cogent
psychology

CrossMark

COGNITIVE SCIENCE & NEUROSCIENCE | RESEARCH ARTICLE

Exploring the lexical competition and repetition priming effects in L2 verb generation

Lin Fan[1]*, Zhen Wang[2], Na Hong[3] and Zhenqian Liu[4]*

*Corresponding authors: Lin Fan, Ph. D. National Research Centre for Foreign Language Education, Beijing Foreign Studies University, No. 2, North Xisanhuan Road, Beijing, 100089, Beijing, P. R. China E-mail: fanlinqd@163.com; Zhenqian Liu School of Foreign Languages and Literature, Shandong University, No. 5, Hongjialou, Jinan 250100, Shandong Province, China E-mail: Zhenqianliu@sdu.edu.cn

Abstract: Word-generation tasks have been frequently used in behavioral and neuroimaging research to explore the mechanisms of semantic retrieval and competition during language production. In the current study, we set out to explore the lexical competition effects in a verb-generation task among Chinese English as a Foreign Language (EFL) learners with the repetition priming paradigm, in which items had either one dominant response (low competition, LC) or no such dominant response (high competition, HC). Effects of lexical selection demands were observed in English verb generation task, indicating there were lexical competition effects. In addition, the mean response time (RT) of studied HC and LC stimuli was significantly shorter compared to that of non-studied ones, suggesting there were repetition priming effects. Taken together, the current study provides evidence supporting the role of lexical competition and repetition priming effects during second language (L2) verb generation.

ABOUT THE AUTHORS

Lin Fan, PhD, is a professor at Beijing Foreign Studies University, P. R. China. Her main fields of interest comprise the cognitive process underlying code-switching, bilingual word generation and inferential processing during discourse reading. Currently, she mainly investigates the neural correlates of emotional words with Stroop paradigm.

Zhen Wang is a PhD candidate in the Research Institute of Foreign Languages at Beijing Foreign Studies University. His main interest is lexical inferencing and bilingual word generation.

Na Hong is a postgraduate in the Faculty of Foreign Languages at Ningbo University, P. R. China. Her main research interest is the processing mechanism of language production.

Zhenqian Liu, PhD, is a professor at the School of Foreign Languages & Literature, Shandong University, P. R. China. He earned his PhD in psychology from East China Normal University, China. His research interest includes psycholinguistics, cognitive linguistics and applied linguistics.

Lin Fan

Zhenqian Liu

PUBLIC INTEREST STATEMENT

As is known to all, economic globalization provides an increasing number of opportunities for people worldwide to strengthen communication and cooperation in English which has become one of the most frequently used languages in the world. In many countries, people need to learn and speak English as a second language. Therefore, it is of significance to carry out research on the mechanisms of English word production. This study examines the lexical competition and repetition priming effects in English word production among Chinese-English bilinguals, based on the data gathered via a verb generation experiment. It was found that the participants responded faster to low competition words than high competition words, and that the reaction times of studied words were shorter relative to those of non-studied words. Clearly, the degree of competition and repetition has significant effects on language production.

cogent oa

cogent ••psychology

1. Introduction

The nature and mechanisms underlying lexical selection is a hotly debated topic in the language production literature (Janssen & Caramazza, 2011). Many models have postulated that the retrieval of lexical entries from the mental lexicon is a competitive process involving the selection of a target word from a set of competing words activated simultaneously in language production (e.g., Dell, 1986; Levelt, Roelofs, & Meyer, 1999; Starreveld & La Heij, 1996). This selection process may be even more complicated and challenging for L2 learners who are faced with the task of selecting the right word in the non-native language, thus they would have to expend more effort in this process and possibly try to negotiate the potential cross-language competition for the target language word. To examine the mechanisms of semantic retrieval and competition in the brain during L1 word production, researchers frequently employed verb generation task in behavioral and neuroimaging studies (Crescentini, Mondolo, Biasutti, & Shallice, 2008; Crescentini, Shallice, & Macaluso, 2009; Martin & Cheng, 2006; Persson et al., 2004; Petersen, Fox, Posner, Mintun, & Raichle, 1988; Petersen, Fox, Snyder, & Raichle, 1990; Thompson-Schill et al., 1998). In a verb-generation task, noun cue words are used to elicit associated potential verb responses. Participants are required to produce a verb (e.g., "dance") that is associated with a presented noun (e.g., "disco"). According to the competitive view, the critical process involved in the verb generation task is the selection among competing alternative responses (see Crescentini et al., 2009, p. 1140), thus requiring more semantic selection at the executive level (Thompson-Schill et al., 1998). Some noun stimuli (e.g., "bed") which have one clear dominant verb response ("sleep") are considered to involve low levels of response competition. Others (e.g., "door") may have several potential responses (e.g., "open", "close", "lock") and none of which are particularly dominant, thus high levels of competition are assumed to be involved in the process of generating associated verbs to these noun stimuli. The nouns used in the verb-generation task with low selection demands refer to those with fewer associated responses or with a clear dominant response, and the nouns with high selection demands refer to those with several alternative potential responses without any dominant response (see Crescentini et al., 2009). In the current study, we attempt to examine the lexical competition effects by comparing high- and low-selection demand conditions, with matched association strength (i.e., cue words with several potential responses without any clearly dominant one versus those with a clearly dominant response) (c.f. Crescentini et al., 2009; Persson et al., 2004) in the verb generation task.

