0), then we added the effects of group (M1), type of pointing (aligned and counteraligned) (M2), and the interaction between group and type of pointing (M3).

As suggested by Raftery (1995), BF ratios below .33 are in favor of the null hypothesis, between .33 and 3 they are "weakly informative", between 3 and 20 they are "positive", between 20 and 150 they are "strong", and above 150 they are "very strong". The inverse of these values has the same meaning but going in the direction of the null hypothesis.

BFs focus on between-model parameters (Kruschke & Liddell, 2018), and then within-model parameters need to be estimated to clarify internal differences in the model (e.g., group differences). This can be done by estimating the higher posterior density interval (HPDI; i.e., the part of the posterior distribution comprehensive of 95% of the most probable values) of the effect sizes of the differences between groups, then comparing it with a region of practical equivalence (ROPE; i.e., a range of values distributed around the null value that are considered practically equivalent to the null) (Kruschke & Liddell, 2018). HPDIs entirely outside the ROPE (out of ROPE value = 1) enable the null value to be rejected. If the HPDI is all within the ROPE (out of ROPE value = 0), then we should accept the null value. When the HPDI is partly inside and partly outside the ROPE, then uncertainty should be accepted. Here, we only discuss values higher than .90.

The meta-analytical Cohen's d of sport practice on visuospatial tasks performance was .38 (Voyer & Jansen, 2017), so we followed Kruschke and Liddell's (2018) suggestion for a small-to-medium effect, and identified a ROPE around the effect size of 0 ± .1. In short, the HPDIs of the between-group effect sizes were calculated from their posterior distributions and compared with the ROPE.

3.1.1 | Group differences

The descriptive statistics of all measures of interest by group are presented in Table 2. Out of ROPE values and median effect sizes are shown in Table 3.

3.1.2 | Visuospatial tasks

Evidence in favor of a general group effect was found for the short mental rotations test (BF = 4.3, positive), Short Embedded Figures Test (BF = 2.97, positive) and Short Minnesota Paper Form Board Test (BF = 97, strong), but not for the Short Object Perspective-Taking task (BF = .25, positive, in favor of the null hypothesis). Judging from the HPDI + ROPE, there are effects indicating: higher scores in experts than in controls for the short mental rotations test; and higher scores in experts than in controls, and in beginners than in controls for the Short Minnesota Paper Form Board and Short Embedded Figures Tests; while the HPDI falls inside the ROPE for the short object perspective-taking task (Table 3). Overall, experts and beginners outperformed controls in visualization tasks (short Minnesota Paper Form Board and short embedded figures tests), and only experts outperformed controls in the short mental rotations test.

3.1.3 | Wayfinding attitude measures

There was evidence in favor of a general group effect for sense of direction—preference for survey mode (BF = 12.5—positive),

TABLE 2 Means and standard deviations of all measures of interest by group

	Range of scores	Experts	Beginners	Controls
sMRT	0–10	6.41 (2.50)	5.65 (2.87)	3.71 (2.08)
sOPT	0–180	140.53 (100.59)	107.82 (95.01)	156.65 (75.46)
sEFT	0–10	7.41 (3.12)	7.76 (3.07)	4.59 (3.32)
sMPFB	0–16	10.65 (2.89)	10.82 (1.91)	8.29 (2.23)
Knowledge and use of cardinal points	3–15	11.35 (1.80)	9.71 (3.75)	7.88 (3.50)
SoD—preference for survey mode	6–30	21.72 (3.33)	17.97 (3.99)	15.96 (5.70)
Preference for route-landmark mode	4–20	15.88 (2.74)	14.70 (2.60)	13.40 (3.86)
Pleasure in exploring	7–70	51.65 (4.36)	46.06 (5.68)	42.06 (6.36)
Spatial anxiety	7–56	15.00 (4.43)	18.18 (3.52)	17.65 (7.32)
Map use	1–6	5.88 (0.33)	4.53 (1.23)	3.06 (1.20)
GPS use	1–6	3.00 (1.58)	4.24 (0.97)	4.00 (1.46)
Use of verbal instructions	1–6	2.71 (1.36)	2.94 (1.25)	3.00 (1.00)
Getting lost in familiar places	1–6	1.47 (1.07)	2.00 (1.27)	1.71 (0.99)
Getting lost in unfamiliar places	1–6	2.35 (0.93)	3.35 (1.22)	3.82 (0.95)
Pointing errors—aligned	0–180	16.59 (6.56)	20.72 (10.79)	22.07 (9.18)
Pointing errors—counteraligned	0–180	26.09 (13.38)	31.04 (19.30)	46.07 (30.99)

Abbreviations: sEFT, short embedded figure test; sMPFB, short Minnesota Paper Form Board; sMRT, short mental rotations test; SoD, sense of direction; sOPT, short object perspective taking.

