Human Movement Science 46 (2016) 23–29

Contents lists available at ScienceDirect

Human Movement Science

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

Influence of divergent and convergent thinking on visuomotor adaptation in young and older adults

Anja Simon *, Otmar Bock

Institute of Physiology and Anatomy, German Sport University Cologne, Am Sportpark Müngersdorf 6, 50933 Cologne, Germany

ARTICLE INFO

Article history:
Received 3 August 2015
Revised 25 November 2015
Accepted 28 November 2015
Available online 17 December 2015

Keywords:
Motor learning
Age-dependence
Convergent thinking
Divergent thinking

ABSTRACT

Visuomotor adaptation declines in older age. This has been attributed to cognitive impairments. One relevant cognitive function could be creativity, since creativity is implicated as mediator of early learning. The present study therefore evaluates whether two aspects of creativity, divergent and convergent thinking, are differentially involved in the age-dependent decline of visuomotor adaptation.

In 25 young and 24 older volunteers, divergent thinking was assessed by the *alternative-uses-task* (AUT), convergent thinking by the *Intelligenz-Struktur-Test-2000* (IST), and sensorimotor-adaptation by a pointing task with 60° rotated visual feedback.

Young participants outperformed older participants in all three tasks. AUT scores were positively associated with young but not older participants' adaptive performance, whereas IST scores were negatively associated with older but not young participants' adaptive performance. This pattern of findings could be attributed to a consistent relationship between AUT, IST and adaptation; taking this into account, adaptation deficits of older participants were no longer significant.

We conclude that divergent thinking supports workaround-strategies during adaptation, but doesn't influence visuomotor recalibration. Furthermore, the decay of divergent thinking in older adults may explain most of age-related decline of adaptive strategies. When the age-related decay of divergent thinking coincides with well-preserved convergent thinking, adaptation suffers most.

1. Introduction

Visuomotor adaptation is degraded in older age, but its aftereffects are not reduced (Buch, Young, & Contreras-Vidal, 2003; Fernández-Ruiz, Hall, Vergara, & Díaz, 2000; McNay & Willingham, 1998). In accordance with established reasoning, this has been interpreted as evidence that older adults may have a poorer strategic control, while the actual adaptive recalibration of their sensorimotor system remains intact (Bock, 2005; McNay & Willingham, 1998; Redding & Wallace, 1996). In order to explain the age-related decay of strategic control, authors have focused on the acquisition and usage of explicit knowledge (Hegele & Heuer, 2013) and the role of executive functions (Anguera et al., 2012; Bock & Girgenrath, 2006; Eversheim & Bock, 2001); both are thought to decay in old age because of shrinkage of the prefrontal cortex of the brain (Raz et al., 1997).

* Corresponding author.
E-mail addresses: a.simon@dshs-koeln.de (A. Simon), Bock@dshs-koeln.de (O. Bock).

http://dx.doi.org/10.1016/j.humov.2015.11.020

The mediating role of cognitive functions in different learning paradigms has been acknowledged by several theoretical accounts (Chein & Schneider, 2012; Fitts, 1964). In particular, Chein and Schneider's model suggests that changes of strategy, flexibility, the generation of new behavioural routines and task generation are important for early learning stages, attention and inhibition for intermediate, and automation for later stages. Since the cognitive mediators proposed by Chein and Schneider for early learning stages are reflected in the construct of creativity, we have recently explored the role of creativity during sensorimotor adaptation in young adults (Simon & Bock, 2015). We assessed creativity with the *Abbreviated Torrance Test for Adults* (ATTA: Goff, 2002), and found no difference between high and low ATTA performers in any phase of adaptation. We thus yielded no evidence that creativity plays a role for visuomotor adaptation.

The present study takes a more detailed look at the relationship between creativity and adaptation. Creativity is often subdivided into two components, divergent and convergent thinking (Guilford, 1967). Specifically, divergent thinking reflects the *generation* of novelty, a variability in answers and the ability to transform information into unexpected forms, whereas convergent thinking reflects the *evaluation* of novelty, deriving the single best answer and the recall of answers stored in information (Cropley, 2006). Divergent and convergent thinking, unfortunately, are not separately assessed by ATTA. It therefore is conceivable that divergent and convergent thinking have opposite effects on adaptation, and that those effects cancelled out when ATTA creativity indices were compared with adaptive success in our earlier study. To scrutinise this view, we now decided to quantify both components of creativity separately, divergent thinking by the *alternative uses task* (AUT; Guilford, 1967) and convergent thinking by a verbal reasoning test taken from the German *Intelligenz Struktur Test 2000* (IST; Amthauer, Brocke, Liepmann, & Beauducel, 1999).

Summing up, we hypothesise that divergent thinking promotes early stages of visuomotor adaptation and that this benefit is reduced in older adults due to their degraded divergent thinking abilities (Simonton, 1991). We further hypothesise that convergent thinking opposes the search for novel solutions during early stages of adaptation and thus interferes with adaptive success; this detrimental effect should stand out when in older persons, degraded divergent thinking abilities are combined with preserved convergent thinking abilities.

2. Methods

2.1. Participants

Twenty-five young and 25 older participants volunteered in this study. All were right handed and healthy by self-report. One of the older participants was excluded from the analysis for not completing the whole test battery, such that 24 older participants remained; 14 males and 10 females at the age of 65.2 ± 3.18 years. The group of young participants consisted of 15 males and 10 females at the age of 25.2 ± 1.73 years. Poor vision was corrected by prescription glasses or contact lenses. All participants signed an informed consent statement before participating in our study, which was approved by a local ethics committee.

2.2. Experimental procedures

Each participant performed two cognitive tasks in randomized order, and then a visuomotor adaptation task.

During the *visuomotor adaptation task*, participants pointed a cursor at visual targets presented on a computer screen in eight possible directions and at a constant distance from a central starting cross. Movements were performed with a pen on a digitizing tablet without vision of the arm, while visual feedback was provided by a cursor on the screen. When a target appeared, participants had to move the cursor quickly and as accurately as possible from the central cross to the target and back. The next target appeared after return to the central cross, etc., until all eight targets have been presented three times, in quasi-random order. Due to the randomization process, target order differed between participants. Each episode of 8×3 targets = 24 trials was followed by a rest break of a few seconds to avoid fatigue, even though fatigue seems not to play a substantial role for adaptation with the given number of trials: increasing the duration of rest breaks beyond a few seconds doesn't influence adaptation and its aftereffects (Bock, Thomas, & Grigorova, 2005).

The task started with a baseline phase of four episodes, in which visual feedback correctly represented the pen position. During the subsequent 20 episodes of the adaptation phase, visual feedback was rotated by 60° about the central cross. The last four episodes constituted the de-adaptation phase, in which visual feedback was represented without rotation again. Thus, the total number of trials was $24 * (4 + 20 + 4) = 672$. Participants were not informed about the feedback manipulation in the adaptation phase, but were told that task difficulty may differ between episodes. An interactive software determined the initial pointing error as the angular difference between ideal and actual movement direction during the initial 150 ms after movement onset, i.e., before errors could be corrected by visual feedback.

The *alternative uses task* (AUT; Guilford, 1967) was used to assess participants' ability for divergent thinking. Three objects (shoe, pen, and brick) were verbally presented in randomized order and participants had to write down as many alternative uses as possible for each given object within two minutes. As per AUT manual, answers were scored with respect to fluidity, originality, elaboration and flexibility, the four scores were added, and the mean across all three objects was taken as the overall indicator of divergent thinking.