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Article

French translation and validation of the Movement Imagery Questionnaire-third version (MIQ-3f)

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Abstract – Objectives: Imagery ability is a variable influencing the effectiveness of imagery practice that can be estimated by means of questionnaires. Among them, the Movement Imagery Questionnaire-Revised, translated and validated in French, is widely used by French speakers. However, it does not allow for the distinction between the two visual imagery perspectives (internal *vs.* external). The Movement Imagery Questionnaire-3 has been recently proposed in the English literature to differentiate between the ease of performing internal visual, external visual and kinesthetic imagery. The aim of this study was to translate and validate a French version of this questionnaire (MIQ-3f). Method: We examined the validity of constructs, internal consistency, and test-retest inter-rate reliability of the visual and kinesthetic items of the MIQ-3f in 272 healthy participants ($M_{age} = 20.26$ years, $SD = 1.73$). Results: The internal consistency (composite reliability scores ≥ 0.88 for the three subscales) and test-retest reliability (intraclass correlation coefficients: 0.87 for visual internal imagery, 0.86 for visual external imagery, and 0.88 for kinesthetic imagery) of the MIQ-3f were satisfactory. The three-factor structure (with 4 items for each factor) was supported by confirmatory factor analysis. The MIQ-3f appears to be a valid and reliable instrument that can be used to assess imagery ability in French speakers.

Key words: imagery, questionnaire, French translation, validation, movement

Résumé – Validation de la traduction française du « Movement Imagery Questionnaire-third version (MIQ-3f) ». Objectifs : La capacité d'imagerie est une variable influençant l'efficacité de la pratique de l'imagerie et pouvant être estimée avec des questionnaires. Parmi eux, le Movement Imagery Questionnaire-revised, traduit et validé en français, est largement utilisé par les francophones. Cependant, ce questionnaire ne permet pas de distinguer les perspectives d'imagerie visuelle (interne et externe). Le Movement Imagery Questionnaire-third version a été proposé dans la littérature anglaise pour différencier la facilité de réalisation des images visuelles internes, externes et kinesthésiques. Le but de cette étude était de traduire et valider une version française de ce questionnaire. Méthodes : Nous avons examiné la validité de construit, la cohérence interne des items, et la fiabilité test-retest, de la version française du Movement Imagery Questionnaire-third version chez 272 participants ($M_{age} = 20{,}26$ years, $SD = 1{,}73$). Résultats : La cohérence interne (score de fiabilité $\geq 0{,}88$ pour les trois sous-échelles) et la fiabilité test-retest (coefficients de corrélation intraclasse : 0,87 pour l'imagerie visuelle interne, 0,86 pour l'imagerie visuelle externe, et 0,88 pour l'imagerie kinesthésique) étaient satisfaisantes. La structure à trois facteurs (4 items pour chaque facteur) a été soutenue par une analyse factorielle confirmatoire. La version française du questionnaire apparaît comme un instrument valide et fiable pouvant être utilisé pour évaluer la capacité d'imagerie de personnes francophones.

Mots clés : imagerie, questionnaire, traduction française, validation, mouvement

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1 Introduction

Motor Imagery (MI) is a conscious process that requires individuals to mentally simulate an action without concomitantly executing it (Robin *et al.*, 2007). MI is frequently used to facilitate motor (re)learning, promote motor rehabilitation, and improve performance in sports settings (Cumming & Williams, 2012; Rulleau, Mauvieux, & Toussaint, 2015). Seiler, Monsma, & Newman-Norlund (2015) argued that the effectiveness of MI as a performance-enhancing strategy might primarily depend on one's capacity to generate accurate and vivid mental images of specific movements. Participants with greater imagery ability have been shown to achieve greater levels of performance following MI practice than their less-skilled counterparts (Goss, Hall, Buckolz, & Fishburne, 1986; Hall, Buckolz, & Fishburne, 1992; Robin *et al.*, 2007; Robin & Coudevylle, 2018). It seems therefore important to screen participants for their visual and kinesthetic imagery abilities before interventions or experiments (Cumming & Ramsey, 2009). A comprehensive, yet inexpensive, method of screening participants' imagery abilities is the use of self-report questionnaires (Hall, Bernoties, & Schmidt, 1995; Williams *et al.*, 2012). Among the wide range of imagery questionnaires, the Movement Imagery Questionnaire (MIQ; Hall & Pongrac, 1983) and its revised version (MIQ-R; Hall & Martin, 1997) are very popular and certainly two of the most frequently used by athletes. Moreover, a second version of this questionnaire (MIQ-RS) has been developed by Gregg, Hall, & Butler (2010), specifically for use in rehabilitation settings. The questionnaires previously evoked assess the ability to mentally feel and visualize simple movements after physical execution of the same movement, based on specific instructions, in contrast to other imagery ability questionnaires such as the Vividness of Movement Imagery Questionaire-2 (VMIQ-2) proposed by Roberts, Callow, Hardy, Markland, & Bringer (2008), in which different interpretations of instructions might occur, depending on individual experience (Williams *et al.*, 2012). According to Williams & Cumming (2011), the first physical execution of the movement is likely to help participants to reduce such discrepancies in imagery content, which is a factor known to influence self-report imagery ability. Atienza, Balaguer, & Garcia-Merita (1994) and Monsma, Short, Hall, Gregg, & Sullivan (2009) revealed that the MIQ and its revised version have good internal (Cronbach alpha coefficients superior or equal to 0.88 and 0.84 for the kinesthetic and visual subscales, respectively) and temporal reliability (test-retest reliability coefficients superior or equal to 0.81 and 0.80 for the kinesthetic and visual subscales, respectively).

