Orthographic Awareness and Phonological Awareness of Late Chinese-English Bilinguals: Evidence from Word-Picture Interference Tasks

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Abstract

The distractor stimuli are highly effective in modulating speech production latencies in word-picture interference task. It is one of the main experimental methods to explore the relationship between speech production network and perception network (Levelt et al., 1999). The distractors can be presented in both visual and auditory modalities (Lupker, 1979; Meyer and Shriefers, 1990). The interference effect (either facilitatory or inhibitory) can vary from interfering stimuli types (Lupker, 1979; Lupker, 1982; Glaser and Dungelhoff, 1984; Meyer and Shriefers, 1990). This study has adopted a visual and an auditory interference experiment on two groups of Chinese-English bilinguals with different L2 proficiency level to figure out if there is the effect of L2 proficiency and the effect of interference modality on response latency or accuracy on two proficiency groups of late Chinese-English bilinguals. From the accuracy result, all the late bilinguals in this study may have limited orthographic awareness and weak phonological encoding ability.

1 Introduction

Speech production is fast and accurate processing in our daily life. However, it can be exceedingly complex which entails the activation of many processes that unfold over time (Levelt et al., 1999; Caramazza, 1997; Dell, 1986). It's involved mainly three levels of processing: conceptualization, formation, and articulation (Jescheniak and Levelt, 1994; Levelt, 1999). For the level of conceptualization, speakers need to prepare the speech concept in mind and link it to a particular spoken word. For the level of formation, it includes stages of grammatical encoding, morpho-phonological encoding, and phonetic encoding (Levelt, 1999). On the stage of grammatical encoding, the syntactic or lexica lemma of the concept is selected. Morpho-phonological encoding is the process of breaking the lemma down into syllables to be produced in overt speech. Phonetic encoding is the process to piece together utterance of the syllables and complete vocal apparatus.

It is wildly accepted that there are relationships between perception and production network. However, the discussion about whether the word perception network and word production network are achieved by the same mechanism (Liberman, 1996; Roelofs et al., 1996; Dell et al., 1997) is controversial. Word-picture interference paradigm, which distractor stimuli are highly effective in modulating the speech production process has been one of the main experimental methods to study this issue since Schriefers (1990). From a review of the theory of lexical access in speech production (Levelt at al., 1999), they made an assumption that the distractor words, whether written or spoken, affects corresponding morpheme node in the production network. This assumption finds supports in word production literature; spoken word recognition involves phonological activation (McQueen et al., 1995); visual word processing occurs along both visual and phonological pathways (Cotheart et al., 1993; Seidenberg and McClelland 1989) . In other words, the phonological activation occurred in both spoken and visual word recognition. They assumed that distractor stimuli could directly affect the stage of activation of phonologically related morpheme units in the formation level of the production network.

The earliest and most powerful finding in word-picture paradigm is that response latency can be adjusted by presenting an interfering word in visual modality (Lupker, 1979) or auditory modality (Schriefers et al., 1990). Moreover, two kinds of picture-distractor relationship have been found to affect the word-picture interference task. One is semantic interference effect, which response time is longer when the distractor word and the target word belong to the same semantic category than when the distractor doesn't have any semantic relationship with the target word (Lupker, 1979; Glaser and Dungelhoff, 1984). Another is phonological facilitation effect, which shorter response time and higher accuracy to name the target picture when the distractor word and the target word share some phonological feature (e.g., onset) than when the distractor doesn't share any phonological feature with the target word. However, see from a review by Abdel Rahman and Melinger (2009), whether semantic interference effect will happen are highly reliant on control of the degree of semantic related.

