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Effects of Gender, Imagery Ability, and Sports Practice on the Performance of a Mental Rotation Task

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Mental rotation is one of the main spatial abilities necessary in the spatial transformation of mental images and the manipulation of spatial parameters. Researchers have shown that mental rotation abilities differ between populations depending on several variables. This study uses a mental rotation task to investigate effects of several factors on the spatial abilities of 277 volunteers. The results demonstrate that high and low imagers performed equally well on this tasks. Athletes outperformed nonathletes regardless of their discipline, and athletes with greater expertise outperformed those with less experience. The results replicate the previously reported finding that men exhibit better spatial abilities than women. However, with high amounts of practice, the women in the current study were able to perform as well as men.

Mental imagery is the ability to form vivid mental representations of an object or a movement by visualizing as many details as possible while preserving the spatial and temporal characteristics of actual movement (Guillot & Collet, 2005). Among the abilities needed to manipulate mental images, mental rotation involves the cognitive manipulation and spatial transformation of imagined objects and may be useful in spatial reasoning and problem solving (Gunzelmann & Anderson, 2004). Mental rotation is among the most widely used paradigms for assessing mental imagery, a concept that was first introduced as a seminal paradigm in cognitive psychology by Shepard and Metzler (1971). During mental rotation tasks, participants are asked to view images of three-dimensional objects at various orientations. In each trial, observers are asked to judge whether two images of asymmetric objects depict the same or different objects, regardless of any differences in orientation (Figure 1). The typical findings show that a participant's response time increases linearly with increasing angular disparity between the two images presented (e.g., Corballis, 1982; Shepard & Cooper, 1982; Shepard & Metzler, 1971).

Shepard and Metzler (1971) suggested that participants solve these tasks by mentally rotating one of the objects until both objects are mentally aligned before comparing the two images. They assumed this mental rotation process to be an internal counterpart to the

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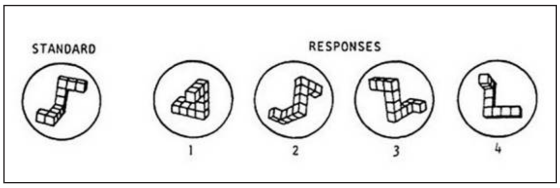

FIGURE 1. A sample mental rotation task from Shepard and Metzler (1971)

physical rotation of a real object. Nevertheless, whether the experience of mental imagery is essential for the typical pattern of findings in mental rotation studies remains unclear. Several researchers have performed neuroimaging experiments to examine whether visual images play a significant role in mental rotation tasks (reviewed in Zacks, 2008). These researchers have attempted to identify the brain networks that are involved in mental imagery and to determine which of these areas are activated during mental rotation tasks. However, Zacks noted that almost every area of the brain has been implicated in mental rotation.

This observation could be explained by the use of a variety of strategies by different participants, with each participant using distinct brain networks to perform similar mental imagery tasks (Logie, Pernet, Buonocore, & Della Sala, 2011). Although behavioral data cannot detect the real role of visual images during mental rotations, the first aim of this study was to investigate the usefulness of mental imagery in performing mental rotations by comparing the performance of high and low imagers in the mental rotation task of Shepard and Metzler (1971). A significant difference between these two large groups (low and high imagers), without controlling for potential differences in the strategies used by individuals, would highlight the importance of mental imagery in mental rotation.

