Journal of Experimental Child Psychology 147 (2016) 39–52

Contents lists available at ScienceDirect

Journal of Experimental Child Psychology

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

Age-related differences in working memory updating components

Rocío Linares [a], M. Teresa Bajo [b], Santiago Pelegrina [a,*]

[a] Department of Psychology, University of Jaén, 23071 Jaén, Spain
[b] Research Center for Mind, Brain, and Behavior, University of Granada, 18071 Granada, Spain

ARTICLE INFO

Article history:
Received 17 November 2015
Revised 1 February 2016
Available online 14 March 2016

Keywords:
Working memory
Working memory updating
Working memory retrieval
Working memory development
Working memory updating development
Age-related changes in updating children adolescents

ABSTRACT

The aim of this study was to investigate possible age-related changes throughout childhood and adolescence in different component processes of working memory updating (WMU): retrieval, transformation, and substitution. A set of numerical WMU tasks was administered to four age groups (8-, 11-, 14-, and 21-year-olds). To isolate the effect of each of the WMU components, participants performed different versions of a task that included different combinations of the WMU components. The results showed an expected overall decrease in response times and an increase in accuracy performance with age. Most important, specific age-related changes in the retrieval component were found, demonstrating that the effect of retrieval on accuracy was larger in children than in adolescents or young adults. These findings indicate that the availability of representations from outside the focus of attention may change with age. Thus, the retrieval component of updating could contribute to the age-related changes observed in the performance of many updating tasks.

Introduction

Working memory (WM) is a cognitive system that enables us to maintain and manipulate information (Baddeley, 1983; Cowan, 1999). WM is crucial for optimal cognitive functioning and is necessary

* Corresponding author.
E-mail address: spelegri@ujaen.es (S. Pelegrina).

http://dx.doi.org/10.1016/j.jecp.2016.02.009
0022-0965/

in numerous daily activities (Gathercole, 1999). Given the limited capacity of WM, an updating process is needed that quickly allows us to modify the WM content in order to accommodate new information. This updating mechanism is central to the mental architecture (Friedman et al., 2008; Schmiedek, Hildebrandt, Lövdén, Wilhelm, & Lindenberger, 2009) and is involved in numerous cognitive tasks. In fact, updating is the executive function that best predicts fluid intelligence (Friedman et al., 2006) in both older adults (Chen & Li, 2007) and children (Belacchi, Carretti, & Cornoldi, 2010). Updating also plays a role in academic achievement, accounting for individual differences in key areas such as mathematics (Passolunghi & Pazzaglia, 2004; Pelegrina, Capodieci, Carretti, & Cornoldi, 2015), reading (Carretti, Cornoldi, De Beni, & Romanò, 2005; Palladino, Cornoldi, De Beni, & Pazzaglia, 2001), and professional translation (Morales, Yudes, Gómez-Ariza, & Bajo, 2015).

WM develops from birth and continuously improves throughout childhood and adolescence (Brocki & Bohlin, 2004; Gathercole, Pickering, Ambridge, & Wearing, 2004; Huizinga, Dolan, & van der Molen, 2006; Luciana, Conklin, Hooper, & Yarger, 2005; Luna, Garver, Urban, Lazar, & Sweeney, 2004). The ability to efficiently update information in WM also undergoes changes across childhood and adolescence (Huizinga et al., 2006; Kwon, Reiss, & Menon, 2002; Lendínez, Pelegrina, & Lechuga, 2015; Schleepen & Jonkman, 2009; Vuontela et al., 2003). This study aimed to investigate age-related changes in this mechanism focusing specifically on its underlying component processes.

Components of updating

During recent years, proposals have been made to decompose the updating process into more basic constituent components (Bledowski, Kaiser, & Rahm, 2010; Ecker, Lewandowsky, Oberauer, & Chee, 2010; Zhang, Verhaeghen, & Cerella, 2012). There is consensus about the involvement of an access or retrieval process and a substitution or replacement component. On the basis of a task analysis, Ecker and colleagues (2010) isolated three specific processes that participate in different tasks: retrieval, transformation, and substitution. They assumed that these processes would be combined serially. Thus, to update an element in WM, it needs to be selectively retrieved, then a transformation may be applied to this representation, and finally the new information is stored, making it available for future operations.

The access or retrieval process consists of accessing information outside the focus of attention in WM. Embedded models of WM (e.g., Cowan, 1995, 1999; Oberauer, 2002) assume that information may be held in different regions of WM depending on its state of activation. The focus of attention constitutes one of the levels proposed by Oberauer's concentric tripartite model (Oberauer, 2002; see also Oberauer, 2009) along with the direct-access region and the activated part of long-term memory. When a WM task is carried out, the relevant information is maintained in the direct-access region until an element is selected for processing in the focus of attention. Thus, any information that is to be updated needs to be retrieved in the focus of attention. This region usually holds only a single item or chunk selected from the active elements maintained in the direct-access region. Garavan (1998) showed that there is a temporal cost when accessing one object in WM in order to perform a cognitive operation. This temporal cost is considered the time needed to retrieve the information in the focus (McElree, 2001). Since this early study, similar results have been reported across a variety of experiments (Kessler & Meiran, 2006; Lendínez et al., 2015; McElree, 2001; Oberauer, 2002, 2003; Verhaeghen & Basak, 2005; Voigt & Hagendorf, 2002).

The retrieval process involves searching for a specific representation among different competing elements maintained in the direct-access region of WM. Other information stored in WM may cause interference and, as a consequence, may lead to incorrect representation selection. The success of an adequate retrieval, therefore, stems from a proper activation process of the target representation and the control of possible interference from other competing representations. As shown by Ecker and colleagues (2010), retrieval is the component that induces more commission errors and determines, to a large extent, the accuracy of the responses.

Transformation is another component of working memory updating (WMU) that involves applying cognitive operations in order to modify a representation maintained in WM. Given that transformation is mediated by operations that may vary in difficulty, it can be assumed that the more complex the operations, the fewer the resources available to other processes such as retrieval (Garavan, 1998;