This present study will only test the phonological effect. It is obvious that phonologically related distractors contain some phonological cues related to the target word. Most studies have conducted in alphabetic languages, so the phonological distractor is also similar to the target word in orthography. It results in the different interpretation of phonological effect whether the phonological effect is produced by phonologically related segments or orthographic related features. Lupker (1982) had examed the contribution of orthographic versus phonological segments in visual modality. He found that phonologically related distractors facilitated picture naming by 55ms compared with unrelated distractors, which is similar to the facilitation that only orthographic features were shared. This finding indicates that phonologically related feature may not play an important role in the effect of response latencies in visual modality. Schriefers, Meyer, and Levelt (1990) firstly use auditory modality stimuli to test phonological facilitation effect, in his experiment, participants named the picture while hearing distractors that shared word-initial segments and word-final segments with the target word, and found onset-related distractors facilitated response if stimuli presented at the same time as picture onset. So far seldom research compared visual modality with auditory modality on bilinguals.

It is obvious that second language (L2) speakers often show less fluency and more errors than native speakers (L1) do while they are speaking their second language (Hieke, 1981; Wiese and Dechert, 1984; Riazantseva, 2001).

Bilinguals can be separated into early bilinguals and late bilinguals.The architecture of bilinguals mind may be a reflection of the level of expertise in the second language and the context in which the second language acquired. Early bilinguals are usually regarded as high proficiency bilinguals because they started learning a second language in a very young age. Their second language acquisition is quite similar to the way in which native speakers acquire their native language. However, the second language acquisition for late bilinguals can be various. Thus, their second language proficiency can vary greatly. Late Chinese-English bilingual is a large group of the current society. Many Chinese children started to learn English since 9 years old or even earlier. Most of them stopped learning it after they graduate from university. It's a long learning period, however, many of they still in a limit proficiency of English. As an alphabetic writing system, English is believed as an ideal candidate to test phonological awareness effect. Phonological awareness has been shown to affect L2 learner reading development, strong readers have strong phonological awareness and poor readers have poor phonological awareness (Ehri L et al., 2001; Torgesen J et al., 1994). It's interesting to explore how does L2 proficiency influence their production and perception network?

This study adopts the assumption that distractor words cause phonological activation in both spoken word and visual word recognition, which will affect the state of activation of phonologically related morpheme units of the production network. The main purpose is to see if there is the effect of L2 proficiency and the effect of interference modality on response latency or accuracy on two proficiency groups of late Chinese-English bilinguals.

2 Experiment

2.1 Participants

32 Chinese-English bilinguals divided into two groups vary from different English proficiency level

were asked to perform the picture-word interference task in their L2 (English). All of them are native Mandarin speakers (Chinese as L1) who grew up in mainland China. They all have learned English (English as L2) since age 9-10. Both groups subjects' English proficiency is controlled to be less fluent than English monolinguals do (Bergmann C, 2015). All of them are non-linguistic or psychology related and had either normal or corrected-to-normal vision and audition. For each group, there are 16 students (half male and half female).

For group 1 participants who enrolled from the Hubei University of Art and Science, mean age 21 years, have all passed CET-4, is considered to be lower L2 proficiency group. For the group 2 participants who enrolled from The Hong Kong Polytechnic University, mean age 24.21 years, have all passed IELTS with grade 6.5 is considered to be higher L2 proficiency group. Both groups of subjects were tested at their school. All of them were compensated after the experiment.

2.2 Materials

28 monosyllabic word sets were selected and used in both visual and auditory modality experiment, for each word sets. For each experiment, there are 3 target-distractor relationships which are target-target, target-phonologically related and target-unrelated: (1) 28 target words were chosen from mainland Ordinary High School Curriculum Standard Experimental English Textbook (People's Education Press, 2007) to prevent incognizance and indiscriminate selection. All these selected words are high-frequency words in the textbook to prevent word frequency effect (Oldfield and Wingfield, 1965). (2) The three conditions related words of the target are the corresponding phonologically related distractor (e.g., <bowl> / bəʊl/) which shared phonological onset and orthographic word-initial (Meyer and Schrifers, 1990) with the target word (e.g., <bone> / bəʊn /), the unrelated distractor (e.g., <sand> /sænd /) which don't share any phonological or orthographic feature with the target word（e.g., <bone> / bəʊn /), and the congruent distractor itself (e.g., <bone> / bəʊn /).

