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**Effects of Motor Imagery Training on Service Performance in Novice Tennis Players:  
The Role of Imagery Ability**

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### **Abstract**

The aim of this study was to examine how imagery ability could affect service improvement, following pre-performance motor imagery (MI) intervention, in young novice tennis players. Participants were divided into 3 groups with regard to their MI ability scores (Poor imager, Good imager and Control groups) obtained on the Movement Imagery Questionnaire for Children. During a pre-test, participants performed 10 services. The pre-performance MI practice was included during physical practice for 24 sessions. Each session consisted of 20 services, which were first imagined and then physically performed. Participants of the Poor and Good imager groups were required to use external visual MI, while those of the control group were given a countdown task. Participants performed an intermediate-test, after a first block of 12 practice sessions, and a post-test one-week after the last block of practice session, which were identical to the pre-test. The results of this study showed that MI improved service performance (i.e., percentage of success, speed and efficiency), and that this improvement was faster in the Good imager than in the Poor imager group. More specifically, The Poor imager group required more MI interventions to achieve equivalent performance to Good imager group. The impact of MI practice on service performance, for novice tennis players, is discussed.

*Keywords:* service, tennis, imagery ability, motor learning.

## Introduction

Motor imagery (MI) can be defined as a conscious process that requires mentally simulating a motor action without executing it (Guillot et al., 2013; Robin et al., 2007). MI is frequently used in sport, especially in racket sports, as a complement to physical practice to improve performance and promote motor learning (Cece et al., 2020; Simonsmeier et al., 2020), whatever the level of expertise of the practitioners (Robin et al., 2022; Toth et al., 2020).

Athletes can retrieve images of past matches or competition and their performances, and can imagine actions or matches to come (Fazel et al., 2018) to facilitate psychological processes. They use MI in various ways such as increasing confidence, focus, self-efficacy, concentration or reducing anxiety (i.e., motivational functions) and mental rehearsing of strategies or specific sport skills (i.e., cognitive functions) such as imagining groundstroke shot (Koehn et al., 2006). Guillot et al. (2013) showed that a regular MI intervention, performed in combination with physical practice, improved serving performance in young tennis players.

However, it is important to note that researchers revealed that MI can be specifically affected by numerous factors such as environmental context, MI ability or age (Holmes & Calmels, 2008; Toth et al., 2020). In table tennis, Guillot et al. (2005) highlighted that the environmental context (i.e., being on the play ground, in sportswear with the racket in hand) in which MI is performed, can facilitate an individual's ability to build up the mental simulation of a motor action. Other authors evoked the necessity to take into consideration players' imagery abilities to properly individualize MI and promote motor learning (e.g., Robin et al., 2022; Seiler et al., 2015). Indeed, although it seems that all individuals are able to generate mental images, Hall (2001) mentioned that there are inter-individual differences in MI. By definition, imagery ability refers to "an individual's capability of forming vivid,

controllable imagery and retaining them for sufficient time to effect the desired rehearsal” (Morris et al., 2005). Gregg et al. (2005) added that imagery ability refers to the quality of an individual’s MI. Therefore, it seems important to screen athletes for MI abilities before and during imagery intervention (Cumming & Ramsey, 2009). Research showed that, in terms of imagery ability, high-imagers outperform lower or occasional imagers (Guillot & Collet, 2008; Robin et al., 2007; Smith & Holmes, 2004; Taktek et al., 2004). Different methods have been used to assess the ability to generate mental images such as mental rotation tasks (Logie et al., 2011), the mental chronometry paragraph which compares the duration of real actions with that of imagined actions (Guillot & Collet, 2005) or the evaluation of the quality of the simulation of motor actions previously carried out (Hall, 2001).

According to Robin et al. (2017), a valid, simple, easy to implement and inexpensive method of assessing MI ability is the use of self-report questionnaire. In the field of sport, the most commonly used questionnaire is the Movement Imagery Questionnaire (MIQ; Hall & Pongrac, 1983) and its revised versions (MIQ-R; Hall & Martin, 1997 or MIQ-3; Williams et al., 2012), which assesses the ability to mentally see and feel simple motor actions. In the Robin et al. (2007) study, of the eighty tennis players fulfilling the MIQ, 15 were considered as poor imagers and 15 were considered as good imagers. The authors showed that MI practice improved return of service performance and that this improvement was greater in good imagers than in poor imagers. Toussaint, Robin and Blandin (2010) suggested that a good MI ability allowed better and faster learning, acquisition, and memory encoding than poor MI ability. So, although they can benefit from MI practice (Robin et al., 2007), poor imagers need more practice trials than good imagers to acquire simple movement in a laboratory task (Goss et al., 1986; Hall et al., 1992).

