UNIVERSITY OF CAMBRIDGE

Bilingual Cross-language Activation and Lexical Control in Production

Songqi LI

Psycholinguistics Laboratory, Faculty of Modern and Medieval Languages and Linguistics, University of Cambridge

Introduction

Background

Bilingual Language Co-activation in Lexical Access:

-Language Non-selectivity in Speech Production:

Research shows both languages are activated during bilingual speech, but the specifics of this activation need further exploration.

-Effects of Language Experience and Cognitive Adaptation:

The impact of language experience on lexical access is acknowledged, yet the detailed dynamics between experience and cognitive control remain to be dissected.

Language Control and Selection Mechanism in Lexical Production:

-Bilingual Language-specific selection versus Language-non-specific selection models:

Debate continues over language-specific versus non-specific control mechanisms, with a unified explanatory model still out of reach.

-The Asymmetry of Switch Costs and the Reversed Language Dominance Effect:

Asymmetric switch costs and reversed dominance are observed, but their causes are not yet fully understood.

-Cross-language Intrusion Errors and Reversed language dominance effects:

Cross-language errors point to complex bilingual processing, necessitating more research on their predictive factors and relationship to language dominance.

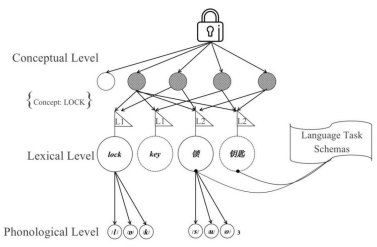

Figure 1. An illustration of the Inhibitory Control Model in English-Mandarin bilinguals (adapted from Finkbeiner et al., 2006; Schwieter, 2013).

The present study

Gaining a deeper understanding of **cross-language control and selection** in bilingual speech production by examining t**he access and planning of bilingual lexical system**s. To achieve this goal, the study will adopt both the trial-by-trial and blocked switching tasks in the language switching paradigm to investigate the consequences of Language switching and mixing, such as reversed language dominance effects, the asymmetry of switch costs, and cross-language intrusion errors.

(1) Is there parallel activation of languages in bilingual lexicon production competing for selection?

(2) What is the underlying mechanism of bilingual language control in production?

(3) How do various aspects of language experience and individual cognitive ability influence language control?

Experiment 1

Experiment 1 examined bilingual language control and its interaction with relevant language experience in lexical production. These tasks not only provide observations of lexical production to test the hypotheses of competing models, but provide more objective measurements of proficiency and dominance in both languages during lexical retrieval.

Multilingual Naming Test (MINT) Sprint : Since self-ratings are subjective and questionnaires like the LEAP-Q is validated to provide bilingual sub-types, the Sprint version of MINT offers a more objective proficiency measurement of language dominance. The language dominance score was calculated on a continuous scale with the Edinburgh handedness method.

In terms of blocked switching tasks, this study adapts **Letter Verbal fluency tasks and Semantic Verbal Fluency tasks** for bilingual lexicon production, and further developed a free-switching condition to investigate bilingual lexicon retrieval in a more natural way.

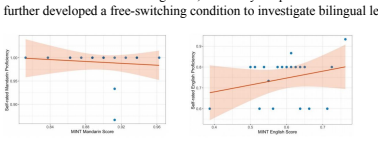

Figure 2. MINT scores its correlation with the composite scores of self-rated proficiency.

Note: numbers were calculated in percentage with MINT(0-80), and self-rated proficiency (0-5).

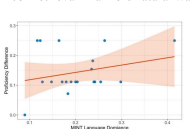

Figure 3. MINT Dominance and its correlation with the composite scores of self-rated proficiency in Experiment 1.

Note: Dominance refers to what extent Mandarin is more dominant than English.

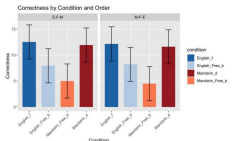

Figure 4. The total number of correct responses for the letter VTF

Note: conditions in English and Mandarin were in two testing orders, English-Free-Mandarin (E-F-M) vs Mandarin-Free-English(M-F-E)

Main findings suggest that bilingual language production involves the parallel activation of both languages, leading to a reduced or reversed language dominance effect. In verbal fluency tasks (VFT), participants showed a tendency to produce more responses in their non-dominant language (English) compared to their dominant language (Mandarin). This was evident through observed **cross-language intrusion errors** and **an absence of a dominant language advantage** in single-language tasks. The results align with the inhibitory control model, indicating that bilingual speakers may suppress their dominant language to facilitate language production across two languages.

Additionally, the study found that **language experience** factors such as the frequency of language mixing and exposure to code-switching significantly influence bilingual language control. While these factors don't necessarily correlate with language proficiency, they affect cognitive control processes like shifting and inhibition. These insights underscore the complex nature of bilingual language processing and point towards further research required to understand the mechanisms underlying bilingual language selection and control.

