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Original Article

Effects of Dual Sports and Their Practice Environments on the Determination of Motor Imagery Modality and Vividness in Young

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ABSTRACT

This study aims to verify the effect of dual sports as well as their practice environments on the determination of MI modality and vividness. 240 athletes practicing judo, karate and tennis; boys and girls aged 13 to 15 years, took part in this study. This sample was divided into two age groups: (age-group 1 and age-group 2). The “Movement Imagery Questionnaire - Revised second version” was used to assess the visual and kinesthetic motor imagery vividness. Three non-verbal neuropsychological tests were used, as inclusion criteria, to assess visuospatial memory and reasoning processes. Results show that judo develops kinesthetic motor imagery, tennis develops visual motor imagery; karate doesn’t show any difference between the two modalities. Subjects belonging to age-group 2 had greater MI vividness and boys are more imager than girls. Conclusion: MI modalities as well as its vividness are determined through the type and the environment of dual sports.

Keywords: Adolescent, Motor Imagery, Dual Sports, MIQ-Rs

INTRODUCTION

Motor imagery (MI) is a cognitive strategy facilitating acquisition, recovery, improvement, or rehabilitation of the motor skills and has two forms “internal or external”, and two modalities “visual or kinesthetic” (Decety et al., 1991; Guillot & Collet, 2013; Vasilyev et al., 2017). It is well established that imagery training improves sporting performance (Behrendt et al., 2021). Conversely, Dhouibi et al. (2021) have shown that overall sporting and physical practice improve motor imagery ability in young athletes. But unfortunately, it is important to note that, to best of our knowledge no studies have investigated the relationship between MI and both the dual sport types and their practice environments; to show whether these two conditions can enhance the vividness of MI and determine its modalities. It is well known that sports have neither the same requirements (technical strategic perceptive cognitive) nor the same practice environment (full air sports, halls, tatami) nor the same infrastructures (natural spaces artificially landscaped spaces) nor the same equipment (tennis rackets, judogi). Therefore it is obvious that these differences could have an effect on MI skill. Referring to the taxonomy of Parlebas (1999) the ranking tree of sport situations and motor behavior

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precisely sociomotor behaviors brings together dual sports such as fighting and tennis (in single) in the same category. He adds that these sports are mainly based on the interaction between two opponent athletes (without partner) and are practiced in a "certain environment". By "certain environment" factor, this classification emphasized "stability and/or instability" (stable and unpredictable environment or on the contrary a moving and not completely predictable environment). He explains, too, that this interaction is based on two essential aspects: motor communication and counter-communication. These sports are referred to as "confrontational sports" and classified according to the "guard distances". Indeed, Parlebas (1999) always specifies that, judo is characterized by a gripping guard which puts the two judokas in a situation of "direct and permanent body-contact"; karate, for its part, is characterized by a distant guard which puts the two karatekas in a situation of "direct and episodic body-contact" and finally, tennis is characterized by "non-contact" between the two tennis players. This leads us to think hypothetically that MI modality and vividness could be influenced; first by the kind of dual sports practiced, then by the interaction type which characterizes the body-contact of the athletes and their motor behavior and finally by the environment type in which one dual-sport is practiced. Differences may include gender and age. In this sense, equivocal findings have emerged. In gender, some studies have noted significant differences between boys and girls (Dhouibi et al., 2021; Habacha et al., 2014; Munroe-Chandler et al., 2007); unlike other studies have shown the opposite (Campos, 2014; Hall et al., 2009). In age too, studies have showed the same things: some of them have noted significant differences between old and young subjects (Dhouibi et al., 2021; Mitra et al., 2016) and some others have noted no differences (Storm & Utesch, 2019).