Although many variations of Shepard and Metzler's experiment have been developed, including two-dimensional objects (Cooper, 1975), pictures of unfamiliar polygons (Cooper & Podgorny, 1976), and asymmetric alphanumeric characters (Cooper & Shepard, 1973), the majority of research on mental rotation has been conducted using the classic mental rotation task to investigate the factors that regulate mental rotation ability. Mental rotation ability repeatedly has been shown to exhibit one of the largest gender biases reported in the cognitive literature (Linn & Petersen, 1985; Voyer, Voyer, & Bryden, 1995), especially on the mental rotation task of Vandenberg and Kuse (1978). Although the effect of gender on mental rotation is well established, we have investigated it again in the present study, not to replicate previous findings but to explore the effects of motor expertise on this gender difference. Voyer and Isaacs (1993) suggested that an important relationship exists between gender and the amount of sports practice, and they speculated that more extensive practice in women would reduce the magnitude of the gender difference in the mental rotation test. This study sought to evaluate this assumption. A significant interaction between gender and amount of practice would facilitate our understanding of this process and determine whether extensive practice would improve the mental rotation ability of women and eliminate the observed gender difference.

The impact of motor expertise on mental rotation performance has been demonstrated in several previous studies (Naito, 1994; Ozel, Larue, & Molinaro, 2002), but its effects have not been examined in relation to gender. Practice can assist athletes in learning to process spatial information under time pressure and to deal with game constraints. In addition, every practice session presents athletes with different spatial parameters. According to Campos and Cofán (1986), training develops the skill of finding the relationships between different spatial parameters, which can then be used during the performance of mental rotation tasks. Based on the work of Ozel et al., it appears that playing sports improves mental rotation skills. In the present study, participants with various amounts of practice were selected and divided into different groups to examine the effects of practice on mental rotation ability. Our hypothesis was that sports participants (i.e., athletes) would perform better than those who do not play sports (i.e., nonathletes). Furthermore, we expected that athletes who had spent more years practicing would achieve higher scores than athletes who had practiced less.

The number of spatial abilities that are relevant to a given sport increases with the number of skills needed for that sport (Hult & Brous, 1986). High levels of athletic performance in sports necessitate a high level of spatial abilities, and relevant experience is needed to develop effective spatial skills (Casey, 1996). Consequently, previous studies of motor expertise have classified sports as either spatial or nonspatial and have examined whether athletes who participate in spatial sports outperform other athletes.

Steggemann, Engbert, and Weigelt (2011) studied the effects of motor expertise for rotational movements during a mental rotation task of blocks and bodies. In their study, gymnasts were classified as motor experts compared with other athletes who were engaged in sports that involve fewer spins and turns around different body axes. However, the expert participants did not perform rotational tasks faster than nonexperts. This might be explained by the specific group categorizations used, which considered participants in team sports as nonexperts. In contrast, studies by Hult and Brous and by Voyer, Nolan, and Voyer (2000) classified team sports as spatial sports because they require significant spatial abilities. Ozel et al. (2002) also hypothesized that gymnasts would perform better than other athletes on a mental rotation task, but this hypothesis was not validated. In the present experiment, the aim was to examine the effects of specific types of sports on mental rotation performance. Thus, participants were classified as nonathletes (those who do not play sports), spatial sports participants, and non–spatial sports participants (i.e., athletes). Consequently, we hypothesized that athletes would perform better than nonathletes. Furthermore, we expected that there would be no differences in the mental rotation performance of spatial compared with nonspatial athletes.

In the present study, we collected behavioral data from a large sample consisting of many levels of different factors. Our primary aim was to examine the main effects of these factors (mental imagery capacity, gender, amount of practice, and type of sport) on mental rotation performance and to contribute to the ongoing debate concerning the influence of each of these factors on the behavioral patterns of mental rotation. As a secondary aim, we were interested in the potential interactions between these different factors in an attempt to elucidate additional mental rotation patterns.

EXPERIMENT

METHODS

Participants

Two hundred seventy-seven university students (192 male and 85 female), aged 18–31 years ($M = 19.71$ years, $SD = 2.5$) provided informed consent to take part in this experiment. All had normal or corrected-to-normal vision and were unaware of the purpose of the experiment. The participants were divided into different groups, and their characteristics are presented in Table 1.

