Archives of Gerontology and Geriatrics 56 (2013) 487–491

Contents lists available at SciVerse ScienceDirect

Archives of Gerontology and Geriatrics

journal homepage: www.elsevier.com/locate/archger

Association between imagined and actual functional reach (FR): A comparison of young and older adults

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ARTICLE INFO

Article history:
Received 27 August 2012
Received in revised form 11 December 2012
Accepted 15 December 2012
Available online 9 January 2013

Keywords:
FR
Aging
Imagery
Mental representation

ABSTRACT

Recent studies indicate that the ability to mentally represent action using motor imagery declines with advanced age (>64 years). As the ability to represent action declines, the elderly may experience increasing difficulty with movement planning and execution. Here, we determined the association between estimation of reach via use of motor imagery and actual FR. Young adults ($M = 22$ years) and older adults ($M = 66$ years) estimated reach while standing with targets randomly presented in peripersonal (within actual reach) and extrapersonal (beyond reach) space. Imagined responses were compared to the individual's scaled maximum reach. FR, also while standing, was assessed using the standardized Functional Reach Test (FRT). Results for total score estimation accuracy showed that there was no difference for age; however, results for mean bias and distribution of error revealed that the older group underestimated while the younger group overestimated. In reference to FR, younger adults outperformed older adults (30 versus 14 in.) and most prominent, only the younger group showed a significant relationship between estimation and FR. In addition to gaining insight to the effects of advanced age on the ability to mentally represent action and its association with movement execution, these results although preliminary, may have clinical implications based on the question of whether motor imagery training could improve movement estimations and how that might affect actual reach.

1. Introduction

With aging into older adulthood several cognitive and neurological deficits can influence daily living activities and risk of physical injury. The decline of interest here is the ability to mentally represent action and its association with motor planning and execution. Theory suggests that the ability to mentally represent action reflects an internal forward model. That is, a neural system that simulates the dynamic behavior of the body in relation to the environment (e.g., Penhune & Steele, 2012; Wolpert, 1997). Internal models allow predictions (estimates) about the mapping of the self to parameters of the external world; processes that enhance planning and execution of action. These representations are hypothesized to be an integral part of action planning (Choudhury, Charman, Bird, & Blakemore, 2007; Molina, Tijus, & Jouen, 2008; Skoura, Papaxanthis, Vinter, & Pozzo, 2005).

Complementing the forward model idea and central to our interests is the suggestion that motor imagery is involved in the prediction of the consequences of one's actions (e.g., Bourgeois & Coello, 2009; Kunz, Creem-Regehr, & Thompson, 2009; Lorey et al., 2010). Furthermore, it has been suggested that motor imagery provides a window into the process of action representation (Jeannerod, 2001; Munzert, Lorey, & Zentgraf, 2009); that is, motor imagery is a conscious equivalent to a prediction for that action. Motor imagery, also referred to as kinesthetic imagery, is defined as an internal rehearsal of movements from a first-person perspective without any overt physical movement. It has also been hypothesized that motor imagery plays an important role in the prediction of one's actions. Arguably, one of the important aspects of an action plan is the ability to predict the outcome and consequences of intended actions. Imagining an action can serve several useful goals to that endeavor. For example, during imagery, important timing and biomechanical information are considered in planning intended actions; this aids in predicting the sensory consequences of the movement. According to Bourgeois and Coello (2009), motor representation can be viewed as a component of a predictive system that includes a neural process that simulates via motor imagery, the dynamic behavior of the body in relation to the environment.

Although several studies have recently emerged concerning the early developmental trend of internal models and the ability to mentally represent action, research with older persons has been sparse. From the available information, there are indications of decline with advanced age (>64 years; e.g., Beauchet et al., 2010;

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0167-4943/$ – see front matter © 2012 Elsevier Ireland Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.archger.2012.12.008

Mulder, Hochstenbach, Heuvelena, & Otter, 2008; Personnier, Bally, & Papaxanthis, 2010; Saimpont, Mourey, Manckoundia, Pfitzenmeyer, & Pozzo, 2009; Skoura, Personnier, Vinter, Pozzo, & Papaxanthis, 2008). These studies used self-report questionnaires, whole-body simulations, and pointing tasks in a chronometry paradigm to examine motor imagery ability. Here, we examined the association between estimation of reach via use of motor imagery and actual FR.