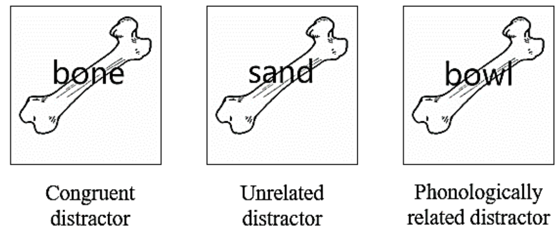

Figure 1. visual stimuli: three kinds of relatedness distractor for target words

For visual stimuli, all the 28 target words are matched with a black and white picture from international picture naming project and Google picture. All the picture only contains the meaning of the target word without any other context images. In the middle of each picture, three kinds of distractor words mentioned above are marked respectively and presented to participants one by once randomly (see figure 1). There is 84 visual stimuli in visual modality interference task in total. All the Pictures are scaled to 240pixels * 240 pixels by PowerPoint. All the visual stimuli have presented on a computer screen.

For auditory stimuli, One female English native speaker has recorded 28 targets word, 28 corresponding phonologically related distractors, and 28 unrelated distractors in the recording room by Pratt. So, there are 84 auditory stimuli in auditory interference task. All recordings were normalized to 500ms and 55 dB. Participants can hear the audio of stimuli by earphone. When the audio was played, the corresponding target-word-picture without any distractor words on it will be presented on the computer screen to provide conceptual information to the participants at the same time.

Experiments were done in a quiet room equipped with on a DELL Inspiron 14 windows laptop to represent the visual stimuli and an earphone to play the auditory stimuli. The experiment is run by DMDX 3.2.2.3 which installed on the laptop. A written instruction was shown to every subject before experiments.

All the 84 visual stimuli and 84 auditory stimuli were mixed in one interference task and were designed to be presented twice. So, there are 336 stimuli in total. One stimulus is one trial. The task was divided into four sub-blocks, free time break was added between each sub-block. Each block contains 84 trials with 42 visual stimuli and 42 auditory stimuli; all the trails will be presented in different orders for each subject.

2.3 Procedure

The participants were tested individually. Before the experiment, there was a familiarization. Participants have been tested all the 28 target pictures and given the feedback when their response divided from the expected answer. During the experiment, participants need to ignore the distractors and response as accurate and as fast as possible. For the visual experiment, a trial consists of following events: 1) a fixation sign '+' appeared on the middle of the screen for 100 ms, followed by a stimulus. 2) A random visual target picture with distractor word on it as visual interference stimuli were presented on the computer screen for 750ms. 3) then there is an instruction ' Please select the word represented by the meaning of this picture 'presented on the screen for 1500ms. For the auditory experiment, a trail consists of the following events: 1) a fixation sign '+' appeared on the middle of the screen for 100 ms, followed by a stimulus. 2) A random visual target picture on the screen for 750 ms. When the picture appeared, the earphone simultaneously played the auditory interference stimulus for 500ms. 3) then there is a response instruction ' Please select the word represented by the meaning of this picture 'presented on the screen for 1500ms. Once the instruction presented, the computer begins to calculate the participants' response time. Participants need to choose only one option by pressing the number key on the keyboarded (if the subject wants to choose option1, then press number key '1' on the keyboard). Options of multiple choice are respectively phonologically related distractor, unrelated distractor and the correct answer itself. The order of these three kinds of options was disrupted randomly to prevent the subject get familiar with the locus of the correct answer. The maximum response time is 2500ms; any response exceeds 2500ms will not be recorded. Once subjects made the response, the next trial would be shown. If they don't respond, the next trial will be displayed after 2500ms after the response instruction.

