

## Assessment of motor imagery ability and training

### *Avaliação da capacidade e treinabilidade da imaginação motora*

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**Abstract** – The aim of this study was to evaluate changes in motor imagery ability in response to a specific dart throwing training. Twelve subjects (17-22 years) with no previous experience in dart throwing or imagery agreed to participate. Changes in imagery ability were assessed using the Sports Imagery Questionnaire before (pretreatment) and after (post-treatment) an imagery training program consisting of 10 sessions. Retention (RET) was assessed 2 weeks after training. The program included mental exercises designed to develop vivid images, to control one's own images, and to increase perception about performance. Comparison of the imagery training conditions (training alone, training accompanied, observing a colleague, and during assessment) showed no differences between the pretreatment, post-treatment and RET evaluations. Although imagery ability did not respond to training, significant differences between imagery domains (visual, auditory, kinesthetic, and anemic) were found ( $p < 0.05$ ), except between the visual and anemic domains ( $p = 0.58$ ). These differences might be related to subject's domain preference subject during the imagery process and to the nature of the task in which the skill technique used seems to be a relevant aspect.

**Key words:** Imagery; Ability; Assessment; Motor program.

**Resumo** – O objetivo do estudo foi determinar mudanças na capacidade de imaginação motora em resposta a um treinamento específico de imaginação do lançamento do dardo. Doze universitários (17-22 anos), sem experiência prévia no lançamento do dardo e na prática de imaginação motora participaram voluntariamente do estudo. Mudanças na capacidade de imaginação foram avaliadas usando o Questionário de Imaginação no Esporte, antes (PRE) e depois (POS) de um programa de treinamento de 10 sessões. A avaliação da retenção (RET) foi realizada após duas semanas do final do treinamento. O programa incluiu exercícios mentais destinados ao desenvolvimento da vivacidade das imagens, ao controle das imagens e ao aumento da auto percepção motora. Quando as condições de treinamento (treinando sozinho, treinando acompanhado, observando um colega e numa situação de avaliação) foram comparadas, nenhuma diferença significativa foi encontrada entre PRE, POS e RET ( $p > 0.05$ ). Embora não se tenha observado mudanças na capacidade de imaginação em resposta ao programa de treinamento realizado, diferenças nos domínios (visual, auditivo, cinestésico e anímico) foram encontradas. Foi observado que apenas os domínios visual e anímico não diferiram ( $p = 0.58$ ), enquanto os outros domínios demonstraram diferenças significativas ( $p < 0.05$ ). Essas diferenças podem refletir um domínio de preferência dos sujeitos durante o processo de imaginação e a natureza da tarefa, na qual a técnica parece ser um aspecto relevante.

**Palavras-chave:** Imaginação; Capacidade; Avaliação; Programa motor.

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## INTRODUCTION

Motor imagery is a process applied to improve motor performance based on the close functional relationship between imagination and motor execution, which are derived from the mental and physical execution of a movement<sup>1,4</sup>. One of the arguments for an improved performance is the preservation of the space-time characteristics of the motor action during imagined movements, which follow the same process of control evoked during its real execution. This equivalence between simulation and execution suggests that the preparation of the action and the movement programming are functionally similar when an action is executed or imagined<sup>2,5,6</sup>. Therefore, if a movement is vividly imagined, the same neural pathways used during the movement may facilitate its physical performance<sup>7,8</sup>.

The conscious motor representations become more effective when a movement is performed because it depends on an internal imaginative representation, in which a multisensory response with a large kinesthetic component is generated<sup>4,8</sup>. The kinesthetic component permits subjects to feel themselves performing the imagined movement in a first person perspective<sup>3,9</sup> and allows the system to determine the body segment position and to identify the agent that causes movement<sup>10</sup>. Some studies suggest that conscious motor representations created in the system reflect biomechanical limitations of the body commanding the action<sup>13</sup>. Therefore, muscle and peripheral structures activated during imagination provide proprioceptive feedback to the central nervous system that influences or modifies the scheme or motor program that improves performance.