Despite their popularity, many authors have argued that these questionnaires remain limited by their inability to allow for a distinction between external visual (third-person) and internal visual (first-person) imagery perspectives (Roberts *et al.*, 2008; Williams *et al.*, 2012). Internal visual imagery (IVI) requires participants to imagine a movement through their own eyes, while during external visual imagery (EVI), individuals must mentally simulate the movement as spectators (*i.e.*, by viewing themselves from another person's perspective) (Hall, 2001). Interestingly, Ruby & Decety (2001) reported different brain activation when imaging from an EVI perspective compared to an IVI perspective (see also Jackson, Meltzoff, & Decety, 2006; Jiang, Edwards, Mullins, & Callow, 2015; Lorey *et al.*, 2009; Seiler *et al.*, 2015). From a practical viewpoint, there is also substantial evidence that the differentiation of the two visual imagery perspectives is critical to achieve peak performance and deliver fruitful imagery interventions. For instance, White & Hardy (1995) revealed that IVI might be primarily beneficial for open motor skills when timing is important, whereas EVI would be more efficient in learning movements to reproduce, such as body coordination or form. Cumming & Ste-Marie (2001) further observed that some athletes could switch from one perspective to another, whereas others prefer imaging from one perspective more than another. Consequently, Williams *et al.* (2012) extended the MIQ-R and validated another version called MIQ-3 to more extensively capture an individual's visual imagery ability. The MIQ-3 is composed of three subscales assessing EVI, IVI, and kinesthetic imagery (KI) modalities. Four movements (*e.g.*, arm movement, knee lift, waist bend, or jump) are physically performed and then imaged three times, for a total of twelve items. Participants rate the difficulty of forming visual imagery (first-person and third-person perspectives) and KI using two 7-point scales ranging from 1 (*very hard to see/feel*) to 7 (*very easy to see/feel*). A higher average score for a subscale represents greater ease of imaging. The aim of this study was to test the validity of constructs (factor structure and internal consistency) as well as the reproducibility of a French translated version of the questionnaire (MIQ-3f). We additionally intend to show that the results obtained with the MIQ-3f were consistent with the literature. For instance, women reported lower imagery ability than men in some studies (Atienza *et al.*, 1994; Goss, Hall, & Buckolz, 1983), while elite athletes presented higher imagery ability scores than subelite and nonelite athletes (Nezam, Isazadeh, Hojjati, & Zadeh, 2014); furthermore, a high amount of time and a high frequency of practice induced higher imagery ability scores (Lorant & Gaillot, 2004; Lorant & Nicolas, 2004).

2 Method

2.1 Participants

Two hundred and seventy-two self-declared right-handed students gave their informed consent to participate in the study (187 men, $M_{age} = 20.26$, $SD = 2.47$; 85 women, $M_{age} = 19.99$, $SD = 1.73$). All were volunteers and were recruited at the sport university. Two samples were employed. A first sample was composed of 100 participants (72 men, $M_{age} = 20.36$, $SD = 2.99$; 28 women, $M_{age} = 19.96$, $SD = 1.86$) to run exploratory factor and reliability analyses. A second sample included 172 participants

(115 men, $M_{age} = 20.19$, $SD = 2.11$; 57 women, $M_{age} = 19.98$, $SD = 1.67$) to run a confirmatory factor analysis and a concurrent/predictive validity assessment. These latter participants reported the type of their dominant sport activity, the number of years of practice, and their level of expertise with regard to four predetermined categories: international, national, regional or beginner. Finally, students were requested to choose between two categories for the frequency of their physical activity: "high" (*i.e.*, 2 or more training sessions per week) or "moderate" (*i.e.*, 1 or less of training per week) (see Lorant & Gaillot, 2004 and Lorant & Nicolas, 2004 for similar procedures). Participants declared practicing soccer ($n = 36$), basketball ($n = 21$), track and field ($n = 27$), martial arts ($n = 13$), tennis ($n = 10$), handball ($n = 7$), surf ($n = 7$), volleyball ($n = 6$), rugby ($n = 6$), swimming ($n = 10$), dance ($n = 7$), gymnastics ($n = 3$), fitness ($n = 5$), biking ($n = 4$), kayaking ($n = 4$), windsurfing ($n = 1$) or not specified ($n = 13$). The current study was approved by the local ethics committee of the university and was conducted in accordance with the Declaration of Helsinki.