Substantial research on the role of lexical competition in word generation of L1 speakers of English and other Indo-European languages have been carried out. Employing neuroimaging (e.g., ERP, fMRI, PET) and behavioral (i.e., RT) methods, prior studies have investigated lexical competition effects in the verb generation task (e.g., Lepron, Péran, Cardebat, & Démonet, 2009; Persson et al., 2004; Prull, 2010, 2013; Thompson-Schill et al., 1998). Thompson-Schill et al.'s (1998) test of verb generation performance on patients with focal frontal lesions found that those patients with lesions in the left inferior frontal gyrus (IFG) had difficulty in generating verbs particularly under conditions with high selection demands, suggesting the role of response competition in verb generation. Crescentini et al. (2008) compared the verb generation performance of non-demented patients with Parkinson's disease (NDPD) and normal control participants. Significant difference was observed between the RTs of high selection-strong association (HS-SA) and low selection-strong association (LS-SA) conditions for both groups, indicating lexical competition effects. Using fMRI, Crescentini et al. (2009) further investigated the effects of lexical selection demands within frontal cortex and the basal galia (BG) circuits known to be involved in verb generation processes. Both neuroimaging data (i.e., the mid part of the left IFG was more activated in high lexical competition condition) and behavioral data (i.e., faster responses to low lexical competition condition) indicate that the selection demands play an important role in the verb generation

task. Persson et al. (2004) explored the differences of neural mechanisms underlying selection demands between older and younger adults during verb generation. Age-related changes in multiple regions (e.g., bilateral frontal, left anterior frontal and the dorsal anterior cingulate cortex, dACC) were found to contribute to aspects of lexical selection demands during verb generation (see Persson et al., 2004); response latency data also revealed significant difference between high and low selection conditions for both young and older participants. Lepron et al. (2009) compared Huntington's disease (HD) patients and normal control participants' generation of semantically appropriate verbs in high and low lexical competition conditions. In both groups, RTs were longer and the error rates were higher in the HC condition as compared to the LC condition. More recently, two other behavioral studies on the role of lexical competition provide robust evidence for the lexical competition effects in the verb generation task. Prull (2010, 2013) examined participants' verb generation performance for high- and low-competition nouns in a single-encoding version of the verb generation task. Lexical competition effects were observed; responses to HC noun stimuli were slower than those to LC ones.

Furthermore, researchers have investigated the lexical competition effects during verb genera-tion with the repetition priming paradigm, shedding more light on the cognitive processes under-lying verb generation. In the basic overt verb generation task, the stimulus words are never repeated (Seger, Rabin, Desmond, & Gabrieli, 1999). However, when the cue words are subse-quently repeated, facilitation is observed as reduction in response latency or neural activity to produce a word as a result of the repetition priming effect—a well-documented facilitation effect in performance that results from subsequent repeated exposure to a stimulus (i.e., a primed stimulus) relative to a novel stimulus (Henson, Shallice, & Dolan, 2000; Thompson-Schill & Kan, 2001). The cognitive mechanisms underlying the repetition priming effects can be accounted for in the theory of transfer appropriate processing proposed by Morris, Bransford, and Franks (1977). According to this framework, the mental processing involved during the initial exposure to a stimulus may be transferred to the subsequent exposure to the same stimulus (Kan & Thompson-Schill, 2005), and the magnitude of the repetition priming effect can be considered as a reliable index of overlap in the processing between the two exposures of the cue stimulus—the greater the extant of the shared processes, the larger the priming effect (Kan & Thompson-Schill, 2005, p.1131). Moreover, it is hypothesized that the facilitation effect in verb generation is a form of conceptual repetition priming as the response needs accessing the meaning of the stimulus (Gabrieli et al., 1996; Seger et al., 1999).

In the verb-generation task, repetition priming is measured by participants' faster and more accurate responses to recently studied word stimuli than to words that have not yet been studied, and behavioral facilitation effect was observed in both monolinguals (e.g., Lepron et al., 2009; Persson et al., 2004; Thompson-Schill & Kan, 2001) and bilinguals (de la Riva López, Francis, & García, 2012; Seger et al., 1999). This facilitation effect is manifested as decreased activations in the left prefrontal cortex, cingulated cortex and cerebellum during L1 verb generation, as observed in both fMRI (Seger, Desmond, Gabrieli, & Glover, 1997; Thompson-Schill, D'Esposito, & Kan, 1999) and PET (Raichle et al., 1994) studies. As was noted above, a handful of studies have examined the repetition priming effects in verb generation; studies directly address the role of response compe-tition with the repetition priming paradigm, however, are quite scarce. In this regard, only two studies in L1 verb-generation task are readily available (i.e., Prull, 2010, 2013). Employing the repetition priming paradigm, Prull (2010) explored the effects of age on repetition priming for HC and LC noun stimuli in L1 verb generation. The results indicated that verb-generation priming was not reliably modulated by age-related factors. However, the results did reveal a repetition priming effect; responses to studied cue words were faster than those to unprimed stimuli. Furthermore, the results indicated that the magnitude of priming was significantly greater for HC stimuli than for LC stimuli. Likewise, Prull (2013) found a facilitation effect on prior presented cue words during verb generation, that is, faster RTs to studied cue words relative to new stimuli. In addition, verb-generation priming was numerically larger for HC items than for LC items across five experiments, and that reliable difference in priming was also observed (Experiments 1 and 3).

