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Research article

Semantic violation in sentence reading and incongruence in chord sequence comprehension: An ERP study

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ABSTRACT

To address the controversy on cognitive resources sharedness between language and music in semantic processing, two experiments were conducted via the interference paradigm using the Event-Related Potential (ERP) technique. In Experiment 1, a five-word sentence and a five-chord sequence were simultaneously presented in a trial. The sentence (e.g., '警察捡到了一部手机/钱包*,' *The policeman found a mobile phone/wallet*) ended with a semantically acceptable or unacceptable number-classifier-noun collocation (NCN), and the final chord of the chord sequence was congruent or incongruent with the preceding chords in tone. The stimuli in Experiment 1 were adapted in Experiment 2: The particle '了' was removed, and a three-word-long, object-gap relative clause was inserted ahead of the noun of the NCN in each sentence; two chords were inserted ahead of the third chord in each chord sequence. Both similarities and differences were revealed between Experiments 1 and 2, concerning the influences of the manipulated variables on the amplitude of the ERP component N400. In conclusion, the dissolution of semantic violation in sentence reading was likely to happen in parallel with music processing in chord sequence comprehension by non-musician Chinese native speakers, but interaction was observable between language and music in semantic processing when the sentences ended with long-distance NCNs.

1. Introduction

Language and music both are organized by single elements with a set of compositional principles [1-6]. Similarities exist between language and music in syntactic processing [7-13], but there is debate about the event to which resources are shared between language and music in semantic processing [9–11,13–18]. The present study attempts to address this issue via the interference paradigm using the Event-Related Potential (ERP) technique.

1.1. Research question

In ERP studies, the P600 effect is observed when participants encounter difficulties in syntactic processing in sentence reading

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[19-22]. In Patel et al. [22], for example, the amplitude of the P600 was significantly larger when participants read syntactically incongruent sentences than when they read syntactically congruent sentences. Prominently, the amplitude of the P600 was also significantly larger when the chord sequences were violated by distant-key than by nearby-key chords, and was significantly larger when the chord sequences were violated by nearby-key chords than when they included no violation. Moreover, no significant differences were observed between language and music processing concerning the amplitude and the scalp distribution pattern of the P600 component. Similarly, Koelsch et al. [23] simultaneously presented a sentence, in which the noun was in syntactic agreement (e.g., 'Er trinkt das kühle Bier. *He drinks the$_{[neuter]}$ cool$_{[neuter]}$ beer$_{[neuter]}$*') or disagreement (e.g., 'Er trinkt den kühlen Bier. *He drinks the$_{[masc.]}$ cool$_{[masc.]}$ beer$_{[neuter]}$*') with the preceding definite article and adjective, and a regular or irregular chord sequence, and recorded participants' ERP responses. The amplitude of the left anterior negativity for the sentence in syntactic disagreement was significantly smaller when paired with an irregular than with a regular chord sequence. In other words, there was competition for the same resources between language and music in syntactic processing.

Similar to language, music also communicates complex and nuanced meanings [24] and is capable of transferring semantic concepts [18,25–27]. However, in-consistence appears to exist among the relevant conclusions concerning the relationship between language and music in semantic processing. On the one hand, several studies suggest that music is independent of language in semantic processing [9,11,13–15,23]. For example, Carrus et al. [15] manipulated probability level of the final notes in melodies and semantic violation between verbs and nouns in sentences (e.g., ' … driving a car/a book') in a similar paradigm. Participants were required to decide whether or not the sentences were acceptable. The electroencephalogram (EEG) results yielded null interactions between the processing of the last word in sentence reading and that of the last note in music comprehension.

On the other hand, there are other studies [16–18] which clearly indicate that domain-general resources might be used in music and language processing in semantics. In the interference paradigm, for example, Steinbeis and Koelsch [18] simultaneously presented sentences, which ended with nouns of high ('Er trinkt das kühle Bier. *He drinks the cool beer*') or low predictability ('Er sieht das kühle Bier. *He sees the cool beer*'), and chord sequences, the final chords of which were congruent or incongruent with the preceding chords. Participants were instructed only to pay attention to the chord sequences. The results showed that the amplitude of N500 was significantly reduced when both semantic violations existed in the sentences and incongruence existed in the chord sequences. N500 is supposed to indicate semantic integration in chord sequence comprehension, which is observed in the right anterior region during the time window of 600–800 ms after the onset of the final chords. Similarly, Poulin-Charronnat et al. [17] presented chord-sung sentences to participants, the last words of which were semantically related or unrelated to the linguistic contexts (e.g., 'La girafe an un très grand pied/crou.' *The giraffe has a very long foot/neck*). The target words were sung on chords that acted either as referential tonic chords or as congruent but less referential subdominant chords. The differences in participants' lexical decision responses to the target words were significantly smaller when the last chords were of a low-leveled probability than when they were of a high-leveled probability. The same pattern of interaction effect was revealed between the reading of semantic garden-path sentences (e.g., 'The old man went to the bank to withdraw his net which was empty') and the processing of chord sequences with out-of-key chords [16].

In fact, there appeared to be differences in language stimuli between these two types of studies. Long-distance dependencies existed between the critical words and the preceding contexts in the sentence stimuli in Poulin-Charronnat et al. [17], Steinbeis and Koelsch [18] and Perruchet and Poulin-Charronnat [16]. For example, participants would not experience a processing difficulty in semantic integration until they encountered the last word in 'La girafe an un très grand pied' (*The giraffe has a very long foot*) in Poulin-Charronnat et al. [17]. However, semantically unacceptable local-distance phrases (e.g., 'angry pigs,' 'driving a book' and 'feeding one kite') were used in Slevc et al. [13], Carrus et al. [15] and Sun et al. [28], for example.

According to the Dependency Locality Theory (DLT) [29], the procedure of sentence reading can be divided into structural storage and structural integration. Structural storage keeps track of predicted syntactic categories, and the incoming word is connected with a previous one in the procedure of structural integration. Integration cost increases as the distance becomes larger between the new element and the previous one. In other words, it is possible that the different conclusions arrived at by the two schools of thought were influenced by participants' differences in resources consumption in semantic integration. Therefore, the present study seeks to address the following research question: Will an interaction between language and music in semantic processing be seen via the interference paradigm in which long-distance rather than local-distance semantic predictability is manipulated?

To answer this question, we conduct two experiments. In Experiment 1, we manipulate local-distance semantic predictability and expect a null interaction between language and music in semantic processing. In Experiment 2, we manipulate long-distance semantic predictability and expect to see a significant interaction between language and music in semantic processing.