2.2 Materials and methods

The MIQ-3 (Williams *et al.*, 2012) is a self-report questionnaire composed of 12 items assessing an individual's ability to imagine four movements (*e.g.*, arm abduction and adduction, standing hip flexion, knee lift and jump) after physical performance, using EVI, IVI, as well as kinesthetic imagery (KI) modalities. Participants rated the difficulty of forming EVI, IVI, and KI using two 7-point scales ranging from 1 (*very hard to see/feel*) to 7 (*very easy to see/feel*). For each participant and each imagery modality, a mean score ranging from 1 to 7 is computed, with a higher score representing higher motor imagery ability.

After we informed the designers of the questionnaire, the MIQ-3 was first translated from English to French. We asked a perfectly bilingual external English teacher to translate the questionnaire from French to English afterwards, through a blind procedure, and the comparison between the two versions revealed very few differences, which were amended and adjusted for the final version. Since there were few corrections, we used the procedure of Vallerand & Halliwell (1983), which is more relevant when one suspects differences in assessment or interpretation related to cultural factors, which might be the case in studies relating opinions, attitudes, representations or in any questionnaire involving differences in semantic or cultural aspects. It is important to note that the items concerning KI were identical to the items found in the French validated version of the MIQ (Lorant & Gaillot, 2004). Essentially, items concerning visual imagery perspectives were very similar to the items found in the French validated version of the MIQ-R (Lorant & Nicolas, 2004), and these items were merely added "from an internal perspective" for IVI and "from an external perspective" for EVI MIQ-3f items.

2.2.1 Procedure

Before each session, participants were provided with definitions of the perspectives of EVI ("*When you watch yourself performing the movement from an outside point of view or third- person perspective, it can be likened to watching yourself on television or from another person's perspective*"), IVI ("*When you watch yourself performing the movement from an inside point of view or first person perspective, it is as if you were looking out through your own eyes whilst performing the movement and is therefore what you would see while actually doing the movement*"), and KI ("*The feelings and sensations experienced if you were actually producing the movement, it includes things such as feeling your muscles contract or feeling an object your body makes contact with*"; for a similar procedure, see Williams *et al.*, 2012).

During each session, participants completed the MIQ-3f in a quiet gym under standardized conditions in the presence of the same examiner. A first sample of 100 healthy volunteers completed the questionnaire during a unique session. A second sample of 172 other participants completed a first session (*i.e.*, test) and, 16 to 19 days later, completed a second session (*i.e.*, retest) intended to control fidelity (test-retest reliability) under identical conditions. No intervention that could to modify the participants' motor imagery abilities was carried out during the interval between the two sessions (see Lorant & Nicolas, 2004 for a similar procedure).

2.2.2 Data analysis

With regard to the test and retest, the computation of mean scores (average, standard deviation) was carried out for the EVI, IVI, and KI scales in the population taken as a whole. Resultant values may vary from 1 to 7, with a score of 7 constituting maximal motor imagery ability. Normality was checked (Kolmogorov-Smirnov test) for all dependent variables. Exploratory factor analysis with the first sample ($n = 100$) was used to determine if the MIQ-3f includes the kinesthetic, internal visual and external visual dimensions of motor imagery. The factor loadings with varimax rotation were used to assess the trifactorial structure of the MIQ-3f. The varimax rotation was used to minimize the complexity of the loadings within each factor and to represent the clearest factor structure. The internal consistency of the questionnaire was assessed by computing the composite reliability scores, based on factor loadings, for the IVI, EVI, and KI subscales (see McNeish, 2018 for a similar procedure). Internal consistency is generally deemed acceptable with a coefficient greater than 0.7, good with a minimum of 0.8, and excellent when superior to 0.9.

A second independent sample ($n = 172$) was used to perform a confirmatory factor analysis and a reliability analysis (test-retest repeatability) on the basis of the obtained data. The confirmatory factor analysis was run by specifying the expected three-subscale model (KI, IVI, and EVI) for the MIQ-3f. The maximum likelihood

Table 1. Means, standard deviations, skewness and kurtosis for each item in sample 1.