After completing the French adaptation of Marks's Vividness of Visual Imagery Questionnaire (VVIQ) (1973), the participants were classified as either high imagers (HIs) or low imagers (LIs) according to whether their VVIQ scores were above or below the median score of the population (Denis, 1982). The HI group was composed of 154 participants (111 male and 43 female; $M_{age} = 19.58$ years, $SD = 2.33$; $M_{training\ experience} = 7.06$ years, $SD = 5.67$). The LI group was composed of 123 participants (81 men and 42 women; $M_{age} = 19.89$ years, $SD = 2.69$; $M_{training\ experience} = 6.76$ years, $SD = 5.71$ years). There were no significant differences between the mean age, $t(275) = -1.019$, $p = .309$, or the mean training experience, $t(275) = 0.428$, $p = .669$, of the two groups.

The participants were also divided into three groups based on the amount of practice. The first group was the high practitioner (HP) group, composed of 134 participants (103 male and 31 female; $M_{age} = 19.88$ years, $SD = 2.37$), each of whom had several years of practice. The inclusion criteria for the HP group were that its participants had regular training and had been competitive for at least the past 8 years ($M_{training\ experience} = 12.16$ years, $SD = 2.69$). The second group was the medium practitioner (MP) group, which was composed of 53 participants (35 male and 18 female; $M_{age} = 18.96$ years, $SD = 1.16$). The inclusion criteria for the MP group were that its participants had regular training and had been competitive for 3 to 7 years ($M_{training\ experience} = 4.89$ years, $SD = 1.48$). The last group, the low practitioner (LP) group, was composed of 90 participants (54 male and 36 female; $M_{age} = 19.91$ years, $SD = 3.12$). The inclusion criteria for the LP group were that its participants were not athletes or had athletic training for less than 2 years ($M_{training\ experience} = 0.34$ years, $SD = 0.72$). There were no significant differences in the mean age of any of the groups, $F = 3.014$, $p = .051$. This seemed to be a particularly relevant method of categorization because it allows accurate classification of participants into three groups according to their amount of practice because previous studies have not provided a precise definition of "extensive practice" (Voyer & Isaacs, 1993).

Finally, the participants were also divided into three groups according to the type of sport they played (spatial and nonspatial). The first group consisted of 62 participants (47 male and 15 female;

TABLE 1. Characteristics of the Different Groups Formed According to the Type of Sport, Imagery Capacity, and Amount of Practice

Type of sport	Imagery capacity	Amount of practice	Mean age (years)	SD	Distribution by gender
Nonsport	LI	LP	20.83	4.09	15 male, 20 female
	HI	LP	19.62	2.99	26 male, 10 female
Nonspatial sport	LI	HP	18.94	1.22	11 male, 5 female
		MP	19.21	1.13	7 male, 1 female
		LP	19.17	0.98	6 male
	HI	HP	19.30	1.77	10 male, 5 female
		MP	18.31	0.53	7 male, 3 female
		LP	19.58	1.17	6 male, 1 female
Spatial sport	LI	HP	19.84	1.94	33 male, 9 female
		MP	18.67	0.61	9 male, 6 female
		LP	20.00		1 female
	HI	HP	19.92	2.52	48 male, 12 female
		MP	19.17	1.31	12 male, 8 female
		LP	18.50	0.64	2 male, 4 female

Note. *HI = high imager; HP = high practitioner; LI = low imager; LP = low practitioner; MP = medium practitioner.*

M_{age} = 19.11 years, SD = 1.47; $M_{training\ experience}$ = 7.32 years, SD = 4.24) practicing nonspatial sports (NSS) such as track and field, wrestling, and water sports. The second group was composed of 144 participants (104 male and 40 female; M_{age} = 19.74 years, SD = 2.24; $M_{training\ experience}$ = 10.10 years, SD = 4.57) practicing spatial sports (SS) such as football, handball, basketball, racket sports, hockey, and gymnastics. Sports were categorized as spatial and nonspatial based on previous classifications provided by Hult and Brous (1986) and Voyer et al. (2000). The third group, the no sports (NS) group, was composed of 71 people (41 male and 30 female; M_{age} = 20.20 years, SD = 3.46) who had never participated in sports competitions and whose recreational sports practice did not exceed 2 hours per week.