1.2. Hypotheses

In Chinese, there is a particular type of collocation (e.g., '一部手机,' *a mobile phone*), which is composed of a number word (e.g., '一,' *one*), a classifier (e.g., '部') and a noun (e.g., '手机,' *mobile phone*). This type of collocation is referred to as NCN (number-classifier-noun) hereafter. The classifier functions as a semantic categorization for the noun. The classifier '本' in '一本书' (*a book*), for example, indicates a kind of object that looks like a book, but the classifier '摞' in '一摞书' (*a stack of books*) suggests the cluster configuration of three or more book-like things with one above another. Meanwhile, the noun determines the use of a classifier to some extent. The blank in '一 树,' for example, can only be filled with the classifier '棵' or '排.' '棵' means a single plant, and '排' a line of things that stand like a row of trees. In other words, the combination of a number word and a specific classifier can only be followed by one of a certain number of nouns. For example, '一部手机' (*a mobile phone*) and '一部汽车' (*a car*) are semantically acceptable, but '一部钱包*' (*a wallet*) and '一部汽艇*' (*a motor boat*) are not.

Therefore, the classifier of an NCN provides a strong cue in semantics for the expectation of the upcoming noun in comprehension.

Indeed, the recognition of the noun (e.g., '钱包,' *wallet*) preceded by an inappropriate classifier (e.g., '部' instead of '个') resulted in a significant increase in the amplitude of the N400 [30,31]. In other words, the integration is more resource-consuming between the noun and the classifier of a semantically unacceptable NCN (e.g., '一部钱包*,' *a wallet*) than between those of a semantically acceptable one (e.g., '一部手机,' *a mobile phone*).

Reading (1) or (2) in Table 1, for example, participants listen to a chord sequence that ends with a chord of a high or low level of probability (see Fig. 1) in the interference paradigm. Both (1) and (2) are syntactically correct. While (1) ends with a semantically acceptable NCN ('一部手机'), (2) ends with a semantically unacceptable NCN ('一部钱包*'). Each sentence is divided into five parts, and the music stimuli (3) and (4) each consist of five chords. These two types of stimuli are presented simultaneously. The sentences are presented in a word-by-word style. The presentation of each word is accompanied by one chord. When the fifth part of the sentence is visually shown, the fifth chord is aurally played at the same time. Thus, Hypothesis One is proposed as follows.

If semantic processing in local-distance sentence reading will be interfered with by music processing, then the amplitude of the N400 on the fifth part of (2) will be affected by whether the music stimulus is (3) or (4).

(1) in Table 1 is changed into (5) in Table 2, with the particle '了' removed and with an object-gap relative clause (e.g., '游客丢失的,' *that a tourist might have left*) inserted between the classifier (e.g., '部') and the noun (e.g., '手机') of the NCN (e.g., '一部手机'). The reason why '了' is removed is that its meaning of completion often comes from the meaning of the verb with which it occurs [32], and thus its use is largely optional from a semantic point of view. Meanwhile, a short sentence like '警察捡到了一部游客丢失的手机,' for example, would sound redundant, due to the co-existence of the two particles '了' and '的.' According to DLT, readers will experience a larger integration cost encountering the noun in (5) than in (1). Thus, Hypothesis Two is proposed as follows.

If semantic processing in long-distance sentence reading will be interfered with by music processing, then the amplitude of the N400 on the seventh part of (6) will be affected by whether the music stimulus is (7) or (8) (see Fig. 2).

Two experiments were conducted to test these two hypotheses. In Experiment 1, the language stimuli were sentences that were divided into five parts (see (1) in Table 1, for example), and there were no words inserted between the classifiers and the nouns in the NCNs. In Experiment 2, the language stimuli were sentences that were divided into seven parts (see (2) in Table 2, for example), and there was a three-word, object-gap relative clause inserted between the classifier and the noun in the NCN of each sentence. Accordingly, the chord sequences consisted of five (see Fig. 1) and seven chords (see Fig. 2) in Experiments 1 and 2, respectively.

2. Method

2.1. Participants

Experiment 1. Twenty-six students (11 females; $M = 18.68$ years, $SD = 0.77$ years) were recruited on the campus of Qufu Normal University by means of a flyer advertisement. They were all right-handed Chinese native speakers. None of them had a history of neurological, language-related, or hearing problems, and all had normal or corrected-to-normal vision. They received an average of 0.30 years ($SD = 0.81$ years) of music training and listened to music for 0.79 h ($SD = 0.63$ h) every day. They achieved an average score of 90.30% ($SD = 3.03\%$) in responding to the Montreal Battery of Evaluation of Amusia [33].

Experiment 2. Twenty-six participants (13 males, $M = 19.11$, $SD = 1.29$) were recruited in the same way as in Experiment 1, who received 0.31 years ($SD = 0.81$ years) of music training and listened to music for 0.77 h ($SD = 0.62$ h) every day. They achieved an average score of 90.33% ($SD = 3.14\%$) in responding to the MBEA.

All the participants were naive to the purpose of the research. They provided written informed consent in accordance with the Declaration of Helsinki, and each of them received 50 yuan as a reward for his or her participation. The study was approved by the Biomedical Ethics Committee of Qufu Normal University.

2.2. Stimuli

With reference to Guo [34] we obtained 30 semantically acceptable NCNs and the same number of semantically unacceptable NCNs. Twenty-five students from the same pool as participants rated the acceptability of the 60 NCNs on a seven-point scale (1 = very unacceptable; 7 = very acceptable). The evaluation scores were significantly larger for the semantically acceptable ($M = 6.84$, $SD = 0.37$) than for the semantically unacceptable NCNs ($M = 1.08$ $SD = 0.59$) ($t_{(58)} = 52.54$, $p < .001$, $d = 15.27$). The nouns of the NCNs in the semantically acceptable NCNs ($M_{\text{frequency}} = 6.89$, $SD_{\text{frequency}} = 7.71$; $M_{\text{stroke}} = 16.93$, $SD_{\text{stroke}} = 4.10$) were not significantly

Table 1
Examples of language stimuli in Experiment 1.

(1)	警察	捡到	了	一部	手机。
	Jingcha	Jiandao	le	yibu	shouji
	The policeman	*Found*		*one*	*mobile phone.*
(2)	警察	捡到	了	一部	钱包。*
	Jingcha	Jiandao	le	yibu	qianbao
	The policeman	*Found*		*one*	*wallet.*

Note. The combination of the number word '一' and the classifier '部' is taken as a number-classifier combination. The particle '了' functions to specify the tense for the verb '捡到.' Since '了' is regarded as a functional word, it is presented as a separate junk.

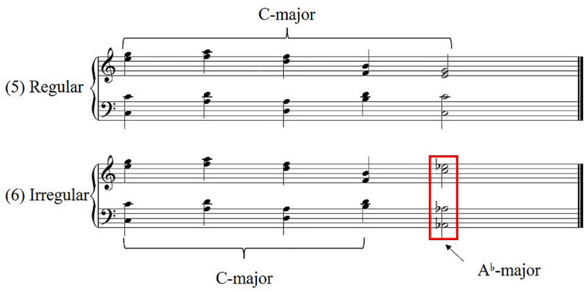

Fig. 1. Examples of music stimuli in Experiment 1.

Table 2
Examples of language stimuli in Experiment 2.

