J Psycholinguist Res (2016) 45:85–101
DOI 10.1007/s10936-014-9319-1

Influence of Second Language Proficiency and Syntactic Structure Similarities on the Sensitivity and Processing of English Passive Sentence in Late Chinese-English Bilinguists: An ERP Study

Xin Chang · Pei Wang

Published online: 12 October 2014

Abstract To investigate the influence of L2 proficiency and syntactic similarity on English passive sentence processing, the present ERP study asked 40 late Chinese-English bilinguals (27 females and 13 males, mean age = 23.88) with high or intermediate L2 proficiency to read the sentences carefully and to indicate for each sentence whether or not it was correct. Sentences were classified into literal translation sentences with the similar structure between the two languages and free translation sentences with the different structure. Behavioral data showed: shorter reaction times and higher accuracy rates occurred in the high-proficient group than those in the intermediate-proficient group; shorter reaction times and higher accuracy rates were observed in literal translation sentences than those in free translation sentences. ERP results showed literal translation sentences elicited an enhanced P200 and P600 while free translation sentences elicited a larger N400. The high-proficient group showed a larger P600 in syntactic violations and double violations while the intermediate-proficient group evoked an enhanced N400 in semantic violations and double violations. Literal translation sentences caused a larger P200 while free translation sentences elicited more negative-going N400. Behavioral and ERP data revealed the influence of L2 proficiency and syntactic similarity on L2 sentence processing, and L2 proficiency played a predominate role.

Keywords Late Chinese-English Bilinguists · English passive sentence · Second language proficiency · Syntactic structure similarities

X. Chang
School of Foreign Languages, Shanghai Jiaotong University, 800, Dongchuan Road,
Minhang District, Shanghai 200240, China
e-mail: changxinwp@sina.com

P. Wang (✉)
Department of Psychology, Shanghai Normal University, 100, Guilin Road,
Xuhui District, Shanghai 200234, China
e-mail: wangpei1970@163.com; wangpei@shnu.edu.cn

Introduction

In the past 30 years, a large number of ERP studies have been conducted to explore the real-time sentence processing in native language (L1) with the results indicating that sentence processing involves semantic and syntactic processing. The ERP index of semantic processing is the negative brain wave locating in the central parietal lobe with about 400 ms of latency (called N400) (Osterhout and Nicol 1999). On the other hand, syntactic processing relates to Early Left Anterior Negativity (ELAN) or Left Anterior Negativity (LAN) and P600 (Friederici 2002). The ERP patterns for the native speakers consist of a LAN/ELAN followed by a P600. These two components presumably reflects an early automatic syntactic analysis (ELAN/LAN) and subsequent re-analysis and integration of sentence structures (Friederici 2002; Hahne and Friederici 1999). LAN effect occurs between 300 and 500 ms which have been found in violations of number, case, gender and tense (Münte et al. 1993) and word-category constraints (Friederici et al. 1996; Münte et al. 1993). While ELAN effect occurs between 125 and 180 ms (Friederici et al. 1996; Neville et al. 1991) which relates to syntactic-category violations (Gunter et al. 1999). ELAN/LAN are largest over left anterior (Hagoort et al. 1993; Münte et al. 1993; Neville et al. 1991; Osterhout and Holcomb 1992, 1993; Osterhout et al. 1994; Osterhout and Mobley 1995; Rösler 1993). P600 effects have been reported in a number of different types of syntactic anomalies in different languages involving phrase structure (Hagoort et al. 1993; Neville et al. 1991; Osterhout and Holcomb 1992), verb subcategorisation violations (Ainsworth-Darnell et al. 1998; Osterhout and Holcomb 1992; Osterhout et al. 1994) and violations in the verb tense, subject-verb number agreement, number and gender pronoun-antecedent agreement, case, and constituent movement (Coulson et al. 1998; Hagoort et al. 1993; Münte et al. 1993; Osterhout 1997) as well as syntactic preference violations and syntactic complexity (Friederici et al. 2002; Kaan and Swaab 2003; Osterhout et al. 1994; VanBerkum et al. 1999).

Compared with above-mentioned findings, ERP studies of second language (L2) semantic processing indicate: the latency and the amplitude of N400 observed in early L2 learners are similar to that of native speakers, while findings from late L2 learners lead to controversy. Some researchers reported that compared with native speakers, late L2 learners showed a smaller N400 (Hahne 2001) and longer latency (Ardal et al. 1990; Hahne 2001). However, other studies (Hahne and Friederici 2001; Li et al. 2003; Sanders and Neville 2003) found no such differences. Weber-Fox and Neville (1996) used ERPs to compare 5 groups of participants with different starting ages of English learning (1–3, 4–6, 7–10, 11–13, >16), and found that semantic violations evoked N400, while in the last two groups, a delayed N400 was observed, indicating that L2 semantic processing of the late L2 learners was relatively slower. Weber-Fox and Neville (2001) further discovered that if the learning interval between L1 and L2 was more than 10 years, the N400 latency of late L2 learners would appear to be different, but there were no differences between early L2 learners and native speakers. With the English–French word repetition priming paradigm, Natalie et al. (2006) found that L2 proficiency affected the semantic activation degree: high-proficient participants showed no difference in the N400 between L1 and L2, while the N400 effect in low-proficient ones significantly reduced. From the above, semantic violations evoke the N400 effect in both native speakers and L2 learners though its latency and amplitude are different a bit (Dussias and Cramer Scaltz 2008; Roberts and Felser 2011; Williams 2006).

The results from ERP studies of L2 syntactic processing seem quite different. Second language learners encounter special syntactic processing difficulty (Birdsong and Molis 2001; Hawkins 2001; Johnson and Newport 1989; McDonald 2000; White 2003), whose L2 syntactic processing is very different from native speakers' (Roberts and Meyer 2012). Studies

(Hahne et al. 2006; Kutas and Kluender 1994; Weber-Fox and Neville 1996) reported that early L2 learners (or high-proficient L2 learners) presented more native-like processing, that is, ELAN/LAN and P600 components appeared simultaneously under syntactic incongruent condition, whereas other related studies only found P600 effect (in spite of delayed latency), but no ELAN/LAN.

As for the reasons underlying in these differences, relevant studies claimed that L2 syntactic processing may be influenced by L2 proficiency to a large extent (Flege and MacKay 2004; Ylinen et al. 2005; Hopp 2006). By comparing ERP components evoked by the phrase structure violations (the active voice structure) and agreement violations in late German L2 learners and Italian L2 learners, Rossi et al. (2006) found the similar ERP components evoked both in L2 learners with high proficiency and native speakers, but only a reduced and lagged P600 was observed in L2 learners with low proficiency. Hahne et al. (2006) also found that the EEG activity of Russian-German L2 learners with high proficiency exhibited diphase features of ERP response (LAN/P600), which was similar to those of native speakers.