As a form of motor imagery, the estimation of reach paradigm has drawn the interest of contemporary researchers for examining the processes involved in action representation (Coello et al., 2008; Coello & Delevoye-Turrell, 2007; Gabbard, Cordova, & Lee, 2009a, 2009b; Lamm, Fischer, & Decety, 2007). Determining whether an object is reachable or not is primarily a function of the observer's perceived body capabilities. An idea that complements the internal modeling notion of "can I do this?" and, "what are the consequences?" which arguably, are relevant questions in planning movements. More specific to reach, one of the initial steps in programming such movements is to derive a perceptual *estimate* of the object's distance and location relative to the body. This means that an individual must be able to perceive critical reach distances beyond which a particular reach action is no longer afforded and to which a transition to another reach mode must occur. For example, is the object close enough to reach while seated, or do I need to stand? Furthermore, with relevance to this proposal and older persons, could I lose balance and fall?

In a recent paper using that paradigm for 'seated' reach estimations, Gabbard, Cacola, and Cordova (2011) reported that younger adults (mean age 20 years) were significantly more accurate than the older adults (mean age 77 years). Whereas both groups made more errors in extrapersonal space, the values were significantly higher for the older group; that is, they overestimated to a greater extent. In summary, the findings supported previous work indicating that older persons have more difficulty mentally representing action.

With the present study, we were interested in determining the association between estimation of reachability via use of motor imagery and actual FR. FR is defined here as the maximal distance an individual is capable of reaching forward while standing, without taking a step or losing balance. According to Duncan, Weiner, Chandler, and Studenski (1990), creators of the widely used and reported FRT, FR is a dynamic measure of postural control. Its underlying conceptual framework is that the boundary of stability, which can be represented by maximal reach distance, reflects the integrity of the postural control system. Liao and Lin (2008) report that FRT scores are significantly associated with the results from laboratory tests such as center of pressure (COP) performance. Studies of FR using the FRT indicate a decrease with advanced age (Costarella, Monteleone, Steindler, & Zuccaro, 2010; Kikuchi, Kozaki, Iwata, Hasegawa, & Toba, 2009; Zuccaro, Steindler, Scena, & Costarella, 2012).

Here, we examined the association between estimation of reach while standing and FR in young and older adults. Based on the assumption that FR and simulation of reach estimation share common neurological processes, we expected a positive association would be found in young adults. For older adults, we predicted that the associated would be significantly weaker due in large part to difficulty with mentally representing action.

2. Subjects and methods

2.1. Subjects

This study involved 51 participants representing young adults ($n = 18$, $M_{age} = 22.61$, $SD = 3.01$), and older adults ($n = 33$, $M_{age} = 66.00$, $SD = 6.71$). Subject selection required that participants have normal or corrected vision (as demonstrated by reading an eye chart at 20/30 or better) and no presence of any neurological, cardiovascular, muscular or cognitive disorders, or take any medications that influence central nervous system function. Cognitive capacities were evaluated by means of the *Mini Mental State Exam* (score of ≥ 27).

2.2. Measures and procedure

2.2.1. Estimation of reach paradigm

Actual maximum reach (used as the comparison) and imaged reach responses were collected via short-throw projection system (Sanyo Model PLC-XL50) linked to a computer programmed with Visual Basic. Visual images were systematically projected onto a table surface at midline (90°). The table was constructed on a sliding bracket frame, allowing it be moved back and forward for adjustment to the participant. Table height was adjusted to be equivalent to the distance of eye and table height thereby providing an equivalent perspective view of the table surface. The room was darkened with the exception of light from the computer monitor and visual images projected onto a black colored tabletop; reach targets consisted of white 2 cm diameter circles. The fixation point was projected onto a rectangular box (with a 45° angle surface) placed at midline approximately 45 cm from the most distal target. Fig. 1 presents an illustration of the general experiment setup.