(5)	警察	捡到	一部	游客	丢失	的	手机。
	jingcha	Jiandao	yibu	youke	diushi	de	shouji
	The policeman	*found*	*one*	*tourist*	*might have left*		*mobile phone that*
(6)	警察	捡到	一部	游客	丢失	的	钱包。*
	jingcha	jiandao	yibu	youke	diushi	de	qianbao
	The policeman	*found*	*one*	*tourist*	*might have left*		*wallet that*

Note. The particle '的' functions to end the relative clause.

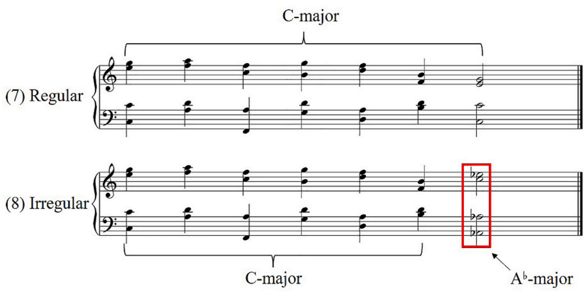

Fig. 2. Examples of music stimuli in Experiment 2.

different from those in the semantically unacceptable NCNs ($M_{frequency} = 4.97$, $SD_{frequency} = 7.28$; $M_{stroke} = 16.67$, $SD_{stroke} = 4.47$) in frequency [35] ($t_{(58)} = 0.991$, $p = .326$) or in number of strokes ($t_{(58)} = 1.81$, $p = .076$).

Experiment 1. A sentence was created for each NCN, in which the NCN functioned as an object. In total, we obtained 30 sentences that ended with semantically acceptable NCNs and 30 sentences that ended with semantically unacceptable NCNs (see Appendix I). Thirty semantically acceptable filler sentences were created that were similar to the experimental sentences in length and readability. The filler sentences also ended with semantically acceptable NCNs but were different from the experimental sentences in syntactic structure. Thirty semantically unacceptable filler sentences were created in the same way. Each sentence would be followed by a reading comprehension question. Participants' high accuracy in answering the questions would guarantee their carefulness in their task performance.

Thirty pairs of five-chord sequences were composed by a professional musician. The two sequences in each pair were different from each other only in the fifth chord (see Fig. 1). The chord sequence of high-level probability ended with an in-key chord, but the one of low-level probability with an out-of-key chord.

Experiment 2. The stimuli in Experiment 1 were adapted, with the particle '了' removed in each sentence and with a three-word-long, object-gap relative clause inserted ahead of the noun of each NCN (see Appendix II). The chord sequences in Experiment 1 were adopted in Experiment 2 and were lengthened by inserting two chords that were in tone with the previous two chords ahead of the third chords (see Fig. 2).

2.3. Design

The design formed a 2 (sentence type: sentences that ended with semantically acceptable or unacceptable NCNs) * 2 (chord sequence type: chord sequences that ended with a chord of high- or low-level probability) repeated factorial in each experiment. The dependent variable was the amplitude of the N400, which should indicate violation detection of semantic processing in NCN understanding [31,36]. With 26 participants at each treatment level of the design there would be an 82% power to achieve an effect size of 0.25 at the two-sided significance level of 0.05.

2.4. Procedure

The experiment was conducted in the Lab of Psycholinguistics at Qufu Normal University. Participant was seated in front of the computer screen in a sound-attenuated and electrically shielded room. He or she was instructed to move as little as possible, and an EEG cap was put on his or her head to record the brain response during the experiment. The sentences were presented visually word by word with the music sequences presented aurally simultaneously: one word matching one chord. Each trial started with a fixation cross that lasted for 500 ms, and then the first words were presented at the center of the screen. The first four segments each lasted 600 ms, and the final part lasted 1200 ms. Participants were instructed to pay attention to the sentences (ignoring the music) and answer the question 'Is the sentence acceptable?' by pressing buttons with the first finger of the right or the left hand, and then the next trial began. The association between response buttons was counterbalanced across participants. The presentation order was pseudo-randomized and no more than three sentences from the same condition were presented consecutively. The stimuli were split into two blocks, with each block containing 60 trials of all types of conditions. A short break of about 10 min was provided to each participant, and the whole experiment lasted around an hour including preparation.

The EEG was recorded in DC mode from a 64-channel Ag/AgCl electrode Quick-Cap that was extended according to the 10–20 system, using NeuroScan Acquire Software with a SynAmps^2 amplifier (Compumedics, Melbourne Australia), digitized at a sampling rate of 1 kHz. The EEG was physically referenced to the nose tip. The VEOG electrodes were recorded from electrodes placed above and below the left eye, and the HEOG electrodes were recorded from electrodes placed at the outer canthus of each eye. The electrode impedance was kept below 5 KΩ.

The EEG data were re-referenced offline to the average of the left and right mastoid with a band-pass filter of 0.1–30 Hz (24Db/