3 Result

Averaged reaction times of correct responses (Gollan and Montoya, 2005; Zeelenberg and Pecher, 2003) and accuracy (Gollan and Montoya 2005) were submitted to repeated measures analysis of variance (ANOVA). The analyses involved three fixed variables: group (participants with higher L2 proficiency versus participants with lower L2 proficiency), distractor type (congruent distractors, phonologically related distractors, and unrelated distractors), modality (visual versus auditory). The reaction time has calculated from the moment participants see the response instruction to the moment they respond. The accuracy has calculated the proportion of the correct answer they chose. For the data of each participant, reaction times from incorrect responses or deviated by more than ± 2 SD were all discarded.

The mean reaction time and the mean accuracy rate by modality and distractor type on group 1 and group 2 can be seen in Table 1.

		Group 1		Group 2	
Modality	Distractor Type	RT(ms)	%AC	RT(ms)	%AC
Visual	PHO-V	1093.42	62.81	985.61	74.18
	UNR-V	1128.20	62.59	1006.16	74.44
	CON-V	1034.12	74.80	957.41	87.39
Auditory	PHO-A	1138.76	64.29	1027.30	81.21
	UNR-A	1089.64	61.39	1006.63	75.54
	CON-A	1066.79	72.24	986.48	89.06

Table 1. Mean Reaction Time (RT) and Percentage Accuracy Rate(% AC) by Modality and Distractor Type for Group 1 and Group 2

For RT results, there is a main effect of modality [F(1,30)=5.923, $p<0.05$] and a main effect of distractor type [F(2,60)=13.092, $p<0.001$]. The modality also interacted with distractor type [F(2,60)=7.094, $p<0.05$]. The modality main effects indicate that response latencies in auditory modality were slower than that in visual modality(auditory:1052.60ms; visual:1034.15ms, $p<0.05$). In the main effect of distractor type [F(2,60)=13.092, $p<0.001$], participants had shorter response time when presented with congruent distractors compared to phonologically related distractors (congruent distractor:1011.20ms; phonologically related distractor:1061.274ms). No significance was observed in RTs between unrelated distractors and phonologically related distractors.Importantly,the interaction of modality and distractor type [F(2,60)=7.094, $p<0.05$] reflecting that 1) the RT results of unrelated distractors do not significantly differ from auditory modality to visual modality, 2) the RT of the congruent distractors are significantly shorter than that of the phonologically related distractors and unrelated distractors.

For the result of accuracy rate, there is a main effect of group [F(1,30)=20.717, $p<0.001$] and the main effect of distractor type [F(1,30)=44.822, $p<0.001$]. No main effect of modality was observed. However, there is an interaction between modality and group [F(1,30)=7.998, $p<0.05$] and an interaction between modality and distractor type [F(2,60)=8.874, $p<0.001$]. The main effect of group [F(1,30)=20.717, $p<0.001$] reflected that the accuracy of group1 high proficiency participants is higher compared to group2 lower proficiency participants: 80% versus 66.4%. Significant main effect of distractor type [F(1,30)=44.822, $p<0.001$] reflecting the accuracy rate of congruent distractors is higher than that of unrelated distractors: 80.4% versus 70.6%.

Group	Modality	Sig.	Mean
Group1	Visual	0.374	66.7%
	Auditory		66%
Group2	Visual	0.004*	78.7%
	Auditory		81.3%

Table 2. The Accuracy Result of Interaction Effect Between Modality and Group

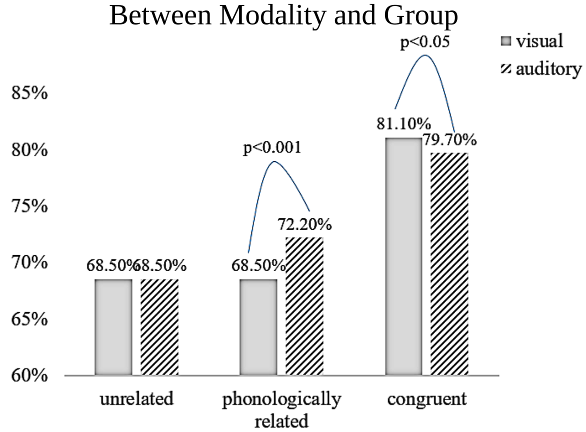

Figure 2. The Accuracy Result of Interaction Effect between Modality and Distractor Type