Although there appears to be a consensus among researchers that MI ability improves with age and experience due to the refinement of internal models (Caeyenberghs et al., 2009),

it is important to note that children as young as 7 years are able to perform MI (Skoura et al., 2009). By using an adapted version of the MIQ for children, Quinton et al. (2014) found that young futsal players (7-12 years) more easily imaged movement from a visual imagery perspective than a kinesthetic imagery perspective. In addition, studies showed that MI intervention was beneficial in young participants performing a throwing task toward a target (Taktek et al., 2008) and tennis task such as forehand, backhand, or volley (Cherappurath & Elayaraja, 2017) and service (Atienza et al., 1998; Guillot et al., 2013; Robin et al., 2022).

The aim of this original study was to assess whether a pre-performance MI intervention performed in addition to actual practice could improve service performance in young novice tennis players and whether this improvement may be influenced by the amount of MI practice and participant's MI ability. Since previous research has shown MI to be an effective strategy for developing motor skill and improving performance in young tennis player performing services (Malouff et al., 2008) and that the effect of MI intervention could be moderated by the individual's MI ability (Robin et al., 2007), we first hypothesized that the participants who would benefit from the MI intervention would have higher performance than those of the control condition. We secondly hypothesized that good imagers would have better service performance than poor imagers after a moderate amount of practice and that the latter would need more trials to be as efficient as the good imagers.

## **Materials and Methods**

### ***Participants***

Thirty-three right-handed novice (one to two years of practice) tennis players ranging in age from 9 to 13 years ( $M_{age} = 10.97$ ,  $SD = 2.09$ ) voluntarily participated in this study. Participants, and their parents, were given details of their required involvement and were assured about their right to withdraw. Participants had never been exposed to formal mental imagery preceding the experiment, and were unfamiliar with the experimental protocol of the

present study. The current study was approved by the local ethics committee of the University and was conducted according to the guidelines of the Declaration of Helsinki.

### ***Material, Task and Measures***

The experiment was conducted on a tennis court meeting the international standards.

*Imagery Ability.* The first step of this experiment was to assess MI ability using the Movement Imagery Questionnaire for Children (MIQ-C), which is an adapted version of the MIQ-3 (Williams et al., 2012). The MIQ-C (Martini et al., 2016) is a valid self-report questionnaire that has demonstrated adequate internal reliability for external visual ( $\alpha = 0.70$ ), internal visual ( $\alpha = 0.74$ ), and kinesthetic ( $\alpha = 0.85$ ) MI modalities (Quinton et al., 2014). It assesses children's ability to image four movements using external visual imagery, internal visual imagery and kinesthetic imagery. The children assign a value, on a 7- point Likert scale, which reflects the ease/difficulty with which they mentally simulate the movement. A high rating indicates that the movement is easy to imagine, while a low rating indicates greater difficulty.

*Service Test.* During the pre-test, intermediate-test and post-test, the participants of the experimental groups performed 10 services filmed with two Canon HD, Legria HF G25 cameras. The task was to perform the services alternating service box after each trial. The participants were informed about the number of trials and were instructed to serve in the service box and to change diagonals after each attempt. Percentage of success (i.e., number of service balls in the adequate service box); service speed recorded by means of a radar (Cordless MPH radar Gun Type R1000); and technical quality scores relating to: Starting position, ball throw, arm-racket movement backwards, arm-racket movement forward, point of contact and end of movement and rated with a scale ranging from "0" poor to "7" excellent were collected by two tennis coaches (for a similar procedure see Atienza et al., 1998). The coaches (certified by French Tennis Federation), who did not know each other, assessed the

technical quality with blinding video sequences. In order to determine the interrater reliability concerning the scores, Cohen's Kappa were calculated and showed strong levels of agreement ( $Kappa > 0.874$ ). During a meeting, the coaches compared and discussed the scores and a third external reviewer (last author) was consulted to resolve any disagreements and avoid bias.