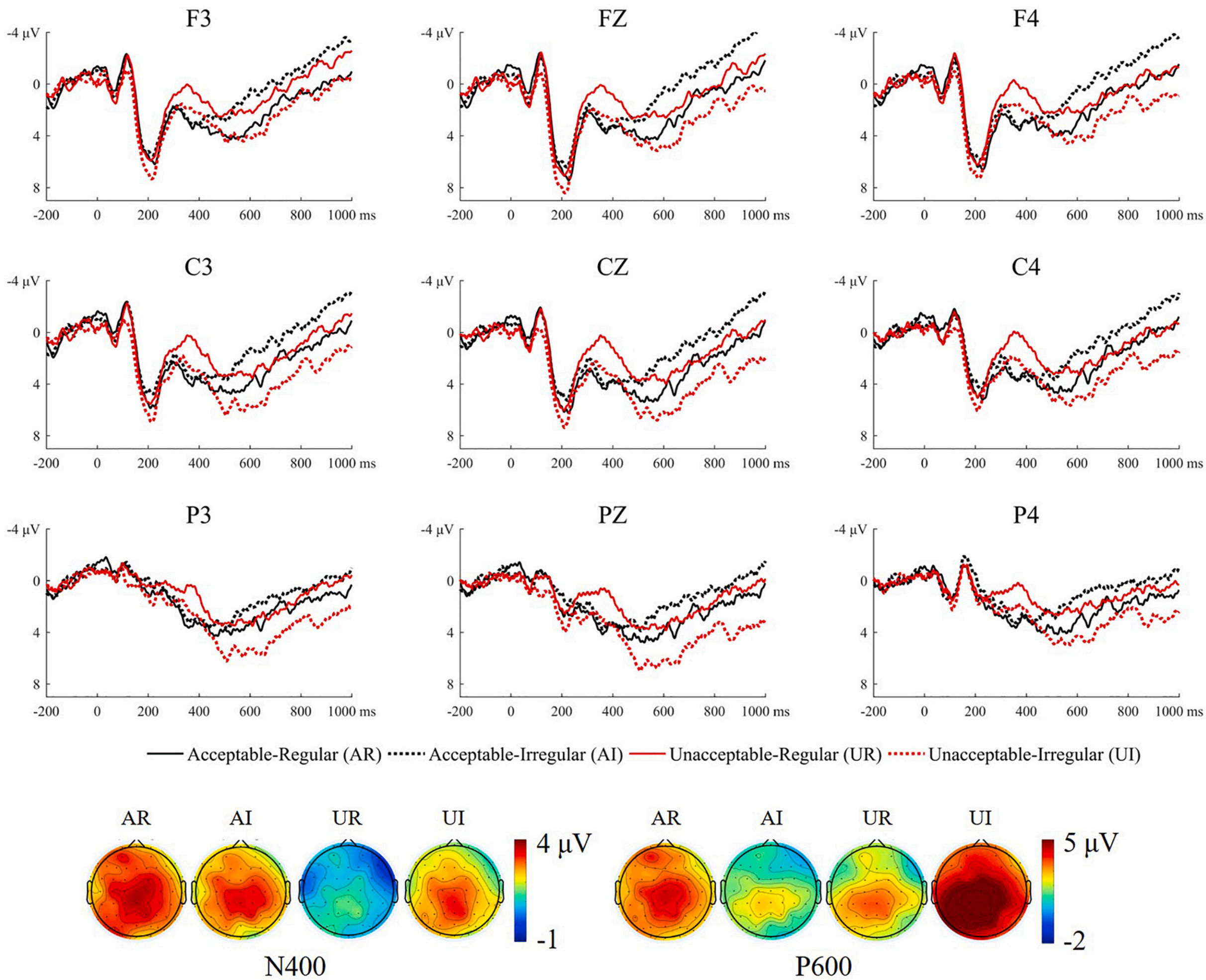

Fig. 3. *Grand averages of ERP waveform in Experiment 1.*

octave roll-off) in MATLAB 2016a using version 13.5.4 b of EEGlab [37], version of 7 of ERPlab [38] and the toolbox of Evoked ERP_ERO_v1.1 [39].

3. Results

3.1. Experiment 1

The data for two participants were excluded because of their excessive artifacts in the ERP data. The 24 participants achieved an accuracy average of 0.92 ($SD = 0.07$) in answering the reading comprehension questions, indicating that they had performed the task very carefully. The ERPs were averaged offline within the epoch from 200 ms before to 1000 ms after the onset of the last word, with the 200 ms pre-stimulus measurements as the baseline. The electrodes were grouped into four regions of interest: left anterior (F1, F3, F5, FC1, FC3, FC5), right anterior (F2, F4, F6, FC2, FC4, FC6), left posterior (CP1, CP5, CP3, P1, P3, P5) and right posterior (CP2, CP4, CP6, P2, P4, P6) [15]. Fig. 3 illustrates the waveform patterns of the components at nine representative electrodes, a visual inspection of which suggested the appearance of the P600 in the time window of 500–700 ms after the presentation onset of the last pair of stimulus segments. Similar to previous studies [15,31], we adopted a data-driven approach and determined 300–450 ms as the time window for the N400. 2 (sentence type) * 2 (chord sequence type) * 2 (anteriority: anterior or posterior regions) * 2 (hemisphere: left or right hemisphere) ANOVAs of repeated measurements were conducted to the amplitudes of the N400 and the P600 (see Appendix III for the effect results), and only significant effects are reported here.

The N400. The main effects were significant for sentence type ($F_{(1, 23)} = 11.07$, $p = .003$, $\eta 2\ p = .36$) and chord sequence type ($F_{(1, 23)} = 6.34$, $p = .020$, $\eta 2\ p = .22$). The amplitude of N400 was significantly larger for the sentences ending with semantically unacceptable ($M = 1.35$ μV, $SE = 0.65$) than with semantically acceptable NCNs ($M = 3.02$ μV, $SE = 0.59$). It was significantly smaller when

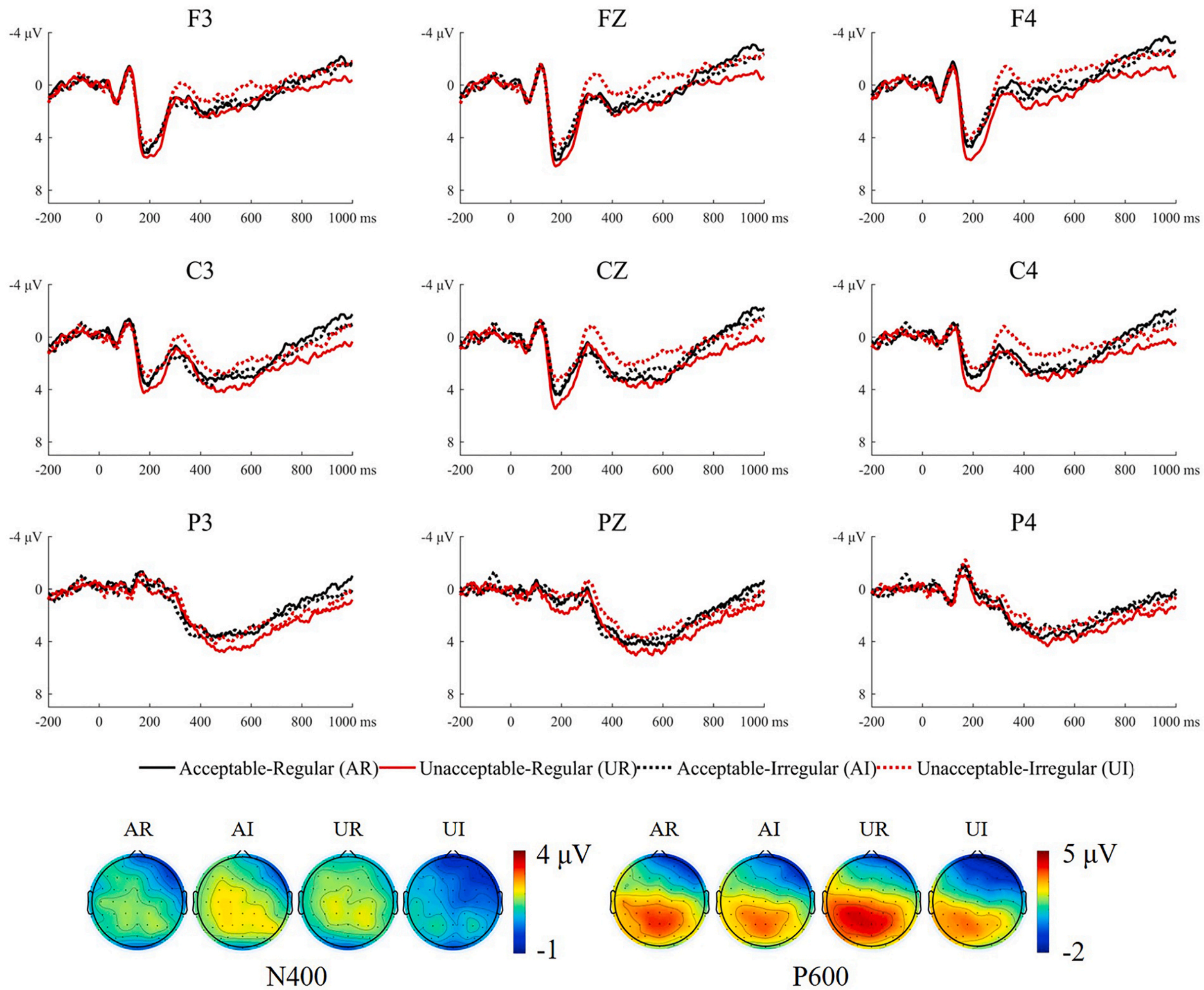

Fig. 4. Grand averages of ERP waveform in Experiment 2.

the chord sequences ended with the chords of a low level ($M = 2.67$ μV, $SE = 0.64$) than with those of a high level of probability ($M = 1.70$ μV, $SE = 0.57$).