Importantly, the interaction between modality and distractor type [F(2,60)=8.874, $p<0.001$] reflecting the fact that the accuracy rate of phonologically related distractor 72.2% was significantly higher than the accuracy rate of unrelated distractors 68.5% only in the auditory modality. Although the congruent facilitation was found in both visual modality and auditory modality, reflecting that the accuracy rate of the congruent distractors was the highest among that of the phonologically related distractor and the unrelated distractor in both visual modality and auditory modality; phonological facilitation effect was only found in the auditory modality, in which the accuracy rate of phonologically related distractors is higher than that of unrelated distractors (see figure.2). Besides, the interaction of modality and group [F(1,30)=7.988, $p<0.05$] was also significant (see table.2). Although the accuracy rate in visual modality 66.7% and auditory modality 66% was almost the same for lower L2 proficiency group; it was significantly different in higher L2 proficiency group that the accuracy rate of visual modality is 78.7%, and the accuracy rate of auditory modality is 81.3%.

4 Discussion

The visual and auditory modalities word-picture interference test on two kinds of English proficiency late bilinguals shows a significant proficiency difference: high proficiency participants respond more accurately than low proficiency participants do. The interaction of distractor type and modality on accuracy also demonstrate that the response accuracy of the auditory modality is significantly higher than that of the visual modality only in high proficiency late bilinguals. Some discussion of it is as follows.

Phonological awareness is an individual awareness which involves detection and manipulation of the sound structure of words, such as syllables and phoneme (Gillon, 2004; Rvachew et al., 2003). It is also an important determiner of the success of learning to read and spell in both monolingual children (Torgesen et al., 1994; Ehri et al., 2001) and bilingual children (Campbell and Sais, 1995; Leafstedt, 2005). Lots of previews study have proved that phonological awareness instruction improves reading and spelling skills, but the reverse is also true (Perfetti et al., 1987; Burgess and Lonigan, 1998; Troia, 1999; Bus and Van, 1999). Phonological awareness is often explained by decoding and encoding (Seidenberg and McClelland, 1989; Ehri, 1992; Frost, 1998; Harm and Seidenberg, 1999), decoding refers to the process of relating a word's written representation to its verbal representation. It involves mapping letters of the specific word to its corresponding phonologically related morphemes and combining those phonemes of the morpheme to a verbal word. In contrast , encoding is a process of spelling, with a words verbal representation encoded to a written form, which involves determining the verbal representation and mapping the phonemes of its morpheme to the letter sequence. Participants' perception network in our auditory experiment is almost like the process of phonological encoding.

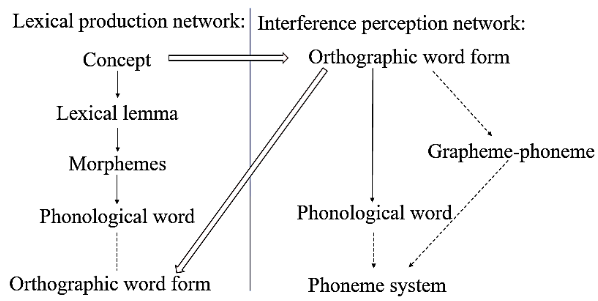

Figure 3. The Process Model in Visual Experiment

In the visual experiment, the distractor words' written form were presented in the middle of the picture. Participants were asked to ignore the distractor and response as accurate and as fast as possible. From Coltheart's research (1993), the visual word processing occurs both visual and phonological pathways from the visual word form to its phoneme system; he called this network the dual-route model. The interference perception network in figure 3 is designed by his outline of a dual-route model of reading, both visual and phonological pathways occurred in it, the phonological pathway is just like the process of phonological decoding. The production network in figure 3 is designed by Levelt's WEAVER++ model of lexical access in speech production (1999), but we changed the final stage of the production network as the experiment is not an oral naming task (see figure 3). Theoretically, participants will see the letter of the distractor word and obey the perception network to process the visual distractor word in both visual pathway and phonological pathway automatically. But it's kind of tricky that this experiment is an option choosing the task. Participants were asked to choose one option on the screen which they think is the word form of the message from the target picture instead of producing it orally. Participants may not need to complete the whole decoding process. They may just see the distractor word form without decoding it and response the task directly with the orthographic information.