Materials

VIVIDNESS OF VISUAL IMAGERY QUESTIONNAIRE (VVIQ).

The vividness of mental imagery is thought to improve the quality of mental representations and the efficiency of mental imagery processes (Denis, 1985; Isaac & Marks, 1994; Juhel, 1991; Roure et al., 1999). Analyzing the performance of each participant on this test allows an evaluation of his or her imagery ability. The present study used a French adaptation of the VVIQ published by Marks (Denis, 1982). This test consists of 16 items (4 groups of 4) in which the participant is asked to consider the image formed by thinking about specific scenes and situations. VVIQ appears to be a reliable measure of the subjective experience of imagery, and Cui, Jeter, Yang, Montague, and Eagleman (2007) showed that a person's VVIQ scores are correlated with the activation of his or her primary visual cortex while performing an imagery task, as determined by functional magnetic resonance imaging.

MENTAL ROTATION TASK (VANDENBERG & KUSE, 1978).

The Mental Rotation Task (MRT) of Vandenberg and Kuse (1978) measures the mental rotation abilities of participants. This test is a paper-and-pencil version of the Shepard and Metzler (1971) mental rotation task using three-dimensional objects. It consists of 20 items, each of which consists of a target figure, two correct alternatives, and two distractors. Correct alternatives are always identical to the standard figure, but they are shown in various three-dimensional rotations (see Figure 1).

Procedure

Small groups of participants were tested (MRT and VVIQ) in a classroom under standardized and calm conditions. For the VVIQ, the participants were asked to rate the vividness of each image on a 5-point scale, from 1 (*perfectly clear*) to 5 (*no image*). The participants were instructed to refer to the rating scale to judge the vividness of each image and were asked to rate each image separately, regardless of how they rated other images.

For the MRT, the experimenter read aloud the instructions on the cover page of the test. The participants then performed and verified the accuracy of the three sample problems provided in the test. The participants were given 6 min to complete the test, which consisted of 2 groups of 10 items.

The experimenter conducted the counting and scoring of tests according to the procedures recommended by Marks (1973) and Vandenberg (1985). The order of the VVIQ and the MRT was randomized for each group of participants.

Data Analysis

Each participant was coded for each of the four factors: sport (SS, NSS, or NS), gender (male or female), amount of practice (HP, MP, or LP), and imagery capacity (HI or LI). Data were subjected to a four-way ANOVA with these four factors as between-participant variables and scores on the MRT as the dependent variable. Scheffe post hoc tests were applied for the sport and amount of practice variables, where significant differences were observed.

RESULTS

The ANOVA revealed a significant effect of gender, $F(1, 251) = 13.332$, $p < .001$, $\eta^2 = .050$, with men ($M = 21.28$, $SD = 7.857$) outperforming women ($M = 16.04$, $SD = 8.486$). Concerning the effect of imagery capacity on MRT scores, only a trend was observed, $F(1, 251) = 3.878$, $p = .050$, although HIs ($M = 19.95$, $SD = 4.682$) slightly outperformed LIs ($M = 18.65$, $SD = 6.294$). A significant effect of practice amount was observed, $F(2, 251) = 15.338$, $p < .001$, $\eta^2 = .109$, and Scheffe post hoc tests indicated that the HP group outperformed the MP and LP groups (both $p < .001$). The type of sport also had a significant effect on task performance, $F(2, 251) = 7.353$, $p < .001$, $\eta^2 = .055$, but Scheffe post hoc tests revealed no differences between the scores of the NSS and SS groups ($p = .259$). However, both of these groups achieved

TABLE 2. Mean (*SD*) Scores on the Mental Rotation Task According to the Type of Sport, Imagery Capacity, and Amount of Practice