Furthermore, it was found that syntactic similarity between L1 and L2 also seemed to be a critical factor on L2 syntactic processing (Tolentino and Tokowicz 2011). Hahne (2001) and Hahne and Friederici (2001) compared the syntactic processing between native German speakers and late German L2 learners: German native speakers showed ELAN and P600; P600 was observed in Russian-German L2 learners and no related components was found in Japanese-German L2 learners, which shows that syntactic processing of late L2 learners whose L1 syntactic structures are similar to L2 (like Russian-German L2 learners) seems to be similar to native speakers than that of L2 learners whose L1 syntactic structures are totally different from L2 (like Japanese-German L2 learners). Tokowicz and MacWhinney (2005) compared L1 and L2 in their tense-marking (the similar structure between L1 and L2) and determiner number agreement (the different structure between L1 and L2) and determiner gender agreement (unique to L2). They found that violations of tense-marking and determiner gender agreement elicited a similar P600, but no ERP effects were observed in violations of determiner number agreement. By controlling L2 proficiency (all participants were high-proficient L2 learners) of native German speakers (L1 is similar to L2) and native Romance speakers (L1 is different from L2), Sabourin and Stowe (2008) probed into the influence of L1 (German and Roman) on L2 (Dutch) sentence processing for two grammatical constructions (verbal domain dependency and grammatical gender). The results revealed that native Dutch speakers showed a P600 effect in both constructions. However, when syntactic structures between L1 and L2 were similar, a P600 effect only occurred in Dutch L2 learners. To be specific, German speakers showed a P600 effect under two violation conditions. Romance speakers only showed a P600 effect within the verbal domain. However, when there was no structural similarity between L2 and L1 (for Roman speakers), P600 was observed only in verb-dominating-domain violation condition.

As for the influence of syntactic similarity and L2 proficiency on L2 processing, researchers advocate when syntactic structures of L2 are similar to those of L1, the implicit effect of L1 syntactic structure but not L2 proficiency will play a significant role; while L2 proficiency play a major role in L2 processing when L2 syntactic structures are different from L1. Most of previous studies focused on the influence of either syntactic similarity or L2 proficiency on L2 processing but not on the interaction of the two factors. And it remains to be resolved which one plays a decisive role (Chen et al. 2007; Kotz et al. 2008; Ojima et al. 2005). What's more, the above-mentioned mainly came from Indo-European language (like English). Attention should also be paid on sentence processing of Chinese English learners. For Chinese English learners, English passive sentence is a difficult grammatical point. First, Chinese focuses on language meaning and does not have meaningful morphological change while English emphasizes on language form (Pan 2004) with a wealth of morphological changes. It is a bit difficult to master different verb (especially irregular verbs) forms; Second, there is much difference onexpressions of "passiveness" between Chinese and English languages (Xiong and Wang 2003); Third, in understanding some English passive sentences, we need to change the order of the words and translate them into sentences of active voice to form understandable Chinese sentences, which here are defined as free translation sentences (FTSs) in our traditional classroom teaching (e.g. 'The violin was made by my father.' Chinese version: '我父亲制作了这把小提琴。' If we do not change the order of the subject and the object, and directly translate this sentence as '这把小提琴被我父亲制作了。', it can be very strange in Chinese and difficult to understand.). On the other hand, some English passive sentences can be directly translated into Chinese *'bei'* sentences (e.g. 'The boy was injured by the broken glass.' Chinese version: '男孩被碎玻璃扎伤了。'), which are defined as 'literal translation sentences' (LTSs) reflecting the similarity in the grammatical function and form between English and Chinese. Clearly, these literal translation sentences in English have a similar syntactic structure with Chinese language (its corresponding sentence pattern in Chinese is so called *'bei'* sentences.), while free translation passive sentences are different from Chinese language. And then, will these big differences lead to distinctiveness in Chinese-English bilingual's L2 processing? How do L2 proficiency and those possible syntactic similarities and dissimilarities affect their L2 processing as well? As the answer of the above problems, the study aims to explore the influence of syntactic similarity and L2 proficiency on English passive sentence processing of Chinese-English bilinguals.

Methods

Participants

Forty neurologically and psychiatrically normal native Chinese university students (27 female, 13 male) served as participants (mean age = 23.88 years, range = 20–29 years) and received payments for their participation. All participants were right-handed with normal or correct-to-normal visual acuity. They had no history of problems in language learning. All the participants were late L2 learners because they began to learn English from 11 or 13 years old. Participants were divided into two groups, the intermediate-proficient group and the high-proficient group, according to their levels of English proficiency. The intermediate-proficient group consisted of 20 participants (10 female, 10 male) who scored less than 460 on College English Test Band 4 (CET-4), while the high-proficient group consisted of 20 participants (17 female, 3 male) who passed the Test for English Majors-Band 8 (TEM-8) . Both CET-4 and TEM-8 are standard tests of English proficiency level in China for 20 years. Chinese National Test Center claims that learners who pass CET-4 achieve the intermediate proficiency of English, while TEM-8 indicates the high proficiency of English.

Stimuli

English passive sentences composed of 6–8 simple words within CET-4 word list were used in the experiment. These sentences were divided into eight categories according to a *Translation* (2) × *Violation* (4). The dimension of *Translation* type included literal translation sentences which corresponded to Chinese '*bei'* sentences (e.g. 'The apple was eaten by my uncle.') and free translation sentences which cannot be directly expressed by Chinese '*bei'* sentences (e.g. 'The violin was made by my father.'). The violation type included four dimensions: non-violation, semantic violation, syntactic violation, and double violation. Semantic violation referred to the inappropriate meaning of verbs (e.g. 'The violin was cooked by my father.'). Syntactic violation involved a misuse of past participle as base forms of verbs (e.g. 'The violin was make by my father.'). Double violation referred to a misuse of past participle as base forms of verbs with inappropriate meaning (e.g. 'The violin was cook by my father.'). Stimuli were composed of 224 sentences including 112 literal translation sentences (28 sentences respectively in four violation conditions) and 112 free translation sentences (28 sentences respectively in four violation conditions). All stimuli were presented in black, Courier New font at the center of a computer monitor and viewed from a distance of 70 cm.

Procedure

Participants were asked to read the sentences carefully and to indicate for each sentence whether or not it was correct. Sentences were presented word by word at the center of the computer screen during the presentation. All sentences were repeatedly presented one time and divided into eight blocks of 56 trials each. Each trial was initiated by a 500 ms presentation of a small black cross. Then, each word was presented for 350 ms, followed by a blank inter-stimulus interval (ISI) of 400 ms, after which the next word of the sentence appeared. After the 1,000 ms delay from the sentence offset, a sign appeared on the screen to wait for the participant to response. The presentation of the sign was terminated by a button pressing which, then was followed by 1,000 ms of a blank screen. Buttons were reversed for half of the participants. All the 448 trials were delivered randomly and a rest break was provided between blocks. A practice block with 20 trials was used before the formal experiment in order to familiarize participants with the procedure.

EEG Recording and Analysis

Electroencephalogram (EEG) was recorded continuously using an electrode cap outfitted with 64 sintered Ag/AgCI electrodes mounted according to the extended international 10–20 system. The signals were re-referenced offline to the average of the left and right mastoids. Electrooculogram (EOG) was recorded via two pairs of additional electrodes, with one placed above and below the left eye and the other placed to the external canthi of both eyes. The EEG and EOG were amplified and digitized by a Neuroscan SynAmps2 Amplifier with a band pass of 0.05–100 Hz and a sampling rate of 500 Hz. Electrode impedance was maintained below 5 kΩ throughout the experiment. The EOG artifacts were corrected using a correlation method proposed by Semlitsch et al. (1986). The EEG was segmented into 1,200-ms epochs beginning 200 ms prior to stimulus onset. Epochs in the correct trials were selected, but those contaminated with artifacts exceeding $\pm 80\,\mu$V, were rejected before averaging. The averaged ERP waveforms were digitally filtered with a low pass filter of 20 Hz (24 dB/Octave).