Positioning for reach estimation was designed to be relatively similar to the FRT described in a subsequent section (see Fig. 2 for task postures). Participants began by positioning both feet (barefooted) comfortably apart and touching a marked line in alignment with the midline of the table. The distance from the body (back of the right-foot heel) to table edge was adjusted to be equivalent to the participant's arm length. The purpose of this procedure was to minimize the possibility of participants leaning on the table's edge (with the torso) during actual reach measurement. When instructed, the non-dominant (left) arm was placed comfortably on the same side at the hip and the right ('focus') hand positioned at chest level facing the target at midline. For actual maximum reach determination and imagery trials, participants were instructed to actually reach or imagine reaching by leaning forward to a comfortable maximum distance without lifting heels off the ground. During actual reach measurement (posture shown in Fig. 2a), the torso was not allowed to touch the table edge while leaning forward and participants were asked not to place their weight on the fingers and slide to the maximum reach point. We used the best of 3 trials for actual reach. We wish to

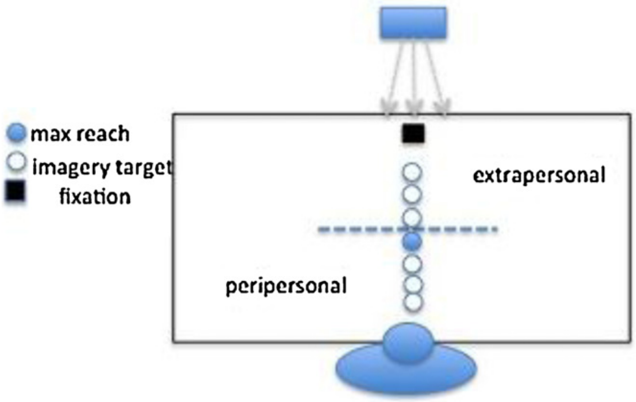

Fig. 1. General experimental setup for reach estimation.

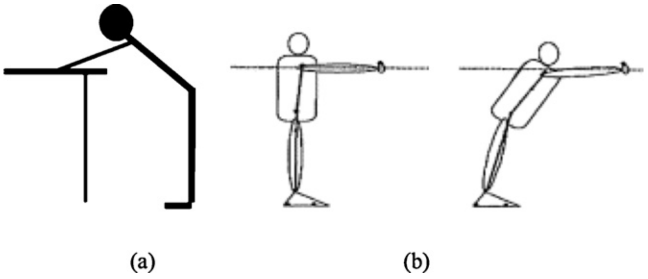

Fig. 2. General postures for: (a) determining maximum reach for estimation comparison (participant was upright for imagery trials) and (b) FR.

note that while imaging 'leaning forward,' the participant remained upright. As with the FRT, for safety purposes, an assistant monitored stability for potential falling. In addition, for this condition the edge of the table next to the torso was covered with a 2 in. cushioned mat.

Based on maximum reach, seven imagery targets (2 cm diameter) were randomly programmed with '4' representing actual reach complemented with three target sites farther and three sites closer touching at the rims. In essence, actual reach was 'scaled' to individual arm lengths, therefore allowing acceptable comparison. Participants were asked to focus while kinesthetically 'feeling' themselves (first-person perspective/motor imagery) executing the movement with the right limb – therefore being more sensitive to the biomechanical constraints of the (motor imagery) task (Johnson, Corballis, & Gazzaniga, 2001; Sirigu & Duhamel, 2001; Stevens, 2005). Participants were asked to make judgments relative to whether the target was within ('yes') or out of reach ('no'). Each participant was trained and provided practice in use of motor imagery. For imaged trials, data collection began with a 5 s "Ready!" signal – immediately followed by a central fixation point lasting 3 s, at the end of which was a tone. The image appeared immediately thereafter and lasted 500 ms with another tone at the end – which required an immediate (after imaging) verbal response. Target presentation was given in random order with 5 trials at each of the seven targets.

