Neuroscience 294 (2015) 51–59

PRESERVED MOTOR ASYMMETRY IN LATE ADULTHOOD: IS MEASURING CHRONOLOGICAL AGE ENOUGH?

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Abstract—When comparing motor performance of the dominant and nondominant hands, older adults tend to be less asymmetric compared to young adults. This has suggested decreased motor lateralization and functional compensation within the aging brain. The current study further addressed this question by testing whether motor asymmetry was reduced in a sample of 44 healthy right-handed adults ages 65–89. We hypothesized that the older the age, the less the motor asymmetry, and that 'old old' participants (age 80+) would have less motor asymmetry than 'young old' participants (age 65–79). Using two naturalistic tasks that selectively biased the dominant or nondominant hands, we compared asymmetries in performance (measured as a ratio) across chronological age. Results showed preserved motor asymmetry across ages in both tasks, with no difference in asymmetry ratios in the 'old old' compared to the 'young old.' In the context of previous work, our findings suggest that the aging brain may also be characterized by additional measures besides chronological age.

Key words: motor lateralization, asymmetry, aging, upper extremity, naturalistic task.

INTRODUCTION

Hemispheric specialization is considered a key feature of neural organization (Toga and Thompson, 2003). One outcome of such organization is the lateralization of certain behaviors, including upper extremity movement. A growing amount of evidence in animals and humans has strongly suggested that the control system for upper extremity movement is lateralized across the two cerebral hemispheres (Uomini, 2009; Frayer et al., 2010; Zhao et al., 2012; Chatagny et al., 2013; Meguerditchian et al., 2013; Sainburg, 2014). More specifically, the dominant hemisphere (i.e. the left hemisphere of right handers) appears to be specialized for controlling movements through predictive mechanisms that effectively coordinate multiple limb segments, which are optimal when movement conditions are consistent and stable (Sainburg and Kalakanis, 2000; Bagesteiro and Sainburg, 2002; Coelho et al., 2013). Beyond and in contrast to this, the nondominant hemisphere (i.e. the right hemisphere of right handers) may be specialized for maintaining limb stability and resisting unexpected perturbations from the environment (Bagesteiro and Sainburg, 2003; Mutha et al., 2012). Further research suggests that with this nondominant hemispheric advantage, the left hand may also be better at static object manipulation compared to the right hand (Judge and Stirling, 2003; Ferrand and Jaric, 2006) when limb choice/preference is constrained, perhaps through better limb stability at the end-effector (hand).

In concert with hemispheric differences in motor planning and execution, the lateralization of other sensorimotor functions may also contribute to manual asymmetries (for review see Starkes et al., 2002; Goble and Brown, 2008). For example, the left and right hemispheres appear to utilize (Flowers, 1975; Todor and Doane, 1978; Roy and Elliott, 1986), process and weight (Adamo and Martin, 2009; Martin and Adamo, 2011) movement-related visual and somatosensory feedback differently, and may even allocate spatial attention differently (Hodges et al., 1997). Although these sensorimotor asymmetries are strongest in right-handed individuals, the respective roles of the dominant and nondominant hemispheres during voluntary upper extremity movement are relatively maintained in left-handed adults as well (Wang and Sainburg, 2006; Goble et al., 2009; Legon et al., 2010; Przybyla et al., 2012). Thus, depending on a given task and its requirements, the dominant and nondominant hands may perform differently, with one hand being better at the task than the other.

Dominant and nondominant hand performance may, however, become more symmetric with age. Numerous behavioral studies have documented age-related reductions in motor asymmetry when moving unimanually (Przybyla et al., 2011; Raw et al., 2012), transferring learned information between the limbs (Wang et al., 2011), and even imagining movements (Paizis et al., 2014), such that the intermanual difference is smaller than in young adults. One explanation is that

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Abbreviations: ADL, activities of daily living; D, Dominant; MoCA, Montreal Cognitive Assessment; ND, Nondominant.

http://dx.doi.org/10.1016/j.neuroscience.2015.03.013
0306-4522/

reductions in age-related asymmetries may reflect functional compensation in older adults through increased ipsilateral hemispheric activation. This hypothesis has emerged from research in other lateralized non-motor systems, such as working memory encoding and retrieval (Reuter-Lorenz et al., 1999; Cabeza, 2002; Cabeza et al., 2002; Dolcos et al., 2002), yet may not hold as true for voluntary motor control given the often co-morbid aspects of aging like muscle and bone loss, cardiopulmonary dysfunction, and response slowing (Spirduso et al., 2005). Nevertheless, models of compensatory cortical recruitment may be applicable when considering less asymmetry in motor performance of older adults.