Type of sport	Imagery capacity	Amount of practice	Mean	SD
Nonsport	LI	LP	7.64	4.28
	HI	LP	12.04	5.24
Nonspatial sport	LI	HP	27.15	5.53
		MP	18.21	3.99
		LP	21.67	7.74
	HI	HP	25.35	5.25
		MP	22.21	3.06
		LP	16.50	8.44
Spatial sport	LI	HP	23.19	4.96
		MP	17.67	3.97
		LP	15.00	
	HI	HP	24.40	5.18
		MP	18.42	5.10
		LP	20.75	7.94

Note. *HI = high imager; HP = high practitioner; LI = low imager; LP = low practitioner; MP = medium practitioner.*

higher scores (both $p < .001$) than the NS group. Accordingly, athletes performed better than nonathletes, but no differences were observed between athletes who engaged in different types of sports (spatial vs. nonspatial). The performances of the different groups based on type of sport, imagery capacity, and amount of practice are presented in Table 2.

A significant two-way interaction between gender and amount of practice was observed, $F(2, 251) = 3.994$, $p = .020$, $\eta^2 = .031$ (Figure 2). Tests of the simple effects of gender within each level of amount of practice showed that the gender difference did not reach significance only for HP men and women, $F(1, 271) = .039$, $p = .844$. A significant three-way interaction between gender, type of sport, and imagery capacity was also observed, $F(1, 251) = 5.019$, $p = .026$, $\eta^2 = .020$. Tests of the simple effects indicated that men outperformed women only when they were HIs and nonathletes, $F(1, 448) = 6.899$, $p = .010$, or HIs involved in spatial sports, $F(1, 448) = 17.657$, $p < .001$ (Figure 3).

No further interactions reached significance; this may be because of the unbalanced composition and the small number of participants of the subgroups (see Table 1).[1]

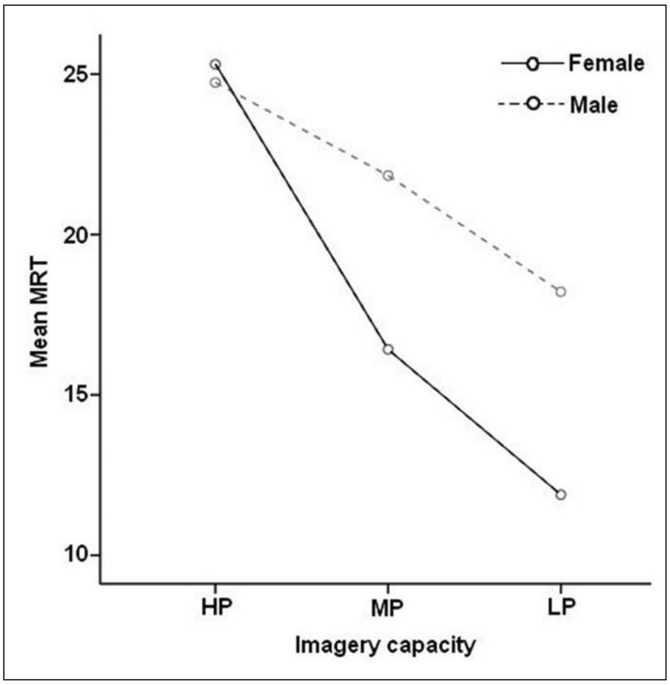

FIGURE 2. Two-way interaction between gender and amount of practice. HP = high practitioners; LP = low practitioners; MP = medium practitioners; MRT = Mental Rotation Task

DISCUSSION

The data presented here indicate that HIs and LIs performed mental rotation tasks equally well. These results are consistent with those of Logie et al. (2011), who observed similar mean response times for HIs and LIs in a mental rotation task. However, they reported that LIs exhibited less accuracy for large angle rotations of images than for small angle rotations. The authors concluded that LIs probably used a different strategy to solve the task than HIs and that their strategy was prone to error. In contrast, the task used in our study did not investigate the angles of rotation, only the accuracy of the answers.