According to the grand ERP waveforms, peak latency and amplitude of the P200 were measured between 140–220 ms post-stimulus. A repeated-measures analysis of variance (ANOVA) was conducted separately for the P200 latency and amplitude, with *Group* (the high-proficient, the intermediate-proficient) as the between-subjects factor and with *Translation* (literal translation, free translation), *Violation* (non-violation, syntactic violation, semantic violation and double violation), *Site* (F3/Fz/F4, FC3/FCz/FC4, and C3/Cz/C4), and *Hemisphere* (left, midline, and right) as within-subjects factors. Due to the fact that there was always no discernable peak of N400 and P600 across participants, the mean

Table 1 RT and ACC in different violation conditions

Groups	Translation	Violation	RT (ms)	SD of RT (ms)	ACC (%)	SD of ACC (%)
High-proficient group	LTSs	Non-violation	654	42	89.6	3.4
		Syntactic	577	37	98.0	3.1
		Semantic	727	47	84.2	4.0
		Double	581	42	95.0	3.5
	FTSs	Non-violation	681	43	90.4	3.3
		Syntactic	571	41	97.2	2.5
		Semantic	701	43	86.8	4.2
		Double	590	38	96.2	3.2
Intermediate-proficient group	LTSs	Non-violation	678	42	69.6	3.4
		Syntactic	616	37	73.6	3.1
		Semantic	727	47	70.6	4.0
		Double	670	42	68.6	3.5
	FTSs	Non-violation	711	43	68.2	3.3
		Syntactic	713	41	71.8	2.5
		Semantic	705	43	68.2	4.2
		Double	655	38	68.4	3.2

amplitude of the N400 (330–430 ms) and P600 (650–850 ms) were measured respectively. Analyses of the N400 and P600 data were performed in two phases. The primary analyses focused on the five midline electrodes (Fz, FCz, Cz, CPz, and Pz). For the N400 and P600 component, a 2 (*Group*) $\times$ 2(*Translation*) $\times$ 4(*Violation*) $\times$ 5(*Site*) repeated-measures ANOVA was conducted separately. The secondary analyses examined hemisphere effects. A 2 (*Group*) $\times$ 2(*Translation*) $\times$ 4(*Violation*) $\times$ 8(*Site:*F3/F4, F7/F8, FT7/FT8, FC3/FC4, C3/C4, CP3/CP4, P3/P4, and TP7/TP8) $\times$ 2(*Hemisphere*) ANOVA was conducted separately. The Greenhouse-Geisser epsilon correction was applied for all repeat-measures with more than 1 degree of freedom; Post hoc comparisons were made by used a Bonferroni procedure.

Results

Behavioral Data

Trials with behavioral response beyond the interval of 200–2,000 ms were excluded from analysis. Table 1 shows response times and accuracy rates in each condition for the high-proficient and intermediate-proficient groups. A repeated-measures ANOVA of *Group* $\times$ *Translation* $\times$ *Violation* was conducted separately for accuracy rates and reaction times.

Accuracy

There was a significant main effect of G*roup* ($F(1, 38) = 33.8$, $p < 0.001$) with higher mean accuracy in the high-proficient group (92.2 %) relative to the intermediate-proficient group (69.9 %). The main effect of *Violation* was also significant ($F(3, 114) = 7.9$, $p < 0.001$), indicating that the mean accuracy rate was highest in syntactic violation condition (85 %) and lowest in semantic violation condition (78 %). The interactive effect of *Group* × *Violation* was significant ($F(3, 114) = 4.14$, $p = 0.013$). Simple effect analysis revealed that the accuracy rate of the high-proficient group was higher under each condition ($p < 0.001$, respectively, 97.6 % for syntactic violation; 85.5 % for semantic violation; 90 % for non-violation; 95.6 % for double violation) than the intermediate-proficient group showing no significant effect in violation type ($p = 0.144$, 68.9 % for non-violation; 72.7 % for syntactic violation; 69.4 % for semantic violation; 68.5 % for double violation).

Response Time

For the high-proficient group, there was a significant main effect of *Violation type* ($F(3, 114) = 18.0$, $p < 0.001$) with longer response time in non-violation (681 ms) and semantic violation (715 ms) than syntactic violation (619 ms) and double violation (624 ms).

The interaction effect of *Violation* × *Translation* ($F(3, 114) = 3.6$, $p = 0.019$) indicated that the effect of *Translation* existed under the condition of syntactic violation with response times of LTSs (654 ms) shorter than that of FTSs (666 ms) but did not reach its significance. The three-way interaction effect was also significant ($F(3, 114) = 2.8$, $p = 0.049$), indicating the significant interaction of *Violation* × *Translation* was found only in the intermediate-proficient group ($p < 0.025$). Further analysis showed that for LTSs, there was significant difference respectively between semantic violation and syntactic violation, between non-violation and syntactic violation as well as between semantic violation and double violation ($p < 0.005$); while for FTSs, there was significant difference respectively between syntactic violation and double violation, as well as between non-violation and double violation ($p < 0.005$).

Electrophysiological Data

See Figs. 1, 2, 3 and 4.

P200

For the latency of P200, there was a significant main effect of *Site* ($F(2, 37) = 4.416$, $p = 0.044$) with longest P200 at central scalp (187 ms) and shortest at frontal scalp (184 ms). There was a marginally significant main effect of *Group*, $F(1, 37) = 3.92$, $p = 0.055$, with the larger P200 amplitude in the high-proficient group (5.6 μV) than that in the intermediate-proficient group (3.7 μV), but with no significant interaction ($p > 0.1$). A main effect of *Translation* was significant ($F(1, 37) = 4.099$, $p = 0.050$), indicating that the P200 amplitude was significantly larger in the LTSs (4.9 μV) than that in FTSs (4.4 μV). A main effect of *Hemisphere* ($F(2, 74) = 5.505$, $p = 0.012$), *Site* ($F(2, 74) = 22.504$, $p < 0.001$) and the two-way interaction ($F(4, 148) = 3.761$, $p = 0.014$) were all significant, and the P200 amplitude was largest at FC3 (5.4 μV).