The P600. The main effect was significant for hemisphere ($F_{(1, 23)} = 12.94$, $p = .002$, η2 p = .37). The amplitude of the P600 was significantly larger in the left ($M = 3.29$ μV, $SE = 0.61$) than in the right hemisphere ($M = 2.56$ μV, $SE = 0.65$).

3.2. Experiment 2

Participants achieved an accuracy average of 0.89 ($SD = 0.09$) in answering the reading comprehension questions. The ERPs data were pre-treated and analyzed in the same way as in Experiment 1. Probably due to the long-distance dependency of the NCNs, the onsets of the N400 and the P600 were about 50 ms earlier than those in Experiment 1. Thus, the time windows for these two ERP components were selected as 250–400 ms and 450–700 ms. Fig. 4 illustrates the waveform changes of the components at nine representative electrodes.

The N400. The two-way interaction was significant between sentence type and chord-sequence type ($F_{(1, 25)} = 7.22$, $p = .013$, η2 p = .22). The amplitude of the N400 was significantly larger for the sentences that ended with semantically unacceptable ($M = 0.64$ μV, $SE = 0.63$) than for those that ended with semantically acceptable NCNs ($M = 1.76$ μV, $SE = 0.68$) when the chord-sequences ended with chords of low-level probability ($F_{(1, 25)} = 8.21$, $p = .008$, η2 p = .25), and was significantly larger for the chord-sequences of low-level ($M = 0.64$ μV, $SE = 0.63$) than for those of high-level probability ($M = 1.61$ μV, $SE = 0.60$) when the sentences ended with semantically unacceptable NCNs ($F_{(1, 25)} = 11.09$, $p = .003$, η2 p = .31).

The P600. The main effect was significant for chord-sequence type ($F_{(1, 25)} = 7.60$, $p = .011$, η2 p = .23). The amplitude of the P600 was significantly larger for the chord-sequences of high-level ($M = 2.44$ μV, $SE = 0.92$) than for those of low-level probability ($M = 1.74$ μV, $SE = 0.92$).

4. Discussion

We aimed to discover whether there is an interaction between language and music in semantic processing via the interference paradigm in which long-distance instead of local-distance semantic predictability is manipulated in the sentence stimuli. We conducted two experiments using the ERP technique. In Experiment 1, participants read a five-word sentence in a word-by-word style, which ended with a semantically acceptable (e.g., '一部手机,' *a mobile phone*) or unacceptable (e.g., '一部钱包*,' *a wallet*) local-distance NCN (sentence type). At the same time, they were supposed to listen to a sequence of five chords, the last one of which was of high- or low-level probability (chord sequence type). The aural presentation of the chords was in step with the visual presentation of the words. The stimuli of Experiment 1 were adapted in Experiment 2 with the particle '了' removed ahead of the number-classifier combination and a three-word-long, object-gap relative clause inserted in front of the noun of the NCN in each sentence, and with two chords in tone with the preceding chords inserted ahead of the third chord in each chord sequence. The procedure was exactly the same as in Experiment 1. As expected, the two experiments yielded different patterns of results for the influences of sentence type and chord sequence type on the amplitude change of the N400.

In Experiment 1, the amplitude of the N400 was significantly larger for the sentences ending with semantically unacceptable NCNs than for those ending with semantically acceptable NCNs, and was significantly smaller for the chord sequences of low-than for those of high-level probability. In Experiment 2, the amplitude of the N400 was significantly larger for the unacceptable than for the acceptable sentences when the last chords of the chord sequences were of a low level of probability, and was significantly larger for the chord sequences of low-than for those of high-level probability when the sentences ended with semantically unacceptable NCNs. While no effect of the manipulated variables was revealed on the P600 component in Experiment 1, the amplitude of the P600 was significantly larger for the chord sequences of a high level than for those of a low level of probability.

4.1. Semantic processing

The result that no interaction was observed between sentence type and chord sequence type on the ERP components in Experiment 1 seems compatible with previous studies [7,9,10,13,15]. However, the results of Experiment 1 may have an innovative indication when understood in combination with the results of Experiment 2.

When finishing reading the combination of the number word and the classifier (e.g., '一部') of an NCN (e.g., '一部手机,' *a mobile phone*), participants would expect the appearance of a semantic congruent noun (e.g., '手机') in the procedure of sentence comprehension [30]. In accordance with previous studies [31,36,40], Experiment 1 found that the amplitude of the N400 was significantly larger for the sentences that ended with semantically unacceptable NCNs (e.g., '一部钱包*,' *a wallet*) than for those with semantically acceptable NCNs.

Before actually encountering the noun of the NCN (e.g., '手机' or '钱包') in Experiment 2, however, participants had to assign resources to keep the semantic representation active for the number-word-classifier combination (e.g., '一部') while sequentially understanding the three-word relative clause (e.g., '游客丢失的,' *that a tourist might have left*) after the disappearance of the classifier. As predicted by the DLT, their resources might have been severely limited in semantic integration, compared with the case in Experiment 1 when they encountered the noun of the NCN. Meanwhile, music processing was supposed to have occurred during the semantic integration procedure for the NCN. Probably due to the limited availability of neural cognitive resources, competition for the same resources between language and music in semantic processing was observed in the N400 measurement, as predicted by Hypothesis Two. In other words, semantic integration in participants' understanding of the unacceptable NCNs [31,36,40] and music integration in their comprehension of chord sequence of low-level probability [10,22,23] seemed to share the same cognitive resources in the time-window of 250–400 ms. Different from Experiment 2, however, participants should have sufficient resources available for these two types of processing in Experiment 1. As the result, the interference effect had not become strong enough to be observed.

4.2. Chord sequence processing

In Experiment 1, the larger observed amplitude of the N400 for the chord sequences of high probability than of low probability can be explained via the following assumption. Having received little training in music, participants were probably not very experienced in chord sequence comprehension. On encountering the last chords, they might have simply ignored music processing in the condition when the chord sequences were a low-level probability. They only appeared able to attend to the music stimuli in the condition when the chord sequences were of a high-level probability while experiencing semantic integration on the last words in sentence reading. Probably due to the limitation of cognitive resources, however, this type of music processing was postponed to be revealed in the time window of 450–700 ms in Experiment 2. If this line of argument is reasonable, future studies into chord sequence comprehension in musicians are likely to yield a different pattern of results.