In the auditory experiment, the distractor words were presented with a no-word-printed target picture by earphone. Participants wouldn't see the distractor word. They heard its verbal representation and encoded the verbal word into the corresponding letter form, and finally, they choose the written option which they think is the word form of the message of the target picture. Orthographic priming did not occur in the process, whereas spoken word recognition obviously involves phonological activation (McQueen et al. 1995). Therefore, participants must complete the whole encoding process during the auditory experiment (see figure 4). It may explain why the participants responded faster in visual modality than in auditory modality.

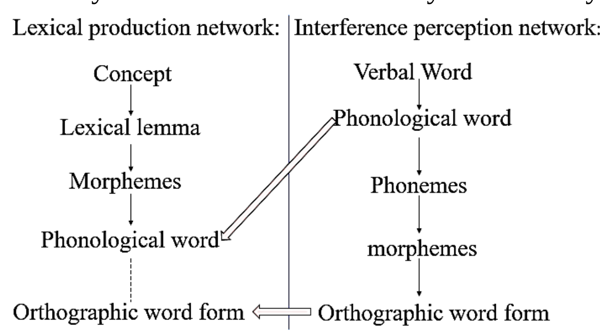

Figure 4. The Process Model in Auditory Experiment

The different process network of auditory experiment and visual experiment may also account for the interaction between accuracy and group. For high proficiency bilinguals, the accuracy rate of the auditory experiment is significantly higher than that of the visual modality experiment. The verbal distractor words can contain some phonological cues, especially for the phonologically related distractors and congruent distractors. When they do an auditory experiment, these phonological cues may activate the phonological representation in lexical production network and help participants to choose the right answer. In the visual experiment, the written form of the distractor word can prime participant's response by orthographic feature. It can speed response time whereas it may also cause large confusion when participants respond without complete the whole lexical production process.

In contrast, for low proficiency participants, the accuracy in the auditory experiment is not significantly different with the accuracy in the visual experiment. In addition, an interesting thing can be seen in group and modality interaction effect on accuracy. Although participants' L2 proficiency significantly differs from auditory modality to visual modality, the group difference of auditory modality [F(1,30)=25.912, *p*=0.000] is more significant than that of visual modality [F(1,30)=14.885, *p*=0.001]. It might be evidence of the weaker phonological awareness and phonological encoding ability of low proficiency late bilinguals. They may not be proficient enough to identify the phonological cues in auditory experiments and use the cues to activate the corresponding letters of the word, whereas high proficiency participants may use the cues to respond more accurately. In other words, high proficiency participants may have stronger phonological awareness and encoding ability. The group difference of accuracy in visual experiment seems mainly due to language proficiency difference. Besides, no group difference was observed in the RT results. It might indicate that visual orthographic priming occurs in both groups participants, while high proficiency participants are less interfered and got less confusion from it.

The effect of distractor type may be accounted for further exploration on language development of the cohort of late bilinguals in this study.

Congruent facilitation was observed in both visual experiment and auditory experiment. The RT of congruent distractors is the shortest among the three types distractors in both visual and auditory experiments. And the and accuracy of congruent distractors is the highest among the three types distractors in both two modalities experiments. The congruent distractor words provide complete-valuable visual orthographic information and oral phonological information, which can be most facilitative on response latencies and response accuracy in both visual and auditory experiments.

However, the phonological effect on different modality experiment is complex.