N400

Midline Electrodes There was no obvious difference between the high-proficient and intermediate-proficient group ($F(1, 37) = 1.8$, $p = 0.183$). But there was a significant

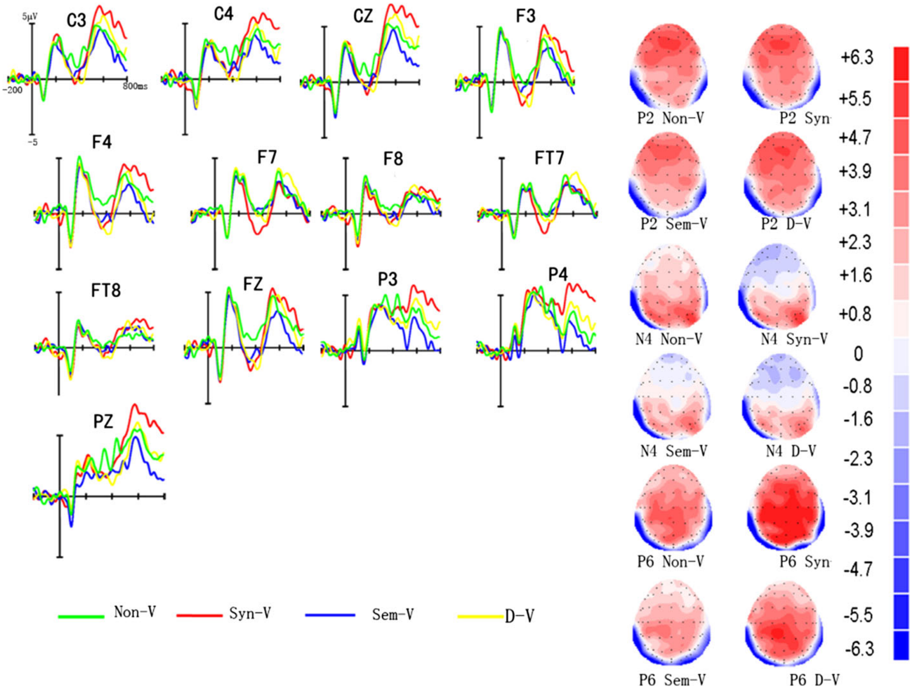

Fig. 1 ERP components and topography observed in high-proficient participants under LTSs

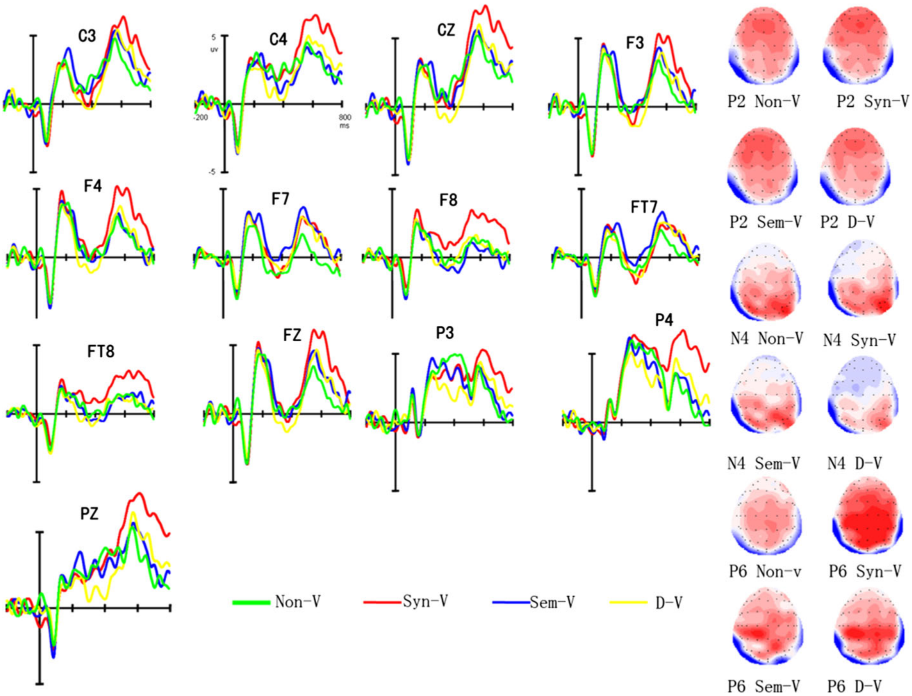

Fig. 2 ERP components and topography observed in high-proficient participants under FTSs

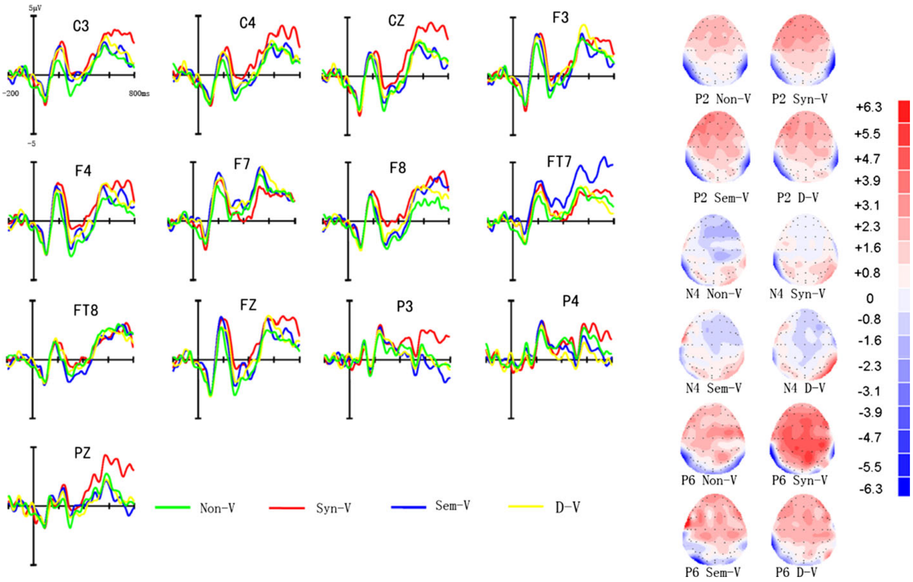

Fig. 3 ERP components and topography observed in intermediate-proficient participants under LTSs

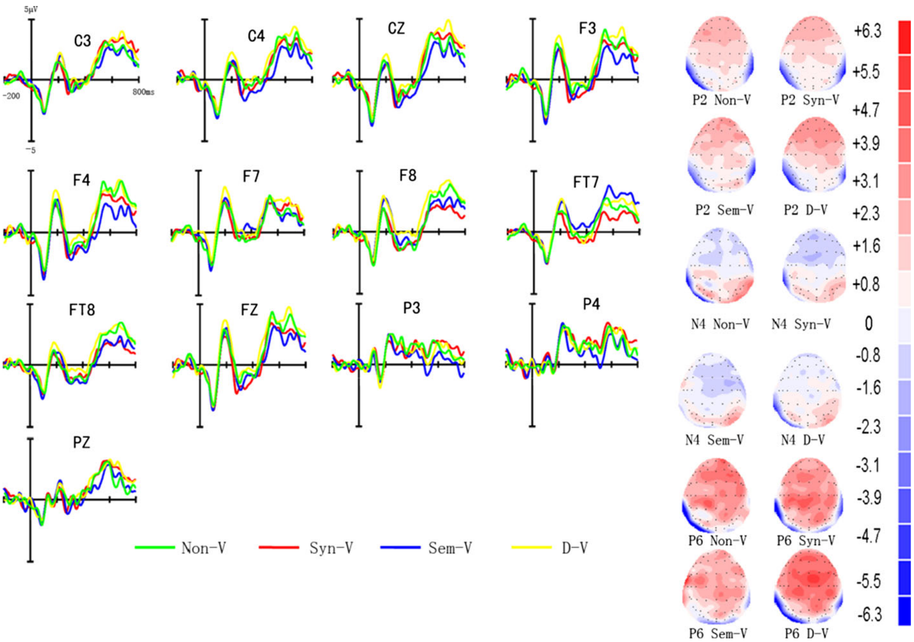

Fig. 4 ERP components and topography observed in intermediate-proficient participants under FTSs

