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Disparate bilingual experiences modulate task-switching advantages: A diffusion-model analysis of the effects of interactional context on switch costs

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ABSTRACT

Drawing on the adaptive control hypothesis (Green & Abutalebi, 2013), we investigated whether bilinguals' disparate interactional contexts modulate task-switching performance. Seventy-five bilinguals within the single-language context (SLC) and 58 bilinguals within the dual-language context (DLC) were compared in a typical task-switching paradigm. Given that DLC bilinguals switch between languages within the same context, while SLC bilinguals speak only one language in one environment and therefore rarely switch languages, we hypothesized that the two groups' stark difference in their interactional contexts of conversational exchanges would lead to differences in switch costs. As predicted, DLC bilinguals showed smaller switch costs than SLC bilinguals. Our diffusion-model analyses suggest that DLC bilinguals' benefits in switch costs are more likely driven by task-set reconfiguration than by proactive interference. Our findings underscore the modulating role of the interactional context of conversational exchanges in task switching.

1. Introduction

Bilinguals are unique in their practice of flexible language-switching between two or more languages. Given that the neurocognitive mechanisms that underlie bilinguals' language switching and task switching are partially shared (e.g., Abutalebi & Green, 2007; Weissberger, Gollan, Bondi, Clark, & Wierenga, 2015), the question arises as to whether bilinguals' qualitatively different language-switching practices affect their task-switching ability to switch back and forth between multiple tasks, operations, and mental sets (Monsell, 2003).

Bilinguals' task-switching abilities have been studied by using a typical task-switching paradigm that considers both switch costs and mixing costs, which have been found to implicate different control mechanisms (Braver, Reynolds, & Donaldson, 2003). Specifically, switch costs—i.e., the actual cost of switching between different task sets—arise from local control mechanisms that involve transient task-set reconfiguration (Rogers & Monsell, 1995) and proactive interference from previous task sets (Wylie & Allport, 2000). Mixing costs—i.e., the cost of monitoring and coordinating multiple streams of incoming information—entail activation of global and sustained control mechanisms (Rubin & Meiran, 2005). Because of the conceptual overlap between bilinguals' language- and task switching, it has been suggested that bilingualism attenuates task-switching costs. In recent years, however, the question of whether bilingualism confers benefits on task switching has been debated, and findings have been inconsistent. For instance, some studies have found bilingual advantages in switch costs (Prior & MacWhinney, 2010), while others report bilingual advantages in mixing costs (Gold, Kim, Johnson, Kryscio, & Smith, 2013; Wiseheart, Viswanathan, & Bialystok, 2014). Moreover, recent attempts to replicate these effects found neither switch- nor mixing-cost advantages, even among bilinguals who frequently switch languages (Hernández, Martin, Barcelo, & Costa, 2013; Paap & Greenberg, 2013; Paap & Sawi, 2014). These inconsistencies highlight the need for a more rigorous, theory-driven approach.

The adaptive control hypothesis (Green & Abutalebi, 2013) postulates that bilinguals' interactional contexts of conversational exchanges implicate different demands on bilinguals' language control and adaptively alter their cognitive-control abilities. Specifically, (a) the *dual-language* context (DLC)—in which bilinguals use two languages within the same context (e.g., both L1 and L2 at home and work)—requires a more taxing level of

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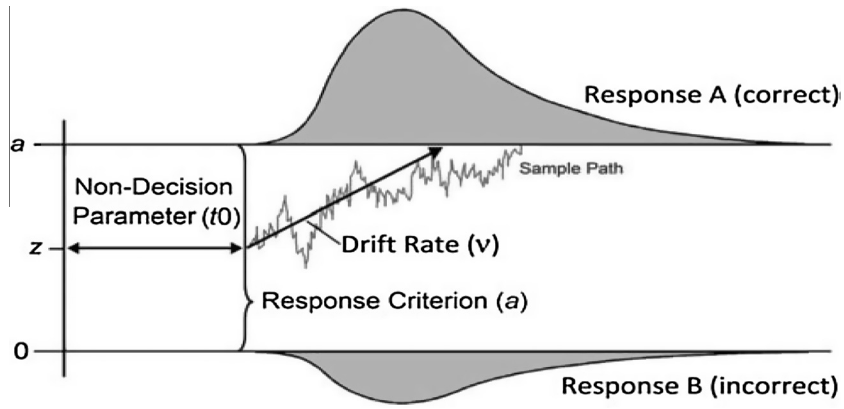