	Means	Standard deviations	Skewness	Kurtosis
External visual 1	5.83	1.26	−1.29	1.92
External visual 2	5.71	1.22	−0.70	−0.19
External visual 3	5.06	1.19	−1.06	1.45
External visual 4	5.79	1.28	−0.83	0.42
Internal visual 1	4.73	1.87	−0.49	−0.86
Internal visual 2	4.59	1.72	−0.40	−0.70
Internal visual 3	4.69	1.82	−0.52	−0.60
Internal visual 4	4.86	1.86	−0.60	−0.61
Kinesthetic 1	4.49	1.98	−0.38	−1.11
Kinesthetic 2	4.56	2.03	−0.51	−1.13
Kinesthetic 3	4.29	1.89	−0.33	−1.03
Kinesthetic 4	4.41	2.00	−0.31	−1.15

A higher score represents higher motor imagery ability.

estimation was used. First, we computed the correlations between each of the 12 items of the MIQ-3f and the dimension with which it is supposed to be related (IVI, EVI, or KI ability). Then, to verify the adequacy of our data with regard to the three-subscale expected model, the following adjustment indexes were computed: Chi-square divided by degrees of freedom (χ^2/ddl, a value between 2 and 5 is considered acceptable; Byrne, 1989), comparative fit index (CFI, index values greater than 0.90 are usually considered satisfactory; Hooper, Coughlan, & Mullen, 2008), and root mean square errors of approximation (RMSEA) and residual and standardized (RMSR) values (approximately 0.08 indicate reasonable fit of a model; Hooper *et al.*, 2008). Concerning the reliability analysis, the scores on each of the KI, IVI, and EVI scales were assessed through comparison of the scores registered for the test and retest by means of repeated-measures ANOVAs. Moreover, reliability was assessed by calculating a Bravais-Pearson intraclass correlation coefficient. The assessment of group differences with regard to gender (women *vs.* men), level of expertise (beginner, regional, national, and international), time of practice (5 years and less *vs.* 10 years and more), and intensity frequency (moderate *vs.* high) was tested using the analysis of variance. Post hoc analyses of the significant main effects and interactions were conducted using the Newman-Keuls test. Effect sizes ($\eta_p{}^2$) were indicated, and α was set at 0.05 for all the analyses. The software package Statistica (12, 64-bit) was used.

3 Results

To evaluate the factor structure of the MIQ-3f, both exploratory factor analysis and confirmatory factor analysis were performed.

Table 2. Exploratory factorial analysis with varimax rotation in sample 1.

	Factor 1	Factor 2	Factor 3	Alpha if deleted
External visual 1	0.15	0.17	0.87	0.85
Internal visual 1	0.33	0.83	0.10	0.95
Kinesthetic 1	0.90	0.22	0.09	0.92
External visual 2	0.19	0.12	0.81	0.86
Internal visual 2	0.17	0.92	0.14	0.94
Kinesthetic 2	0.90	0.26	0.18	0.91
External visual 3	0.10	0.13	0.81	0.88
Internal visual 3	0.21	0.91	0.14	0.93
Kinesthetic 3	0.87	0.22	0.14	0.91
External visual 4	0.21	0.11	0.74	0.88
Internal visual 4	0.21	0.89	0.11	0.94
Kinesthetic 4	0.89	0.21	0.14	0.92
Explained variance	3.53	3.43	2.74	
% variance	43.63	14.56	17.71	

Factor 1: kinesthetic imagery; Factor 2: internal visual imagery; Factor 3: external visual imagery.

3.1 Exploratory factor analysis

The descriptive statistics concerning the mean, standard deviation (SD), skewness and kurtosis in sample 1 are presented in Table 1.

The exploratory factor analysis strongly differentiated among the three factors, namely, the kinesthetic, the visual internal and the external visual dimensions of the MIQ-3f, which contribute 80.90% of the explained variance (48.63% for factor 1; 14.562% for factor 2 and 17.71% for factor 3, respectively). The factorial weights of each item in visual and kinesthetic factors are detailed in Table 2.

3.2 Confirmatory factor analysis

The confirmatory factor analysis on sample 2 ($n = 172$) revealed that the correlations between the 12 items and the three dimensions of the MIQ-3f were strong, that is, higher than 0.89, 0.89, and 0.85 for the KI, IVI and EVI dimensions, respectively (Tab. 3). In addition, the adjustment index values were 0.08 and 0.07 for the RMSR, respectively, 2.23 for the χ^2/ddl (120.75/54), 0.91 for the CFI, and 0.09 for the RMSEA.