main effect of *Violation* ($F(3, 111) = 3.49,\ p = 0.021$), suggesting that the N400 amplitude was largest under double violation condition ($-0.4\,\mu$V) and semantic violation elicited the smaller N400 bearing no significant difference with double violation. No obvious N400 was observed in non-violation and syntactic violation conditions. The interaction between *Group* and *Violation* was significant, $F(3, 111) = 3.52$, $p = 0.020$. Further analyses indicated that N400 amplitude was significantly larger in the intermediate-proficient group ($-0.7\,\mu$V) than the high-proficient group ($0.7\,\mu$V, $p < 0.04$). What's more, a significant main effect of *Violation* was observed only in the high-proficient group ($p = 0.002$), with the largest N400 amplitude in double violation ($-0.2\,\mu$V). There was no significant difference in other conditions ($1.7\,\mu$V for non-violation; 0.7μV for syntactic violations; $0.7\,\mu$V for semantic violations; $p > 0.1$). A main effect of *Site* was significant ($F(4, 148) = 17.8$, $p < 0.001$), revealing that N400 amplitude was largest at Fz ($-0.7\,\mu$V). The interaction between *Group* and *Site* was significant ($F(4, 148) = 3.6$, $p = 0.038$), indicating that a main effect of *Site* was found only in the high-proficient group ($p < 0.001$). The N400 amplitude at Fz in the intermediate-proficient group ($-0.03\,\mu$V) was larger than the high-proficient group ($2.3\,\mu$V, $p = 0.005$).

Laterality Analyses A frontal distribution for the N400 component was significantly observed ($F(7, 259) = 21.466$, $p < 0.001$) and the largest N400 amplitude was at $F3/4(-0.6\,\mu$V). The interaction between Site and Hemisphere was significant ($F(7, 259) = 6.059$, $p = 0.001$), indicating a left hemisphere distribution for the N400 at TP7/8 (left hemisphere: $-0.3\,\mu$V; right hemisphere: $1.0\,\mu$V, $F(1, 37) = 14.150$, $p = 0.001$).

Although there was no significant main effect of the N400 between groups ($F(1, 37) = 1.53$, $p = 0.224$), a two-way interaction between *Group* and *Hemisphere* ($F(1, 37) = 7.281$, $p = 0.010$) and between *Group* and *Site* ($F(7, 259) = 5.861$, $p = 0.005$) were significant. Further analyses indicated that a left hemisphere effect for the N400 in the high-proficient group was significant (right hemisphere: $1.2\,\mu$V; left hemisphere: $0.5\,\mu$V, $p < 0.02$), whereas there was no significant hemisphere effect in the intermediate-proficient group (right hemisphere: $-0.3\,\mu$V; left hemisphere: $0.04\,\mu$V; $p = 0.24$). Only at CP3/4 and P3/4, the N400 amplitude between the two groups was different, with larger N400 amplitude elicited in the intermediate-proficient group ($p < 0.020$). In addition, the main effect of *Site* was found only in the high-proficient group ($p < 0.001$), with a significant distribution of the frontal scalp and the largest N400 amplitude at F3/4 ($-0.5\,\mu$V). While in the intermediate-proficient group, there was no significant frontal-posterior distribution of the N400 ($p = 0.105$).

The interaction between Violation and Hemisphere was significant, $F(3, 111) = 6.319$, $p = 0.001$. Simple effect analyses indicated that Violation effect was significant on left hemisphere ($F(3, 111) = 3.944$, $p = 0.016$), but paired comparison among violation types did not show significant differences ($p > 0.05$). The main effect of *Hemisphere* was observed only in semantic violation condition ($p = 0.014$), suggesting significant left hemisphere distribution. The interaction between Violation and Site was significant ($F(21, 777) = 2.236$, $p = 0.029$). Simple effects analyses also indicated that the main effect of *Site* was significant in all violation condition, but their distributions on hemispheres were different: the largest N400 amplitude in non-violation condition was at F7/8 ($-0.4\,\mu$V); syntactic violation at FT7/8 ($-0.5\,\mu$V); semantic-violation ($-0.6\,\mu$V) and double-violation at F3/4 ($-0.9\,\mu$V).

The interaction between *Translation* and *Site* was significant ($F(7, 259) = 5.623$, $p = 0.001$), indicating that literal and free translation sentences had similar hemispherical distribution (LTPS: $F(7, 31) = 12.187$, $p < 0.001$, largest at F3/4(-0.667 μV); FTPS: $F(7, 259) = 14.746$, $p < 0.001$, largest at F3/4 ($-0.6\,\mu$V)), while at F7/8 and FT7/8, N400 amplitude was larger in FTSs than LTSs (F7/8: the N400 amplitude in LTSs was $-0.1\,\mu$V and that in FTSs was $-0.52\,\mu$V; FT7/8: N400 amplitude in LTSs was $-0.2\,\mu$V and that in FTSs was $-0.6\,\mu$V).

P600

Midline Scalp There was a significant main effect of *Group* ($F(1, 37) = 5.028,\ p = 0.031$) with greater P600 in the high-proficient group (4.5 μV) relative to the intermediate-proficient group (2.6 μ V). This intergroup difference was found in middle-posterior scalp (Cz/CPz/Pz) ($F(4, 148) = 5.231,\ p = 0.015$). There was also a significant main effect of *Violation* ($F(3, 111) = 9.667,\ p < 0.001$) with greater P600 for syntactic violation (4.7 μV) than double-violation (3.6 μV) and semantic violation (2.8 μV). Paired comparison revealed that there was significant difference respectively between non-violation and syntactic violation ($p < 0.001$), and between semantic and syntactic violation ($p < 0.001$) while no significance reached between double violation and syntactic violation ($p > 0.05$).

Laterality Analyses The main effect of *Violation* was significant ($F(3, 111) = 4.635,\ p = 0.005$), with the maximum amplitude in syntactic violation condition (3.0 μV) and the minimum amplitude in semantic violation condition (1.9 μV). The main effect of Site was also significant ($F(7, 259) = 13.718$, $p < 0.001$), with the largest P600 at C3/4 sites (3.358 μV). The interaction between Translation and Site was also significant ($F(7, 259) = 5.013$, $p = 0.001$). And follow-up analysis revealed that the P600 elicited in LTSs (2.3 μV) was larger than that in FTSs (1.9 μV) at F7/8 sites ($F(1, 37) = 4.780,\ p = 0.035$). While at FT7/8 sites, the P600 elicited in FTSs (1.0 μV) was larger than that in LTSs (0.7μV) ($F(1, 37) = 5.537$, $p = 0.024$).

Discussion

According to behavioral data, the high-proficient group performed better than the intermediate-proficient group in all experimental conditions, which showed that L2 proficiency does affect L2 processing.