In Experiment 2, the result may suggest that the amplitude of the N400 was significantly larger for the chord sequences of a low probability than of a high probability when the sentences ended with semantically unacceptable NCNs. Roncaglia-Denissen et al. [41] simultaneously presented syntactically correct or incorrect sentences and melodies with correct or incorrect keys, and required participants to judge the syntactic correctness of one of these two types of stimuli. Participants' response accuracy was significantly lower when only the sentences or only the melodies were syntactically incorrect than when syntactic violations existed in both or in neither of the two kinds of stimuli. The authors argued that different mechanisms were employed in language and music processing, which interacted with each other. We agree with this argument and similarly propose that the semantic integration mechanism in sentence reading might be distinct from that in music comprehension. The two mechanisms may mutually interact with each other, and the amplitude of the N400 in the condition of semantically unacceptable NCNs was only facilitated by irregularity of the chord sequences of low-level probability. Future research is needed to confirm this argument.

4.3. Implications and limitations

The fact that dissolution of semantic violation in sentence reading was likely to happen in parallel with music processing in chord sequence comprehension is compatible with the fact that music is similar to language, in terms of being able to transfer semantic concepts [18,25–27] and to communicate complex and nuanced meanings [24]. When the availability of cognitive resources was severely constrained, however, interruption was likely to happen between semantic processing in sentence reading and music processing in chord sequence comprehension in the interference paradigm, elegantly confirming Steinbeis and Koelsch [18], Poulin-Charronnat et al. [17], and Perruchet and Poulin-Charronnat [16].

The implication of the present study is crucial. When there is a rich availability of cognitive resources, as displayed in Experiment 1, the readers seem able to process the language stimuli separately from how they process the music stimuli. When they have to perform semantic processing in sentence reading and experience music comprehension at the same time with a certain amount of extra consumption of cognitive resources, as illustrated in Experiment 2, however, their semantic processing will be severely hampered by their efforts in music comprehension.

There are at least two limitations to the present study. First, the influence of sentence type on the wrap-up effect might be different between the two experiments. Future studies that manipulate sentence type and chord sequence type before the last pairs of language-music segments would provide further evidence on this issue. Second, the amplitude of the P600 was significantly larger in the left than in the right hemisphere in Experiment 1. Since this cross-hemisphere effect was missing in Experiment 2, there might be a kind of information processing that was intensively demanding for cognitive resources. Given the independence of the manipulated variables and the lack of relevant literature, it is difficult to speculate on the underlying mechanism. Furthermore, not removing the particle '了' in Experiment 2 would appear to have increased comparability, since the two experiments basically used the same stimuli. In that way, however, the language-music stimulus would have been of eight segment pairs in each trial in Experiment 2, and the testing time have been extended.

5. Conclusion

The controversy about resource sharedness between music and language processing in semantics is likely to be settled via experimental work using the interference paradigm, in which long-distance instead of local-distance semantic predictability is manipulated in sentence reading. The dissolution of semantic violation in sentence reading seems to happen in parallel with music processing in chord sequence comprehension. When the sentences end with long-distance NCNs, however, interruption is likely to occur between semantic processing in sentence reading and music processing in chord sequence comprehension.

Author contribution statement

Xing Wang: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

Degao Li: Conceived and designed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Yi Li: Conceived and designed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data.

Li Zhu: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data.

Dangui Song: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.

Wenling Ma: Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data.

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Data availability statement

Data will be made available on request.

Declaration of interest's statement

The authors declare no competing interests.

Appendix I

Sentence Stimuli in Experiment 1

No	Acceptable	Unacceptable
1	保安检查了一把斧头。 The security guard inspected an axe.	保安检查了一把行李。 The security guard inspected a piece of baggage.
2	警察捡到了一部手机。 The police found a mobile phone.	警察捡到了一部钱包。 The police found a wallet
3	妹妹清洗了一串葡萄。 My sister washed a bunch of grapes.	妹妹清洗了一串苹果。 My sister washed some apples
4	公园摆放了一顶帐篷。 The park was placed with a tent.	公园摆放了一顶舞台。 The park was placed with a stage.
5	男孩相中了一件衬衫。 The boy took fancy to a shirt.	男孩相中了一件手机。 The boy took fancy to a mobile phone.
6	教练收到了一封请帖。 The coach received an invitation.	教练收到了一封学费。 The coach received the tuition.
7	教室张贴了一幅地图。 A map was posted in the classroom.	教室张贴了一幅国旗。 A national flag was posted in the classroom.
8	政府重建了一个村庄。 The government rebuilt a village.	政府重建了一个公路。 The government rebuilt a road.
9	国家公布了一剂疫苗。 The government announced a vaccine.	国家公布了一剂芯片。 The government announced a chip.
10	老师调试了一架钢琴。 The teacher tuned a piano.	老师调试了一架电脑。 The teacher tested a computer.
11	学校改造了一间教室。 The school remodeled a classroom.	学校改造了一间操场。 The school remodeled a playground.
12	战士发现了一颗炸弹。 The soldier found a bomb.	战士发现了一颗电缆。 The soldier found a cable.
13	班长找回了一块橡皮。 The class monitor retrieved an eraser.	班长找回了一块铅笔。 The class monitor retrieved a pencil.
14	杂志发表了一篇文章。 The journal published an article.	杂志发表了一篇著作。 The journal published a book.
15	爷爷摘下了一片树叶。 Grandpa plucked a leaf.	爷爷摘下了一片桃子。 Grandpa plucked a peach.
16	姐姐购买了一瓶香水。 Sister purchased a bottle of perfume.	姐姐购买了一瓶外套。 Sister purchased an overcoat.
17	模特展示了一身礼服。 The model showed a gown.	模特展示了一身玉器。 The model showed modeled a jade.
18	电台播放了一首歌曲。 The radio played a song.	电台播放了一首特效。 The radio played a special effect.
19	女孩采摘了一朵玫瑰。 The girl picked a rose.	女孩采摘了一朵草莓。 The girl picked a strawberry.
20	小王带走了一双球鞋。	小王带走了一双相机。

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(*continued*)

No	Acceptable	Unacceptable
	Wang took away a pair of sneakers.	Wang took away a camera.
21	官员拒绝了一套茶具。 The officer rejected a kit of tea set.	官员拒绝了一套手表。 The officer rejected a watch.
22	工人清扫了一条街道。 The worker swept a street.	工人清扫了一条广场。 The worker swept a square.
23	经理修改了一项政策。 The manager revised a policy.	经理修改了一项工装。 The manager revised the workwear.
24	老刘弄丢了一支钢笔。 Liu missed a pen.	老刘弄丢了一支鼠标。 Liu missed a mouse.
25	牧民放生了一只野兔。 The herdsman released a hare.	牧民放生了一只蟒蛇。 The herdsman released a python.
26	律师调查了一桩命案。 The lawyer investigated a homicide case.	律师调查了一桩疑犯。 The lawyer investigated a suspect.
27	军队接管了一座工厂。 The army took over a factory.	军队接管了一座公司。 The army took over a company.
28	孩子打碎了一扇窗户。 The child broke a window.	孩子打碎了一扇玻璃。 The child broke a glass.
29	客人弄坏了一台电脑。 The guest crashed a computer.	客人弄坏了一台衣架。 The guest broke a coat rack.
30	市长参观了一幢大楼。 The mayor visited a building.	市长参观了一幢港口。 The mayor visited a port.