3.3 Internal consistency of the MIQ-3f

The internal consistency of the EVI, IVI, and KI scales was excellent with respect to composite reliability scores (equal to 0.88, 0.92 and 0.92, respectively).

Table 3. Confirmatory factor analysis of the three-dimensional structure of the MIQ-3f, $n = 172$, calculation parameters by maximum likelihood estimation.

Scale	Items	Standard error	Parameter estimate	T values
Kinesthetic	1	1.73	0.12	15.05*
	4	1.76	0.11	15.54*
	7	1.68	0.11	14.89*
	10	1.82	0.12	15.60*
Internal visual	2	1.62	0.11	15.06*
	5	1.70	0.10	16.50*
	8	1.65	0.10	16.02*
	11	1.63	0.10	16.41*
External visual	3	1.21	0.09	13.72*
	6	1.26	0.09	14.85*
	9	1.22	0.08	14.61*
	12	1.19	0.08	14.47*

*$p < 0.01$.

Table 4. Descriptive statistics for the imagery scores (kinesthetic, internal visual, external visual scales) at the test and retest.

Imagery scales	N	Mean scores	Standard deviations
Test (week 1)			
External visual	100	5.76	1.21
Internal visual	100	4.72	1.81
Kinesthetic	100	4.44	1.97
External visual	172	5.82	1.38
Internal visual	172	5.12	1.77
Kinesthetic	172	4.69	1.92
Retest (week 2)			
External visual	172	5.85	1.30
Internal visual	172	5.08	1.75
Kinesthetic	172	4.71	1.88

A higher score represents higher motor imagery ability.

3.4 Test-retest reliability

Mean scores and standard deviations of the EVI, IVI, and KI scales are presented in Table 4. The computed test-retest Bravais-Pearson intraclass correlation coefficient was $r = 0.88$ for KI, $r = 0.87$ for IVI, and $r = 0.86$ for EVI items ($n = 172$; $p < 0.05$), hence confirming a high degree of repeatability over time. Moreover, the repeated measure ANOVAs revealed no significant pretest-posttest difference on mean KI [$F(1, 271) = 0.61$, $p = 0.43$, $\eta_p^2 = 0.00$], IVI [$F(1, 271) = 1.47$, $p = 0.23$, $\eta_p^2 = 0.00$], and EVI [$F(1, 271) = 1.67$, $p = 0.20$, $\eta_p^2 = 0.00$] scale scores. Taken as a whole, the results confirm the expected three-dimensional structure of the MIQ-3f.

3.5 Influence of gender, level of expertise, time of practice, and frequency

Table 5 presents the mean scores and standard deviations for the EVI, IVI, and KI scales at the test, taking into account the gender, level of expertise, frequency and time of practice. The mean score ($n = 272$) was higher for EVI ($M = 5.80$) than for IVI ($M = 4.97$) [$F(1, 271) = 134.47$, $p = 0.00$, $\eta_p^2 = 0.33$] and for KI ($M = 4.59$) [$F(1, 271) = 66.51$, $p = 0.00$, $\eta_p^2 = 0.20$]. Moreover, the mean score was higher for the IVI scale than for the KI scale [$F(1, 271) = 13.81$, $p = 0.00$, $\eta_p^2 = 0.05$]. These results provide strong evidence that the participants found it easier to imagine movement from the EVI perspective than from the IVI or KI perspectives.

3.5.1 Gender

There were no significant score differences [$F(1, 270) = 0.82$, $p = 0.36$, $\eta_p^2 = 0.00$] between women ($n = 85$, $M = 4.45$) and men ($n = 187$, $M = 4.67$) for the KI or IVI scales [$F(1, 270) = 0.44$, $p = 0.51$, $\eta_p^2 = 0.00$, respective mean scores for women and men being 4.87 and 5.02]. However, the data revealed a significant difference when EVI scores were compared [$F(1, 270) = 4.41$, $p = 0.03$, $\eta_p^2 = 0.09$], with better scores reported by men than by women.

Women had higher IVI than KI scores [$F(1, 84) = 4.87$, $p = 0.03$, $\eta_p^2 = 0.05$] and reported higher EVI than IVI scores [$F(1, 84) = 15.85$, $p < 0.01$, $\eta_p^2 = 0.16$] and KI scores F(1, 84) = 36.91, $p < 0.01$, $\eta_p^2 = 0.31$]. Men reported significantly higher EVI than KI [$F(1, 186) = 97.40$, $p < 0.01$, $\eta_p^2 = 0.34$] and IVI scores [$F(1, 186) = 50.88$, $p < 0.01$, $\eta_p^2 = 0.21$]. Additionally, IVI scores were higher than KI scores [$F(1, 186) = 8.88$, $p < 0.01$, $\eta_p^2 = 0.05$].

