

Ipsilateral coordination at preferred rate: Effects of age, body side and task complexity

Annouchka Van Impe, James P. Coxon, Daniel J. Goble, Nici Wenderoth, Stephan Patrick Swinnen *

Laboratory of Motor Control, Research Center for Motor Control and Neuroplasticity, Group Biomedical Sciences, K.U.Leuven, Tervuursevest 101, B-3001 Heverlee, Belgium

ARTICLE INFO

Article history:

Received 20 March 2009

Revised 10 June 2009

Accepted 11 June 2009

Available online 17 June 2009

Keywords:

Aging

fMRI

Motor control

Interlimb coordination

Task complexity

Body side

ABSTRACT

Functional imaging studies have shown that elderly individuals activate widespread additional brain networks, compared to young subjects, when performing motor tasks. However, the parameters that effect this unique neural activation, including the spatial distribution of this activation across hemispheres, are still largely unknown. Here, we examined the effect of task complexity and body side on activation differences between older and younger adults while performing cyclical flexion–extension movements of the ipsilateral hand and foot. In particular, easy (isodirectional) and more difficult (non-isodirectional) coordination patterns were performed with either the left or right body side at a self-selected, comfortable rate. Even in the absence of imposed pacing the older group activated a larger brain network, suggestive of increased attentional deployment for monitoring the spatial relationships between the simultaneously moving segments and enhanced sensory processing and integration. Evidence of age-dependent underactivation was also found in contralateral M1, SMA and bilateral putamen, possibly reflecting a functional decline of the basal ganglia–mesial cortex pathway in the older group. An ANOVA model revealed significant main effects of task complexity and body side. However the interaction of these factors with age did not reach significance. Consequently, we conclude that under self-paced conditions, task complexity and body side did not have a modulatory effect on age-related brain activation.

© 2009 Elsevier Inc. All rights reserved.

Introduction

Healthy aging is characterized by neuroanatomical (Good et al., 2001; Sullivan and Pfefferbaum, 2006) and neurochemical changes (Volkow et al., 1998). This has implications not only for cognitive performance (Reuter-Lorenz and Lustig, 2005), but also for general motor ability. Indeed, movement slowing and increased variability of motor performance are some of the most prominent changes associated with the aging process (Spirduso and MacRae, 1990).

In addition, functional magnetic resonance imaging (fMRI) work has shown alterations in brain activity, as measured by the blood oxygenation level dependent (BOLD)-response (Cabeza et al., 2005; Ward, 2006). Age-related increases in brain activation, either over-activations in regions recruited by young subjects or unique, additional activations, have been observed, even for simple unilateral motor tasks. In some cases, these activations have been linked with more successful performance (Heuninckx et al., 2008; Ward, 2006). Whereas some have primarily observed increases in the hemisphere contralateral to the moving limb (Heuninckx et al., 2008), others have shown additional recruitment of sensorimotor and premotor regions ipsilateral to the moving limb (Calautti et al., 2001; Hutchinson et al., 2002; Mattay et al., 2002; Naccarato et al., 2006; Riecker et al., 2006; Rowe et al., 2006). This bilateral activation pattern is consistent with

the HAROLD (Hemispheric Asymmetry Reduction in Old Age) model of aging, originally formulated from age-related memory research (Cabeza, 2002).

In healthy adolescents, increased neural (also ipsilateral) recruitment is usually observed only when tasks become more complex (Verstynen et al., 2005) or when movements are made with non-dominant as compared to dominant limb segments (Kapreli et al., 2006; Kim et al., 1993; Mattay et al., 1998; Nirkko et al., 2001; Rogers et al., 2004). In view of this evidence for a modulatory effect of body side and task complexity on the degree and distribution of brain activation in adolescents, one is prompted to ask how these factors influence brain activation in elderly and, more generally, what are the boundary conditions for increased activation? Nevertheless, few studies have tested their impact on neural activity in older groups. Some have studied non-dominant limb movements in the elderly, using relatively simple motor tasks (Calautti et al., 2001; Hutchinson et al., 2002; Ward et al., 2008; Ward and Frackowiak, 2003). In this case, Calautti et al. (2001) found no differences in brain activation between young and old adults when moving their left index finger, whereas Hutchinson et al. (2002) found higher activations in bilateral supplementary motor area (SMA), caudate and thalamus in the elderly. Ward and Frackowiak (2003) and Ward et al. (2008), found a significant positive correlation between age² and the BOLD-signal in ipsilateral M1, irrespective of the hand moved.

The impact of task complexity on brain activity in the context of aging was studied by Heuninckx et al. (2005). Participants performed metronome paced ipsilateral cyclical movements, with the right hand

* Corresponding author. Fax: +32 16 32 91 97.

E-mail address: Stephan.Swinen@faber.kuleuven.be (S.P. Swinnen).

and foot moving in the same (isodirectional, ISO) versus different direction (non-isodirectional, NON-ISO). Even though a more extensive activation pattern was observed in the aged as compared to the young group during both coordination modes, the effects were more pronounced for the NON-ISO coordination condition. Specifically, prefrontal cortex (including dorsolateral prefrontal cortex (DLPFC)), pre-SMA, anterior cingulate cortex, precentral, parietal, and occipital regions, as well as cerebellum, were more activated during NON-ISO than during ISO coordination.

In the present study, we investigated age-related differences in neural recruitment as a function of body side and movement complexity during coordination of the ipsilateral hand and foot. First, we tested whether increased activation (or underactivation) was observed in the elderly as compared to the young group when participants were allowed to perform the coordination patterns at their individualized preferred speed (comfort pace). Previous work in this area imposed a movement frequency above comfort rate, resulting in age-related activation of areas associated with cognitive task involvement, sensory processing and intersensory integration (Heuninckx et al., 2005, 2008).

