Journal of Memory and Language 95 (2017) 138–145

Contents lists available at ScienceDirect

Journal of Memory and Language

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

Is language control just a form of executive control? Evidence for overlapping processes in language switching and task switching ☆,☆☆

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ARTICLE INFO

Article history:
Received 18 August 2016
revision received 10 March 2017
Available online 22 March 2017

Keywords:
Language switching
Task switching
Language control
Executive control

ABSTRACT

Whereas some models claim that language control is part of more general executive control, others have proposed that there is little overlap between these two processes. To shed light on this controversy, we compared switching effects observed in closely matched language switching and task switching tasks. The correlation analyses showed a positive moderate to strong correlation between the two switching variants in all three experiments. The results further showed that language- and task-switch costs differed although the cues, stimuli, response modality, and the number of response alternatives were identical across the two switching variants (Experiments 1), and when additionally the same linguistic tasks (picture naming/category naming) were used in both switching variants (Experiment 3), at least for the error rates. However, similar language- and task-switch costs were obtained when the same non-linguistic tasks (parity/magnitude) were used (Experiment 2). These results point towards overlapping mechanisms for language control and executive control.

Introduction

It has long been debated whether executive functions that operate during language processing are domain general or language specific. This is also the case for language control (e.g., De Baene, Duyck, Brass, & Carreiras, 2015; de Bruin, Roelofs, Dijkstra, & FitzPatrick, 2014; Dijkstra & Van Heuven, 2002; Green, 1998; Weissberger, Gollan, Bondi, Clark, & Wierenga, 2015), which is the process that ensures that bilingual language production occurs in the target language. This claim has mainly been investigated by comparing the effects observed in language switching (LS; for a review, see Declerck & Philipp, 2015), used to measure language control, and task switching (TS; for reviews see Kiesel et al., 2010; Vandierendonck, Liefooghe, & Verbruggen, 2010), used to measure cognitive ("executive") control. In the present study, we set out to directly compare LS and TS, using a similar setup for both switching variants, to further investigate the relationship between language control and executive control.

According to Meuter and Allport (1999), language control and executive control rely on the same mechanism (see also Dijkstra & Van Heuven, 2002). More specifically, they assume that competing languages or tasks are both controlled by inhibitory processes that persist into the following response. In Thomas and Allport (2000), this process was further elaborated by indicating that language control, just like executive control, occurs via task schemas. These task schemas are mental devices that are implemented to achieve task-specific goals, such as speaking a certain language or performing a certain task, and are located outside of language processing. Hence, Allport and colleagues assume that language control is part of the more general executive control process.

Other authors have also proposed that language control is part of executive control (e.g., Green, 1998; Schwieter & Sunderman, 2008). Yet, these accounts additionally introduced a language-specific aspect of language control that is not part of executive control. The inhibitory control model (ICM; Green, 1998), for example, assumes that language control first occurs between task schemas. Similar to the previous account, this is where the ICM assumes language control and executive control to overlap. The language-specific control process occurs between translation-equivalent

☆ The authors would like to thank the reviewers for their helpful comments, and Janika Thielecke, Pia Bütow, and Agnès Guerre-Genton for their help in conducting the experiments.
☆☆ This project has received funding from the European Union's Horizon 2020 research and innovation program under the Marie Sklodowska-Curie grant agreement No. 706128. This research was also supported by funding from the French National Research Council (ANR-11-LABX-0036, ANR-11-IDEX-0001-02).
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http://dx.doi.org/10.1016/j.jml.2017.03.005
0749-596X/

lemmas (mental representations of words), which are influenced by these task schemas.

There are also language control models that do not assume language control to be operated by task schemas (e.g., Declerck, Koch, & Philipp, 2015; Grainger, Midgley, & Holcomb, 2010). Declerck et al. (2015), for example, proposed a similar structure as the ICM. The major difference is that there is no control process between task schemas, and thus that language control is not part of executive control. In turn, language control occurs between language nodes, which represent language membership, and translation-equivalent lemmas. Hence, these models assume language control and executive control to differ from each other.

The similarity between language control and executive control has, for the most part, been investigated by looking at the overlap between LS and TS. During a typical LS experiment, bilingual participants name a digit or picture in one of two languages, depending on a cue (e.g., blue or green square) that is presented at the same time or prior to the digit/picture. During a typical TS experiment, a cue is also presented, so that participants know which task (e.g., magnitude or parity task for number classification) they have to perform. Since multiple languages are used in LS and multiple tasks are used in TS, a trial is always preceded by either the same language/task or the other language/task. Performance is typically worse when a trial is preceded by a different language/task (switch trial) than when the same language/task is used (repetition trial). This difference in performance is called "switch costs" which is used as a measure for language control when obtained in a LS study (e.g., Declerck & Philipp, 2015), and it is used as a measure for executive control when obtained in a TS study (e.g., Kiesel et al., 2010).