On the other hand, there are arguments defending the idea that motor imagery changes the central motor program, with muscle activation being only a consequence of this process. In this case, muscle activation is believed to be a leakage of the centrally generated image<sup>7,11,12</sup>. Despite substantial differences between imagined and executed movements, it has been emphasized that the neural processes involved in imagined actions (inflow and outflow of information) are more related to the degree of activation than to the type of activation<sup>12,13</sup>. Evidence indicates that the effectiveness of imagery is intimately related to the subject's ability to generate vivid and manageable images, which depends on the level of the subject's conscience during mental performance of the motor action<sup>7,8</sup>.

Vividness (clearness of the images) highlights the details of the image in all dimensions

(visualizing images, listening to sounds, feeling body movements, perceiving emotions, mood and mental state) and allows the subject to bring imagination as close as possible to the real execution of the movement. Controllability (i.e., the ability to transform an image into a symbolic representation) permits the subjects to return in time and visualize themselves during imagination, watching and observing their own behavior, increasing their emotional experience and recreating sensations and thoughts that occur under real conditions<sup>4</sup>.

Therefore, the ability to create vivid and controllable images (the ability to imagine an actual movement) shows individual differences. Some subjects may not be able to generate and manage their imagined actions and do not fully benefit from this practice<sup>8</sup>. Despite these theoretical arguments, the main criticism to imagery research is related to the lack of control of individual differences in imagery ability<sup>4</sup>. In addition, there are no studies investigating whether an individual can train and improve his ability to generate and control vivid images. The aim of the present study was to evaluate changes in imagery ability in response to a specific dart throwing training.

## METHODS

### Participants

Initially, 16 undergraduate students aged 17 to 22 years with no previous experience in dart throwing or imagery volunteered to participate in the study. Of these, 12 (2 women and 10 men) completed the experimental procedures. Before enrollment in the study, all participants received information about the experimental procedures and protocols, which were approved by the Ethics Committee of the University (protocol number 024-06).

### Experimental procedures

Imagery ability was assessed using the Sports Imagery Questionnaire<sup>14</sup>. The questionnaire comprises four general situations of the task, i.e., practicing dart throwing alone, being watched by a colleague, observing a colleague performing the task, and during an assessment situation. For each situation, the subject was asked to report in as much detail as possible the degree of vividness with which images, sounds, kinaesthetic and animic senses (i.e., mood, emotional and motivation status) were perceived using the following scale: (1) no images; (2) not very clear, but recognizable image; (3) image moderately clear and vivid; (4) image clear and vivid,

and (5) image extremely clear and vivid. For this assessment, all subjects received the same recorded verbal instructions.

To determine changes in the imagery ability of the participants in response to training, the subjects underwent 4 weeks of a training program. The program consisted of 10 sessions of mental exercises designed to develop vivid images (strengthening sensory areas involved in imagery), to control one's own images (manipulating them voluntarily), and to increase perception about sports performance.

The first four sessions (called pre-conditioning) consisted of basic imagery exercises using regular actions (e.g., obtain a clear and well-defined image of someone, concentrating on all particular traces, his/her voice, the way he/she moves in a delimited space). The last six sessions included imagery practice of dart throwing, in which the site, details of the object, mental execution and execution strategies applied to real dart throwing were emphasized. The execution strategies included practicing dart throwing alone, being watched by a colleague, observing a colleague performing the task, and during an assessment situation.

The sessions were performed in the actual performance scenario, but without distraction or interferences. All sessions were preceded by a relaxation exercise in order to prevent participants from concentrating on any events that occurred before the experiment. The participants sat in a comfortable chair with their eyes closed (using a blindfold) and were asked to focus on the imagery session. The subjects were also asked to mentally repeat the verbal instructions of the audio tape. All sessions were accompanied and conducted by the examiners.