Both accuracy rates and reaction times indicated that the high-proficient group was more sensitive to syntactic and double violations (accuracy rates and response times in double violations had no significant differences from those in syntactic violations). In contrast, there were no significant differences between semantic and syntactic violations in the intermediate-proficient group, though slightly higher accuracy rates and shorter response times were found in syntactic violations (accuracy rates and response times for double violations were similar to those for semantic violations). According to the results, we can make the following inference: when reading sentences with double violations, participants of different L2 proficiency will use different language cues to retrieve and process the language information. Specifically, high-proficient participants give priority to syntactic cues, while the intermediate-proficient participants rely largely on semantic cues, which are is consistent with Shallow Structure Hypothesis (SSH), from Clahsen and Felser (2006a, b). According to SSH, L2 syntactic processing is different from L1 in nature. The grammatical representation built in L2 learners is shallower. They can process morphological violations but syntactic processing in a native—like pattern. So, L2 learners (especially low proficient L2 learners) heavily rely on semantic and pragmatic information of lexicon as compensatory processing strategies to understand the L2 sentences, which do not necessarily indicate that L2 learners are lack of syntactic knowledge but their grammatical representation is incomplete (Clahsen and Felser 2006a, b). In fact, the process of L2 acquisition and comprehension is not static but dynamic: during L2 learning, learners first develop their abilities of L2 semantic processing while responses to syntactic information are a little slower. The result is also consistent with findings from

Jiang (2007). With the improvement of L2 proficiency, L2 learners become more sensitive to syntactic information. Thus, we can make the assumption: L2 proficiency is the manipulated variable determining which process will gain the priority, syntactic information process or semantic process, which also was supported by Perani et al. (1998) that L2 proficiency is more important as a determinant of the cortical representation of L2.

At the same time, behavioral data also found the transfer effect in syntactic structure: only *translation* effect was found in syntactic violations for the response times of literal translation sentences (597 ms) were shorter than those of free translation sentences (642 ms, $p < 0.01$). This revealed that there was the cognitive assimilation of syntactic structure between Chinese '*bei*' sentences and corresponding English passive sentences. This *translation* effect was more significant in the intermediate-proficient group: in LTSs, the shortest reaction time was found in syntactic violations and the longest reaction time was in semantic violation; while for FTSs, the longest reaction time was found in syntactic violation. The result indicated that being without positive transfer effect from L1 and not having formed a stably internalized 'syntactic system' of FTSs, the intermediate-proficient L2 learners had much difficulty in syntactic processing.

The ERP components analyses found an ERP component: P200. According to the overall average figure, we measured the peak and latency of P200 on the frontal-central region (the time window is 140–220 ms following stimulation). While Ojima et al. (2005) found a dorsal lateral region P200 with right hemispheric superiority effect evoked by Japanese-English L2 learners. They found, in syntactic violations, the amplitude of P200 in the midline area evoked by both high-proficient and low-proficient L2 learners were greater than that by English native speakers, which was also reported by Weber-Fox and Neville (2001). Accordingly, Ojima et al. suggested that the P200 component reflected an unfamiliarity of language materials, But P200 was not the essential difference between L1 and L2. In addition, Ojima et al. found that the amplitude of P200 evoked by low-proficient L2 learners was greater than high-proficient ones ($6.896\,\mu V > 6.363\,\mu V$), but they did not make further analyses. Furthermore, King and Kutas (1998) reported that the amplitude of P200 evoked by low-frequency words was greater than that by high-frequency words in L1 processing.

We found that the amplitude of P200 in the high-proficient group was greater than that in the intermediate-proficient group, with a significant distribution in left frontal-central region. This finding could not be explained simply by claims from Ojima et al. that 'P200 reflects the unfamiliarity of language materials'. We suggested that the P200 may reveal L2 learners' 'awareness' mode of English passive sentences. That is to say, L2 learners may construct a different 'mental module' about English passive sentences from L1. When they are aware that upcoming language information is similar to their 'mental module', they will retrieve the 'mental module'. High-proficient learners had stronger 'awareness' and higher excitability to the critical label of 'English passive sentences', so the greater P200 was observed. On the other hand, it also indicated that the syntactic knowledge about English passive sentences was not internalized to be a stable mental syntactic system in those low-proficient L2 learners. But for literal translation sentences (similar structures with L1) with the explicit label of 'English passive sentences', the 'awareness' process was easily triggered, so the P200 evoked by literal translation sentences was evidently greater than that by free translation sentences, and correspondingly, the reaction time of the former was also shorter (LTSs: 654 ms $<$ FTSs: 666 ms). This result indicated that there was the syntactic similarity between L1 and L2: literal translation sentences with similar structures to Chinese *'bei'* sentences will easily evoke participants' 'awareness' and elicit the greater P200.

However, there is another explanation about P200. According to Luck (2005), the early exogenous ERP components are believed to reflect sensory and perceptual characteristics of the eliciting stimulus. Thus, the P200 indicated that the L2 learners had searched and detected the stimulation features quickly in English passive sentences, and then they would choose some easy and familiar information to process: for semantic and double violations, intermediate-proficient participants would process semantic information first, while for syntactic and double violations, high-proficient participants would make syntactic analyses first. In the same conditions, the P200 effect elicited by the high-proficient group was greater than that by the intermediate-proficient group, indicating that high-proficient participants were better at the detection of stimulation features than intermediate-proficient participants, which is also inconsistent with findings from Ojima et al. (2005). As to different translation types, the P200 effect evoked by literal translation sentences was greater than that by free translation sentences, which also indicated that for L2 learners, characteristics of LTSs were easier to be detected than FTSs.

This study also found that both semantic violations and double violations evoked a significant N400. At the same time, the high-proficient group evoked an evident N400 only in double violations, but the intermediate-proficient group evoked the N400 in all conditions. These findings indicated that two groups of participants adopted different analysis strategies during English passive sentence processing: high-proficient participants paid more attention to syntactic analysis, while intermediate-proficient participants focused thoroughly on the semantic processing strategy. It proved that with the development of the L2 proficiency, L2 learners would process the semantic information automatically, and the main indicator of L2 proficiency level is the L2 syntactic processing ability. However, the *Site* effect was observed only in the high-proficient group, showing a significant anterior scalp distribution, while the intermediate-proficient group did not show significant anterior and posterior scalp distribution of N400. This finding showed that the distribution of N400 effect observed in high-proficient participants was similar with native speakers, but different from intermediate-proficient participants. Meanwhile, the semantic information in free translation sentences was more important than that in literal translation sentences, indicating that participants had not formed syntactic structural consciousness in free translation sentences. Furthermore, both the high-proficient group and the intermediate-proficient group evoked the obvious N400 in double violations, and especially the maximum amplitude of N400 was found in high-proficient participants. According to this result, when both syntactic and semantic information are available simultaneously or competitive, participants would automatically make use of semantic information and ignore syntactic information. That is, in English passive sentences processing, L2 learners would automatically or preferentially activate semantic processing, indicating a ‘semantic-processing-centered’ processing instead of ‘syntactic-processing-centered’ which was reported in native speakers of Indo-European languages.

P600 is another important ERP component in L2 comprehension as Sabourin and Stowe (2008) held that P600 related with ungrammaticality can be used to track the native-like L2 processing. The results of the study showed that L2 learners can show a P600 evoked by sentences with syntactic and double violations and the amplitude of P600 evoked by syntactic violations reached the maximum, which was inconsistent with the results reported by Weber-Fox and Neville (1996) suggesting that L2 learners who acquired English between the ages of 11 and 13 showed a P600-like effect. The main effect of*Group* was significant, showing that the amplitude of P600 evoked by the high-proficient group (4.5 μV) was significantly greater than that by the intermediate-proficient group (2.6 μV), which suggested that the high-proficient group was more sensitive to syntactic violation than the intermediate-proficient group. The results indicated that in English passive sentences processing, the essential difference between the high-proficient group and the intermediate-proficient group was syntactic processing ability. So we can conclude from the results of study that L2 proficiency played an important role on syntactic processing.