*Motor Imagery Task.* Before each actual execution of a service, the participants of the Poor imager and Good imager groups were instructed to imagine serving, in the service box they wanted to reach before serving, by using an external visual modality (i.e., seeing each other in third person as if they were being filmed with a camera). In order to generate and then control the mental imagery task, an imagery script was read to the participants at the beginning of each session: *“Close your eyes. Imagine that you are on the tennis court and you see yourself as if you were filmed with a camera placed on the side. You are positioned behind the baseline, the racket in your hand and you are about to serve. Imagine yourself throwing the ball, hitting it, and seeing its trajectory from impact until it hits the service box”*. Finally, at the end of each intervention session, individual debriefings were scheduled to investigate adherence of the participants who performed MI (i.e., Poor imager and Good imager groups) to the imagery instructions notably the use of MI from an external visual modality, and to determine whether they encountered difficulty in performing mental images (for similar MI instruction, see Robin et al., 2022). *“Participants were also asked to rate the quality (i.e., clarity and control) of MI, from an external visual modality, by using a Likert-type scale (from 1 = poor mental representation to 6 = extremely vivid mental representation)”* (for further details, see Guillot et al., 2013, p. 3). Spittle (2001) underlines that *“Rating scales represent a quick and easy method of assessment because participant response is simple and fast, and there is no need for transcription or content analysis”*.



*Mental Task.* During the intervention phase and before each actual execution of a service, the players in the Control group had to countdown from 10 to 0 corresponding approximately to the time that participants of the other groups spent on MI (for a similar procedure see Robin et al., 2019).

### ***Procedure***

Before the start of the study, the experimenters met with the young tennis players to determine their knowledge about MI and proceeded to administer the MIQ-C to all of them. The participants were divided into 3 groups as a function of their external visual imagery scores: Poor imagers ( $N = 11$ ; scores about 2), Good imagers ( $N = 11$ ; scores  $> 5$ ) and Control ( $N = 11$ ; with  $N = 5$  poor imagers and  $N = 6$  good imagers) groups (see Robin et al., 2007 for similar participant selection and Robin and Blandin (2021) for the cut-off values concerning the Poor and Good imagers). All the results are presented in Table 1. Participants responded individually in a quiet area (i.e., room) to the MIQ-C (Martini et al., 2016).

*Pre-test.* During the pre-test, held in week 1, participants performed a standardized 20-minute warm-up, and then performed 10 services by alternating the service box after each trial. For all the participants, the instructions were strictly identical and clearly indicated that the services should only be carried out physically.

*Intervention.* After the pre-test and during 3 months (from week 2 to week 24), the participants performed the intervention phase composed of 2 blocks of 12 sessions (1 session a week). Each session started with the standardized 20 minutes warm-up. Then the participants had to serve 20 times by alternating the service box after each trial (for a total of 20 imagined and 20 actual trials during each session). The participants of the Control group had to only countdown before serving, and those of the Poor imager and Good imager groups were instructed to use pre-performance MI (i.e., to imagine, in a third person perspective,

performing a successful service towards the "correct" service box) before each real service execution (for similar procedure see Robin et al., 2022).

*Intermediate-test.* A test, similar to the pre-test, was performed after the first block of the intervention phase, during week 13.

*Post-test.* The participants performed a test that was similar to the pre-test and intermediate-test, during Week 25.

### ***Data Analysis***

The percentage of success (i.e., number of valid services multiplied by ten), the service speed and the technical quality scores of the service balls performed during the pre-, intermediate- and post-tests, served as dependant variables and indicators of performance. The four ANOVAs assumptions (independence of observations, normality of observations, homogeneity of group variances, and sphericity) were satisfied.” (Taktek et al., 2008). The dependent variables were submitted to 3 Groups (Control vs. Poor imager vs. Good imager) x 3 Tests (pre-test vs. intermediate-test vs. post-test) ANOVAs with repeated measures on the second factor. Effect sizes ( $\eta_p^2$ ) were indicated,  $\alpha$  was set at  $p = .05$  for all the analyses that were performed on Statistica (12.0, 64-bit). As multiple paired and unpaired t-tests were conducted for post-hoc analyses, to control for the possibility of a Type I error occurring, Holm Bonferroni adjustments were applied to the alpha level.

## **Results**

### ***Imagery Ability***

The results concerning the imagery ability (i.e., MIQ-C) scores are presented in Table 1.