One of the most commonly accepted assumptions in research on speech production is that lexical selection is a competitive process in which co-activated lexical representations compete against each other (Spalek, Damian, & Bölte, 2013). The goal of the present study is to test this prediction in as direct a way as possible with L2 population. Results of previous studies lend support to the role of lexical competition effects in L1 verb generation (e.g., Crescentini et al., 2008, 2009; Lepron et al., 2009; Persson et al., 2004; Prull, 2010, 2013; Thompson-Schill et al., 1998). As was mentioned previously, the cognitive processes involved in competitive lexical selection during verb generation would be more complex for non-native speakers due to the constraint of their L2 proficiency levels. However, thus far, no study has been conducted to examine the cognitive processes underlying L2 verb generation. As such, an understanding of the cognitive processes underlying L2 verb generation seems necessary. Moreover, prior studies on the repetition priming effects of verb generation performance elicited by HC and LC stimuli are scant, with only two studies on L1 verb generation readily available (Prull, 2010, 2013). However, no attempt has been made to examine long-term repetition priming effects when L2 learners respond to HC and LC cue words during verb generation. In view of this, we set out to explore the role of lexical competition using the repetition priming paradigm to further elucidate the mechanisms underlying the competitive lexical selection processes with Chinese EFL learners. As such, we would assess, for the first time, L2 verb-generation priming associated with the presented HC and LC stimuli that we have established following the criteria specified in previous studies (e.g., Prull, 2010, 2013). Specifically, the following questions would be addressed: (1) Are there any effects of lexical competition during verb generation task for Chinese EFL learners? (2) Are there long-term repetition priming effects during verb-generation performance elicited by HC and LC noun stimuli for Chinese EFL learners?

2. Methodology

2.1. Participants
Forty-four postgraduates, majoring in *English Language and Literature* as well as *Linguistics and Applied Linguistics in Foreign Languages* in Ningbo University, participated in the experiment. Among them, 37 of whom are female and 7 are male. Their age ranges from 20 to 23 years, with an average age of 21.8. They started learning Chinese (L1) since their birth and the time for their study of English (L2) ranges from 6 to 14 years (*M* = 10.7).

2.2. Materials and tasks
We assembled 132 nouns in English, for the verb generation task by consulting the appendices of previous studies (de la Riva López et al., 2012; Seger et al., 1999; Seger, Rabin, Zarella, & Gabrieli, 1997), *Oxford Advanced Learner's Dictionary* and by brainstorming. One hundred and thirty undergraduate students, none of whom participated in the present experiment, were given these nouns printed on sheets of paper for each of which participants were required to write a related verb. Based on the frequency of the verbs being produced by these students, 60 nouns were selected. Among them, 30 English nouns are HC nouns and the other 30 LC nouns. According to the criterion in Prull's (2010, 2013) and Thompson-Schill et al.'s (1997, 1998) studies, an HC noun is defined as one in which the ratio of the most frequent to the second most frequent verb response is relatively low, specifically between 1.0 and 3.0 (*M* = 2.12). For example, if the noun "airplane" receives 42 responses to "fly" and 41 responses to "take", the ratio is 42/41 = 1.02. An LC noun, on the contrary, is defined as one in which the ratio of the most frequent to the second most frequent verb response is relatively high, specifically between 5.0 and 82.0 (*M* = 18.03).

The experimental materials were divided randomly into two 30-item lists, A and B, each of which contained half of the HC nouns and half of the LC nouns. All the stimuli used in the experiment were programmed and presented with E-prime 2.0. One list was studied and the other served as the new list. For half of the participants, List A was studied and List B was new, whereas for the other half this arrangement was reversed. Participants were randomly assigned to this arrangement.

2.3. Procedure

Participants were tested individually in a soundproof lab. Stimulus presentation, timing, and data collection were all controlled by E-prime 2.0. Prior to the experiment, participants received spoken and written instructions to familiarize themselves with the procedures of the experiment. They also practiced the verb generation task during a 5-min training session to check whether instructions were fully understood. Participants were told that they would see some nouns appearing one at a time on the computer screen and they were required to respond to each noun by saying aloud the first appropriate verb that came to their mind into a microphone. Each trial started with the presentation of a fixation mark for 500 ms. Nouns were displayed in the center of the computer screen and remained visible until a vocal response was registered by the computer. Participants were instructed to generate verbs elicited by the noun stimuli as quickly as possible.

The experiment consisted of two phases: a study phase and a test phase. In the study phase, 30 English noun stimuli were presented in random order to half of the participants and the other 30 experimental stimuli were presented to the other half. Subsequently, all the 60 English experimental stimuli were presented in the test phase. Specifically, the 60 experimental stimuli in the test block consisted of 30 studied words (i.e., words that had been presented in the study phase) and 30 new words (i.e., words that had not been presented earlier). RTs were measured at the onset of overt verb generation during the session and were analyzed later. The experiment lasted approximately 20 mins.