MATERIALS AND METHODS

Participants

The sample population consisted of 240 adolescents (120 boys and 120 girls) divided into two equal age-groups: (age-group 1, A-G1 with 13 years ≤ age ≤ 14 years 6 months *vs* age-group 2, A-G2 with 14 years 6 months < age < 16 years). Each group was sub-divided into three sub-groups depending on the kind of sport practiced: 40 judo, 40 karate and 40 tennis players (20 girls and 20 boys in each sub-groups). All subjects are engaged each year in training in sport club for at least the last 4 years. All participants belong to the mid-adolescent age-group which is characterized by the increase of the abstraction cognitive capacity (Devernay & Viaux-Savelon, 2014). Taken account of this developmental perspective, we have divided our population into two age groups, as suggested by Puyjarinet et al. (2020) to verify the impact of age factor on MI vividness. Out of respect for research ethics, written informed consent was requested from the legal tutors/parents of each participating child following the explanation of the study protocol. Participant characteristics are presented in Table 1.

Procedure

A statement of the research protocol including the description of the survey explaining the purpose of the study was sent to the sports club managers. After agreement a second letter was sent to potential subject's parents/guardians requesting their agreement regarding the participation of their children in this study. Prior to administering the Movement Imagery Questionnaire-Revised Second version (MIQ-Rs), all participants were tested with three non-verbal neuropsychological tests: the Corsi Block Task to measure the spatial short-term memory capacity (Corsi, 1972); the Revised Visual Retention Test 4th edition (RVRT) to evaluate visual memory and visuospatial functions in their various aspects "visuomotor visuospatial and visuoconstructive" (Benton, 1974) and the Test Of Nonverbal Intelligence-Second edition (TONI 2) to evaluate the nonverbal intelligence (Brown, 1990). None of the participants scored below expected norms hence showing normal intellectual functioning (table 2). Then, the participants completed the MIQ-Rs (Gregg et al., 2008) in its French translated-language and valid (Loison et al., 2013). The 14 items of this questionnaire are divided into 7 items to evaluate VMI and 7 other items for the KMI. The tasks to be mentally imagined involve the upper limb, the lower limb, the body as a whole, and tasks in daily life. For each item, the experimenter reads to the participant a description of the task to be carried out. Then, the adolescent actually performs the task, and is then asked to either visually or sensorially imagine it. The participant is asked to rate the ease or difficulty (from a 7-point Likert scale) with which he has executed each mental task. The score for each item thus ranged from 1 ("very hard") to 7 ("very easy"). For each scale (VMI and KMI) and for each participant, a mean score was

Table 1: Distribution of population by type of dual sport, age, and gender

Groups	Age groups	Age ranges	Sex	*n*	Age	Practice duration
Judo	A-G1	13.0-14.5 y	Boys	20	13,92 ± 0,39	5,49 ± 0,59
			Girls	20	13,84 ± 0,43	5,24 ± 0,40
	A-G2	14.5-16.0 y	Boys	20	15,29 ± 0,33	6,14 ± 0,54
			Girls	20	15,30 ± 0,26	5,94 ± 0,77
Karate	A-G1	13.0-14.5 y	Boys	20	13,95 ± 0,41	5,14 ± 0,30
			Girls	20	13,77 ± 0,50	5,29 ± 0,43
	A-G2	14.5-16.0 y	Boys	20	15,41 ± 0,37	5,69 ± 0,79
			Girls	20	15,11 ± 0,32	5,74 ± 0,84
Tennis	A-G1	13.0-14.5 y	Boys	20	13,81 ± 0,46	7,64 ± 0,58
			Girls	20	13,63 ± 0,37	7,44 ± 0,73
	A-G2	14.5-16.0 y	Boys	20	15,59 ± 0,20	8,99 ± 0,50
			Girls	20	15,18 ± 0,39	8,74 ± 0,46

Legend. A-G1 with 13 years ≤ age ≤ 14 years 6 months; A-G2 with 14 years 6 months < age < 16 years;
n: sample size.