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Table 1 near here

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### ***Percentage of Success of the Service***

The ANOVA computed on the percentage of successful service revealed significant main group [ $F(2, 30) = 3.48, p = .04, \eta^2_p = .19$ ] and test [ $F(2, 30) = 23.07, p < .001, \eta^2_p = .44$ ] effects. In addition, the analysis revealed a significant interaction between group and test [ $F(4, 30) = 17.50, p < .001, \eta^2_p = .54$ ]. As illustrated in Figure 1, the participants of the Good imager group significantly increased their performance from the pre- to the intermediate-test ( $t = -8.19, p < .001, d = .87$ ); and they also had significantly higher percentage of success than the participants of the control ( $t = -6.05, p < .001, d = .78$ ) and Poor imager ( $t = 4.89, p < .001, d = .70$ ) groups at the intermediate-test and than those of Control group only at the post-test ( $t = -4.58, p < .001, d = .68$ ). Moreover, the participants of the Poor imager group increased significantly their performance from the intermediate-test to the post-test ( $t = -5.57, p < .001, d = .76$ ) and had significantly higher percentage of success than the participants of the Control group at the post-test ( $t = 3.51, p < .01, d = .55$ ).

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Figure 1 near here

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### ***Service Speed***

The results for the service speed revealed significant main group [ $F(2, 30) = 11.91, p = .001, \eta^2_p = .44$ ] and test [ $F(2, 30) = 57.81, p < .001, \eta^2_p = .66$ ] effects. However, the ANOVA revealed an absence of interaction between group and test [ $F(4, 30) = 0.49, p = .74, \eta^2_p = .03$ ]. The analysis revealed that the participants of the Poor imager and Good imager groups had significantly higher service speed than those of the Control group ( $t = 2.67, p < .017, d = .42$  and  $t = 2.13, p < .05, d = .32$  respectively). Besides, all the participants

significantly increased their service speed from the pre- to the intermediate-test ( $p < .01$ ) and tend to increase ( $p = .07$ ) it from the intermediate-test to the post-test.

### ***Technical Quality***

The analysis computed on technical quality scores revealed significant main group [F(2, 30) = 6.03,  $p < .001$ ,  $\eta^2_p = .29$ ] and test [F(2, 30) = 73.64,  $p < .001$ ,  $\eta^2_p = .71$ ] effects. The ANOVA also revealed a significant interaction between group and test [F(4, 30) = 18.64,  $p < .001$ ,  $\eta^2_p = .55$ ]. The post-hoc tests for intermediate-test revealed that technical quality performance for Good imager group was significantly higher than that for Control Group ( $t = 3.90$ ,  $p < .001$ ,  $d = .60$ ). For post-test, technical quality performance for Good imager group or Poor imager group was significantly higher than that for Control Group ( $t = 4.72$ ,  $p < .001$ ,  $d = .69$  and  $t = 3.75$ ,  $p < .001$ ,  $d = .58$  respectively). Furthermore, technical quality performance for Good imager group increased significantly from pre-test to intermediate-test ( $t = 11.01$ ,  $p < .001$ ,  $d = .92$ ) and from intermediate-test to post-test ( $t = -3.68$ ,  $p < .01$ ,  $d = .57$ ). Finally, technical quality performance for Poor imager group at post-test was significantly higher ( $t = 4.84$ ,  $p < .001$ ,  $d = .70$ ) than that at intermediate-test (see Figure 2).

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Figure 2 near here

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## **Discussion**

The aim of this study was to examine how imagery ability could affect service performance when using MI practice in addition to actual practice, in young novice tennis players. As hypothesized, the results of the current study first revealed that the participants who performed MI before serving (i.e., Good imager and Poor imager groups) had significantly higher performance (i.e., percentage of success, service speed and technical quality) than those of the Control group who performed a neutral task before serving; and it's

important to note that employing a tennis service task with the assessment of three dependant variables was a strength with respect to several other mental imagery studies that involved a single dependant variable (Taktek et al., 2004, 2008, 2019). These findings are consistent with previous studies showing the beneficial effect of motor imagery in racket sports and tennis when combined with physical practice (for reviews see Cece et al., 2020 or Robin et al., 2022). Indeed, this study confirms the positive effects of using MI to improve service performance (e.g., Atienza et al., 1998; Cherappurath et al., 2020; Dominique et al., 2021; Fekih et al., 2020), and more specifically the beneficial effect of using external visual imagery practice before actual service in novices (Guillot et al., 2013; Robin et al., 2022).