Interestingly, although all the participants made sure they understand the instruction, some of them unconsciously produced and even repeated the non-target lexicon representation of the item several times to facilitate themselves in retrieving the target language, or spontaneously switched to Mandarin counterpart names indicating they do not know this in English in the fast naming. Furthermore, participants report that they have distractions from the translation equivalent in the non-target language particularly for those uncommon words, this cross-linguistic intrusion can be viewed as a **potential reflection of the co-activation** of both languages. Since these interpretations happen naturally during their lexical retrieval process when they try to access the concepts in their mental lexicon, it can be interpreted as a naturally activated translation of the non-target language.

Evidence from participants' natural simultaneous translations between the target and the non-target language and those language intrusion errors mentioned before are supportive of the non-specific competitive process, where two lexical systems are simultaneously activated and both of the language systems are in competition. These processes were more obvious in tasks and semantics VFT switching conditions. Speech planning is more of a top- down processing, where lexical production is fundamentally conceptually-driven. The reason why there were no salient activations of translation equivalents in the non-target language is that the letter VFT is partially different, as the task requires participants to focus on the initial letter which activates the **phonological word forms** and focuses less on the **conceptual meaning**.

Experiment 2

Experiment 2 was conducted in a larger Mandarin-English bilingual group with more **diverse language experience**.

The Mandarin-dominant group: students from mainland China, studying or have been studying abroad in English-speaking countries.

The Mandarin heritage speaker group: near-native English proficiency, who have grown up in English-speaking countries while using Mandarin with their family and receive most of their educational instruction in English.

This study endeavored to provide empirical evidence of **intrusion errors** resulting from inaccurate language selection by employing a novel paradigm that drew inspiration from real-life scenarios and further exploring the research question by including the cognitive ability factors. Similar to Experiment 1, it included the language background questionnaire, the Sprint version of MINT, and a Semantic Verbal Fluency Task, but additionally a **cognitive control task and an auditory distracting task**. With such measurement, this research can better probe into the mechanisms of bilingual language control with reaction time **reflecting asymmetry switch costs**, further information on the interaction between cognitive ability, language experience and lexical control mechanisms.

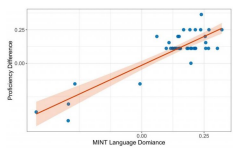

Figure 5. MINT Dominance and its correlation with the composite scores of self-rated proficiency in Experiment 2.

Note: Dominance refers to what extent Mandarin is more dominant than English.

The overall difference between including the English-dominant group or not, seems to have a great influence on the correlation between the MINT test and the self-report proficiency. Combining the observations of Experiment 1, this can be explained by the self_s0002_rated language background being less reliable when it comes to **bilingual sub-types**. In particular, the 5-point Likert scale used in the study may introduce **ceiling effects**, limiting its ability to capture higher levels of language proficiency and variability among native or highly advanced language speakers. Relying solely on self-assessment may not accurately capture fine-grained differences and provide a comprehensive representation of the actual language proficiency.

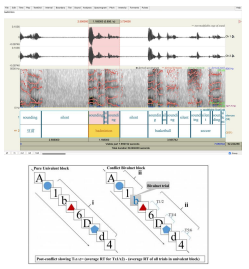

Figure 7. An illustration of the bivalency paradigm to examine post-conflict slowing effects.

Note: To examine the trajectory of the post-conflict slowing effect, the performance on a series of trials following a bivalent stimulus was analyzed by subtracting the baseline performance of univalent trials in blocks consisting purely of univalent stimuli. T1/2 = first two trials following a bivalent stimulus.

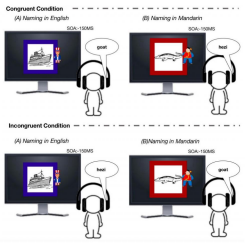

Figure 9. An illustration of the Auditory Distracting Task.

Note: The target language was cued by the interlocutor's nationality with different colour frames. Auditory distractor was playing in -150ms stimulus onset asynchrony (SOA) either congruently with the target language or incongruently. ("hezi" is the Mandarin translation of "box")

Bivalency Cognitive Control Task

Figure 8 displays the post-conflict RT effects of all the bilingual participants. A one-way ANOVA suggested a significant effect of trial position in RT [F(4, 195) = 4.959, p < .001]. As shown in Figure 8, this pattern reveals that participants had already recovered to their baseline RT from the post-conflict slowing effect around trial 3 to 4. The observations of negative conflict slowing can be explained by the fact that participants could be gradually more and more familiarized with the task that they even outperformed their baseline in block 1 when they recover from the post-conflict incongruence. The lack of a significant effect of trial position in Correctness [F(4, 195) = 0.75, p =0.56] can be explained by the fact that all of the participants are young adults with high accuracy in general, thus the post-conflict effect is more evident in the RTs.