Comparing phonologically related distractors with unrelated distractors, the accuracy of phonologically related distractors was significantly higher than that of unrelated distractors in the auditory experiment. It indicates that auditory onset cues of the phonological distractors help participants to respond accurately in the auditory experiment. The orthographic feature, which was mentioned before, is considered to be a most influential factor in the visual experiment. Phonologically related distractors in this study are set to share the same onset as the target word. Thus few word-initial letters of the phonologically related distractor are same as the target word. No difference in accuracy was found between phonologically related distractors and unrelated distractors in the visual experiment. For the late bilingual participants in this study, the orthographic similarity to the target word may not differ from phonologically related distractors to unrelated distractors. It might owe to that they may not be proficient enough to acknowledge the visual orthographic cues of phonologically related distractors which only a few initial letters are the same as the target word.

In the auditory experiment, both phonologically related distractors and congruent distractor provide different degree phonological cues. Phonologically related distractors provide onset-related phonological cues of the target words, while congruent distractors provide complete phonological cues of the target words. In visual modality, phonologically related distractors provide onset-related orthographic cues, while congruent distractors provide complete orthographic cues. Comparing the accuracy of phonologically related distractors and congruent distractors, the accuracy difference between congruent distractors and phonologically related distractors in the auditory experiment is smaller than that in the visual experiment.

The accuracy of phonologically related distractors of the auditory experiment is significantly higher than that in the visual experiments. However, the accuracy of phonologically related distractors of the auditory experiment is significantly lower than that in the visual experiments.It seems that auditory phonological cues have a limited facilitation effect compared with orthographic cues for the late Chinese-English bilinguals in this study. When participants heard the congruent distractor words and got complete phonological information, they have limited ability to encode the oral sound to the word form of the words.

In summary, the result on RT and accuracy have indicated the orthographic awareness and phonological awareness ability in the late Chinese-English bilinguals to some degree. In visual modality, the more orthographic cues of the target word involved in the visual distractors, the stronger facilitation will happen on latencies whereas the stronger interference will occur. No difference in accuracy was found between phonologically related distractors and unrelated distractors in the visual experiment. The cohort of late bilinguals may not be proficient enough to identify orthographic cues of phonologically related distractors which only a few initial letters are the same as the target word. However, they can figure it out fast when the distractor words are congruent with the target words that complete orthographic cues were presented.

Participants' phonological awareness ability can help them encode the auditory distractors to its written word from. In auditory modality, the more phonological cues of the target word involved in the auditory distractors, the stronger facilitation effect will happen on latencies and accuracy. However, from the comparison between visual modality and auditory modality of phonologically related distractors and congruent distractors on accuracy, it seems that when both phonological and orthographic complete cues are provided, phonological cues may have a limited facilitation effect compared with orthographic cues for all the late Chinese-English bilinguals in this study.

When analyzing proficiency difference, significant proficiency difference was found in RT and accuracy that the influence of modality only differs in higher L2 proficiency group, reflecting the accuracy of the auditory experiment is higher than that of the visual experiment . The phonological awareness is stronger of high proficiency participants than that of low proficiency participants.

5 Conclusion

To explore whether the modality of distractors has a certain impact on different proficiency late bilinguals, visual and auditory modalities picture-word interference task was conducted in this study. The production network and perception network of participants in visual and auditory interference experiments were imitated (Figure 3. and Figure 4.) to figure out how different modality distractors affect participants' response. For both groups of late Chinese- English bilinguals, 1) they may not be proficient enough to identify the visually phonologically related distractors that only a few initial letters of the distractor words were the same as the target words. But they can acknowledge the congruent distractors that complete orthographic features are presented. 2) Comparing the condition where complete phonological cues are provided with the condition where the complete orthographic cues are provided, auditory phonological cues for participants might have a more limited facilitation effect than orthographic cues. Their phonological awareness, especially the ability of encoding, needs to be improved. 3) However, the phonological awareness can vary from language proficiency. Only in high proficiency participants, the accuracy of the auditory experiment is higher than that in the visual experiment. It indicates that high proficiency participants might have strong phonological awareness than low proficiency participants do.

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