3. Results

Before comparing the mean response latency, we removed the outliers (± 3SD) and the data of nonverb responses. The data were then statistically analyzed with SPSS 17.0, and only RTs for verb-response trials were included in the analysis. The results of mean response latency for verb generation as a function of item type and item status were presented in Table 1.

A 2 (item type: HC and LC) × 2 (item status: studied and new) ANOVA was performed to the verb generation data. The main effect of item type was significant, $F_{(1, 43)} = 43.4$, $p < 0.001$, and the

Table 1. Descriptive statistics of mean verb generation RT (ms) as function of item status and type

Item Type	Studied		New		Priming
	M	S.D.	M	S.D.	
HC	1926.6	832.7	2307.5	878.4	380.9
LC	1684.7	858.6	2058.5	859.0	373.8

Note: HC = high competition, LC = low competition

Figure 1. Mean verb generation RTs (ms) as a function of item type (HC and LC) and item status (studied and new) in English.
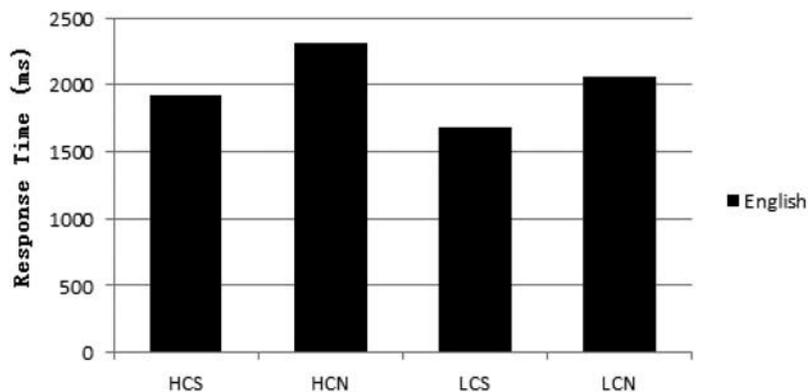
mean response latency of HC cue words (*M* = 2117.1 ms) was longer than that of LC words (*M* = 1871.6 ms), indicating a competition effect. There was also a main effect of item status, *F* (1, 43) = 102.4, *p* < 0.001, with the mean RT of studied noun stimuli (*M* = 1805.7 ms) being shorter than that of non-studied stimuli (*M* = 2183.0 ms). However, no reliable interaction between item type and item status was observed, *F* (1, 43) = .009, *p* > 0.05, indicating that the difference between studied and new items was not reliably greater for HC items than for LC items.

Figure 1 schematically depicted the RTs of participants' verb generation in different experimental conditions.

4. Discussion

The main goal of the experiment presented here was to examine the lexical competition effects during verb generation in Chinese EFL learners. The results indicated that responses to LC words were faster than those to HC words in L2 verb generation, thus indicating lexical competition effects. We report here for the first time, the reliable effects of L2 lexical competition during verb generation. This is consistent with what has been suggested in the literature on L1 verb generation (e.g., Crescentini et al., 2008, 2009; Persson et al., 2004; Prull, 2010, 2013; Thompson-Schill et al., 1997, 1998), suggesting that HC words involve more response competition than LC ones. The current study provides additional evidence supporting the role of lexical competition previously reported in verb generation in behavioral and neuroimaging studies.

This finding could be interpreted as being consistent with the idea that word production typically involves competition from semantically related representations, supporting WEAVER++ model (e.g., Dell & O'Seaghdha, 1992; Levelt et al., 1999; Roelofs, 1992). During the lexical selection process, simultaneously activated lexical representations compete with each other and the lexical selection mechanism selects the potential representation for further processing (Finkbeiner & Caramazza, 2006). In the HC condition, several alternatives compete for production, and much more efforts would be required for retrieval, whereas in the LC condition, the one dominant response is confronted with less interference from other non-dominant competitors, thus making the retrieval a more automatic process. The word that is ultimately generated is the most highly activated lexical candidates at the time of selection. In the verb generation task, participants retrieve related lexical items that are elicited by the noun stimuli (e.g., "eat" or "buy" for "food"), and these lexical items then compete for selection. When the noun stimuli have multiple potential responses (i.e., HC condition), all these items would compete for productions, leading to higher levels of activation from the set of co-activated, competing entries which would delay the lexical selection process of the target word. As a result, response latencies to HC cue stimuli are slower than those to LC stimuli.

Our study also explored the repetition priming effects in L2 verb generation among Chinese EFL learners. In L2 verb generation task, a significant reduction in RT was observed for the repetition condition relative to the unprimed condition, indicating there was repetition priming. This result converged with the small of number of studies showing repetition priming effects in L1 verb generation (Prull, 2010, 2013). For the first time, we have experimentally demonstrated that there was repetition priming effects in L2 verb generation. The results of the present study support the view that prior exposure to a stimulus facilitates an individual's subsequent response to that stimulus (Srinivas & Roediger, 1990; Thompson-Schill et al., 1999). The observed repetition priming effects in our verb generation task can be best explained by the theory of transfer appropriate processing (see Morris et al., 1977) which maintains that shared mental processes are involved in the initial encounter of a cue stimulus and subsequent encounter of the same stimulus (Morris et al., 1977), leading to facilitation effect for the behavioral performance and neural activity in the subsequent test. In the overt verb generation task, participants were required to generate a new verb (e.g., "study") that was associated with the presented cue word (e.g., "school"). Subsequently, when the cue word was presented again, a facilitation effect was observed as revealed by the faster response to generate an associated verb. Moreover, if prior exposure to the word requires the selection of the same type of semantic knowledge (e.g., an action or color) that is more

cogent •• psychology

available, the competition from alternatives would decrease (Thompson-Schill et al., 1999), result-ing in decreased selection competition and reduced response latencies to generate the target word.

