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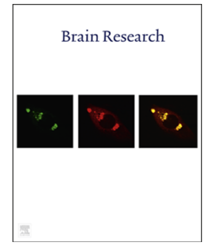

Research Report

Assessing motor imagery ability in younger and older adults by combining measures of vividness, controllability and timing of motor imagery

Arnaud Saimpont[a,b,*], *Francine Malouin*[c], *Béatrice Tousignant*[a], *Philip L. Jackson*[a,d]

[a]*Centre interdisciplinaire de recherche en réadaptation et intégration sociale, École de psychologie, Université Laval, Québec, QC, Canada*
[b]*Centre d'innovation et de recherche sur le sport, UFR STAPS, Université Claude Bernard, Lyon, France*
[c]*Centre interdisciplinaire de recherche en réadaptation et intégration sociale, Département de réadaptation, Université Laval, Québec, QC, Canada*
[d]*Centre de recherche de l'institut universitaire en santé mentale de Québec, École de psychologie, Université Laval, Québec, QC, Canada*

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ABSTRACT

With the population aging, a large number of patients undergoing rehabilitation are older than 60 years. Also, since the use of motor imagery (MI) training in rehabilitation is becoming more popular, it is important to gain a better knowledge about the age-related changes in MI ability.

The main goal of this study was to compare MI ability in younger and older adults as well as to propose a new procedure for testing this ability. Thirty healthy young subjects (mean age: 22.9±2.7 years) and 28 healthy elderly subjects (mean age: 72.4±5.5 years) participated in the experiment. They were administered three tests aimed at assessing three dimensions of MI: (1) the kinesthetic and visual imagery questionnaire (KVIQ) to assess MI vividness; (2) a finger–thumb opposition task to assess MI controllability; and (3) a chronometric task to assess the timing of MI. On average, the younger and older groups showed similar results on the KVIQ and the chronometric task, but the younger group was more accurate at the finger–thumb opposition task. Interestingly, there was a large variability in the performance within both groups, emphasizing the importance of considering each person individually regarding MI ability, whatever his age. Finally, we propose two indexes of MI ability to identify the potential of persons to engage in MI training programs. Future studies are needed to confirm the predictive value of these MI indexes and define inclusion/exclusion thresholds for their use as a screening tool in both younger and older adults.

*Correspondence to: Université Lyon 1, UFR STAPS, Centre de Recherche et d'Innovation sur le Sport, 29 boulevard du 11 novembre, 69622 Villeurbanne Cedex, France.
E-mail address: arnaud.saimpont@univ-lyon1.fr (A. Saimpont).

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1. Introduction

Motor imagery (MI) is a dynamic cognitive process during which a movement is mentally simulated without being actually executed (Jeannerod, 1995). There is accumulating evidence of similarities between imagined and executed actions in particular regarding their temporal characteristics as well as the neural activity subtended by both states (see Decety, 1996; Hétu et al., 2013; Jeannerod, 1995; Munzert and Zentgraf, 2009). The demonstration of these similarities has strengthened the interest for mental practice based on MI (or MI training), i.e. the fact of repeatedly imagining movements with the intention to improve their execution. Mental practice has been used for years to optimize performance in athletes (see Martin et al., 1999; Murphy, 1994) and its usefulness as a complementary rehabilitation approach in people with physical disabilities has been emphasized since the 2000s (Dijkerman et al., 2010; Jackson et al., 2001; Malouin et al., 2013; Malouin and Richards, 2010; Schuster et al., 2011). Considering that a large number of patients in the field of neurological or orthopaedic rehabilitation who could potentially benefit from MI training programs are older than 60 years, there is a need to understand how MI ability evolves with age (Malouin et al., 2010; Mulder et al., 2007). Indeed, it is well-known that normal aging influences cognitive and sensorimotor functions (Reuter-Lorenz and Park, 2010; Seidler et al., 2010), and as MI is at the crossroad of these functions, it is reasonable to expect some age-related changes in the ability to simulate movements.