In the study by Logie et al. (2011), participants were permitted as much time as they needed to complete each trial, thus they had the time to use their own strategies to solve the task. In contrast, the participants in our experiment were given only 6 min to complete 20 answers. Thus, they were under time pressure, which has the potential to affect scores on mental rotation tasks (Goldstein, Haldane, & Mitchell, 1990; Voyer, 1997). Consequently, it is likely that all the participants used similar strategies, specifically the one recommended by the experimenter (i.e., "try to rotate one object until it is aligned with the other").

Both the HI and the LI groups consisted of participants with similar characteristics, with no differences in age or mean training experience. Indeed, the only difference between these groups was in their mental imagery capacity, which was shown to have no effect on mental rotation, as has been consistently shown previously. Consequently, the functional role of mental imagery in mental rotation tasks remains elusive.

Statistical analysis revealed that athletes who engaged in different types of sports outperformed nonathletes in the mental rotation task. These results confirm those of Ozel et al. (2002), who found that people who do not participate in sports take longer than athletes to rotate objects mentally. These results are also consistent with those of Overby (1990) and Naito (1994), who found that athletes exhibit better performance on tests of spatial imagery than nonathletes. Indeed, practicing sports offers an enriched experience in spatial processing. While practicing,

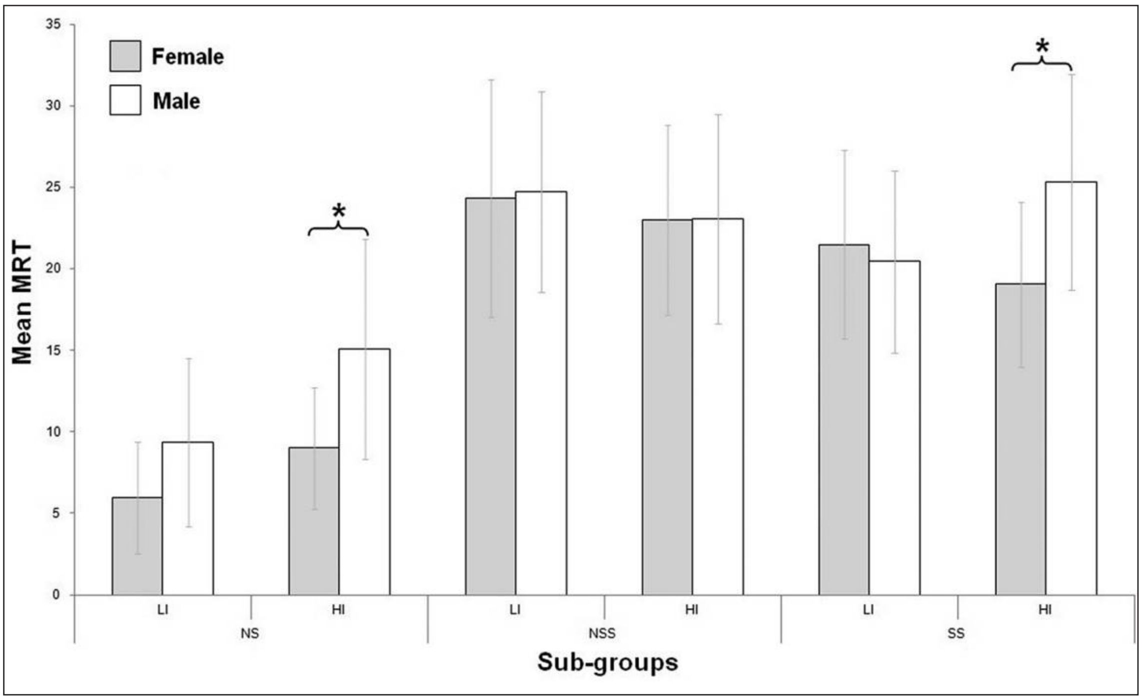

FIGURE 3. Three-way interaction between gender, type of sport, and imagery capacity. HI = high imagers; HP = high practitioners; LI = low imagers; LP = low practitioners; MP = medium practitioners; NS = nonsports; NSS = nonspatial sports; SS = spatial sports