Appendix II

Sentence Stimuli in Experiment 2

No	Acceptable	Unacceptable
1	保安检查一把民工携带的斧头。 The security guard inspected an axe carried by a migrant worker.	保安检查一把民工携带的行李。 The security guard inspected a piece of baggage carried by a migrant worker.
2	警察捡到一部游客丢失的手机。 The police found a mobile phone that might be left over by a tourist.	警察捡到一部游客丢失的钱包。 The police found a wallet that might be left over by a tourist.
3	妹妹清洗一串妈妈挑选的葡萄。 My sister washed a bunch of grapes selected by my mother.	妹妹清洗一串妈妈挑选的苹果。 My sister washed apples selected by my mother.
4	公园摆放一顶士兵搭建的帐篷。 The park was placed with a tent set up by soldiers.	公园摆放一顶士兵搭建的舞台。 The park was placed with a stage set up by soldiers.
5	男孩相中一件模特展示的衬衫。 The boy took fancy to a shirt modeled by a mannequin.	男孩相中一件模特展示的手机。 The boy took fancy to a mobile phone modeled by a mannequin.
6	教练收到一封学员送来的请帖。 The coach received an invitation sent by a trainee.	教练收到一封学员送来的学费。 The coach received the tuition sent by a trainee.
7	教室张贴一张老师手绘的地图。 A map was posted in the classroom hand-drawn by the teacher.	教室张贴一张老师手绘的国旗。 A national flag was posted in the classroom hand-drawn by the teacher.
8	政府重建一个洪水淹没的村庄。 The government rebuilt a village overwhelmed by flood.	政府重建一个洪水淹没的公路。 The government rebuilt a road overwhelmed by flood.
9	国家公布一剂专家研制的疫苗。 The government announced a vaccine developed by experts.	国家公布一剂专家研制的芯片。 The government announced a chip developed by experts.
10	老师调试一架教室摆放的钢琴。 The teacher tuned a piano placed in the classroom.	老师调试一架教室摆放的电脑。 The teacher tested a computer placed in the classroom.
11	学校改造一间学生使用的教室。 The school remodeled a classroom for students.	学校改造一间学生使用的操场。 The school remodeled a playground for students.
12	战士发现一颗敌人埋设的炸弹。 The soldier found a bomb laid by the enemy.	战士发现一颗敌人埋设的电缆。 The soldier found a cable buried by the enemy.
13	班长找回一块同桌扔掉的橡皮。 The class monitor retrieved an eraser discarded by a classmate.	班长找回一块同桌扔掉的铅笔。 The class monitor retrieved a pencil discarded by a classmate.
14	杂志发表一篇教授撰写的文章。 The journal published an article written by a professor.	杂志发表一篇教授撰写的著作。 The journal published a book written by a professor.
15	爷爷摘下一片虫子咬坏的树叶。 Grandpa picked a wormy leaf.	爷爷摘下一片虫子咬坏的桃子。 Grandpa picked a wormy peach.
16	姐姐购买一瓶店员推荐的香水。 My sister purchased a bottle of perfume recommended by a sales clerk.	姐姐购买一瓶店员推荐的外套。 My sister purchased an overcoat recommended by a sales clerk.
17	模特展示一身朋友收藏的礼服。 The model shows a gown from a friend's collection.	模特展示一身朋友收藏的玉器。 The model showed a jade from a friend's collection.
18	电台播放一首明星创作的歌曲。 The radio played a song written by a famous star.	电台播放一首明星演唱的特效。 The radio played a special effect made by a famous star.
19	女孩采摘一朵花农种植的玫瑰。 The girl picked a rose grown by a flower grower.	女孩采摘一朵花农种植的草莓。 The girl picked a strawberry grown by a flower grower.

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(*continued*)

No	Acceptable	Unacceptable
20	小王带走一双爸爸刚买的球鞋。 Wang took away a pair of sneakers newly bought from his father.	小王带走一双爸爸刚买的相机。 Wang took away a camera that newly bought from his father.
21	官员拒绝一套外商赠送的茶具。 The official rejected a kit of tea presented by a foreign investor.	官员拒绝一套外商赠送的手表。 The official rejected a watch presented by a foreign investor.
22	工人清扫一条路灯照亮的街道。 The worker swept a street illuminated by streetlights.	工人清扫一条路灯照亮的广场。 The worker swept a square illuminated by streetlights.
23	经理修改一项公司制定的政策。 The manager revises a policy formulated by the company.	经理修改一项公司制定的工装。 The manager revised the workwear formulated by the company.
24	老刘弄丢一支同事新买的钢笔。 Liu missed a pen newly bought by a colleague.	老刘弄丢一支同事新买的鼠标。 Liu missed a mouse newly bought by a colleague.
25	牧民放生一只猎狗抓住的野兔。 The herdsman released a hare caught by a hunting dog.	牧民放生一只猎狗抓住的蟒蛇。 The herdsman released a python caught by a hunting dog.
26	律师调查一桩新闻报道的命案。 The lawyer investigated a homicide case reported in the news.	律师调查一桩新闻报道的疑犯。 The lawyer investigated a suspect reported in the news.
27	队接管了一座商人投资的工厂。 The government took over a factory invested by a businessman.	军队接管一座商人投资的公司。 The government took over a company invested by a businessman.
28	孩子打碎一扇工人安装的窗户。 The child broke a window installed by a worker.	孩子打碎一扇工人安装的玻璃。 The child broke a glass installed by a worker.
29	客人弄坏一台酒店提供的电脑。 The guest crashed a computer provided by the hotel.	客人弄坏一台酒店提供的衣架。 The guest broke a coat rack provided by the hotel.
30	市长参观一幢富豪建造的大楼。 The mayor visited a building built by a wealthy man.	市长参观一幢富豪建造的港口。 The mayor visited a port built by a wealthy man.