Taken together, the results of the present study demonstrate lexical competition and repetition priming effects in overt L2 verb generation; this is somehow in agreement with the findings of prior studies on L1. Compared with the RTs and priming magnitude of the two extant studies in L1 verb generation (i.e., Prull, 2010, 2013), it can be observed that RTs in L2 verb generation were longer and the magnitude of repetition priming was larger. Although the stimuli used in our study are not identical to those of precursor research, participants both performed an English noun-verb gen-eration task. Consequently, it seems that the verb generation performance of young participants in these studies can be somehow compared with that of our participants. For young participants (college students) in Prull (2010), their average RT to HC (M = 1356 ms) and LC (M = 1218.5 ms) noun stimuli were considerably shorter than that of our participants (M = 2117.1 ms for HC and M = 1871.6 ms for LC). Additionally, the magnitude of the repetition priming for HC (M = 230 ms) and LC (M = 130 ms) stimuli for these L1 participants was considerably attenuated to that for HC (M = 380.9 ms) and LC (M = 373.8 ms) stimuli for L2 verb generation in the current study. In a similar vein, findings from the other relevant study on undergraduate students (i.e., Prull, 2013) also indicated that participants' RTs were considerably shorter and the repetition priming effects were attenuated relative to those of our Chinese EFL learners during verb generation. Although there is no direct empirical evidence supporting the contrast between the performance of L1 and L2 overt verb generation, findings from the picture naming paradigm concerning word generation do provide supporting evidence for this contrast. Previous results reported stronger priming effects and slower response latencies in picture naming among less proficient language learners (e.g., Francis, Corral, Jones, & Sáenz, 2008; Gollan, Montoya, Fennema-Notestine, & Morris, 2005). Francis et al. (2008) examined effects of language proficiency (among other affecting factors) on word production priming with the picture naming paradigm. The results indicated there were stronger priming effects for the non-dominant language than for the dominant language, and stronger effects in bilingual participants who were less proficient in their non-dominant language. Likewise, Francis, Tokowicz, and Kroll (2014) found that participants' language proficiency was negatively associated with response latencies, priming, and the degree of translation asymmetry.

There are plausible interpretations for the differences between prior L1 studies and our L2 verb generation investigation in terms of RTs and priming effects. As is known, lexical selection is a highly demanding process involving complicated cognitive procedures. We argue that this contrast between L1 and L2 verb generation processing supports the view that L2 processing is more demanding in terms of basic cognitive processes such as the speed of processing and cognitive control, and is influenced by the speakers' language proficiency (e.g., Francis et al., 2008, 2014; Gollan et al., 2005) and age of acquisition (AOA) (e.g., Canseco-Gonzalez et al., 2010). Participants in our study are native speakers of Chinese who started learning English after 6 years old, with an average AoA of L2 being 10.7 (range: 6–13). Presumably, the English proficiency of our Chinese EFL participants is not comparable to that of native English-speaking population in the previous studies. The insufficient language proficiency and reduced exposure in L2 may result in weaker and less precise representations of lexicons in memory, rendering more retrieval effort during word generation. Due to restraints of their inadequate L2 proficiency and language experience, partici-pants' speed of L2 processing and cognitive control over L2 would also suffer. As a result, lexical selection process may be more challenging for L2 learners, resulting in longer RTs and larger priming effects in L2 word generation. In addition, some previous studies have provided compel-ling evidence supporting larger priming effects in L2. Francis, Augustini, and Sáenz (2003) asserted that the items with high processing difficulty could get greater benefits. Due to the weaker links between L2 lexical representations and its conceptual representations, participants are required to activate their L1 lexical equivalents as media to produce L2 words, thus L2 priming can get the benefit of form and meaning overlap at both the L2 and L1 lexical level, as well as at the level of meaning (Alvarez, Holcomb, & Grainger, 2003). According to the word association model proposed

by Potter, So, von Eckardt, and Feldman (1984), L1 lexical representations have direct connection with their corresponding concepts. Therefore, L1 priming in previous research will miss the contribution of the overlap at the L2 lexical level, and accordingly can only get smaller benefits. Hernandez and Reyes (2002) also assume that links from both the lexical level and the conceptual level to the lemma level are weaker in the non-dominant language. When repetition occurs close in time, there is an enhancement of these weaker links that results in an increased repetition effect (Hernandez & Reyes, 2002, p.732).