Table 2: Results of the non-verbal neuropsychological tests

Age groups	Sex	Brown nonverbal intelligence test		Corsi block task test	Benton visual retention test					
		IQ	Percentile	M ± SD	Adm. B (correct score)		Adm. C (error score)		Adm. D (correct score)	
					M ± SD	IQ	M ± SD	IQ	M ± SD	IQ
A-G1	Boys	120 ± 8,88	91	6,42 ± 0,88	7,31 ± 0,65	105	0,34 ± 0,17	85-115	7,29 ± 0,68	105
	Girls	117 ± 10,28	87	6,55 ± 0,82	7,27 ± 0,58	105	0,52 ± 0,22	85-115	7,16 ± 0,44	105
	Total	118 ± 9,58	88	6,48 ± 0,85	7,29 ± 0,62	105	0,43 ± 0,19	85-115	7,23 ± 0,56	105
A-G2	Boys	116 ± 7,31	86	6,48 ± 0,89	7,29 ± 0,60	95-109	0,44 ± 0,18	95-109	7,15 ± 0,62	95-109
	Girls	118 ± 9,03	88	6,50 ± 0,82	7,43 ± 0,60	95-109	0,48 ± 0,23	95-109	7,17 ± 0,44	95-109
	Total	117 ± 8,17	86	6,49 ± 0,85	7,32 ± 060	95-109	0,46 ± 0,21	95-109	7,16 ± 0,53	95-109

Legend. A-G1 with 13 years ≤ age ≤ 14 years 6 months; A-G2 with 14 years 6 months < age ≤ 16 years; IQ: Intellectual quotient; Adm: Administration mode; M: Mean; SD: Standard deviation.

obtained, with a higher score representing better MI ability with regard to the modality having been tested.

Data analyses

All values were expressed in the form of mean ± standard deviation. Before using the parametric tests, the normality of distribution was verified by the Shapiro-Wilk W-test test. The data were analyzed using the MANOVA multivariate variance analysis (2x3x2x2). Factors included two age-group categories: (A-G 1 and A-G 2); three kinds of sport (judo, karate and tennis) two gender-groups (Boys and Girls) and two MI modalities (called Conditions: VMI and KMI). When a significant F value was achieved, a Bonferroni post-hoc analysis was performed. The effect size was calculated for all variance analyses using partial eta squared (η^2_p). Values of 0.01; 0.06 and 0.15 were considered small moderate and large respectively (Cohen, 1988). Effect sizes (ESs) were calculated for all paired comparisons and judged according to the following scale: ≤0.2, trivial; >0.2-0.6, small; >0.6-1.2, moderate; >1.2-2.0, large; and >2.0, very large (Hopkins et al., 2009). Statistical analyses were performed using statistical software (SPSS Inc. Chicago IL version 180) where the significance level was set at p <0.05 *a priori*.

RESULTS

The results indicated an effect of the main factors: "Condition" ($F = 81.22$, $p < 0.001$, $\eta^2_p = 0.26$), "Group" ($F = 31.26$, $p < 0.05$, $\eta^2_p = 0.21$), "Age" ($F = 49.90$, $p < 0.001$, $\eta^2_p = 0.18$) and "Gender" ($F = 67.50$, $p < 0.001$, $\eta^2_p = 0.23$). Judokas showed superiority in KMI ($p < 0.001$, ES = 2.21, $d = 3.50$), unlike tennis players who performed better in VMI (p<0,001; d = 3.96). Karatekas don't show any superiority of any MI modality, but they performed better in KMI than tennis players and better than judokas in VMI (p < 0.001, d = 0.40, d = 2.73 respectively) (Tables 3). Subjects belonging to A-G2, boys and girls, had a greater imaging capacity than adolescents in A-G1 (F = 0.27, p < 0.001, d = 0.77) (Table 4). Boys had greater imagery scores than girls in both VMI and KMI (F = 0.32, p < 0.001, d = 1.04) (Table 5). Moreover, interactions were found: "Condition × Group" (F = 541.78, p < 0.001, η^2_p = 0.83), "Condition × Age" (F = 6.32, p < 0.01, η^2_p = 0.03), "Condition × Group × Age" (F = 10.72, p < 0.001, η^2_p = 0.09), and "Condition × Group × Gender" (F = 10.34, p < 0.001, η^2_p = 0.08).