athletes are required to identify relationships between different spatial parameters to respond to the demands of the game, a skill that is probably used during the performance of mental rotation tasks. When practicing their sports, athletes are faced with greater physical constraints requiring greater spatial experience than they are likely to encounter in normal life. Thus, they improve their physical capacities and spatial abilities at the same time. This effect has been confirmed by Pellizzer and Georgopoulos (1993), who observed a relationship between rotation speeds in a visual–motor rotation task and a task of mental rotation.

However, we did not observe any significant differences on the MRT between the two groups of athletes (NSS and SS), regardless of their type of sport. One possible explanation is that mental rotation abilities are needed for a wide variety of sports. This possibility would be consistent with a study by Ozel et al. (2002), who recorded similar mental rotation times for gymnasts (motor rotation experts) and other athletes. In addition, we categorized wrestling as a nonspatial sport according to Hult and Brous (1986) and Voyer et al. (2000). However a previous study showed significant effects of wrestling training on mental rotation performances (Moreau, Clerc, Mansy-Dannay, & Guerrin, 2012). They concluded that training that includes highly coordinative and rotational movement aspects improves mental rotation performance better that training that does not include these aspects. It is also possible that the nature of the task was responsible for the similar scores regardless of the type of spatial activity. If a same–different judgment evoked the object-based transformation of an object, then participants would be unable to benefit from their specific motor expertise to perform the task (Logie et al., 2011). Furthermore, athletes with a greater amount of practice outperformed those with less motor expertise. These results confirm those of Overby (1990) and Casey (1996). Accordingly, the more time athletes spend practicing, the more they improve their spatial abilities. Vestberg, Gustafson, Maurex, Ingvar, and Petrovic (2012) revealed better executive functions among high-division soccer players than among low-division ones. Because working memory is crucial for executive functions (Jansen, Lehmann, & Van Doren, 2012) and working memory plays an important role in visuospatial cognitive abilities (Miyake, Friedman, Rettinger, Shah, & Hegarty, 2001), Jansen et al. assumed that the soccer players who showed higher executive function performance also had better visuospatial abilities. Besides, visuospatial abilities can be differentiated into the abilities of visualization, orientation, and mental rotation (Linn & Petersen, 1985). So practicing spatial activities on higher levels develops better mental rotation abilities. Then our finding suggests that the physical activities have different effects on mental rotation according to our long or short term of practice, corroborating with the study of Vestberg et al. (2012).

In addition to examining the overall effect of practice, we were also interested in determining the relationship between gender and the amount of practice. Our results confirm the well-established finding that men outperform women in mental rotation tasks (Linn & Petersen, 1985; Voyer et al., 1995). Previous work has demonstrated that mental rotation tasks evoke right hemisphere dominance in men but no differences between the two hemispheres in women (e.g., McGlone, 1980; Thomsen et al., 2000; Seigel-Hinson & McKeever, 2002; Vogel, Bowers, & Vogel, 2003; Rilea, Roskos-Ewoldsen, & Boles, 2004; Hugdahl, Thomsen, & Erlsand, 2006). Zacks, Rypma, Gabrieli, Tversky, and Glover (1999) reported that when participants rotate objects or use an object-based approach, the right hemisphere is preferentially activated. Indeed, this was the case for the participants of this study who attempted to rotate three-dimensional objects mentally. Among these participants, men performed better than women, an effect that is expected because tasks requiring greater dependency on right hemisphere processing tend to lead to gender differences that favor men (Rilea et al., 2004).