TABLE 3 Out of ROPE values and median effect sizes (*M*) for differences between groups in all variables considered

	Experts-beginners		Experts-controls		Beginners-controls	
	Out of ROPE	*M*	Out of ROPE	*M*	Out of ROPE	*M*
sMRT	.85	.41	**1.00**	**.85**	.86	.43
sOPT	.67	.22	.31	−.04	.09	−.26
sEFT	.23	−.12	**.97**	**.62**	**.99**	**.74**
sMPFB	.06	−.36	**1.00**	**.93**	**1.00**	**1.28**
Knowledge and use of cardinal points	.64	.21	**1.00**	**.81**	**.95**	**.59**
SoD—preference for survey mode	**.99**	**.70**	**1.00**	**.99**	.72	.28
Preference for route-landmark mode	.36	−.00	.76	.29	.75	.30
Pleasure in exploring	**1.00**	**.93**	**1.00**	**1.50**	**.93**	**.56**
Spatial anxiety	.12	−.45	.23	−.31	.80	.14
Map use	**1.00**	**1.23**	**1.00**	**2.65**	**1.00**	**1.43**
GPS use	**.96**	**−.61**	**.94**	**−.56**	.31	.05
Use of verbal instructions	.15	−.18	.20	−.13	.43	.05
Getting lost in familiar places	.85	−.41	.58	−.16	.10	.25
Getting lost in unfamiliar places	**1.00**	**−.78**	**1.00**	**−1.16**	.82	−.38
Difference between pointing tasks	.24	−.05	**1.00**	**.58**	**1.00**	**.62**

Note: Values in bold = out of ROPE >.90.
Abbreviations: sEFT, short embedded figure test; sMPFB, short Minnesota Paper Form Board; sMRT, short mental rotations test; SoD, sense of direction; sOPT, short object perspective taking.

knowledge and use of cardinal points (BF = 4.28—positive), and pleasure in exploring (BF = 425—very strong). The odds were in favor of no group difference for spatial anxiety (BF = .54, weakly informative) and preference for the route-landmark mode (BF = .33, weakly informative). Looking at the HPDI + ROPE (Table 3), there are effects indicating: higher ratings in experts than in beginners or controls for sense of direction—preference for survey mode; higher ratings in experts than in controls, and in beginners than in controls for knowledge and use of cardinal points; and higher ratings in experts than in beginners or controls, and in beginners than in controls for pleasure in exploring. For spatial anxiety and a preference for route-landmark mode, the HPDIs fall inside the ROPE. Overall, experts scored higher on sense of direction and pleasure in exploring than controls or beginners, and experts and beginners both showed a better pleasure in exploring and knowledge and use of cardinal points than controls.

3.1.4 | Everyday spatial habits

BFs favoring the group effect were also found for map use in everyday life (BF $= 9e10^6$—very strong), and frequency of getting lost in unfamiliar places (BF = 42.7 strong), but not for use of GPS (BF = 1.48—weakly informative) or verbal instructions (BF = .23—positive - in favor of the null hypothesis), or frequency of getting lost in familiar places (BF = .39—weakly informative). Looking at the HPDI + ROPE (see Table 3), map use ratings differed completely between all three groups, rising from controls to beginners to experts; getting lost in unfamiliar places happened less frequently to experts than to beginners or controls. Overall, experts reported using the map more and getting lost less than controls or beginners.

3.1.5 | Environment learning

On pointing performance, M1 shows no evidence in favor of either the null or the group model (BF = 1.8), but M2 generates odds in favor of a difference between aligned and counteraligned pointing (BF = 93). M3, considering the interaction between group and type of pointing, proves the best (BF = 1210) of the three models, with odds of 13.01: experts and beginners have a lower discrepancy between aligned and counteraligned items than controls, whose performance was worse for counteraligned items (Table 3). Overall, experts and beginners—but not the controls - performed equally well in aligned and counteraligned pointing.

4 | DISCUSSION AND CONCLUSION

As orienteering involves navigation, and navigation studies concern small-scale visuospatial abilities and wayfinding attitudes (Hegarty et al., 2006), we examined whether practicing orienteering is associated with greater visuospatial abilities, more positive wayfinding attitudes, and more effective everyday spatial habits and environment (map) learning.

Concerning visuospatial abilities, expert orienteers outperformed controls on object-based mental rotation (assessed with the short version of the mental rotations test) and spatial visualization tasks (assessed with short versions of the embedded figures and Minnesota paper form board tests), and beginners outperformed controls on spatial visualization tasks. Using and turning maps during orienteering exercises may relate to practitioners' object-based mental rotation, while searching environments and maps for signs and patterns (e.g., Eccles, 2006) may relate to their visualization abilities. There were no group differences in perspective taking, consistently with Eccles' (2006) conclusion that expert orienteers tend to orient themselves by rotating the map to keep the map, the North, and their own position aligned in relation to the environment. Managing their egocentric experience (navigation) with object-based strategies (map rotation) would reduce their cognitive load and perspective taking demands. This matter deserves further investigation, however, as Roca-González et al. (2017) found that perspective taking could also improve with orienteering practice.

