Cognitive modeling of different processing modes in task switching: toward an explanation of the effect of aging on switching cost

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Introduction

Cognitive aging is associated with a decrease of executive control ability that results in impaired performance in inhibition tasks (Hasher & Zacks, 1988) or task-switching (Mayr, Spieler, & Kliegl, 2001). Regarding task-switching, mixing costs are generally greater for elderly than for young people (Wasylyshyn, Verhaeghen & Sliwinski, 2011). One explanation of this phenomenon is that individuals fail to maintain task representations in a sufficient active state, (Engle & Kane, 2004). However, this hypothesis can't explain the observation of an equivalent switching cost between young and elderly (Wasylyshyn et al., 2011). Braver and West (2008) made an additional assumption of the effect of aging which presumes a declining ability to maintain goals representations. More specifically, this hypothesis supposes a decrease of the efficacy of proactive control mechanisms (controlled orientation or preparation of activities), resulting in a greater tendency to initiate reactive control processes (on-line processing).

The aim of this study is to test with computational modeling to what extent the Braver and West (2008) hypothesis can account for age and individual differences in task-switching tasks.

Method

The task used in this study runs as follows: cue presentation ("+" or "-") for 1 sec. ; 750 ms later target presentation ("black" or "white" disk); manual response (pressing one of two buttons on a case-response) and disappearance of the target for 1 sec. ; Onset of the next cue. The experimental condition depends on the cue appeared. In condition A, called "congruent" (cue "+"), the participant must press the button which matches the target color (ie "white" to "white" "black" to "black"). In condition B, called "incongruent" (cue "-"), he must press the opposite color (ie "white" for "black" "black" to "white"). The experience includes a first familiarization phase (homogeneous block of 17 trials A; homogeneous block of 17 trials B; mixed block of 17 trials ABAB...) followed by the experimental phase (mixed block of 209 trials ABAB...).

Cognitive model

The cognitive functioning underlying task resolution is modeled using the ACT-R architecture (Anderson, 2007). First, the model incorporates visual, memory and decision processes (Altmann & Gray, 2008), as well as more specific processes of interference (Oberauer, 2002) and top-down cognitive control processes (Meiran, Kessler & Adi-Japha, 2008). Secondly, it incorporates two different modes of task processing, based on two main theories of task-switching discussed in the literature. The first one, called "on-line", is based on the compound-cue theory (Logan & Bundesen, 2003) which supposes that the combination of the stimulus and a simple representation of the cue is sufficient to select effectively the correct answer. The second, called "preparatory", is inspired by the task-switching reconfiguration theory (Rogers & Monsell, 1995) which assumes that individuals use more complex task representations to guide the selection of the response (Dreisbach & Haider, 2009). In this model, the use of each processing mode depends on the type of cue representation (simple or complex) extracts from declarative buffer.

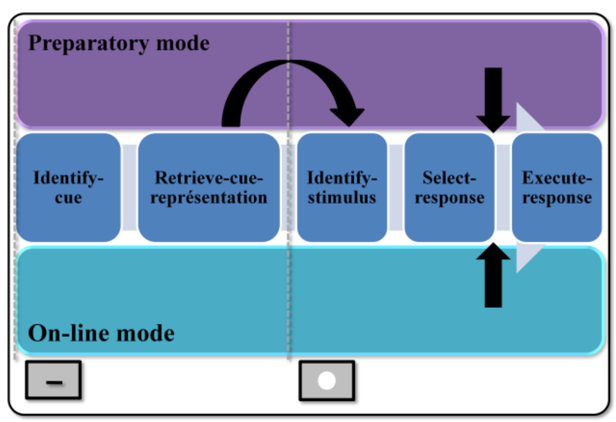

Figure 1: Main steps, control processes and task processing modes implemented in the cognitive model. (Black arrows indicate control processes)

Aging hypotheses testing

Several parameters can be manipulated to test cognitive aging hypotheses: 1) the latency factor *lf* which influences the time to extract knowledge, 2) the goal activation parameter *ga* that modifies the amount of activation spread to knowledge in declarative memory, 3) the noise parameter *ans* which introduces noise in the activation level of knowledge, or 4) the probability of execution of the two processing modes implemented. Different hypotheses are tested according to parameter(s) manipulated: slower processing speed (1), the reduced capacity of working memory (2), increased noise cognitive (3) or the initiation of control processes preferred reagent (4).

Results

The results presented in this work are discussed under the Braver and West (2008) assumption. The parameters of the model manipulated are the activation levels of cue representations that determine the probability of initiation of each processing mode implemented. It consists of a large decrease (resp. increase) of the probability of initiation of the preparatory mode, which increases (resp. decrease) the switching cost simulated (latency difference between incrongruent and congruent trials, in mixed condition). This effect is further accentuated if the parameter value *lf* is high (ie slowing). The analysis of convergence between simulated and empirical data obtained from a sample of 13 women and 10 men aged 20 to 83 years (M = 46.9 years, SD = 20.2; MMS> 26 for people over 65 years old) indicates that the Braver and West (2008) hypothesis for a decrease with aging of the probability of initiation of proactive control processes -associated with slowing- can account for the increase of sensitivity to constraint changes observed empirically in older individuals.

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