The age 'effect' on motor asymmetry has typically been modeled dichotomously, however, where the difference between dominant and nondominant hand performance is compared between young and older adults. To more clearly understand whether reductions in motor asymmetry are in fact age-related, however, one could also investigate this question by modeling age as a continuous variable and within later adulthood. Thus, the purpose of this study was to test whether motor asymmetry was further reduced with advanced chronological age. Using two different motor tasks that theoretically biased either the dominant or nondominant hands for coordination or manipulation respectively, we hypothesized that the older the age, the less the motor asymmetry in a sample of healthy adults ages 65 and over. We also hypothesized the 'old old' (age 80+) would have less motor asymmetry than the 'young old' (age 65–79).

EXPERIMENTAL PROCEDURES

Participants

Forty-four right-handed adults age 65 years or older (mean ± SD: 75.4 ± 6.6 years) from the local community ($n = 43$) or senior assisted-living apartments ($n = 1$) participated in this study. Recruitment was based on individuals who contacted the laboratory with interest in participating as a result of approved postings throughout Cache County. Exclusion criteria included (1) one or more self-reported neurological conditions (e.g., Parkinson's disease, Huntington's disease, Alzheimer's disease, stroke, or transient ischemic attack); (2) acute or chronic musculoskeletal conditions that could affect motor function; and (3) left- or mixed-handedness (see below). All aspects of this study were conducted in accordance with the Declaration of Helsinki, and all procedures were carried out with the adequate understanding and prior written consent of the participants as approved by the University's Institutional Review Board.

Participants' cognitive and sensorimotor functions were characterized prior to completing the motor task. Global cognitive status was measured with the Montreal Cognitive Assessment (MoCA) (Nasreddine et al., 2005), which is a reliable, easily administered, and brief cognitive screening test (max score = 30; "normal" score cutoff ⩾26). General disability was tested for with the Index of Independence in activities of daily living (ADL) (Katz et al., 1970) in order to assess functional ability in daily life. This index is a paper-and-pencil test in which participants self-report their level of assistance needed to complete each of the six ADL functions: feeding, continence, transferring, going to toilet, dressing, and bathing. Reports of "no assistance needed" were scored as 1; the maximum (worst) score was 18, which indicated "dependent in all six functions." No additional measure of physical fitness or activity was collected. Tactile sensation was measured with Semmes Weinstein monofilaments (Touch-Test™, North Coast Medical, Inc., Gilroy, CA, USA) at the distal end of the dominant and nondominant index fingers. Maximal grip strength of the dominant and nondominant hand was tested via hand dynamometry (Jamar, Sammons-Preston-Rolyan, Bolingbrook, IL, USA) and measured as the average of three consecutive measurements for each hand (Schmidt and Toews, 1970). Hand dominance was determined using a modified Edinburgh Handedness Questionnaire (Oldfield, 1971). Only participants with a laterality quotient of ⩾80% ("strongly right-handed") were included in this study, but no further data regarding their occupation or potential for long-term hand training over their lifespan were collected. All participant characteristics are summarized in Table 1.

Experimental tasks

The two motor tasks used in this study were a simulated dressing task and a simulated feeding task. Additional justification and images of these naturalistic tasks have been published previously (Schaefer and Lang, 2012; Schaefer et al., 2013, 2014). We operationally defined 'naturalistic' in this study as requiring purposeful, multi-step actions (Schwartz et al., 1998; Giovannetti et al., 2002; Hartmann et al., 2005) rather than involving only one movement component (e.g. only reaching).

The simulated dressing task in this study required participants to manipulate buttons and fasten them sequentially with one hand on a button board (Backman et al., 1992) (Fig. 1A). At the start of each trial, participants began buttoning the top of ten buttons (2.5 cm diameter) that were sewn 5.3 cm apart vertically to a piece of heavyweight linen fabric, 3.0 cm from the edge. The buttonholes were 3.7 cm in length. Both pieces of the fabric were double-layered (2-ply) and were secured to a wooden board (61 cm × 34 cm), with the placket centered at the participants' midline, 15 cm in front of them. The button-side of the fabric was folded onto the board, while the button hole-side of the fabric was unfolded lateral to the midline onto the table prior to each trial. Fabric weight (65.6 g/m^2) and thread count (15 per cm) were measured according to ASTM Test Methods D3776-96 and D3775-98, respectively (ASTM, 2001a,b). Buttons were fastened through horizontal button holes in a lateral-over-medial order, relative to the participant. Participants were instructed to fasten the 10 buttons consecutively (from top to bottom) as quickly as possible with either their left (nondominant) or right (dominant) hand, equaling one trial. The experimenter monitored the ongoing trials to ensure that each button was completely through the button hole; if a button was not completely through before the participant moved on to the next