Another plausible reason for the differences between L1 and L2 verb generation processes might be attributed to the cross-linguistic interference of participants' two languages and this may also interact in complex ways with their language proficiency and cognitive control over the two languages. With regard to the cross-linguistic processing interference, it is generally agreed that speakers' two languages can be activated simultaneously even when they are performing tasks in only one of the two languages (Pavlenko, 2009, p. 105). During word generation, the activation of a word in an unwanted language will compete with a word in the intended language in such a way that the former may intrude the lexical access and retrieval processes of the latter. Moreover, the magnitude of interference for each language of the participants may be determined by the fluency of their two languages as well as the varying degrees of cognitive control they exert over the two languages. It seems that if the more proficient language of the speaker is being processed and intended for production, the less proficient language will not be activated as much, and thus will interfere less with the current processing (c.f. Grosjean & Li, 2013). When the non-dominant language is the intended language for production (English in our study), the dominant one may be more activated and may lead to more interference with the processing of the intended language which in turn could slow down this process. The findings of Weber and Cutler's (2004) study indicate that this is the case; they found that the amount of interference experienced by their participants is much greater in L2 than in L1. In order to successfully produce the current speech and manage constant interference from the unintended language, speakers must engage the executive control system to monitor the two languages, trying to inhibit the activation of the unintended language (Grant, Fang, & Li, 2015). They need to exert a higher level of cognitive control when they engage in L2 word production to overcome the greater interference from their L1. Thus, it is reasonable to conclude that it is the combined effects of language proficiency and cognitive control (among other things) that make L2 verb generation such hard work. In our case, when Chinese EFL learners perform the L2 (English) verb generation task, they may experience higher level of interference from their more dominant native language (Chinese) which intervenes more with the process of lexical selection, resulting in longer RTs and stronger priming.

5. Conclusions

A repetition priming experiment was conducted to determine the lexical competition and repetition priming effects in the verb generation task among Chinese EFL learners. A main conclusion of the experiment present here is that there are lexical competition effects for L2 verb generation task. Our results add to a growing body of empirical evidence from behavioral and neuroimaging studies highlighting the role of lexical competition, thus providing additional evidence to support the hypothesis that there is lexical competition in the word generation process for the selection of information among competing alternatives. The effects of repetition priming in L2 verb generation were also present, as revealed by faster responses to primed HC and LC cue words relative to unprimed stimuli. Although this study investigated the lexical competition effects in verb generation among Chinese EFL learners with the repetition priming paradigm, there are still a few limitations due to the complexity of verb generation processes and the inadequacy of the authors' personal understanding. One limitation may result from the sample of participants. The sample size used in the current study is confined to proficient postgraduates majoring in English Language and Literature as well as Linguistics and Applied Linguistics in Foreign Languages. Therefore, the results may not be generalized to other types of L2 learners, such as non-English majors. Another limitation is that the results of this investigation cannot provide a comparison between L1 and L2 verb generation performance, and the route of L2 verb generation cannot be explicitly unfolded. In other words, whether participants generate L2 verbs via L1 or not is unknown to us, which awaits further investigation. Further study can be conducted to examine

bilingual speakers' cognitive and neural mechanisms involved in their L1 and L2 verb generation associated with HC and LC noun stimuli, thus advance our knowledge of the mechanisms underlying word generation and more in general, for theories of lexical selection in spoken word production.

Author details
Lin Fan[1]
E-mail: fanlinqd@163.com
ORCID ID: http://orcid.org/0000-0001-7095-289X
Zhen Wang[2]
E-mail: wangzhenbfs@163.com
Na Hong[3]
E-mail: 1052770010@qq.com
Zhenqian Liu[4]
E-mail: fanlinqd@163.com
[1] National Research Centre for Foreign Language Education, Beijing Foreign Studies University, No. 2, North Xisanhuan Road, Beijing 100089, China.
[2] Research Institute of Foreign Languages, Beijing Foreign Studies University, Beijing 100089, China.
[3] Faculty of Foreign Languages, Ningbo University, Ningbo, Zhejiang 315211, China.
[4] School of Foreign Languages and Literature, Shandong University, No. 5, Hongjialou, Jinan 250100, Shandong Province, China.