3.5.2 Level of expertise

ANOVAs revealed significant main effects for the KI, IVI and EVI scales (respectively, [$F(2, 269) = 78.27$, $p < 0.01$, $\eta_p^2 = 0.37$], [$F(2, 269) = 35.28$, $p < 0.01$, $\eta_p^2 = 0.21$], and [$F(2, 269) = 16.70$, $p < 0.01$, $\eta_p^2 = 0.12$]). Post hoc tests showed that national- and international-level participants had higher imagery scores than both regional and beginner participants. Furthermore, regional athletes reported higher scores than beginners.

Beginners had significantly higher EVI than IVI [$F(1, 120) = 52.58$, $p < 0.01$, $\eta_p^2 = 0.30$] and KI scores [$F(1, 120) = 132.12$, $p < 0.01$, $\eta_p^2 = 0.52$]. They also reported greater IVI than KI scores [$F(1, 120) = 16.68$, $p < 0.01$, $\eta_p^2 = 0.12$].

Regional-level athletes reported comparable KI and IVI scores [$F(1, 108) = 2.04$, $p = 0.15$, $\eta_p^2 = 0.02$] but higher EVI than IVI [$F(1, 108) = 13.32$, $p < 0.01$, $\eta_p^2 = 0.11$] and KI scores [$F(1, 108) = 30.28$, $p < 0.01$, $\eta_p^2 = 0.22$].

In both national and international participants, we did not find a difference when comparing KI and IVI scores [$F(1, 41) = 2.55$, $p = 0.12$, $\eta_p^2 = 0.03$]. The data, however,

Table 5. Descriptive statistics for the imagery scores (kinesthetic, internal visual, external visual scales) at the test, including gender, level of expertise, frequency and time of practice.

		External visual imagery		Internal visual imagery		Kinesthetic imagery	
	N	Mean	SD	Mean	SD	Mean	SD
Gender							
Women	85	5.58	0.13	4.87	0.18	4.45	0.19
Men	187	5.90	0.09	4.02	0.12	4.66	0.13
Level							
Beginner	121	5.42	0.11	4.15	0.14	3.44	0.13
Regional	109	5.95	0.12	5.42	0.14	5.21	0.14
National and international	42	6.53	0.16	6.18	0.23	6.35	0.22
Frequency							
Moderate	182	5.52	0.12	4.42	0.11	3.82	0.11
High	90	6.38	0.09	6.09	0.16	6.16	0.15
Women, moderate	58	5.24	0.14	4.32	0.19	3.70	0.19
Women, high	27	6.29	0.21	6.06	0.28	6.04	0.28
Men, moderate	124	5.64	0.10	4.46	0.13	3.87	0.13
Men, high	63	6.41	0.13	6.11	0.19	6.22	0.18
Time of practice							
5 years and less	111	5.53	0.11	4.22	0.15	3.41	0.15
10 years and more	104	6.06	0.12	5.71	0.16	5.54	0.16
Women, 5 years and less	33	5.14	0.21	4.12	0.28	2.97	0.28
Women, more than 10 years	33	6.00	0.20	5.66	0.27	5.54	0.28
Men, 5 years and less	78	5.69	0.13	4.26	0.17	3.59	0.18
Men, more than 10 years	71	6.09	0.14	5.74	0.18	5.55	0.19

A higher score represents higher motor imagery ability.

revealed higher EVI than IVI [$F(1, 41) = 6.86$, $p = 0.01$, $\eta_p^2 = 0.14$] and KI scores [$F(1, 41) = 4.76$, $p = 0.03$, $\eta_p^2 = 0.10$].

3.5.3 Time of practice

Participants who had "10 years and more" practice ($n = 104$) had significantly higher KI [$F(1, 213) = 91.76$, $p < 0.01$, $\eta_p^2 = 0.30$], IVI [$F(1, 213) = 47.46$, $p < 0.01$, $\eta_p^2 = 0.18$], and EVI [$F(1, 213) = 10.71$, $p < 0.01$, $\eta_p^2 = 0.05$] scores than the participants in the "5 years and less" group ($n = 111$). Moreover, the participants who had "10 years and more" practice reported similar KI and IVI scores [$F(1, 103) = 1.76$, $p = 018$, $\eta_p^2 = 0.01$] but had higher EVI than IVI [$F(1, 103) = 7.86$, $p = < 0.01$, $\eta_p^2 = 0.07$] and KI scores [$F(1, 103) = 18.05$, $p < 0.01$, $\eta_p^2 = 0.15$]. Participants with "5 years and less" practice had higher EVI than IVI [$F(1, 110) = 56.47$, $p < 0.01$, $\eta_p^2 = 0.34$] and KI scores [$F(1, 110) = 139.75$, $p < 0.01$, $\eta_p^2 = 0.55$], as well as higher IVI than KI scores [$F(1, 110) = 19.91$, $p < 0.01$, $\eta_p^2 = 0.15$].