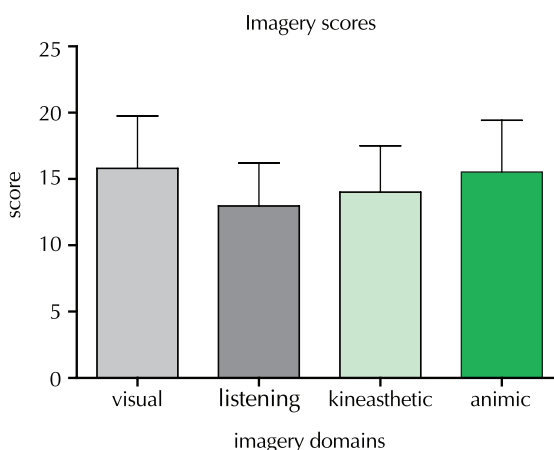
The training program of imagery ability was evaluated immediately before (pretreatment) and after (post-treatment; 24 to 48 h) training and 2 weeks after the end of the training period (retention, RET). Frame 1 illustrates the procedures performed during the study.

### Statistical analysis

The Kruskal-Wallis test was applied to compare the effects of imagery training between the three experimental conditions (pretreatment, post-treatment and RET). Friedman ANOVA was used to determine differences between imagery domains (visual, auditory, kinesthetic and animic). Finally, a number of Kruskal-Wallis tests were applied to determine differences in each imagery domain (visual, auditory, kinesthetic and animic) between the three experimental conditions (pretreatment, post-treatment and RET). Statistical analysis was performed using the Statistics software (Statsoft, version 5.5). The level of significance was set at  $p < 0.05$ .

### RESULTS

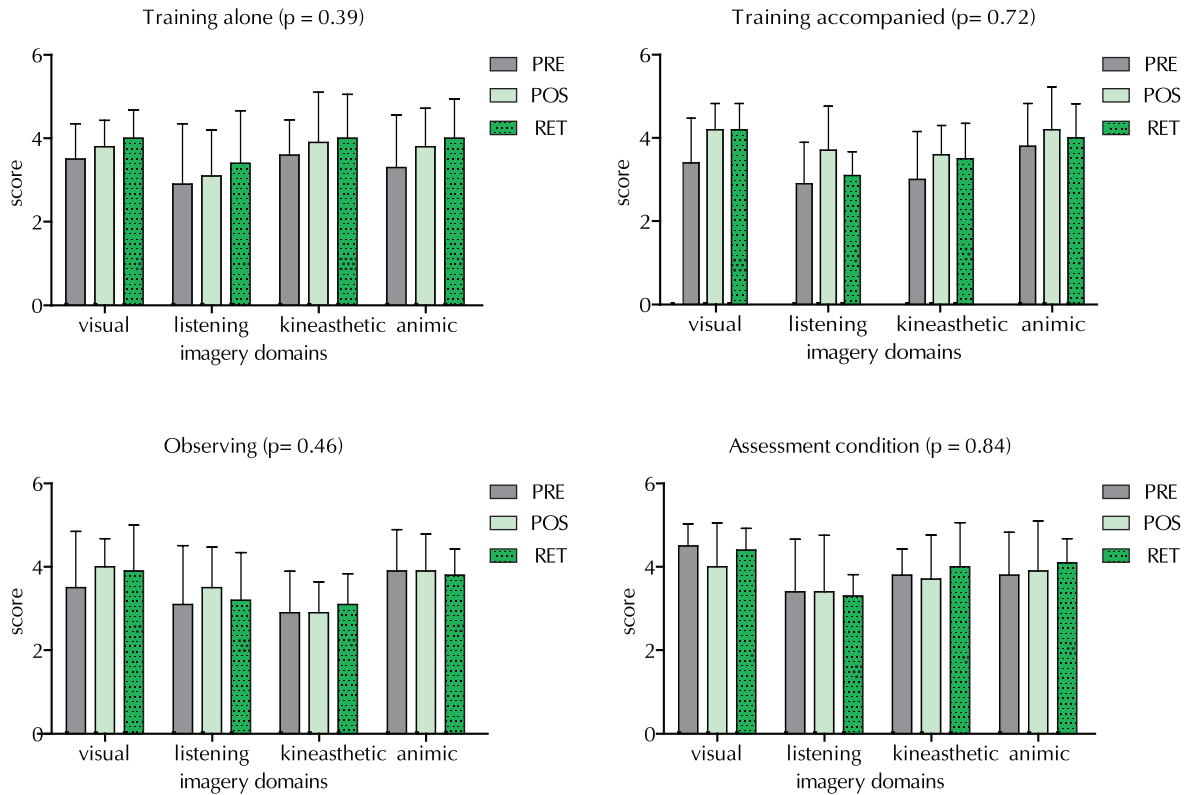
Analysis of the imagery questionnaire scores indicated significant differences ( $p < 0.05$ ) between imagery domains (visual, auditory, kinaesthetic and animic), except between the visual and animic domains ( $p = 0.58$ , K-S test). The largest difference was observed between the visual and auditory domains (Figure 1).