2.2.2. FRT

The FRT (Duncan et al., 1990) has been reported to have acceptable reliability and validity (reviews by: Langley & Mckintosh, 2007; Liao & Lin, 2008) and is one of the most widely used instruments of its kind. FR is defined here as the maximum forward displacement that a participant can achieve, starting from an upright position with the dominant arm extended forward and with the hand extended to form a right angle with the torso, while simultaneously maintaining a fixed support, and the hand always at the same level throughout the movement; the torso must not rotate during the test. After anthropometric data (height, body mass, etc.) was collected, each participant was positioned to stand barefoot with the toes touching a marked line with feet comfortably apart. The participant stood upright with one arm at a right angle to the torso with the hand and fingers extended. The participant held this position for about 5 s and then extended the dominant limb forward as far as possible without lifting the heels off the ground.

Measurement was by means of a simple measuring tape, which was extended between two stands with stand height adjusted so as to be aligned with the extended arm at the height of the acromion. An observer followed the displacement of the arm, moving along with the longest extended finger, reading its initial and final positions. The best of 3 correct trials was used for final data analysis. For safety, mats covered possible fall areas and an assistant aided with any falls.

2.3. General procedure

To begin, potential participants were screened for the criteria described earlier. Participants were tested in counterbalanced order for estimation of reach and FR; testing was conducted in a single session with rest provided between conditions.

2.4. Treatment of the data

Total reach accuracy was analyzed using a one-way ANOVA procedure ($p < 0.05$). Accuracy was defined as the number of correct responses out of the total number of trials (35). That is, when the participant responded "yes" when actually the target was within reach, or "no" when the target was out of reach. To determine the distribution of error across targets (where did the errors occur?), we used frequency data analyses and Chi-square procedures to compare the groups. The reader should keep in mind that there were seven target presentations; targets 1–4 were considered peripersonal (within reach) space, whereas targets 5–7 were defined as extrapersonal (beyond reach) space. Another ANOVA procedure was used to determine the general direction of error in terms of mean bias (i.e., over- or underestimation; how much were they off). These values were derived from mean error (cm) minus actual reach (target 4) by assigning the targets in extrapersonal space a positive value and those targets presented in peripersonal space a negative value. Values were then summed to provide a signed mean bias; values with a negative value corresponded to an underestimation whereas values with a positive value corresponded to an overestimation.

Regarding FRT analysis, a one-way ANOVA was used to compare the differences between the two age groups. In addition, regression analyses were used to determine the degree of relation between FRT scores and estimation of reach data.

3. Results

ANOVA results for total score estimation accuracy showed that there was no difference for age, $F(1,49) = 0.31$, $p = 0.579$, $\eta^2_{\text{partial}} = 0.01$; for the younger group, mean score was 29.28 ± 2.11, and for the older participants, 28.64 ± 4.59. Regarding mean bias (direction of error), results revealed a significant difference, $F(1,1783) = 116.29$, $p < 0.001$, $\eta^2_{\text{partial}} = 0.06$. That is, the older group underestimated ($M = -0.37$ cm) while the younger group overestimated ($M = 0.42$ cm).

Regarding the frequency (distribution) of error across targets, most error occurred for younger adults at target 5 (69%), whereas the older group displayed more error at target 4 (47%); an observation that reflects an overestimation bias for the younger adults and an underestimation bias for the older group. Chi square results for young and older adults were: target 4 (11% compared to 47%; $\chi^2 = 29.75$, $p < 0.001$) and target 5 (69% compared to 28%; $\chi^2 = 32.03$, $p < 0.001$). Fig. 3 provides a graphic illustration of error across targets.

In reference to FRT results, there was an age (group) difference, $F(1,49) = 89.18$, $p < 0.001$, $\eta^2_{\text{partial}} = 0.65$; younger adults = 76.66 cm and older adults = 35.99 cm. Concerning the correlation between reach estimation and FRT, only the younger group showed a significant relationship ($r = 0.56$, $p < 0.05$); correlation for the older group was $r = -0.01$, $p = 0.95$.