Several studies have explored the effects of aging on different dimensions of MI (see Saimpont et al., 2013), such as the vividness of motor representations, i.e. the ability to mentally generate vivid images and sensations of movements (Malouin et al., 2010; Mulder et al., 2007), the timing of MI, i.e. the ability to reproduce the duration of a movement during its mental simulation (Personnier et al., 2010, 2008; Saimpont et al., 2012; Schott and Munzert, 2007; Skoura et al., 2005, 2008), and the controllability of MI, i.e. the ability to manipulate a mental representation of a movement (Schott, 2012). Based on findings from MI questionnaires, it seems that aging does not affect the general level of MI vividness (Mulder et al., 2007; Malouin et al., 2010; Saimpont et al., 2012, but see Schott, 2012). On the other hand chronometric studies have revealed that older adults showed good temporal congruence between executed and imagined simple/familiar movements, but showed some timing discrepancies between execution and imagination for complex/unfamiliar movements (Personnier et al., 2010, 2008; Saimpont et al., 2012; Schott, 2012; Schott and Munzert, 2007; Skoura et al., 2005, 2008). Concerning MI controllability, it was recently shown that the performance of older adults was worse than younger ones in manipulating motor images in a sequential manner (Schott, 2012).

Altogether these observations suggest that the different dimensions of MI can be affected in different ways with increasing age. Whatever the dimension concerned, age-related deficits in MI ability would be linked to age-associated deficits in working memory (Malouin et al., 2010; Saimpont et al., 2009; Schott, 2012). Also, although older adults recruit similar brain regions than younger ones when imagining movements, they show more prominent activity in these regions than their younger counterparts (Nedelko et al., 2010; Zwergal et al., 2012). This greater activity possibly reflects compensation mechanisms that would allow the elderly to correctly imagine simple movements but that would not be sufficient to cope with more difficult MI tasks (Saimpont et al., 2013).

Except in the study of Schott (2012), in the above-mentioned studies, only a single MI dimension was assessed at a time, making it difficult to conclude about the age-related changes in MI process as a whole. The first aim of this study was thus to compare visual and kinesthetic MI ability in younger and older adults by assessing several dimensions of MI in the same individuals. The present study involved selected outcomes for three key dimensions of MI: the vividness, controllability, and timing of MI. Globally, it was anticipated that older adults would show different patterns of responses than their younger counterparts (Saimpont et al., 2013; Schott, 2012). More particularly, it was expected to observe (1) no age-related decline in MI vividness (Malouin et al., 2010); (2) an age-related decline in MI controllability (Schott, 2012); and (3) similar performance between young and elderly subjects in the timing of MI, since the task used for assessing this dimension was not especially complex (Saimpont et al., 2013). Also, the results reported so far in the literature on MI and aging focused on group differences, possibly occulting important individual differences in MI ability within both young and elderly subjects. Hence, the second aim of this study was to examine the individual differences in MI ability in the two age groups, for each dimension studied. Lastly, the third aim was to propose two indexes of MI ability (one for each modality) including all three MI dimensions.

2. Results

An overview of the between-groups comparisons for the main outcomes of the three MI dimensions tested in the study is provided in Table 1.

2.1. *MI vividness (KVIQ-10)*

Data for one young subject were lost due to a technical error. As reported in Table 1, on average, clarity of the images and intensity of the sensations were moderate in both groups (mean vividness scores $>3/5$ for both modalities of MI). Mann–Whitney *U* tests showed no significant differences in vividness scores between groups ($P=.49$ for the visual scores and $P=.47$ for the kinesthetic scores). Wilcoxon signed rank tests also revealed that the visual and kinesthetic scores were not significantly different in the younger ($P=.63$) and older group ($P=.19$). Fig. 1 illustrates individual vividness scores; it can be seen that there was a wide range of scores for both modalities of MI in the two groups. Finally, the visual and kinesthetic scores were moderately but significantly correlated in the young (Spearman's rho$=0.45$, $P<0.05$) and elderly (Spearman's rho$=0.45$, $P<0.05$) subjects.

2.2. *MI controllability (finger–thumb opposition task)*

Data from one elderly subject had to be discarded because he was not able to follow the predetermined pace (1 Hz), which was too fast for him. From the remaining 27 elderly subjects,