DISCUSSION

The aim of this study was first to verify the effect of dual sports and their practice environments on determining the MI modality and its vividness; then to investigate the effect of gender and age on imaging vividness and finally to discern the visual and kinesthetic properties using MIQ-Rs in young Tunisian athletes. Results reported in this study, confirm that both dual sports and their practice environments have a significant effect on determining the MI modality as well as its vividness. However, it seems that these positive effects are dependent on the type of motor interactions which are based on the principle of communication and counter-communication Parlebas (1999). These interactions reflect all the relationships that the athlete has with his opponent; first through the existence or absence of body contact (direct body-to-body contact or prohibited contact), then through the type of this contact (enveloping or distant form) and finally through the duration of this contact (permanent or intermittent contact). Regarding the effects induced by the environment in which dual sports are practiced, we can note that practicing these sports either in confined and restricted spaces (10/10 meter tatami for judo or karate) or in open spaces (tennis court of 40/20 meters) can lead to different results. As a result, and given that judo is a sport where body-to-body contact is direct and permanent, it is obvious that this activity develops KMI's modality and vividness much more than VMI. This is recorded in all boys and girls judokas belonging to both A-G. Unlike Tennis, which develops VMI's modality and vividness much more than KMI in boys and girls of both A-G. As for karate, this sport develops both VMI and KMI modalities at the same time and identically. This corroborates the work of Di Corrado et al. (2019) who have shown that the vividness of MI and its control differ depending on the type of sport as well as on the type of contact between athletes (contact vs non-contact). They demonstrate that athletes who participate in individual sports and those who participate in team sports have distinct abilities and characteristics when it comes to sports-oriented images. Likewise, Di Corrado et al. (2014) and Hall et al. (2001) confirmed that the type of sport practiced affects the use of VMI perspective (internal or external). Fogarty and Morris (2003) confirmed these results through the example of tennis players who develop both internal and external VMI. Griffin et al. (1997) explained this mechanism, among others, by the lack of direct physical contact with the opponent. In summary, concepts that characterize each of the dual sports studied such as: motor interaction, contact with the opponent, guard distance… could justify the results recorded. As a

Table 3: Dual sport effect on motor imagery vividness (comparison of groups 2 by 2)

Motor imagery modalities	Age groups	Gender	Groups			Effect size		
			Judo	Karate	Tennis	Judo *vs* Karate	Judo *vs* Tennis	Karate *vs* Tennis
Visual	A-G1	Boys	3,96 ± 0,46	4,16 ± 0,36[b]	5,93 ± 0,26[a]	0,48	5,27	5,64
		Girls	3,91 ± 0,49	4,21 ± 0,20[b]	5,35 ± 029[a]	0,8	3,58	4,58
	A-G2	Boys	4,62 ± 0,67	5,01 ± 0,44[b]	5,81 ± 0,24[a]	0,69	2,36	2,26
		Girls	4,64 ± 0,38	4,27 ± 0,19	5,32 ± 034[a]	1,23	1,89	3,81
Kinesthetic	A-G1	Boys	5,44 ± 0,28[a]	4,08 ± 0,51[b]	3,99 ± 0,70	3,31	2,72	0,15
		Girls	4,86 ± 0,37[a]	4,25 ± 0,31[b]	3,58 ± 0,42	1,79	3,23	1,81
	A-G2	Boys	5,42 ± 0,28[a]	4,91 ± 0,44[b]	3,91 ± 0,67	1,38	2,94	1,76
		Girls	5,04 ± 0,28[a]	4,29 ± 0,23[b]	3,74 ± 0,54	2,93	3,02	1,32

Legend. A-G1 with 13 years ≤ age ≤ 14 years 6 months; A-G2 with 14 years 6 months < age ≤ 16 years; [a]Significantly higher than the two other groups (p < 0.001); [b]Significantly higher than the sedentary group (p < 0.01).