4. Discussion

We examined the association between estimation of reach via use of motor imagery and FR in young and older adults. With young adults, we expected a positive relationship based on the notion that simulated and actual execution of movements share common

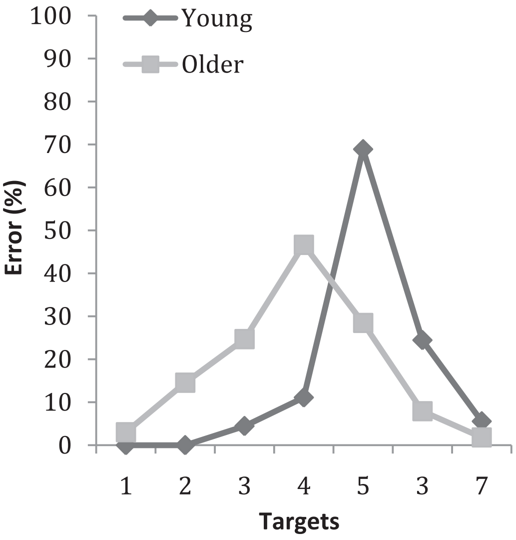

Fig. 3. Distribution of error across targets for young and older adults.

neurological processes. Conversely, we predicted that the association would be significantly weaker in older adults due in large part to difficulty with mentally representing action.

In regard to estimation accuracy, we found no difference in total score between groups (collapsed across all targets), however, group differences did emerge in mean bias (direction of error) and distribution of error. Our results revealed that the younger adults overestimated whereas the older adults were more conservative by underestimating; a similar finding was found in regard to the distribution of error. With that said, it could be reasonably argued that the actual magnitude of the over- and underestimation was small; that is, less than a half cm in each direction and perhaps evident of a planning strategy modification. Overestimation typically infers that the participant perceived that the object was reachable, but actually was not. Conversely, underestimation represented the perception that the object was not reachable, but actually was within reach. One might also argue that underestimation reflects a more conservative strategy; one that we might expect with older persons in regard to self-evaluation of physical abilities. With that in mind, research hints at the possibility of a postural effect (equilibrium constraint) associated with planning strategy. We could hypothesize that the older adults based planning and estimations on perceived postural constraints. As we observed in the present study, there was a greater mismatch between actual and imagined reach in the elderly. The general idea that postural constraints are a significant consideration in motor planning via use of imagery has been reported (e.g., Bakker et al., 2008; de Lange, Helmich, & Toni, 2006; Gabbard, Cordova, & Lee, 2007). For example, Paizis, Papaxanthis, and Berret (2008) reported that, when reaching beyond arm length, older participants (compared to younger adults), restrict their body displacements; a strategy that the researchers suggested was a way to counteract potential falls when one has lost flexibility in postural reactions. One might gather from that study that the elderly understand their limitations and plan accordingly – that is, conservatively. We feel compelled to speculate based on our observations here that perhaps the planning strategy was too conservative for the elderly, hence, the noticeable difference between imagined and actual behavior.

From a practical perspective, is it safer to under- or overestimate? If, the magnitude of difference from actual ability were significant, speculatively either could present a problem for the elderly. For example, if an older adult either significantly underestimates or overestimates a reach target (e.g., drinking glass, table, and railing), they may have more difficulty than a younger person in maintaining postural control resulting in a fall. However, in the context of our results, the key finding was the association between imagined and actual reach. As noted earlier, theoretically the closer that relationship, the more effective the motor plan and execution.