References
Alvarez, R. P., Holcomb, P. J., & Grainger, J. (2003). Accessing word meaning in two languages: An event-related brain potential study of beginning bilinguals. *Brain and Language, 87*, 290–304.
Canseco-Gonzalez, E., Brehm, L., Brick, C., Brown-Schmidt, S., Fischer, K., & Wagner, K. (2010). Carpet or Cárcel: The effect of age of acquisition and language mode on bilingual lexical access. *Language and Cognitive Processes, 25*, 669–705. doi:10.1080/01690960903474912
Crescentini, C., Mondolo, F., Biasutti, E., & Shallice, T. (2008). Supervisory and routine processes in noun and verb generation in nondemented patients with Parkinson's disease. *Neuropsychologia, 46*, 434–447. doi:10.1016/j.neuropsychologia.2007.08.021
Crescentini, C., Shallice, T., & Macaluso, E. (2009). Item retrieval and competition in noun and verb generation: An fMRI study. *Journal of Cognitive Neuroscience, 22*, 1140–1157. doi:10.1162/jocn.2009.21255
de la Riva López, E. M., Francis, W. S., & García, J. (2012). Repetition priming within and between languages in verb generation: Evidence for shared verb concepts. *Memory, 20*, 358–373. doi:10.1080/09658211.2012.667109
Dell, G. S. (1986). A spreading-activation theory of retrieval in sentence production. *Psychological Review, 93*, 283–321. doi:10.1037/0033-295X.93.3.283
Dell, G. S., & O'Seaghdha, P. G. (1992). Stages of lexical access in language production. *Cognition, 42*, 287–314. doi:10.1016/0010-0277(92)90046-K
Finkbeiner, M., & Caramazza, A. (2006). Now you see it, now you don't: On turning semantic interference into facilitation in a Stroop-like task. *Cortex, 42*, 790–796. doi:10.1016/S0010-9452(08)70419-2
Francis, W. S., Augustini, B. K., & Sáenz, S. P. (2003). Repetition priming in picture naming and translation depends on shared processes and their difficulty: Evidence from Spanish-English bilinguals. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 29*, 1283–1297.
Francis, W. S., Corral, N. I., Jones, M. L., & Sáenz, S. P. (2008). Decomposition of repetition priming components in picture naming. *Journal of Experimental Psychology: General, 137*, 566–590. doi:10.1037/0096-3445.137.3.566
Francis, W. S., Tokowicz, N., & Kroll, J. F. (2014). The consequences of language proficiency and difficulty of lexical access for translation performance and priming. *Memory and Cognition, 42*, 27–40. doi:10.3758/s13421-013-0338-1
Gabrieli, J. D., Desmond, J. E., Demb, J. B., Wagner, A. D., Stone, M. V., Vaidya, C. J., & Glover, G. H. (1996). Functional magnetic resonance imaging of semantic memory processes in the frontal lobes. *Psychological Science, 7*, 278–283. doi:10.1111/j.1467-9280.1996.tb00374.x
Gollan, T. H., Montoya, R. I., Fennema-Notestine, C., & Morris, S. K. (2005). Bilingualism affects picture naming but not picture classification. *Memory and Cognition, 33*, 1220–1234. doi:10.3758/BF03193224
Grant, A. M., Fang, S. Y., & Li, P. (2015). Second language lexical development and cognitive control: A longitudinal fMRI study. *Brain and Language, 144*, 35–47. doi:10.1016/j.bandl.2015.03.010
Grosjean, F., & Li, P. (2013). *The psycholinguistics of Bilingualism*. Malden, MA: Wiley-Blackwell.
Henson, R., Shallice, T., & Dolan, R. (2000). Neuroimaging evidence for dissociable forms of repetition priming. *Science, 287*, 1269–1272. doi:10.1126/science.287.5456.1269
Hernandez, A. E., & Reyes, I. (2002). Within- and between-language priming differ: Evidence from repetition of pictures in Spanish-English bilinguals. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 28*, 726–734.
Janssen, N., & Caramazza, A. (2011). Lexical selection in multi-word production. *Frontiers in Psychology, 2*, 1–8. doi:10.3389/fpsyg.2011.00081
Kan, I. P., & Thompson-Schill, S. L. (2005). Conceptual processing in Chinese-English bilinguals: An fMRI study of cross-language conceptual priming. In J. Cohen, K. T. McAlister, K. Rolstad, & J. MacSwan (Eds.), *Proceedings of the 4th international symposium on Bilingualism* (pp. 1131–1138). Somerville, MA: Cascadilla Press.
Lepron, E., Péran, P., Cardebat, D., & Démonet, J. F. (2009). A PET study of word generation in Huntington's disease: Effects of lexical competition and verb/noun category. *Brain and Language, 110*, 49–60. doi:10.1016/j.bandl.2009.05.004
Levelt, W. J. M., Roelofs, A., & Meyer, A. S. (1999). A theory of lexical access in speech production. *Behavioral and Brain Sciences, 22*, 1–38. doi:10.1017/S0140525X99001776

Martin, R. C., & Cheng, Y. (2006). Selection demands versus association strength in the verb generation task. *Psychonomic Bulletin and Review, 13,* 396–401.

Morris, C. D., Bransford, J. D., & Franks, J. J. (1977). Levels of processing versus transfer appropriate processing. *Journal of Verbal Learning and Verbal Behavior, 16,* 519–533. doi:10.1016/S0022-5371(77)80016-9

Pavlenko, A. (2009). Conceptual representation in the bilingual lexicon and second language vocabulary learning. In A. Pavlenko (Ed.), *The Bilingual Mental Lexicon: Lnterdisciplinary approaches* (pp. 99–125). Bristol: Multilingual Matters.

Persson, J., Sylvester, C. C., Nelson, J. K., Welsh, K. M., Jonides, J., & Reuter-Lorenz, P. A. (2004). Selection requirements during verb generation: Differential recruitment in older and younger adults. *Neuroimage, 23,* 1382–1390. doi:10.1016/j.neuroimage.2004.08.004

Petersen, S. E., Fox, P. T., Posner, M. I., Mintun, M., & Raichle, M. E. (1988). Positron emission tomographic studies of the cortical anatomy of single-word processing. *Nature, 331,* 585–589. doi:10.1038/331585a0

Petersen, S. E., Fox, P. T., Snyder, A. Z., & Raichle, M. E. (1990). Activation of extrastriate and frontal cortical areas by visual words and word-like stimuli. *Science, 249,* 1041–1044.