Table 4: Age effect on motor imagery vividness

Motor imagery modalities	Sex	Groups	Age groups		Effect size
			A-G1	A-G2	
Visual	Boys	Judo	3,96 ± 0,46	4,62 ± 0,27[a]	1,75
		Karaté	4,16 ± 0,36	5,01 ± 0,45[a]	2,09
		Tennis	5,93 ± 0,27[b]	5,81 ± 0,25	0,46
	Girls	Judo	3,91 ± 0,49	4,64 ± 0,38[a]	1,66
		Karaté	4,22 ± 0,20	4,27 ± 0,19[b]	0,26
		Tennis	5,35 ± 0,29	5,32 ± 0,35	0,09
Kinesthetic	Boys	Judo	5,44 ± 0,28	5,42 ± 0,28	0,07
		Karaté	4,09 ± 0,51	4,91 ± 0,44[a]	1,72
		Tennis	3,99 ± 0,70	3,91 ± 0,67	0,12
	Girls	Judo	4,86 ± 0,37	5,04 ± 0,28[a]	0,55
		Karaté	4,25 ± 0,31	4,29 ± 0,23	0,15
		Tennis	3,58 ± 0,43	3,74 ± 0,54[b]	0,33

Legend. A-G1 with 13 years ≤ age ≤ 14 years 6 months; A-G2 with 14 years 6 months < age < 16 years; [a]Significantly higher than A-G1 ($p < 0.001$); [b]Significantly higher than A-G1 ($p < 0.01$).

Table 5: Sex effect on motor imagery vividness

Age groups	Motor imagery modalities	Groups	Sex		Effect size
			Boys	Girls	
A-G1	Visual	Judo	3,96 ± 0,46	3,91 ± 0,49	0,10
		Karaté	4,16 ± 0,36	4,22 ± 0,20[b]	0,21
		Tennis	5,93 ± 0,27[a]	5,35 ± 0,29	2,07
	Kinesthetic	Judo	5,44 ± 0,28[a]	4,86 ± 0,37	1,77
		Karaté	4,09 ± 0,51	4,25 ± 0,31[b]	0,38
		Tennis	3,99 ± 0,70[a]	3,58 ± 0,43	0,71
A-G2	Visual	Judo	4,62 ± 0,27	4,64 ± 0,38	0,06
		Karaté	5,01 ± 0,45[a]	4,27 ± 0,19	2,14
		Tennis	5,81 ± 0,25[a]	5,32 ± 0,35	1,61
	Kinesthetic	Judo	5,42 ± 0,28[a]	5,04 ± 0,28	1,36
		Karaté	4,91 ± 0,44[a]	4,29 ± 0,23	1,77
		Tennis	3,91 ± 0,67[b]	3,74 ± 0,54	0,28

Legend. A-G1 with 13 years ≤ age ≤ 14 years 6 months; A-G2 with 14 years 6 months < age < 16 years; [a]Significantly higher than adolescents of the other sex ($p < 0.001$); [b]Significantly higher than adolescents of the other sex ($p < 0.05$).