Using debriefings to investigate adherence of the participants categorized as Poor imagers and Good imagers to the imagery instructions, and to determine whether they encountered difficulty in performing mental images (i.e., external visual imagery) at the end of the treatment phase, was a strength of the research, as it allowed better experimental control (Callow et al., 2013; Morris & Spittle, 2012; Taktek, 2019). One could envision that external visual MI would be effective for form-based movement (Hardy & Callow, 1999; White & Hardy, 1995), such as the service, as it allows users to more easily visualize overall positions and movements (Robin et al., 2022), which could have given an advantage to the Good imager and Poor imager group participants compared to those of the Control group. We could also assume that the beneficial effect of MI intervention may be due to its cognitive function or to its motivational function which complement those induced by physical practice (Robin et al., 2007) and that the fact that participants in the Poor and Good imagery groups made more trials with the mental rehearsal. It is also possible that participants of the Control group were less motivated than those of the Good imager and Poor imager groups due to experimental conditions, which is why given that motivation is a factor likely to influence performance, it should be considered in future research using similar procedures.

As secondly hypothesized, the results of our study showed that MI improved service performance and that this improvement was faster in the Good imager than in the Poor imager group. Indeed, the latter needed more trials to be as efficient as those of the Good imager group. While participants in the Good imager group increased their service performance following only 12 weeks of MI intervention (i.e., intermediate-test), those in the Poor imager group achieved similar performance, than those of the Good imager group, after 24 weeks of MI intervention (i.e., post-test). Use of the MIQ-C (Martini et al. 2016) in order to, initially, assess participants' imagery ability and, then form the diverse experimental groups (i.e., Good imager, Poor imager and Control groups) was also strength of the study (Hall et al., 1992; Taktek, 2008, 2019). As in the Goss et al. (1986) study that used a simple movement laboratory acquisition task involving novice participants and an adult version of the MIQ to distinguished "poor imagers" from "good imagers", the results of the current study showed that the participants of the Good imager group needed less trials than the participants of the Poor imager group to obtain equivalent motor performance. As suggested by Robin et al. (2007), who showed higher service return performance in good imager expert tennis players than in poor imager cohort, we could envisage that good MI ability would facilitate the construction and/or the encoding of information in the mental representations of actions solicited during MI.

Although imagery ability appears to be a variable moderating the effects of MI on sports performance (Martin et al., 1999), it is important to highlight that MI can be beneficial in novice and "poor imagers". It seems necessary to identify "poor imagers" in order to offer them more mental and physical practice trials allowing them to benefit from the beneficial effect of MI on motor learning and performance. In order to facilitate access to the mental representation of the action to be imagined (e.g., a service in tennis), it is recommended to perform MI on the court, while wearing tennis clothing (Guillot et al., 2005) and handling the

racket (Bisio et al., 2014). Indeed, the tactile input associated with holding the tennis racket could improve MI vividness especially in novices and poor imagers (Mizuguchi et al., 2015).

In addition, authors suggested to combine MI with video (e.g., de Sousa Fortes, 2019) or instructional self-talk (e.g., Robin et al., 2021), in order to help the players to imagine all parts of tennis movement to mentally simulate such as the service.

Although the MIQ-C can be used as an evaluative and screening tool in sport setting such as tennis and research (Martini et al. 2016) for identifying children who have difficulties in performing MI (i.e., poor imagers), the use of a pencil-paper test requiring players' self estimation of MI ability could be considered as a limitation of this study. In addition, the type of experimental task used (i.e., service test) in this research may not be the best representative of open and closed motor skills, and the results are specific to the age category of participants recruited in this study (children 9-13 years). Moreover, the experimental protocol included only novice tennis players; therefore, it is not clear to which extent these findings could also apply to more skilled athletes. The generalization of these results should be limited to other sports sharing similar skill sets and training strategies. In addition, although counting down is a neutral task used in the literature (e.g., Robin et al., 2019), it is possible that this task disturbs planning of the following execution. Unlike MI which can prime subsequent action (Toovey et al., 2021), it is possible that counting down did not put the participants of the control group in optimal conditions to perform the service. Finally, although similar to previous studies using similar procedures (e.g., Cherappurath et al., 2020; Féry & Morizot, 2000; Guillot et al., 2013) the sample size ( $n = 33$ ) was relatively small, particularly when considering that the total number of participants were further divided into the 3 experimental groups of 11 participants each, weakening the power of statistical analyses, that is why the results obtained in the current study should be interpreted carefully and confirmed with larger samples before generalization.