Potter, M. C., So, K. F., von Eckardt, B., & Feldman, L. B. (1984). Lexical and conceptual representation in beginning and more proficient bilinguals. *Journal of Verbal Learning and Verbal Behavior, 23,* 23–38. doi:10.1016/S0022-5371(84)90489-4

Prull, M. W. (2010). Age-related influences on repetition priming in the verb generation task: Examing the role of response competiton. *Aging, Neuropsychology, and Cognition: A Journal on Normal and Dysfunctional Development, 17,* 439–461. doi:10.1080/13825580903469846

Prull, M. W. (2013). Attention and repetition priming in the verb generation task. *Acta Psychologica, 143,* 218–226. doi:10.1016/j.actpsy.2013.03.010

Raichle, M. E., Fiez, J. A., Videen, T. O., MacLeod, A. M. K., Pardo, J. V., Fox, P. T., & Petersen, S. E. (1994). Practice-related changes in human functional anatomy during nonmotor learning. *Cerebral Cortex, 4,* 8–26. doi:10.1093/cercor/4.1.8

Roelofs, A. (1992). A spreading-activation theory of lemma retrieval in speaking. *Cognition, 42,* 107–142. doi:10.1016/0010-0277(92)90041-F

Seger, C. A., Desmond, J. E., Gabrieli, J. D., & Glover, G. H. (1997). fMRI studies of verb generation priming and unusual verb generation. *Society for Neuroscience Abstracts, 23,* 1402.

Seger, C. A., Rabin, L. A., Desmond, J. E., & Gabrieli, J. D. (1999). Verb generation priming involves conceptual implicit memory. *Brain and Cognition, 41,* 150–177. doi:10.1006/brcg.1999.1116

Seger, C. A., Rabin, L. A., Zarella, M., & Gabrieli, J. D. (1997). Preserved verb generation priming in global amnesia. *Neuropsychologia, 35,* 1069–1074. doi:10.1016/S0028-3932(97)00041-9

Spalek, K., Damian, M. F., & Bölte, J. (2013). Is lexical competition in spoken word production competitive? Introduction to the special issue on lexical competition in language production. *Language and Cognitive Processes, 28,* 597–614. doi:10.1080/01690965.2012.718088

Srinivas, K., & Roediger, H. L. (1990). Classifying implicit memory tests: Category association and anagram solution. *Journal of Memory and Language, 29,* 389–412. doi:10.1016/0749-596X(90)90063-6

Starreveld, P. A., & La Heij, W. (1996). Time-course analysis of semantic and orthographic context effects in picture naming. *Journal of Experimental Psychology: Learning, Memory and Cognition, 22,* 896–918.

Thompson-Schill, S. L., D'Esposito, M., Aguirre, G. K., & Farah, M. J. (1997). Role of left inferior prefrontal cortex in retrieval of semantic knowledge: A reevaluation. *Proceedings of the National Academy of Sciences, U.S.A., 94,* 14792–14797. doi:10.1073/pnas.94.26.14792

Thompson-Schill, S. L., D'Esposito, M., & Kan, I. P. (1999). Effects of repetition and competition on prefrontal activity during word generation. *Neuron, 23,* 513–522. doi:10.1016/S0896-6273(00)80804-1

Thompson-Schill, S. L., & Kan, I. P. (2001). Perceptual and conceptual sources of priming on a word generation task. *Memory and Cognition, 29,* 698–706. doi:10.3758/BF03200472

Thompson-Schill, S. L., Swick, D., Farah, M. J., D'Esposito, M., Kan, I. P., & Knight, R. T. (1998). Verb generation in patients with focal frontal lesions: A neuropsychological test of neuroimaging findings. *Proceedings of the National Academy of Sciences, U.S.A., 95,* 15855–15860. doi:10.1073/pnas.95.26.15855

Weber, A., & Cutler, A. (2004). Lexical competition in non-native spoken-word recognition. *Journal of Memory and Language, 50,* 1–25. doi:10.1016/S0749-596X(03)00105-0

cogent •• psychology

Appendix: Stimuli Used in the Experiment	
High competition	**Low competition**
Airplane	Food
Tax	Guitar
Task	Bike
List	Wine
Pencil	Music
Picture	Oxygen
Athlete	Chair
Eye	Bed
Clothing	Book
Rule	Experiment
Problem	Mountain
Entrance	Hen
Bridge	Mirror
Joke	Ticket
Tooth	Cleaner
Nightclub	Bathroom
Lip	Tool
Prize	Spokesman
Questionnaire	Actor
Scientist	Student
Dolphin	Designer
Horse	Attention
Star	Pool
Earthquake	Waiter
Festival	Thief
Flag	Key
Clock	Rubbish
Evidence	Accident
Speed	Mother
Earth	Wind

Cogent Psychology (ISSN: 2331-1908) is published by Cogent OA, part of Taylor & Francis Group.

Publishing with Cogent OA ensures:

- Immediate, universal access to your article on publication
- High visibility and discoverability via the Cogent OA website as well as Taylor & Francis Online
- Download and citation statistics for your article
- Rapid online publication
- Input from, and dialog with, expert editors and editorial boards
- Retention of full copyright of your article
- Guaranteed legacy preservation of your article
- Discounts and waivers for authors in developing regions

Submit your manuscript to a Cogent OA journal at www.CogentOA.com