Second, brain activation differences during performance with the non-dominant versus dominant body side were tested. Based on the above mentioned studies in adolescents, it was hypothesized that increased (bilateral) activation in the aged group would be more pronounced during movements of the non-dominant as compared to the dominant body side. Third, differences in brain activation were studied as a function of coordination complexity by comparing the neural activations of NON-ISO versus ISO movements. Based on previous work (Heuninckx et al., 2005), it was hypothesized that age-related activation differences would be most prominent during the task conditions with the greatest demands, i.e., when performing NON-ISO coordination with the non-dominant body side (an “age $\times$ body side $\times$ coordination pattern” interaction).

Methods

Subjects

Seventeen young adults (mean age, 23.8 years, range 19–30) and 21 older adults (mean age 70.3 years, range 62–80) with no history of neurological diseases participated in the study. Scans of 2 seniors contained artifacts and were excluded from all analyses. The older subjects were all community dwelling individuals. The CHAMPS questionnaire (Community Healthy Activities Model Program for Seniors) (Stewart et al., 2001) was used to calculate their average amount of physical activity (kcal/week). All but 2 seniors used over 2900 kcal/week and were thereby classified as being active seniors. All participants were right-handed and right-footed, as assessed by an adapted version of the Edinburgh Handedness Inventory (Oldfield, 1971). The Mini-mental state examination (Folstein et al., 1975) was used to determine general cognitive function, with all elderly scoring within normal limits (score ≥ 27). Participants were informed about

the experimental procedures and provided written informed consent. The study was approved by the local Ethics Committee of K.U.Leuven and was performed in accordance with the 1964 Declaration of Helsinki.

Experimental design

Task

An fMRI block design was utilized whereby participants performed 2 movement conditions and 1 condition during which no movements were performed (REST). The movement conditions required cyclical coordination of the ipsilateral hand and foot according to ISO or NON-ISO modes, while keeping the contralateral body side still (see Fig. 1). During ISO coordination, both limb segments moved in the same direction (i.e., hand flexion combined with foot plantar flexion). During NON-ISO coordination, the limb segments moved in opposite directions (i.e., hand flexion combined with foot dorsiflexion). Right and left body sides were examined in separate runs. Difficulty levels between groups were matched by performing the coordination tasks at a self-preferred movement frequency and amplitude. However, participants were instructed and trained to maintain a single rhythm over their respective movement conditions. To ensure correct performance, participants completed a practice session in a dummy-scanner within 48 h of the experiment.

Scanner set-up

Participants lay supine in the scanner, with forearms pronated. To enable free wrist and ankle rotations, the forearms and legs were supported by cushions. The wrists and feet were positioned in non-ferromagnetic orthoses, enabling on-line registration of movements during scanning and allowing the experimenters to check for possible mirror movements. High-precision shaft encoders (4096 pulses per revolution; sampled at 100 Hz) fixed to the movement axis of the orthoses were used to register angular displacement of the joints. Subjects looked at a display via a mirror that was fixed to the head coil. Visual templates, instructing the task to be performed were projected onto the display by means of a Barco (Kortrijk, Belgium) 6400i liquid crystal display projector (1024 $\times$ 768 pixels, 60 Hz). A bite-bar was used to minimize head movements.

fMRI data acquisition

All scanning was performed on a 3 T Intera MR scanner (Philips, Best, The Netherlands), using a 6-element SENSE head coil (MRI Devices, Waukesha, WI). Six functional time series were acquired, each consisting of 105 whole brain gradient-echo echoplanar images (EPI) (TR/TE = 3000/33 ms, field of view = 230 mm, matrix = 112 $\times$ 112, slice thickness = 4.0 mm, interslice gap = 0.4 mm, 34 sagittal slices, SENSE factor = 2). Each time series consisted of 5 blocks of the ISO, NON-ISO and REST conditions, with the order of the conditions balanced across runs. Three time series were performed with each body side and the order was counterbalanced across participants.

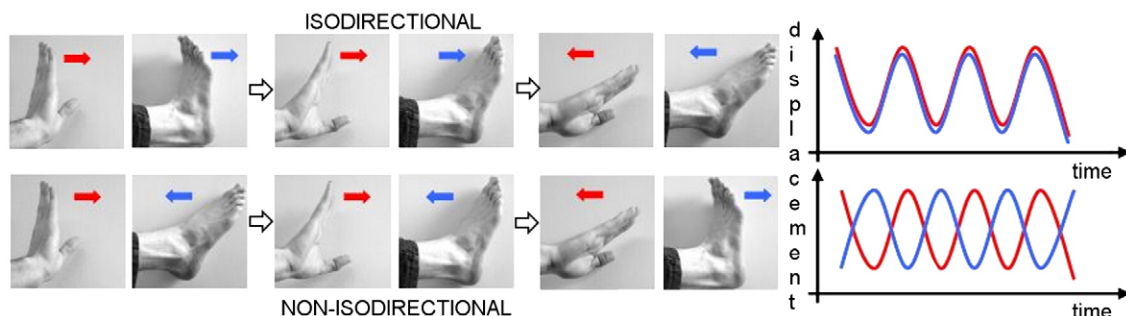


Fig. 1. Cyclical ipsilateral coordination according to the ISO (top panel) and NON-ISO (bottom panel) mode.

Download English Version:

<https://daneshyari.com/en/article/6038619>

Download Persian Version:

<https://daneshyari.com/article/6038619>

[Daneshyari.com](https://daneshyari.com)