To conclude, the objective of this study was to evaluate how imagery ability could influence service performance following a pre-performance MI intervention, in addition to actual practice, in novice tennis players. The results of this original study confirmed that the combination of MI and actual service improved tennis service performance in novice players, and showed that this improvement was faster in the good imagers than in the poor imagers. Indeed, the participants of the Poor imager group needed more MI intervention to obtain equivalent performances to those of the Good imager group. This study revealed that MI can be used regardless of the player's imagery ability and provide ecological implications for novices and non-expert tennis players. Finally, the results of the current study demonstrate that motor imagery can be a useful mental strategy, even when having difficulty in creating and using MI, to promote learning and improve performance.

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### **Declaration of interest statement**

The authors report there are no competing interests to declare.

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Table 1

*Visual and kinesthetic Movement Imagery Questionnaire for Children (MIQ-C) scores across the different groups*

Groups	Internal Visual		External Visual		Kinesthetic	
	Mean	SD	Mean	SD	Mean	SD
<b>Control (N = 11)</b>	3.82	2.28	3.66	1.65	3.55	2.05
<b>Poor imager (N = 11)</b>	2.03	0.37	2.09	0.28	1.7	0.55
<b>Good imager (N = 11)</b>	5.72	0.98	6.01	0.71	5.59	1.17

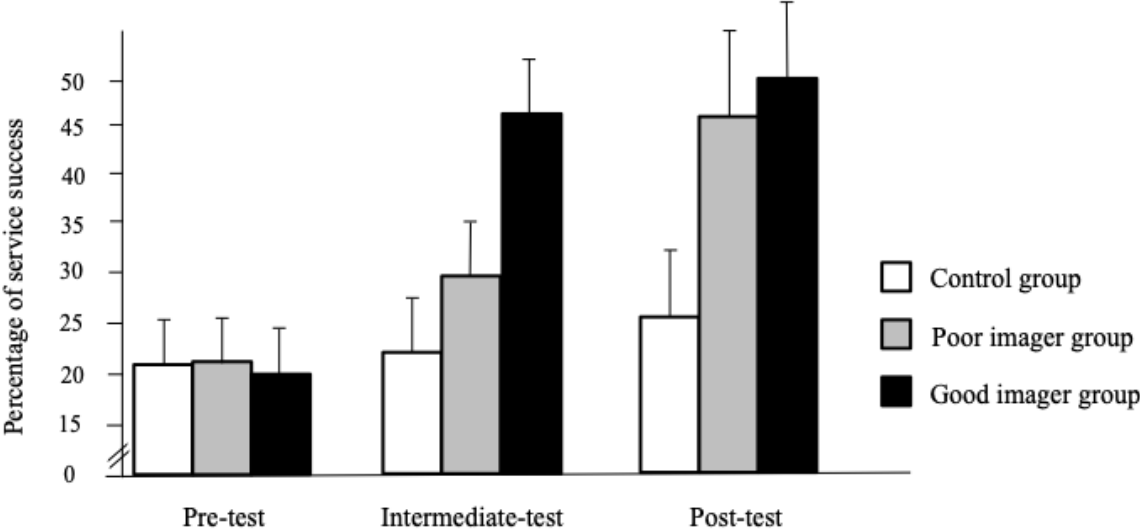


Figure 1.