As one would expect, the younger adults displayed significantly greater FR (77 cm in compared to 36 cm). In reference to the key point of interest in this study, the association between FR and estimated reach, our initial expectation was supported. That is, the association between imagined and actual FR was stronger for young adults; an *r* of 0.56 compared to −0.01 for older adults. From another perspective, these results suggest there is a wide disparity between young and older adults (22 versus 66 years) between mentally represented (imagined) and executed actions. Furthermore, our results suggest that with older adults there maybe more reliance and need for feedback, rather than feedforward control; the latter is commonly associated with internal [forward] models for motor actions. These finding add to the increasing body of evidence that with advanced age (>64 years) there is a decline in the ability to mentally represent action (e.g., Gabbard et al., 2011; Mulder et al., 2008; Personnier et al., 2010; Saimpont et al., 2009; Skoura et al., 2008).

5. Conclusions

In addition to gaining insight to the effects of advanced age on the ability to mentally represent action and its association with movement execution, these results although preliminary, may have clinical implications based on the question of whether motor imagery training could improve movement estimations and how that would affect actual reach. Obviously more work is needed; work that includes a larger small of older persons (>75 years) and different tasks that require similar planning and execution components.

Conflict of interest statement

None.

References

Bakker, M., DeLange, F. P., Helmich, R. C., Scheeringa, R., Bloem, B. R., & Toni, I. (2008). Cerebral correlates of motor imagery of normal and precision gait. *NeuroImage, 41*(3), 998–1010.

Beauchet, O., Annweiler, C., Assal, F., Bridenbaugh, S., Hermman, F. R., Kressig, R. W., et al. (2010). Imagined timed up & go test: A new tool to assess higher-level gait and balance disorders in older adults? *Journal of the Neurological Sciences, 294*, 1–2.

Bourgeois, J., & Coello, Y. (2009). Role of inertial properties of the upper limb on the perception of the boundary of personal space. *Psychologie Française, 54*(3), 225–239.

Choudhury, S., Charman, T., Bird, V., & Blakemore, S. (2007). Development of action representation during adolescence. *Neuropsychologia, 45*, 255–262.

Coello, Y., Bartolo, A., Amiri, B., Devanne, H., Houdayer, E., & Derambure, P. (2008). Perceiving what is reachable depends on motor representations: Evidence from transcranial magnetic stimulation study. *PLoS ONE, 3*(8), e2862.

Coello, Y., & Delevoye-Turrell, Y. (2007). Embodiment, spatial categorization and action. *Consciousness and Cognition, 16*(3), 667–683.

Costarella, M., Monteleone, L., Steindler, R., & Zuccaro, S. M. (2010). Decline of physical and cognitive conditions in the elderly measured through the functional reach test and the mini-mental state examination. *Archives of Gerontology and Geriatrics, 50*(3), 332–337.

de Lange, F. P., Helmich, R. C., & Toni, I. (2006). Posture influences motor imagery: An fMRI study. *NeuroImage, 33*(2), 609–617.

Duncan, P. W., Weiner, D. K., Chandler, J., & Studenski, S. (1990). Functional reach: A new clinical measure of balance. *Journal of Gerontology, 45*(6), M192–M197.

Gabbard, C., Cacola, P., & Cordova, A. (2011). Is there an advanced aging effect on the ability to mentally represent action? *Archives of Gerontology and Geriatrics, 53*, 206–209.

Gabbard, C., Cordova, A., & Lee, S. (2007). Examining the effects of postural constraints on estimating reach. *Journal of Motor Behavior, 39*(4), 242–246.

Gabbard, C., Cordova, A., & Lee, S. (2009a). A question of intention in motor imagery. *Consciousness and Cognition, 18*, 300–305.

Gabbard, C., Cordova, A., & Lee, S. (2009b). Do children perceive postural constraints when estimating reach (motor planning)? *Journal of Motor Behavior, 41*(2), 100–105.

Jeannerod, M. (2001). Neural simulation of action: A unifying mechanism for motor cognition. *NeuroImage, 14*, 103–109.

Johnson, S., Corballis, P., & Gazzaniga, M. (2001). Within grasp but out of reach: Evidence for a double dissociation between imagined hand and arm movements in the left cerebral hemisphere. *Neuropsychologia, 39*, 36–50.