In line with most models, a recent fMRI study found evidence for an overlap between language control and executive control by examining the neural structures involved in LS and TS (De Baene et al., 2015). In this study, Spanish-Basque-English highly proficient trilinguals had to perform a picture naming task with three languages in mixed language blocks (i.e., LS) and a color, gender, or direction decision task in mixed task blocks (i.e., TS). The results of De Baene et al. (2015) showed a large overlap in brain activation for switch costs with these two switching variants (see Weissberger et al., 2015, for similar results).

More evidence for an overlap between language control and executive control was obtained by Prior and Gollan (2011), who investigated language-switch costs (digit naming) and task-switch costs (color/shape decision). Smaller language- and task-switch costs were observed with bilinguals (Spanish-English) who switched often between languages in daily life than with bilinguals who switched less often between languages (Mandarin-English). This was taken as evidence that language control and executive control rely on similar processes, since intensive training in language switching influences control processes during LS, and more importantly also during TS.

Yet, not all studies have found evidence for an overlap between language control and executive control. Prior and Gollan (2013) found that short-term practice of LS (digit naming) or TS (color/shape decision) had no effect on task-switch costs or language-switch costs, respectively. Further lack of evidence for an overlap was found with studies that examined the effect of aging on language-switch costs and task-switch costs. Calabria, Branzi, Marne, Hernandez, and Costa (2015) examined Catalan-Spanish bilinguals, and found an age-related effect on switch costs in TS (color/shape decision), but not on switch costs in LS (picture naming; see Weissberger, Wierenga, Bondi, & Gollan, 2012, for similar results). Moreover, these and other studies that investigated LS and TS observed little evidence for an overlap using correlation analyses on language- and task-switch costs (Branzi, Calabria, Boscarino, & Costa, 2016; Calabria, Hernández, Branzi, & Costa, 2011; Calabria et al., 2015; Klecha, 2013; Prior & Gollan, 2013).[1]

Taken together, there appear to be contradictory findings with respect to the overlap between language- and task-switch costs, and thus language control and executive control. However, it should be noted that very different methodologies were implemented in prior studies with respect to LS and TS. Gollan, Kleinman, and Wierenga (2014), for example, argued that prior studies typically implemented different response modalities for LS (vocal) and TS (manual), which leads to an additional difference between LS and TS. Interestingly, Gollan et al. (2014) implemented identical response modalities (vocal) to respond to the naming task for LS and to the read/add or size/parity task for TS, and observed positive weak to moderate correlations (Evans, 1996) between switch cost of the dominant language and task-switch costs with the voluntary switching paradigm. However, when directly comparing the size of switch costs in both LS and TS, they observed that language-switch costs were still significantly different from task-switch costs.

This difference could be due to other methodological differences that were not controlled for. Declerck and Philipp (2015) indicated three other methodological differences across LS and TS in studies that investigated both switching variants, all of which are applicable to the study of Gollan et al. (2014), such as different stimulus types (e.g., digits/pictures vs. colors/shapes), and a different number of response alternatives, with more response alternatives in LS than TS. Another difference includes the implementation of different tasks: LS typically involves digit naming or picture naming, whereas TS generally involves categorization tasks. Hence, it could be that a difference in switch costs was obtained across LS and TS in Gollan et al. (2014), and other prior studies, due to substantial methodological differences.

In the current study we compared switch costs in LS and TS with similar methodologies over three experiments (see Table 1 for an overview of the similarities and differences between LS and TS across the three experiments). This allowed us to investigate the overlap between language control and executive control, without any major methodological differences between LS and TS. To investigate this, we looked at a direct comparison of the size of switch costs in LS and TS, and correlations of switch costs between LS and TS.

Experiment 1

To investigate the overlap between LS and TS, and thus between language control and executive control, we used LS and TS blocks with similar methodology in Experiment 1. To keep the LS and TS blocks as similar as possible, the same cues and stimuli were used in LS and TS. Furthermore, an identical number of response alternatives were used, and the same response modality (i.e., vocal responses) was used in LS and TS.

Method

Participants

24 native German speakers who spoke English as their second language took part in the experiment (21 female, mean age = 20.5). Prior to the experiment they were asked to fill in a questionnaire about their English age-of-acquisition, how many years of formal English education they had, and how high they

[1] It should be noted that a positive correlation has been observed between language- and task-mixing costs, which is the performance deterioration in mixed language blocks relative to single language blocks, for bilinguals, but not for monolinguals (Prior & Gollan, 2013).