To investigate how participants' language experience and habitual language-switching patterns affect their performance in the bivalency cognitive control task, relevant variables such as daily speaking with language mixing, language exposure and code-switching attitude were included in the models. The overall results revealed that there were significant post-conflict effects in the conflict blocks (T0), but bilinguals in the current study were able to overcome the post-conflict slowing down by redirecting their attention as soon as they were in Trial 3. This aligns with prior research indicating that bilingual individuals possess the ability to quickly shift their attention away from misleading information after experiencing conflict.

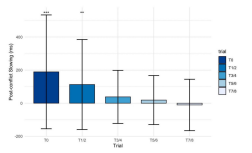

Figure 8. Post-conflict slowing effects for all the participants.

Note: Asterisks indicate where the post-conflict slowing effect is significantly different from 0. T0s: Mean of RTs in Bivalent conflict blocks - Mean of RTs Univalent Trial pure blocks

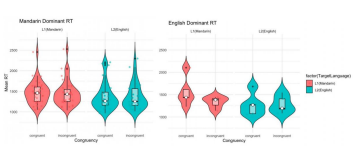

Figure 10. An illustration of the distribution of individual data for mean response time (in milliseconds) in violin plots.

Auditory Distracting Task

Speakers made different types of speech errors on 5% of all trials, including 3.1% language intrusion errors and 0.2% plural errors. All the plural errors were made by Mandarin-dominant participants. There were significantly more errors in the Dominant language trials than in the Non-dominant language trials [$t(73.31)=2.21$, $p=.03$]. Figure 10 shows the violin plots for RTs and language intrusion error rates, and Table 11 present the overall data in both the Mandarin dominant group and English dominant group.

Generalized linear mixed models (GLMEMs) were adopted for RT and error analyses, factors including Language (L1 vs. L2) and Language dominance (Mandarin-dominant vs English-dominant), and congruency (incongruent vs congruent) were sum-coded as fixed effects and participant as the random effect. The results of RT revealed a significant effect of target language, and the post hoc t-test revealed that there was a marginal significance between the target and non-target language and the model for RT was also significant.

To summarize, results in the auditory distracting task suggested that there were reverse- dominance phenomena in both congruent and incongruent conditions. Despite the obvious differences in the orthographic and phonetic system between English and Mandarin, the fact that there were language intrusion errors even in the congruent condition. The reversed language dominance pattern is more in line with the view that languages are activated in parallel and compete for selection. By incorporating other significant variables into the regression models, the findings converge to support the conclusion that the variability of language experience and cognitive ability plays a crucial role in modulating bilinguals' language control.

General Discussion

Summary of Key Results

1. Co-Activation and Competition in Lexical Production:

- Both target and non-target languages are activated during bilingual lexical production, causing competition at the conceptual and lexical selection levels
- Cross-language interference in bilinguals necessitates mechanisms for language control to manage this co-activation.

2. Inhibitory Mechanisms of Language Selection and Control:

- The control of bilingual lexical production may rely on non-language-specific inhibitory control mechanisms.
- Reverse dominance patterns challenge language control theories that overlook inhibitory processes.
- Inhibitory control contributes to managing lexical competition by suppressing non-target language activation.

3. Bilingual Language Experience and Cognitive Adaptation:

- Language experience and cognitive abilities interact and influence bilingual language control.
- Word activation reflects experience with, and familiarity of, languages.
- The onset age of second language learning and habitual language mixing impact cognitive control abilities, specifically inhibition and selective attention.
- Neuroplastic changes due to bilingualism optimize attentional processing and adapt cognitive control to accommodate language competition.

Prospects for Further Inquiry

1. Mechanisms of Language Selection and Control:

- Further research could delve into the specific mechanisms of inhibition and how they interact with language-specific processes.
- The complexity of reverse dominance patterns in bilingual language processing requires more investigation to understand under which conditions they emerge.

2. Language Experience:

- The influence of bilingual language experience, such as age of acquisition and code-switching frequency, on cognitive control abilities is ripe for exploration.
- Future studies could better isolate the effects of language experience variables on language control.

3. Cognitive Adaptations:

- How bilinguals' brains adapt structurally and functionally to the demands of managing two languages is an ongoing area of research.
- Further research could explore how typological similarity between languages influences cognitive control and language processing efficiency.

4. Neuroplasticity:

- Investigations into neuroplastic changes induced by bilingualism could provide insights into the potential for bilingual experience to enhance cognitive abilities beyond language processing.

5. Assessment Methods:

- The methodology for determining language dominance, such as through the MINT task, is debated, especially in accounting for conceptual knowledge and bilingual experience.
- Refinement of assessment tools like the MINT task could help in accurately determining bilingual language proficiency and dominance.
- More nuanced assessments are needed to differentiate between language proficiency and other cognitive factors like conceptual knowledge and selective attention.

E-mail: sl2097@ox.ac.uk