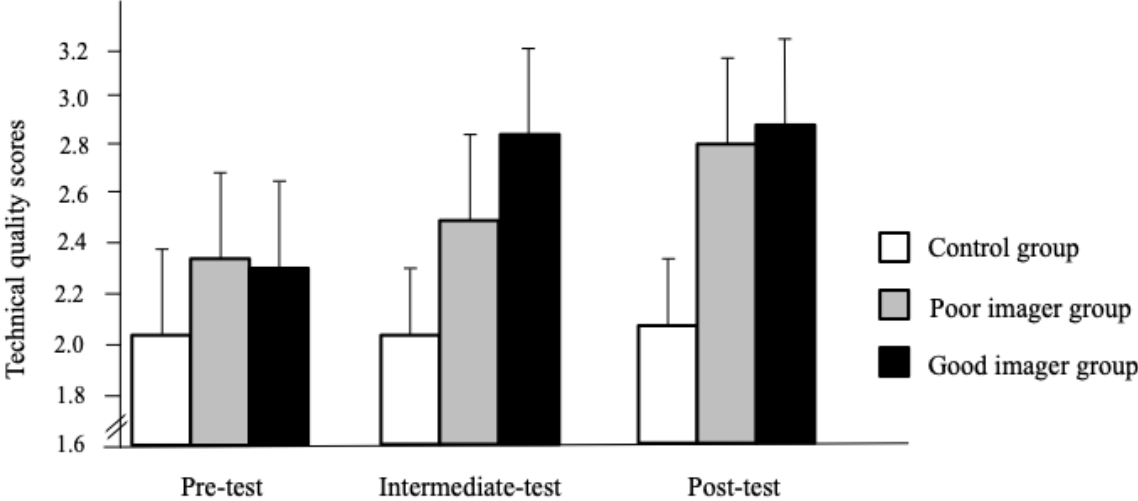


Figure 2.

Figure captions

Figure 1. Significant interaction between group (Control vs. Poor imager vs. Good imager) and test (pre-test vs. intermediate-test vs. post-test) for the percentage of service success

Figure 2. Significant interaction between group (Control vs. Poor imager vs. Good imager) and test (pre-test vs. intermediate-test vs. post-test) for the technical quality scores

## Reviewer(s)' Comments to Author:

Reviewer: 1

## Comments to the Author

I am satisfied with the amendments the authors have implemented in regards to the original manuscript. I wish them well in finalizing the manuscript. I have a small number of comments that are detailed in the attached comments summary.

Dear Reviewer 1,

Thank you for your appreciated supportive comments and suggestions.

Comment on page 2: Thank you for your helpful comment concerning the abstract

Comment on page 3: *As suggested, we added « to facilitate psychological processes » at the end of the sentence that become « Athletes can retrieve images of past matches or competition and their performances, and can imagine actions or matches to come (Fazel et al., 2018) to facilitate psychological processes ».*

Comment on page 4: *We followed your recommendation and added « the » in the sentence. « In the Robin et al. (2007) study, of the eighty tennis players fulfilling the MIQ, 15 were considered as poor imagers and 15 were considered as good imagers.»*

Comment on page 5: Thank you for your constructive comment concerning the introduction part of the manuscript.

Comment on page 9: *We removed the quotation marks from the sentence.*

Comment on page 15: *As suggested, we replaced « use » by « using » page 15.*

Reviewer: 2

#### Comments to the Author

The authors have replied to all of my points and have thoroughly revised the manuscript. All except two points have been adequately addressed by the authors. Given the importance of the two points, I recommend to carefully consider both. I look forward to seeing a revised version of the manuscript that considers the two points as well.

Dear Reviewer 2,

Thank you for your appreciated helpful comments. We carefully considered the two points.

My first main point still stands. The pre-performance imagery groups hold either a high or a low level of imagery ability (which is thought to moderate the impact imagery has on performance). The control group instead does neither partake in pre-performance imagery, nor hold an imagery ability comparable to that in the two other groups. How can we then explain the difference between the control group and one of the imagery groups? Is the control group not getting better because they do not partake in imagery or because they hold a different level of imagery ability than the two other groups? I strongly recommend to carefully consider this point again (together with my more detailed comment in my previous review) and revise the manuscript accordingly, so that the reader is not misled by remaining ambiguity and related conclusions, but is rather made aware about potential limitations/confounds.

None of the participants performed motor imagery during the pre-test, whatever their group. The instructions were strictly identical and clearly indicated that the services should only be carried out physically. Moreover, there was no between group difference, whatever the dependent variables at the pre-test.

The difference in performance between the groups having carried out imagery and the control group can be explained by the fact that the participants of the control group did only real practice while those of the imaging groups did a combination of real and mental practice, that means more practice, more trials.

Imagery ability influence performance when using motor imagery but as few or no influence when using physical practice only. For instance, it is important to note that Robin et al. (2007), who employed a similar procedure, found poor imagers in expert tennis players. The control group did not get better because the participants did not partake in imagery. Besides, it is plausible that this result was obtained because the participants of the control group made less trials than the participants of each of the other Poor and Good imagery groups. Thus, this result could be explained by the cognitive and motivational roles of MI, particularly in racket sports (Cécé et al., 2020; Robin & Dominique, 2022).