Fig. 1. Diffusion process underlying the diffusion model. The model assumes that decisions are based on the accumulation of information over time until a response boundary is reached and a motor response elicited (Ratcliff, 1978). By using both response latency and accuracy, the diffusion model decomposes the decision process into several meaningful parameters. Specifically, drift rate (v) quantifies the speed of information uptake and stimulus difficulty, which map onto participants' processing ability; larger values represent fast and accurate responses. The drift rate is the mean slope of the counter, and differences in drift rate between switch trials and non-switch trials are thought to reflect proactive interference in task switching. Boundary separation (a) quantifies the speed–accuracy trade-off, with a larger value indicating a conservative decision characterized by slow reaction time and high accuracy. Starting point (zr) quantifies a priori bias in decision thresholds, ranging from 0 to 1, with a value of 0.5 indicating the absence of a priori decisional bias. The decision process begins at the starting point, where information is accumulated until a response boundary is reached. Lastly, non-decision time (t_0) quantifies the duration of all non-decisional processes, such as encoding and response execution. Non-decision processes occur before and after the actual decision phase and are thought to reflect the reconfiguration processes in task switching (see Voss et al., 2013, for a practical introduction to diffusion models; see Schmitz & Voss, 2012, for their use in a task-switching paradigm). Adapted from Schmitz and Voss (2012, p. 226).

language control, and therefore should better facilitate task-switching performance than either (b) the *single-language* context (SLC)—in which bilinguals speak only one language in one environment and therefore rarely switch languages (e.g., L1 at home and L2 at work)—or (c) the *dense code-switching* context (i.e., intrasentential code-switching)—in which bilinguals routinely mix linguistic elements (e.g., words) of two languages within a single utterance.

To test those theoretical predictions, we operationalized bilinguals' interactional contexts according to two primary perspectives that closely reflect the complexity of bilingualism in Singapore. First, we assume that DLC bilingualism is the bipolar opposite of SLC bilingualism, both of which fall along a bipolar continuum. Namely, each point on the continuum is influenced by the extent of both DLC and SLC bilingualism: If one's DLC bilingualism is high, his or her SLC bilingualism is likely low. Second, because of the prevalence of English-based creole in Singapore,[1] both DLC and SLC bilinguals likely perform intrasentential code-switching, which signifies the dense code-switching context; in particular, DLC more likely implicates the dense code-switching context. Therefore, DLC or SLC are not clearly separable from the dense code-switching context, and dividing bilinguals into three groups according to different interactional contexts is not straightforward.

Because of these constraints, we examined the impact of bilinguals' interactional contexts as follows. First, we examined whether DLC and SLC differ in switch costs. Consistent with the adaptive control hypothesis, we expected that DLC bilinguals would have smaller switch costs than SLC bilinguals, because DLC bilinguals' complex language-set reconfiguration should be conducive to transient task-set reconfiguration, which is regarded as the primary mechanism of switch costs. Second, given that both DLC and SLC are related to the dense code-switching context, we used regression analysis to examine its relative importance to DLC and SLC in predicting switch costs, while controlling for important individual factors.

Our other important goal was to elucidate the cognitive processing that underlies switch costs in particular. Although the multiple-component model of task switching proposes that switch costs arise from task-set reconfiguration and proactive interference (Mayr & Kliegl, 2003; Ruthruff, Remington, & Johnston, 2001), the literature on bilingualism has not clearly identified the specific cognitive components linked to bilingual advantages in task switching. Therefore, we employed the stochastic diffusion model (Ratcliff, 1978) to decompose switch costs into specific cognitive components. Using this model in the task-switching paradigm, recent studies have reported that differences in the non-decision time parameter (t_0) between switch trials and non-switch trials are related to the early phase of a task switch, which involves task-reconfiguration processes, whereas differences in drift rate (v) between switch trials and non-switch trials are associated with the later stage of task switching, which entails proactive interference (Mansfield, Karayanidis, Jamadar, Heathcote, & Forstmann, 2011; Schmitz & Voss, 2012, 2014). This model, therefore, allows us to examine whether the locus of bilingual advantages in switch costs is pertinent to either task-set reconfiguration or proactive interference (see Fig. 1).

2. Method

2.1. Participants

One hundred and thirty-three bilinguals (female = 89) from a university in Singapore participated for extra course credit or S $13.[2] In addition to English, bilingual participants spoke a variety of languages, which includes Chinese ($n = 110$), Malay ($n = 8$), Indonesian ($n = 1$), Hindi ($n = 3$), Tamil ($n = 3$), Malayalam ($n = 1$), Vietnamese ($n = 5$), Korean ($n = 2$). Using a 5-point Likert scale

[1] Singapore bilinguals speak an English-based creole language, "Singlish," which has been substantially influenced by loan words from Mandarin dialects, Malay, and Tamil (Wong, 2004). Therefore, Singlish involves frequent practice of intrasentential code-switching in everyday conversation. For example, bilinguals in Singapore may sometimes insert a Malay word, *makan*, into a single English utterance—e.g., "Let's find some place to *makan* [eat]."

[2] Five participants were excluded from the analysis for the following reasons. Two had extremely high mixing costs (5.6 and 4.8 *SD* from the overall mean of mixing costs); two violated the model fit when running the diffusion-model analyses ($p = .005$ and $.013$); and one had substantial negative switch costs (−190 ms) in non-decision parameters (t_0).