**Figure 1:** Comparison of imagery domain scores (visual, auditory, kinesthetic and animic).

**Frame 1.** Schematic representation of the experimental protocol.

Pretreatment	Training		Post-treatment	Interval	Retention
	Pre-conditioning	Specific imagery training			
Assessment of imagery ability	Basic exercises designed to improve imagery senses (4 sessions of 10-20 min)	Specific imagery training including dart throwing (6 sessions of 10-20 min)	Assessment of imagery ability	2 weeks interval	Assessment of imagery ability



**Figure 2.** Imagery domain scores (visual, auditory, kinesthetic and animic) before (Pre) and after (Post) training and 2 weeks after the end of training (RET) obtained while training alone (upper left panel), training accompanied (upper right panel), observing (lower left panel), and during an assessment condition (lower right panel).

Comparison of training conditions (training alone, training accompanied, observing a colleague and during an assessment situation) showed no significant differences between pretreatment, post-treatment and RET ( $p > 0.05$ ). These results indicate that the ability to imagine motor actions did not respond to a specific imagery training program (Figure 2).

## DISCUSSION

The main finding of the present study was that imagery ability did not improve in response to a specific training program. None of the imagery domains (visual, auditory, kinesthetic and animic) was influenced by the training protocol applied in the present study. Similar results have been reported by other investigators<sup>3,9,15</sup>, who showed that imagery programs were unable to improve imagery scores. These results can be explained by a number of factors, including previous experience of the participants and a small number of imagery training sessions. In addition, it is arguable whether the questionnaire used for the evaluation of imagery ability is able to express these changes.

Experience is one of the main factors that influence imagery ability, which is a complex mul-

tisensory process that depends on internal movement representations<sup>3,9</sup>. Imagery is suggested to be a building block of conscious experience<sup>16</sup> and has been implicated in working memory<sup>17</sup>. When the movement is relatively new, internal representations may not be sufficiently defined to allow the subject to create a multisensory image<sup>4</sup>. For instance, the kinesthetic domain requires subjects to have the necessary declarative knowledge of the key task components<sup>18</sup>, which may have not been the case in the present study since the participants were not familiar with or trained in the task<sup>19</sup>. Indeed, some investigators argue that the frequent use of images increases imagery scores as subjects develop their ability to imagine vivid actions, in which all details of the movement are clearly perceived. Therefore, the lack of experience in imagery training and in the execution of the actual movement may have influenced the present results. Further studies involving experienced subjects are necessary to clarify these speculations.