As for wayfinding attitudes, expert orienteers rated their sense of direction—preference for survey (map) mode, their use of cardinal points higher than controls, showing a preference for object-to-object relations (in line with Cornoldi et al., 2003). Beginners rated their knowledge and use of cardinal points higher than controls, and their sense of direction—preference for survey mode lower than experts. Intriguingly, experts reported taking more pleasure in exploring places than beginners or controls: taken together with their preference for survey mode and use of cardinal points, this shows that orienteering relates to functional wayfinding attitudes (He & Hegarty, 2020). The three groups surprisingly did not differ much on spatial anxiety, though expert orienteers' reported less spatial anxiety (descriptively, at least) than the other groups. This issue should be further examined in future. Concerning environment knowledge after learning from maps, experts and beginners performed equally well on aligned and counteraligned pointing, while controls performed better on aligned pointing, suggesting that the orienteers' mental maps were not orientation-dependent, while the controls' were oriented according to their initial learning view (as seen in the general population; Levine, 1982). Experts reported using maps more and getting lost less than controls or beginners, suggesting a relation between orienteering and everyday spatial habits. This finding should be taken with caution, however, because our participants are all Veneto residents, but they might live in rural areas, villages, towns or cities—and the geographical features of where people live relate to how they move around and the support they use to do so (maps, GPS e.g. Vazquez-Prokopec et al., 2013). This aspect should be considered in further studies.

The beginners' profile is intriguing. After only a few years of orienteering, they already had greater visuospatial abilities, in terms of spatial visualization (even beginners seem to have descriptively higher scores in these tasks than experts) and rated their use of cardinal points and pleasure in exploring higher than controls. However, they gave less positive ratings than experts on their wayfinding attitudes (i.e., sense of direction, pleasure in exploring places), everyday map use, and getting lost. Their profile seems to come in between those of the experts and controls.

Our results offer new insight in the spatial cognition domain by showing that experience of a sport involving path search (Wiener et al., 2009) relates to small-scale visuospatial abilities (in mental rotation and spatial visualization tasks), wayfinding attitudes (e.g., sense of direction, use of cardinal points), and (large-scale) environment learning (from maps at least). These findings also broaden our knowledge of how practicing sports relates to general (visuospatial) cognitive abilities, everyday environment learning and wayfinding attitudes. The link between orienteering and general cognitive abilities (needed in small-scale visuospatial and environment learning tasks) contributes to the ongoing research on how sports and physical exercise relate to these cognitive abilities (Chang & Etnier, 2015; Voss et al., 2010). This type of research poses problems, however, due to the low-moderate effect sizes found in athletes (Scharfen & Memmert, 2019; Voss et al., 2010), and other types of expert (Sala & Gobet, 2017). Our (cross-sectional) study design and the measures used could not disentangle this issue, which would demand a longitudinal study in which any benefits of orienteering can be assessed pre–post, in terms of both specific skills (as required during a race; for example, Eccles et al., 2006) and general (visuospatial) cognitive abilities, or more everyday environment learning competences and wayfinding attitudes. Evidence of orienteering having benefits on the visuospatial domain (Roca-González et al., 2017) is encouraging; even if these benefits were not examined in relation to specific abilities needed while practicing this sport. A longitudinal design could also test the causality of relations between variables, possibly excluding the option that individuals with already greater visuospatial abilities might choose to practice this type of exploratory activity (Malinowski, 2001), or the influence of other individual predispositions and personality factors (e.g., Malinauskas et al., 2014). Related to this issue, there is the expectations effect to consider (Rosenthal, 1976). Factors such as motivation can have a relevant role in task performance (e.g. wayfinding self-efficacy relates to visuospatial task performance; for example, Pazzaglia et al., 2017), especially in athletes driven by a strong competitive spirit (e.g., Warner & Dixon, 2015). For instance, the belief that orienteers make good use of a map can influence their map use in orienteering practice or generally in everyday life. While the relationship between practicing sports and (visuospatial) cognitive abilities is well proven (Voyer & Jansen, 2017), other non-cognitive factors may relate to an individual's orienteering practice and this should be better examined in further studies.

An important limitation of our study concerns the small sample size, and the large number of variables considered. Though this issue was taken into account using the Bayesian approach (which generates more reliable estimates with small samples than other approaches), the results should be interpreted with caution. It should also be noted that most of the studies published in the field of sport expertise and cognition describe underpowered samples, which rarely exceed 50 participants per group, and this makes them more susceptible to publication bias problems (see meta-analyses, Scharfen & Memmert, 2019; Voss et al., 2010; Voyer & Jansen, 2017). Larger sample sizes will be needed to obtain stronger evidence of the relation between domain-specific abilities in sport and domain-general cognitive abilities.

To conclude, this study offers some preliminary evidence of the relationship between a navigation-based sport, such as orienteering, and the visuospatial domain, in terms of visuospatial abilities, wayfinding attitudes, and environment learning (from maps), that it would be worth investigating in more detail with further studies.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The dataset analyzed for this study can be found on Figshare, doi:10.6084/m9.figshare.14169761.

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