3.5.4 Frequency

Participants who had a "high" frequency of practice ($n = 90$) reported significantly higher KI [$F(1, 270) = 155.34$, $p < 0.01$, $\eta_p^2 = 0.36$], IVI [$F(1, 270) = 74.14$, $p < 0.01$, $\eta_p^2 = 0.22$], and EVI scores [$F(1, 270) = 35.48$, $p < 0.01$, $\eta_p^2 = 0.12$] than those who declared "moderate" practice ($n = 182$). Moreover, the participants who had a "high" frequency of practice had similar KI and IVI scores [$F(1, 89) = 2.32$, $p = 0.09$, $\eta_p^2 = 0.02$] but reported higher EVI than IVI [$F(1, 89) = 20.11$, $p < 0.01$, $\eta_p^2 = 0.18$] and KI scores [$F(1, 89) = 46.01$, $p < 0.01$, $\eta_p^2 = 0.34$]. Participants who argued for a "moderate" practice reported higher IVI than KI scores [$F(1, 181) = 6.65$, $p = 0.01$, $\eta_p^2 = 0.03$] and had higher EVI than IVI [$F(1, 181) = 46.22$, $p < 0.01$, $\eta_p^2 = 0.20$] and KI scores [$F(1, 181) = 88.01$, $p < 0.01$, $\eta_p^2 = 0.33$].

4 Discussion

The primary aim of this study was to test the validity of constructs (factor structure and internal consistency) as well as the reproducibility of a French translated version of the questionnaire (MIQ-3f). We additionally intended to show that the results obtained in the current study were consistent with previous research.

First, the validity of constructs was tested by exploratory factor analysis. This analysis strongly differentiated among the three factors. The KI, IVI and EVI dimensions of the MIQ-3f confirmed the results obtained in previous studies (Budnik-Przybylska, Szczypinska, & Karasiewicz, 2016; Mendes *et al.*, 2016). Second, the reliability of the MIQ-3f, which was evaluated in terms of internal consistency and repeatability, was very good. Indeed, the composite reliability scores for the three subscales were superior to 0.88, which means that the internal consistency of the MIQ-3f may be considered excellent. Moreover, the test-retest intraclass correlation coefficients were superior to 0.86 for the KI, IVI and EVI scales, hence confirming a high degree of repeatability over time. The analysis of variance showed that there was no learning effect altering the repeatability (*i.e.*, the mean scores at test and retest were very similar to underscore the satisfactory reproducibility of the MIQ-3f over a specified length of time). Third, the three-dimensional (external visual, internal visual, and kinesthetic) structure of the MIQ-3f was confirmed by confirmatory factor analysis. The current study therefore extensively supports the metrological qualities of the MIQ-3f.

Concerning the difference among the three imagery perspectives, the present results revealed that the mean score was higher for the EVI than the IVI and KI scales and for the IVI than the KI scales. These results provide strong evidence that the participants found it easier to imagine movement from both visual imagery perspectives than with KI, hence confirming the findings of previous research (Atienza *et al.*, 1994; Fishburne & Hall, 1989; Lorant & Nicolas, 2004; Robin & Coudevylle, 2018). Moreover, the results revealed that it was easier to imagine from an EVI perspective than from an IVI perspective, which confirms the result obtained by Williams, Guillot, Di Rienzo, & Cumming (2015).

Concerning the gender effect, the results of the current study showed that there was no difference between women and men in KI and IVI scores, hence supporting previous findings reported in the literature (Loison *et al.*, 2013; Lorant & Nicolas, 2004; Monsma *et al.*, 2009; Williams *et al.*, 2012). However, a small EVI scale score difference between women and men was observed. This result supports the findings of Atienza *et al.* (1994) and Hall, Pongrac, & Buckolz (1985) who reported that gender might influence the visual imagery of movement but not KI. However, it is important to note that the effect size (Cohen, 1977) was low (*i.e.*, 0.09), and we cannot completely rule out that the gender difference was explained by the sample size, as there were more men ($n = 187$) than women ($n = 85$).