Interestingly, we observed a significant interaction between gender and the amount of practice. Women who had practiced for at least 8 years were able to perform mental rotation tasks as well as men, but it seems necessary to note the very small variance accounted for by this interaction ($p = .020$, $\eta^2 = .031$) that we are trying to interpret. These results confirm the hypothesis of Voyer and Isaacs (1993), which predicted that practice would reduce the magnitude of gender differences on mental rotation tests. In general, boys and girls do not typically exhibit similar preferences for toys, do not practice the same activities (Etaugh, 1983; Newcombe, Bandura, & Taylor, 1983), and do not have the same amount of experience with spatial tasks (Baenninger & Newcombe, 1989). Moreover, women, who typically exhibit a lower level of spatial performance, could benefit more than men from practicing spatial activities to develop their spatial abilities (Hult & Brous, 1986). In our study, we think that this benefit resulted specifically from better perceiving or encoding processes, the first processing stages of the mental rotation (Jansen et al., 2012; Shepard & Cooper, 1982), not the mental rotation itself. Indeed, practicing spatial activities increases visual search behavior (Memmert, 2006), so HP women benefited from this better visual search capacity to perceive and encode the mentally rotated figures easily and efficiently. We may assume that when girls begin to practice sports at an early age, they receive more years of practice and greater spatial benefits. As a result, their athletic experience is more similar to that of boys, and they can therefore perform as well as men on spatial tasks.

The significant interaction between gender, type of sport, and imagery capacity is more difficult to explain because men outperformed women when they were nonathletes or practicing spatial sports only with high imagery ability. Although the effect size of this interaction was small ($p = .026$, $\eta^2 = .020$), and these results seem paradoxical, we propose two explanations.

First, people who do not play sports may be strongly influenced by their ability to generate mental images and the vividness of these images. Indeed, it may be appropriate to compare these people to beginners, and many studies have shown that imaging activity is critical in the learning tasks of spatial ability (Feltz & Landers, 1983). In addition, according to Logie et al. (2011), healthy adults might use mental imagery to perform mental rotation, but others might use a propositional strategy for the same task. Indeed, both strategies are available. In the present study, high imagery ability may have promoted the use of mental imagery during the performance of mental rotation tasks, and men may have been more efficient than women in using this strategy. Consequently, we suppose that men benefited from their high imagery and outperformed women because they used more efficient strategies during mental imagery tasks. However, male LIs failed to outperform female LIs because, unlike male HIs, they used less effective strategies.

Second, SS athletes, in contrast to NSS athletes, engage in activities that provide them with conditions that train their spatial abilities under critical time and biomechanical constraints. In our experience, only male athletes who are also HIs benefited from their high spatial ability to perform the task. The supposed ability of male HIs to use more efficient strategies when solving mental rotation tasks compared with women may be explained by the time constraints provided by the task. In support of this view, many studies have demonstrated that time constraints increase gender differences in favor of men (Goldstein et al., 1990; Voyer, 1997). We may suppose that when participants were under time constraints, they used their privileged strategy to solve the task.

As Alexander and Evardone (2008) explained, the early life play experiences of boys provide more familiarity with constructing figures out of blocks or cubes, and this familiarity or comfort promotes the use of holistic strategies that facilitate task performance. Consequently, in the present experiment, men were able to use holistic strategies that facilitated the performance of mental rotation tasks, thus allowing them to outperform women while under time constraints. In contrast, LIs used different strategies while under time constraints because their low self-reported imagery experience did not allow for the optimal strategies, so female LIs were able to perform as well as male LIs in the mental rotation task.

NOTES

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1. The experimental sampling did not allow homogeneous subgroups in the current study. The sports practitioners participants practiced often and in a medium/high way. Consequently, there are few low practitioners. Despite the low number of participants in some subgroups, a four-way ANOVA was conducted. In future studies, the Gauss distributions of the variable in the various examined subgroups must be verified.

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