Imagery can be considered a trainable ability as long as it is responsive to regular and deliberate practice. In fact, studies have demonstrated a greater imagery ability in high-performance athletes since they engage in more deliberate imagery practice than low-level athletes<sup>20-23</sup>. Thus, the effects of an imagery

program would be expected to be greater. However, only a few studies have investigated whether imagery ability improves after a specific training program<sup>15,22</sup>. It seems that, similarly to any other skill, a number of training sessions are required to improve performance. Unfortunately, most studies focused on the duration of the sessions required to improve imagery ability, but did not investigate the number of sessions necessary to increase imagery efficacy. One of the few studies in which imagery ability improved after a 16-week imagery training program showed that the figure skaters first improved their visual imagery domain, while the kinesthetic domain only improved later during the training program<sup>22</sup>. Shorter training periods (5 weeks) failed to improve imagery ability in most subjects in a skating task<sup>15</sup>. Thus, it is likely that the 4-week period used in the present study was not sufficient to permit comprehensive changes in the imagery ability of the subjects, although dart throwing is less complex than figure skating actions. The minimum time to improve imagery ability is still unknown and further studies are necessary.

Another factor to consider when analyzing the improvement of imagery ability is the efficacy of the assessment instruments. Most of the self-report questionnaires designed to assess imagery ability present good psychometric properties<sup>7,8</sup>. However, these questionnaires do not include a clear measure of the concept of motor imagery used<sup>8</sup>, which may differ from those employed in the imagery training sessions since differences exist in the subject's awareness level between implicit and explicit motor imagery<sup>7</sup>. Tasks involving explicit motor imagery require a conscious motor representation in which a first person is used and no visual stimulus is presented.

In the present study, differences between imagery domains were only observed when the results did not discriminate between imagery conditions (training alone, training accompanied, observing a colleague, and in an assessment condition). The visual (visualization of the image) and anemic (perception of feelings, mood, and mental state) domains showed a higher vividness than the other domains. On the other hand, the auditory and kinesthetic domains corresponded to the dimensions in which the participants were less able to create a clear and controllable image of the movement.

Implicit motor imagery requires the performed a decision regarding a visual stimulus<sup>8</sup>. It is needed to mention interchangeable nature of the concepts of visual and kinesthetic images since the performer is required to be "inside his/her body" to experience the movement sensations using both modalities

simultaneously<sup>24</sup>. Our results do not support these arguments and differences between these two modalities were demonstrated. Similar findings have been reported by Roberts et al.<sup>17</sup>, who were able to distinguish between the two modalities.

The differences in vividness between domains found in the present study suggest the existence of individual differences in imagery ability<sup>4,7,8,25-28</sup>, an aspect rarely analyzed in most studies. It has been proposed that subjects who are able to generate images tend to have a preferred or dominant imagery domain (i.e., visual)<sup>4</sup>. This fact induces a third-person representation which involves visual, cognitive and external images<sup>29</sup>. For instance, dart throwers that performed imagery describing the target with greater vividness than they were able to feel muscular sensations during the practice sessions<sup>7</sup>.

Other evidence<sup>30</sup> suggests that the predominance of different aspects of imagery is influenced by the type and the condition in which the movement is imagined. When the movement form (i.e., movement technique) is relevant for task performance, an external visual perspective seems to be more efficient because it emphasizes the determinant parameters of the movement<sup>19</sup>. On the other hand, the emotional component (affective states associated with confidence) mediates the visual image generated<sup>4</sup>.

The present study shows some limitations, including the small number of subjects, short period of training and inexperience of the subjects in the task and imagery. In addition, to our knowledge, the questionnaire applied in this study has not been validated. However, this questionnaire is currently the most widely used instrument in the sports context in which all imagery modalities are assessed.

## CONCLUSION

Although imagery ability did not respond to the training program, differences in imagery domains were found. These differences might be related to a domain preference of the subject during the imagery process and to the nature of the task in which the technique used seems to be a relevant aspect. Thus, inexperienced subjects may benefit more from visual information than from the other domains (kinesthetic).

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