The impact of the level of expertise on self-report ratings of imagery ability has already been identified (Williams & Cumming, 2011). It was therefore hypothesized that elite athletes (*e.g.*, national- and international-level athletes) would have better imagery ability than lower-level athletes in self-reported questionnaires (Barr & Hall, 1992). The results of the current study confirm this hypothesis by revealing that the national- and international-level participants had higher imagery scores than the beginner- and regional-level participants and that the latter achieved higher scores than the beginner-level participants. These results are in line with those of Nezam *et al.* (2014), who showed that MIQ-3 scores were significantly higher in elite than subelite and nonelite players and that subelite athletes had higher scores than nonelite participants. Moreover, all participants in the current study had higher EVI than IVI scores, and the beginner- and regional-level participants achieved higher EVI than KI scores, while the beginners reported higher IVI than KI scores. These results suggest that all participants found it easier to imagine movement from EVI than from IVI, regardless of their level of practice, and that the ease with which KI is used increases with the degree of expertise, as suggested by Hardy & Callow (1999).

Expectedly, the results concerning the level of expertise are in line with those related to the time of practice or frequency factors. Indeed, the participants who declared “high” frequency or “10 years and more” practice had higher KI, IVI, and EVI scores than those with “moderate” or “5 years and less” practice. While both groups reported higher EVI than IVI and KI scores, only the “5 years and less” group had higher IVI than KI scores. These results indicate that the increase in frequency and time of practice is likely to facilitate the use of motor imagery, which confirms the findings of previous research (Lorant & Nicolas, 2004). In particular, the ability to use KI should increase with the frequency and time of practice. Finally, the results of the current study indicate that only a high degree of expertise (*i.e.*, national or international level) seems to make it possible to use KI as easily as EVI, as suggested in previous research (Barr & Hall, 1992; Callow & Hardy, 2004; Mahoney & Avener, 1977; Ungerleider & Golding, 1991). For example, Hardy & Callow (1999) argued that KI could be beneficial once performers have acquired a certain degree of expertise. Moreover, cognitive theories of learning have proposed that practitioners rely largely on verbal and visual cues during early stages of learning (Fitts, 1964), and kinesthetic information is used in later stages (Fleishman & Rich, 1963). Further experimental research is certainly needed to confirm this hypothesis before firm conclusions can be drawn.

Finally, it is important to note that the participants with national or international levels of practice, 10 years of practice, and a high frequency of practice had higher EVI than IVI scores. According to Callow, Jiang, Roberts, & Edwards (2017), the use of EVI and IVI might exert influences on the motor system, resulting in selectively different brain activations (Jiang *et al.*, 2015; Lorey *et al.*, 2009; Ruby & Decety, 2001; Seiler *et al.*, 2015) that depend on task constraints (Hardy & Callow, 1999). For example, White & Hardy (1995) showed that EVI was efficient in the learning of movements, including body coordination or form to reproduce (*e.g.*, gymnastics), whereas IVI was beneficial for open skills when timing is important (*e.g.*, slalom line-based activities such as downhill slalom skiing). We may therefore consider that because few participants ($n = 4$) were practicing open-skills activities involving timing (*e.g.*, a slalom-based task such as kayaking), the use of IVI was not favored. Moreover, studies revealed that some athletes could switch from one perspective to another (Cumming & Ste-Marie, 2001), and authors indicated that sometimes participants can confuse kinesthetic and internal visual perspectives by simply referring to them as a "first-person perspective". It is therefore important to note that the national- or international-level participants, those with 10 years of practice and those with a high frequency of practice had similar KI and IVI scores and that the KI and IVI items were correlated (Tab. 3). Further research, including more expert participants in slalom-based tasks (*e.g.*, skiing or kayaking), is needed for improved clarification.

This study is not without limitations. First, there were more men than women in the sample, which can be explained by the important gender proportion at the university where the correlational study was conducted. Second, there are few practitioners in sports who are supposed to favor the use of IVI, such as those participating in slalom-based activities; thus, larger sample sizes should be considered in future research in which the test of concurrent validity should be included. Third, the test-retest interval used in the current study (*i.e.*, more than two weeks) could be considered insufficient and thus favor the use of memory, although this interval is similar to that used in similar studies (Budnik-Przybylska *et al.*, 2016; Loison *et al.*, 2013; Lorant & Gaillot, 2004; Paravlić, Pišot, & Mitić, 2018 for examples). Finally, postquestionnaire interviews would have been necessary to control in greater detail whether/how participant made a clear distinction between IVI and KI.

To conclude, the aim of this study was to translate and validate a French version of the most frequently used imagery questionnaire (MIQ-3). The validity of the constructs of the MIQ-3f (*i.e.*, three-factor structure) was supported by an exploratory factor analysis and the questionnaire's good internal consistency and very satisfactory test-retest reliability. Moreover, the confirmatory factor analysis confirmed the KI, IVI and IVE scale dimension structure. Based on these data, the MIQ-3f seems to be a robust, valid and reliable instrument that can be used to assess imagery ability in the French-speaking population.

Author contribution

All authors contributed equally to the paper.

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