In the condition of double violations, P600 found in the high-proficient group (4.5 μV) was definitely greater than the one in the intermediate-proficient group (2.8 μV); while N400 in the intermediate-proficient group (−0.04 μV) was largely greater than the high-proficient group (0.2 μV). It proved our previous assumption: the high-proficient group tends to adopt syntactic processing strategy in processing sentences with double violations while the intermediate-proficient group will make use of semantic processing strategy. Taking behavioral data and ERP data together, we claimed that L2 proficiency plays a predominated in processing English passive sentences.

In fact, in the majority of L1 and L2 comprehension studies, researchers did not find or report P200. In our study, however, P200, N400 and P600 were observed, but no ELAN/LAN was visible, which deserves more attention. Some ERP studies proved that early L2 learners or L2 learners of high proficiency show more native-like processing but for late learners or L2 learners of low proficiency, ELAN/LAN or P600 is not observed (Hahne 2001; Hahne and Friederici 2001; Weber-Fox and Neville 1996).

In addition, Hahne et al. (2006) suggested that high levels of proficiency with specific structures are one of the prerequisites for automatic grammatical processing as indexed by the LAN. The specific difficulties L2 learners encounter may partly be influenced by transfer effects from the related L1. Moreover, Steinhauer et al. (2009) claimed that even within the same L2 learners, L2 proficiency levels may differ between specific structures resulting distinct ERP patterns. Hence, we failed to find the ELAN/LAN partly because the similarities and differences between Chinese '*bei*' sentences and English passive sentences and English passive sentences are a kind of difficult grammatical knowledge for Chinese English learners who were influenced by transfer effects from the L1. Participants in our study including high-proficient and intermediate-proficient participants encountered processing difficult. That is, participants may not be proficient in this specific structure and therefore automatic grammatical processing indexed by LAN was not observed. On the other hand, this result can be explained by the claim that the absence of LANs is a typical pattern for late L2 learners (Steinhauer et al. 2009). All in all, Sentence processing mechanisms of Chinese English learners are a little different from the previous findings, which may result from the characteristics of Chinese language.

As shown in the study by Tokowicz and MacWhinney (2005), syntactic similarity between L1 and L2 may also play an important role. In our study, behavioral data revealed that syntactic similarity influenced passive sentence processing. But ERP data about P600 showed the significant interaction between *Translation* and *Site* and P600 elicited by LTSs was larger than that by FTSs at F7/8 sites. So it remains to be further investigated about the role of syntactic similarity on Chinese English learners' English passive sentence processing.

Conclusion

High-proficient participants performed better than intermediate-proficient participants both in reaction times and accuracy rates in all experimental conditions. Shorter reaction times and higher accuracy rates were observed in literal translation sentences than those in free translation sentences. P200 was observed in literal translation sentences which may demonstrate the detection of internalized 'English passive sentences' syntactic structure' or fast detection of semantic features or syntactic features with obvious meanings. High-proficient participants showed most evident P600 in syntactic violation and double violation, while intermediate-proficient participants showed more significant N400 in semantic violation and double violation. Sentence processing of high-proficient and intermediate-proficient participants may be essentially different—the former focused on semantic information processing; the latter focused on syntactic processing. Literal translation sentences caused a larger P200 and P600 while free translation sentences elicited more native-going N400. Behavioral and ERP data supported the influence of L2 proficiency and syntactic similarity on L2 sentence processing, but L2 proficiency played a predominate role.

Acknowledgments Youth project of China national natural science fund "the Moderating mechanism of Late Chinese-English Second Language Learners' Syntactic Processing: behavior and ERP research" (31300928).

References

Ainsworth-Darnell, K., Shuman, H., & Boland, J. (1998). Dissociating brain responses to syntactic and semantic anomalies: Evidence from event-related potentials. *Journal of Memory and Language*, *38*, 112–130.

Ardal, S., Donald, M. W., Meuter, R., et al. (1990). Brain responses to semantic incongruity in bilinguals. *Brain and Language*, *39*(2), 187–205.

Birdsong, D., & Molis, M. (2001). On the evidence for maturational constraints in second-language acquisition. *Journal of Memory and Language*, *44*(2), 235–249.

Chen, L., Shu, H., Zhao, L. J., et al. (2007). ERP signatures of subject-verb agreement in L2 learning. *Bilingualism, Language and Cognition*, *10*, 161–174.

Clahsen, H., & Felser, C. (2006a). Grammatical processing in language learners. *Applied Psycholinguist*, *27*(1), 3–42.

Clahsen, H., & Felser, C. (2006b). How native-like is non-native language processing? *Trends in Cognitive Sciences*, *10*, 564–570.

Coulson, S., King, J. W., & Kutas, M. (1998). ERPs and domain specificity: Beating a straw horse. *Language and Cognitive Processes*, *13*(6), 653–672.

Dussias, P. E., & Cramer Scaltz, T. R. (2008). Spanish-English L2 speakers' use of subcategorization bias information in the resolution of temporary ambiguity during second language reading. *Acta Psychologia*, *128*(3), 501–503.

Flege, J. E., & MacKay, I. R. A. (2004). Perceiving vowels in a second language. *Studies in Second Language Acquisition*, *26*(1), 1–34.

Friederici, A. D. (2002). Towards a neural basis of auditory sentence processing. *Trends in Cognitive Sciences*, *6*(2), 78–84.

Friederici, A. D., Hahne, A., & Saddy, D. (2002). Distinct neurophysiological patterns reflecting aspects of syntactic complexity and syntactic repair. *Journal of Psycholinguistic Research*, *31*(1), 45–63.

Friederici, A. D., et al. (1996). Temporal structure of syntactic processing: Early and late event-related potential effects. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *22*, 1219–1248.

Gunter, T. C., Friederici, A. D., & Hahne, A. (1999). Brain responses during sentence reading: Visual input affects central processes. *NeuroReport, 10*, 3175–3178.

Hagoort, P., Brown, C., & Groothusen, J. (1993). The syntactic positive shift (SPS) as an ERP measure of syntactic processing. *Language and Cognitive Processes*, *8*, 439–483.

Hahne, A. (2001). What's different in second language processing? Evident from event-related brain potentials. *Journal of Psycholinguistic Research*, *30*, 251–266.

Hahne, A., & Friederici, A. D. (1999). Electrophysiological evidence for two steps in syntactic analysis: Early automatic and late controlled processes. *Journal of Cognitive Neuroscience*, *11*, 194–205.

Hahne, A., & Friederici, A. D. (2001). Processing a second language: Late learners' comprehension mechanisms as revealed by event-related brain potentials. *Bilingualism: Language and Cognition*, *4*, 123–141.

Hahne, A., Mueller, J. L., & Clahsen, H. (2006). Morphological processing in a second language: Behavioral and event-related brain potential evidence for storage and decomposition. *Journal of Cognitive Neuroscience*, *18*, 121–134.

Hawkins, R. (2001). *Second language syntax*. Malden: Blackwell Publishers.

Hopp, H. (2006). Syntactic features and reanalysis in near-native processing. *Second language research*, *22*(3), 369–397.