martial art, judo mainly consists of throwing techniques, ground control, strangulation and arm locks during a codified confrontation between two fighters (Calmet & Franchini, 2011). Lascau et al. (2021) noted that this practice is based on the solicitation and the development of proprioceptive and kinesthetic sensations through exercises aimed to unbalance, fall, roll or immobilize one's opponent. The simple grasp between the two judokas plays a preponderant role; it is considered as a vector for the perception of sensations and the transmission of forces useful to control, unbalance or project (Lascau et al., 2021). It is therefore quite clear that judo is based mainly on proprioceptive sensations as sources of information thus developing the quality of kinesthetic perception. This provokes, implicitly or explicitly, the mention of the KMI and develops its vividness. Yoshikazu (2015) presented Karate as a martial discipline whose techniques aim to defend oneself and then respond with an attack using different parts of the body: fingers, hands, forearms, feet, elbows and knees. Charles (2003) adds that the practice of karate consists of training and competing by applying the techniques and positions learned before (for more details see Froidure (2014)). This shows that karate practice is based on the "action-reaction" principle which can only be realized through the simultaneous involvement of sensorimotor and perceptual systems of visual and kinesthetic origin. The purpose of visual perception is to define the "motor situation" and to transmit all of the resulting information for processing. As a result, a "motor action" (as a reaction) is triggered (Parlebas, 1999). This reaction can only guarantee its effectiveness if all parts of the body were well adjusted with all the biomechanical and kinetic parameters requirements (Sacripanti, 2008). It is obvious that karate is a discipline that brings into play, and at the same level of importance, both perceptual perspectives. This confirms our results which show that karate practice develops both VMI and KMI modalities similarly. Pinon (1975) defines tennis as an opposition sport, a dual confrontation starting from a situation of exchange of ball. This definition includes fundamental concepts in sport such as "dual, attack/defense, target and exchange situation". The mastery of these concepts is based on what Dugal (1991) designates by the "rapid information analysis" to develop an organized and effective action plan. Skilled tennis players are endowed with important abilities to obtain prior information from an opponent's postural orientation (Williams et al., 2002) and to employ highly effective visual search behaviors (Murray & Hunfalvay, 2016). This develops in the practitioner the capacity for anticipation that Richelle and Lejeune (1980) define as a perceptual-motor skill which consists "in the realization of behaviors clearly ordered to some subsequent event". In this skill, visual system is the dominant sensory system (Zupan & Merfeld, 2005) and is accomplished through gaze control which is influenced by environmental conditions (Murray & Hunfalvay, 2016) and follows skill development (Vickers & Lewinski, 2011). The current results show that age plays an important role in the development of MI vividness, where subjects belonging to A-G2 possessed better imagery skills than their A-G1 counterparts (see Table 5). These findings corroborate those of Subirats et al. (2018) and Arvinen-Barrow et al. (2008) who showed that the oldest group of synchronized skaters (18.5 years) used imagery skill more than the middle age athletes (15.3 years), who themselves employed more MI than the youngest (12.9 years) age groups. Mitra et al. (2016) and Souto et al. (2020) argued that imagery ability is subject to changes with maturity, and age would have an influence in this process. With age, and compared to other skills, the vividness of an image is subject to improvements in both visual and kinesthetic modalities (Parker & Lovell, 2012). This could be mediated by very large volumes of sporting or physical practicing, which may offer more opportunities to use MI, allowing low and high performers to be distinguished (Robert S. Weinberg & Gould., 2003). On the other hand, Choudhury et al. (2007) suggested that the development of the parietal cortex could explain the improvement of MI between adolescence and adulthood. Future studies are needed to determine the differential involvement of cortical circuits in MI in adolescents compared to adults (Choudhury et al., 2007). Overall, the results of this study suggest that boys perform better than girls in MI (see Table 5). These findings correspond to those of Campos and Lustres (2019) Habacha et al. (2014) who noted that gender may play a role in the development of MI. In the same way, Yoxon (2012) specifies that in children, differences in VMI between boys and girls could be the result of sports practice and motor experiences (Yoxon, 2012). Indeed, increasing participation in sports and motor events could increase, or at least facilitate, the use of MI. De Caroli and Sagone (2007), as well as Hoyek et al. (2009), reported that boys were better at forming a dynamic mental image of movements compared to girls who had more difficulty in preserving the temporal organization of an imagined movement. Further, Gao et al. (2014) suggested that game preferences during childhood have determining roles: in boys, they mainly develop the visuospatial capacity and body image; whereas in girls, they develop the ability of communication. Contrary, some previous studies have shown that gender has minimal influence on the use of MI (Hall Craig, 2001). Munroe-Chandler et al. (2007) studied the content of MI in young athletes aged 7 to 14 years; they found no gender effect in the overall ability to form mental images. this remains to be confirmed (Hall Nathan & Fishburne Graham, 2010), highlighting that further research is needed.

CONCLUSION

Until recently, much of the existing literature on the use of images in sport has focused on adult athletes, with a paucity of research in the use of images by children and young athletes (Miller, 2017). Thus, the present study sought to clarify MI and its relationship with dual sport, especially in adolescents. Our results are important for athletes and coaches in relation to the best use of MI to enhance sport performance and show that dual sport engagement is associated with enhanced MI vividness as well as the determination of its modalities (VMI and KMI). Moreover, older adolescents evoke clearer images than younger adolescents, and boys have greater imagery ability than girls. It is necessary to conduct further work in order to elucidate the causal impact of sport on MI.

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