Kikuchi, R., Kozaki, K., Iwata, A., Hasegawa, H., & Toba, K. (2009). Evaluation of risk of falls in patients at a memory impairment outpatient clinics. *Geriatrics and Gerontology International, 9*, 298–303.

Kunz, B. R., Creem-Regehr, S. H., & Thompson, W. B. (2009). Evidence for motor simulation in imagined locomotion. *Journal of Experimental Psychology: Human Perception and Performance, 35*(5), 1458–1471.

Lamm, C., Fischer, M. H., & Decety, J. (2007). Predicting the actions of others taps into one's own somatosensory representations – A functional MRI study. *Neuropsychologia, 45*, 2480–2491.

Langley, F. A., & Mckintosh, S. F. H. (2007). Functional balance assessment of older community dwelling adults: A systematic review of the literature. *The Internet Journal of Allied Health Sciences and Practice5(4).*

Liao, C., & Lin, S. (2008). Effects of different movement strategies on forward reach distance. *Gait & Posture, 28*(1), 16–23.

Lorey, B., Pilgramm, S., Walter, B., Stark, R., Munzert, J., & Zentgraf, K. (2010). Your mind's hand: Motor imagery of pointing movements with different accuracy. *NeuroImage, 49*(4), 3239–3247.

Molina, M., Tijus, C., & Jouen, F. (2008). The emergence of motor imagery in children. *Journal of Experimental Child Psychology, 99*(3), 196–209.

Mulder, T., Hochstenbach, J. B. H., Heuvelena, M. J. G., & Otter, A. R. (2008). Motor imagery: The relation between age and imagery capacity. *Human Movement Science, 26*(2), 203–211.

Munzert, J., Lorey, B., & Zentgraf, K. (2009). Cognitive motor processes: The role of motor imagery in the study of motor representations. *Brain Research Reviews, 60*(2), 306–326.

Paizis, C., Papaxanthis, C., & Berret, B. (2008). Reaching beyond arm length in normal aging: Adaptation of hand trajectory and dynamic equilibrium. *Behavioral Neuroscience, 22*(6), 1361–1370.

Penhune, V. B., & Steele, C. J. (2012). Parallel contributions of cerebellar, striatal and M1 mechanisms to motor sequence learning. *Behavioural Brain Research, 226*(2), 579–591.

Personnier, P., Bally, Y., & Papaxanthis, C. (2010). Mentally represented motor actions in normal aging. III. Electromyographic features of imagined arm movements. *Behavioural Brain Research, 206*(2), 184–191.

Saimpont, A., Mourey, F., Manckoundia, P., Pfitzenmeyer, P., & Pozzo, T. (2009). Aging effects the mental simulation/planning of the "rising from the floor" sequence. *Archives of Gerontology and Geriatrics available on-line.*

Sirigu, A., & Duhamel, J. R. (2001). Motor and visual imagery as two complementary but neutrally dissociable mental processes. *Journal of Cognitive Neuroscience, 13*(7), 910–919.

Skoura, X., Papaxanthis, C., Vinter, A., & Pozzo, T. (2005). Mentally represented motor actions in normal aging. I. Age effects on the temporal features of overt and covert execution of actions. *Behavioural Brain Research, 165*, 229–239.

Skoura, X., Personnier, P., Vinter, A., Pozzo, T., & Papaxanthis, C. (2008). Decline in motor prediction in elderly subjects: Right versus left arm differences in mentally simulated motor actions. *Cortex, 44*, 1271–1278.

Stevens, J. A. (2005). Interference effects demonstrate distinct roles for visual and motor imagery during the mental representation of human action. *Cognition, 95*(3), 329–350.

Wolpert, D. M. (1997). Computational approaches to motor control. *Trends in Cognitive Sciences, 1*, 209–216.

Zuccaro, S. M., Steindler, R., Scena, S., & Costarella, M. (2012). Changes of psychical and physical conditions in the elderly after a four-year follow-up. *Archives of Gerontology and Geriatrics, 54*, 72–77.