Jiang, N. (2007). Selective integration of linguistic knowledge in adult second language learning. *Language Learning*, *57*(1), 1–33.

Johnson, J. S., & Newport, E. L. (1989). Critical period effects in second language learning: The influence of maturational state on the acquisition of English as a second language. *Cognitive Psychology*, *21*, 60–99.

Kaan, E., & Swaab, T. Y. (2003). Repair, revision, and complexity in syntactic analysis: An electrophysiological differentiation. *Journal of Cognitive Neuroscience*, *5*, 335–344.

King, J. W., & Kutas, M. (1998). Neural plasticity in the dynamics of human visual word recognition. *Neuroscience Letters*, *244*(2), 61–64.

Kotz, S. A., Holcomb, P. J., & Osterhout, L. (2008). ERPs reveal comparable syntactic sentence processing in early bilinguals and monolinguals. *Acta Psychologica*, *128*(3), 514–527.

Kutas, M., & Kluender, R. (1994). What is who violating? A reconsideration of linguistic violations in light of event-related brain potentials. In H. J. Heinze, T. F. Münte, & G. R. Mangun (Eds.), *Cognitive electrophysiology: Basic and clinical applications*. Boston: Birkhäuser.

Li, R. B., Peng, D.-L., & Guo, T.-M. (2003). A study on Chinese and English semantic access with ERP technology. *Acta Psychologica Sinica*, *35*(3), 309–316.

Luck, S. J. (2005). *An introduction to the event-related potential technique*. Cambridge, MA: MIT Press.

McDonald, J. L. (2000). Grammaticality judgments in a second language: Influences of age of acquisition and native language. *Applied Psycholinguistics*, *21*(3), 395–423.

Münte, T. F., Heinze, H., & Magnum, G. (1993). Dissociation of brain activity related to syntactic and semantic aspects of language. *Journal of Cognitive Neuroscience*, *5*, 335–344.

Natalie, A. P., Denise, K., Mercier, J., et al. (2006). ERP measures of auditory word repetition and translation priming in bilinguals. *Brain Research*, *1125*(1), 116–131.

Neville, H. J., Nicol, J., Barss, A., Forster, K., & Garrett, M. F. (1991). Syntactically based sentence processing classes: Evidence from event-related brain potentials. *Journal of Cognitive Neuroscience*, *3*, 151–165.

Ojima, S., Nakata, H., & Kakigi, R. (2005). An ERP study of second language learning after childhood: Effects of proficiency. *Journal of Cognitive Neuroscience*, *17*(8), 1212–1228.

Osterhout, L. (1997). On the brain response to syntactic anomalies: Manipulations of word position and word class reveal individual differences. *Brain and Language*, *59*(3), 494–522.

Osterhout, L., & Holcomb, P. J. (1992). Event-related potentials elicited by syntactic anomaly. *Journal of Memory and Language*, *2*, 785–806.

Osterhout, L., & Holcomb, P. J. (1993). Event-related potentials and syntactic anomaly: Evidence of anomaly detection during the perception of continuous speech. *Language and Cognitive Processes*, *8*, 413–438.

Osterhout, L., Holcomb, P. J., & Swinney, D. A. (1994). Brain potentials elicited by garden-path sentences: Evidence of the application of verb information during parsing. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *20*(4), 786–803.

Osterhout, L., & Mobley, L. A. (1995). Event-related potentials elicited by failure to agree. *Journal of Memory and Language*, *34*, 739–773.

Osterhout, L., & Nicol, J. (1999). On the distinctiveness, independence, and time course of the brain responses to syntactic and semantic anomalies. *Language and Cognitive Processes*, *14*(3), 283–317.

Pan, W.-G. (2004). *Comparative guidelines of Chinese and English*. Beijing: Beijing Language University Press.

Perani, D., Paulesu, E., Sebastian-Galles, N., Dupoux, E., Dehaene, S., & Bettinardi, V. (1998). The bilingual brain: Proficiency and age of acquisition of the second language. *Brain*, *121*(10), 1841–1852.

Roberts, L., & Felser, C. (2011). Plausibility and recovery from garden paths in second language sentence processing. *Applied Psycholinguistics*, *32*(2), 299–331.

Roberts, L., & Meyer, A. (2012). Individual differences in second language sentence processing. *Language Learning*, *62*(2), 1–4.

Rösler, F. (1993). Event-related brain potentials while encountering semantic and syntactic constraint anomalies. *Journal of Cognitive Neuroscience*, *5*, 345–362.

Rossi, S., Gugler, M. F., Friederici, A. D., & Hahne, A. (2006). The impact of proficiency on syntactic second-language processing of German and Italian: Evidence form event-related potentials. *Journal of Cognitive Neuroscience*, *18*, 2030–2048.

Sabourin, L. D., & Stowe, L. A. (2008). Second language processing: When are first and second languages processed similarly? *Second Language Research*, *24*(3), 397–430.

Sanders, L. D., & Neville, H. J. (2003). An ERP study of continuous speech processing: II. Segmentation, semantics, and syntax in non-native speakers. *Cognitive Brain Research*, *15*(3), 214–227.

Semlitsch, H. V., Anderer, P., Schuster, P., & Presslich, O. (1986). A solution for reliable and valid reduction of ocular artifacts, applied to the P300 ERP. *Psychophysiology*, *23*, 695–703.

Steinhauer, K., White, E. J., Cornell, & Drury, J. E. (2009). Temporal dynamics of second language acquisition: Evidence from event-related brain potentials. *Second Language Research*, *25*(1), 13–41.

Tokowicz, N., & MacWhinney, B. (2005). Implicit and Explicit measures of sensitivity to violations in second language grammar: An event-related potential investigation. *Studies in Second Language Acquisition*, *27*, 173–204.

Tolentino, L. C., & Tokowicz, N. (2011). Across languages, space, and time: A review of the role of cross-language similarity in L2 (morpho)syntactic processing as revealed by fMRI and ERP methods. *Studies in Second Language Acquisition*, *33*(1), 91–125.

VanBerkum, J. A., Hagoort, P., & Brown, C. M. (1999). Semantic integration in sentences and discourse: Evidence from the N400. *Journal of Cognitive Neuroscience*, *11*(6), 657–671.

Weber-Fox, C. M., & Neville, H. J. (1996). Maturational constraints on functional specializations for language processing: ERP and behavioral evidence in bilingual speakers. *Journal of Cognitive Neuroscience*, *8*, 231–256.

Weber-Fox, C. M., & Neville, H. J. (2001). Sensitive periods differentiate processing of open and closed class words: An ERP study of bilinguals. *Journal of Speech, Language, and Hearing Research*, *44*, 1338–1353.

White, L. (2003). *Second language acquisition and Universal Grammar*. Cambridge: Cambridge University Press.

Williams, J. N. (2006). Incremental interpretation in second language sentence processing. *Bilinguialism: Language and Cognition*, *9*(1), 71–81.

Xiong, X.-L., & Wang, Z.-J. (2003). The cognitive interpretation of passive sentences. *Foreign Language Teaching and Research*, *35*(3), 195–199.

Ylinen, S., Shestakova, A., Alku, P., & Huotilainen, M. (2005). The perception of phonological quantity based on durational cues by native speakers, second-language users and non speakers of Finnish. *Language and Speech*, *48*(3), 313–338.