The procedure, validated by the expert 1, is also used in several other researches (e.g., Dominique et al., 2021; Guillot et al., 2013; 2015; Hatchi et al., 2022; Robin et al., 2007; 2019; 2020; 2021).

We added precisions in the manuscript for better clarity.

On my data analysis points: The authors now report that "Holm Bonferroni adjustments were applied to the alpha level for post-test between group comparisons". This is confusing. What does this mean? Did the authors apply corrections only for the post-test comparison? If so why? (As a side comment: I personally prefer to read the uncorrected p-values, and to compare them to the adjusted alpha levels for each of the comparison made; this brings much more transparency for the reader [and the reviewers]. For instance, if three comparisons are made in a given design, then the corrected alpha values are .017, .025 and .05 to be compared against each of the p values.) Please also report d values (as already indicated in my previous review) for post-hoc comparisons. I think the reader would profit from insights into exact (preferable uncorrected) p values (and adjusted alpha levels) for each of the comparisons made together with effect sizes.

We apologize for this reading error. We modified the last sentence of the "data analysis" part of the manuscript (please see page 9). We also employed uncorrected p values and adjusted alpha levels for each comparison.

Please see pages 10 to 11.

*The ANOVA computed on the percentage of successful service revealed significant main group [ $F(2, 30) = 3.48, p = .04, \eta^2_p = .19$ ] and test [ $F(2, 30) = 23.07, p < .001, \eta^2_p = .44$ ] effects. In addition, the analysis revealed a significant interaction between group and test [ $F(4, 30) = 17.50, p < .001, \eta^2_p = .54$ ]. As illustrated in Figure 1, the participants of the Good imager group significantly increased their performance from the pre- to the intermediate-test ( $t = -8.19, p < .001, d = .87$ ); and they also had significantly higher percentage of success than the participants of the control ( $t = -6.05, p < .001, d = .78$ ) and Poor imager ( $t = 4.89, p < .001, d = .70$ ) groups at the intermediate-test and than those of Control group only at the post-test ( $t = -4.58, p < .001, d = .68$ ). Moreover, the participants of the Poor imager group increased significantly their performance from the intermediate-test to the post-test ( $t = -5.57, p < .001, d = .76$ ) and had significantly higher percentage of success than the participants of the Control group at the post-test ( $t = 3.51, p < .01, d = .55$ ). (...)*

*The results for the service speed revealed significant main group [ $F(2, 30) = 11.91, p = .001, \eta^2_p = .44$ ] and test [ $F(2, 30) = 57.81, p < .001, \eta^2_p = .66$ ] effects. However, the ANOVA revealed an absence of interaction between group and test [ $F(4, 30) = 0.49, p = .74,$*

$\eta^2_p = .03$ ]. The analysis revealed that the participants of the Poor imager and Good imager groups had significantly higher service speed than those of the Control group ( $t = 2.67, p < .017, d = .42$  and  $t = 2.13, p < .05, d = .32$  respectively). Besides, all the participants significantly increased their service speed from the pre- to the intermediate-test ( $p < .01$ ) and tend to increase ( $p = .07$ ) it from the intermediate-test to the post-test.

(...)

The analysis computed on technical quality scores revealed significant main group [ $F(2, 30) = 6.03, p < .001, \eta^2_p = .29$ ] and test [ $F(2, 30) = 73.64, p < .001, \eta^2_p = .71$ ] effects. The ANOVA also revealed a significant interaction between group and test [ $F(4, 30) = 18.64, p < .001, \eta^2_p = .55$ ]. The post-hoc tests for intermediate-test revealed that technical quality performance for Good imager group was significantly higher than that for Control Group ( $t = 3.90, p < .001, d = .60$ ). For post-test, technical quality performance for Good imager group or Poor imager group was significantly higher than that for Control Group ( $t = 4.72, p < .001, d = .69$  and  $t = 3.75, p < .001, d = .58$  respectively). Furthermore, technical quality performance for Good imager group increased significantly from pre-test to intermediate-test ( $t = 11.01, p < .001, d = .92$ ) and from intermediate-test to post-test ( $t = -3.68, p < .01, d = .57$ ). Finally, technical quality performance for Poor imager group at post-test was significantly higher ( $t = 4.84, p < .001, d = .70$ ) than that at intermediate-test (see Figure 2).