Appendix III

Statistical Results

	Effect	N400			P600		
		F	*p*	η2 p	*F*	*p*	η2 p
Experiment 1	Sentence type	11.065	.003*	0.335	1.783	0.202	0.106
	Chord sequences type	6.339	.020*	0.224	0.300	0.592	0.020
	Hemisphere	0.243	0.627	0.011	12.939	.002*	0.370
	Anteriority	0.783	0.390	0.050	1.511	0.238	0.092
	Sentence type × Chord sequence type	0.314	0.581	0.014	0.657	0.426	0.029
	Sentence type × Hemisphere	0.266	0.611	0.012	0.691	0.419	0.044
	Sentence type × Anteriority	2.422	0.141	0.139	0.336	0.455	0.024
	Chord sequence type × Hemisphere	0.771	0.389	0.034	0.081	0.778	0.004
	Chord sequence type × Anteriority	0.015	0.903	0.001	2.187	0.160	0.127
	Sentence type × Hemisphere × Anteriority	0.147	0.706	0.010	2.124	0.166	0.124
	Chord sequence type × Hemisphere × Anteriority	0.068	0.798	0.005	0.616	0.445	0.039
	Sentence type × Chord sequence type × Hemisphere	0.002	0.969	0.000	0.021	0.885	0.001
	Sentence type × Chord sequence type × Anteriority	0.009	0.925	0.001	1.233	0.284	0.076
	Sentence type × Chord sequence type × Hemisphere × Anteriority	0.184	0.674	0.012	0.001	0.976	0.000
Experiment 2	Sentence type	1.513	0.230	0.057	0.000	0.985	0.000
	Chord sequences type	1.029	0.320	0.040	7.597	.011*	0.233
	Hemisphere	2.117	0.158	0.078	2.351	0.138	0.086
	Anteriority	1.005	0.326	0.039	1.801	0.192	0.067
	Sentence type × Chord sequence type	7.222	.013*	0.224	1.917	0.178	0.071
	Sentence type × Hemisphere	0.502	0.485	0.020	1.534	0.227	0.058
	Sentence type × Anteriority	0.612	0.441	0.024	2.161	0.154	0.080
	Chord sequence type × Hemisphere	1.847	0.074	0.122	1.643	0.212	0.062
	Chord sequence type × Anteriority	2.108	0.159	0.078	0.832	0.370	0.032
	Sentence type × Hemisphere × Anteriority	2.593	0.120	0.094	1.060	0.313	0.041
	Chord sequence type × Hemisphere × Anteriority	0.046	0.832	0.002	0.036	0.851	0.001
	Sentence type × Chord sequence type × Hemisphere	2.521	0.125	0.092	0.18	0.675	0.007
	Sentence type × Chord sequence type × Anteriority	1.489	0.234	0.056	1.556	0.224	0.059
	Sentence type × Chord sequence type × Hemisphere × Anteriority	0.144	0.708	0.006	0.762	0.391	0.030

*, $p < .05$.

References

[1] M.A. Arbib, Language, Music, and the Brain: A Mysterious Relationship (Volume 10) (Strüngmann Forum Reports (10)), The MIT Press, Cambridge, 2013.

[2] R. Asano, C. Boeckx, Syntax in language and music: what is the right level of comparison? Front. Psychol. 6 (2015) 942, https://doi.org/10.3389/fpsyg.2015.00942.
[3] N. Chomsky, Knowledge of language: its elements and origins, Philos. Trans. R. Soc. Lond. B Biol. Sci. 295 (1077) (1981) 223–234, https://doi.org/10.1098/rstb.1981.0135.
[4] R. Jackendoff, F. Lerdahl, The capacity for music: what is it, and what's special about it? Cognition 100 (1) (2006) 33–72, https://doi.org/10.1016/j.cognition.2005.11.005.
[5] S. Koelsch, S. Jentschke, D. Sammler, D. Mietchen, Untangling syntactic and sensory processing: an ERP study of music perception, Psychophysiology 44 (3) (2007) 476–490, https://doi.org/10.1111/j.1469-8986.2007.00517.x.
[6] A.D. Patel, Language, music, syntax and the brain, Nat. Neurosci. 6 (7) (2003) 674–681, https://doi.org/10.1038/nn1082.
[7] E. Fedorenko, A. Patel, D. Casasanto, J. Winawer, E. Gibson, Structural integration in language and music: evidence for a shared system, Mem. Cognit. 37 (1) (2009) 1–9, https://doi.org/10.3758/mc.37.1.1.
[8] A. Fiveash, G. McArthur, W.F. Thompson, Syntactic and non-syntactic sources of interference by music on language processing, Sci. Rep. 8 (1) (2018), 17918, https://doi.org/10.1038/s41598-018-36076-x.
[9] L. Hoch, B. Poulin-Charronnat, B. Tillmann, The influence of task-irrelevant music on language processing: syntactic and semantic structures, Front. Psychol. 2 (2011) 112, https://doi.org/10.3389/fpsyg.2011.00112.
[10] S. Koelsch, T.C. Gunter, M. Wittfoth, D. Sammler, Interaction between syntax processing in language and in music: an ERP study, J. Cognit. Neurosci. 17 (10) (2005) 1565–1577, https://doi.org/10.1162/089892905774597290.
[11] R. Kunert, R.M. Willems, P. Hagoort, Language influences music harmony perception: effects of shared syntactic integration resources beyond attention, R. Soc. Open Sci. 3 (2) (2016), 150685, https://doi.org/10.1098/rsos.150685.
[12] M. Musso, C. Weiller, A. Horn, V. Glauche, R. Umarova, J. Hennig, et al., A single dual-stream framework for syntactic computations in music and language, Neuroimage 117 (2015) 267–283, https://doi.org/10.1016/j.neuroimage.2015.05.020.
[13] L.R. Slevc, J.C. Rosenberg, A.D. Patel, Making psycholinguistics musical: self-paced reading time evidence for shared processing of linguistic and musical syntax, Psychon. Bull. Rev. 16 (2) (2009) 374–381, https://doi.org/10.3758/16.2.374.
[14] M. Besson, F. Faïta, I. Peretz, A.M. Bonnel, J. Requin, Singing in the brain: independence of lyrics and tunes, Psychol. Sci. 9 (6) (1998) 494–498, https://doi.org/10.1111/1467-9280.00091.
[15] E. Carrus, M.T. Pearce, J. Bhattacharya, Melodic pitch expectation interacts with neural responses to syntactic but not semantic violations, Cortex 49 (8) (2013) 2186–2200, https://doi.org/10.1016/j.cortex.2012.08.024.
[16] P. Perruchet, B. Poulin-Charronnat, Challenging prior evidence for a shared syntactic processor for language and music, Psychon. Bull. Rev. 20 (2) (2013) 310–317, https://doi.org/10.3758/s13423-012-0344-5.
[17] B. Poulin-Charronnat, E. Bigand, F. Madurell, R. Peereman, Musical structure modulates semantic priming in vocal music, Cognition 94 (3) (2005) B67–B78, https://doi.org/10.1016/j.cognition.2004.05.003.
[18] N. Steinbeis, S. Koelsch, Shared neural resources between music and language indicate semantic processing of musical Tension-Resolution Patterns, Cerebr. Cortex 18 (5) (2008) 1169–1178, https://doi.org/10.1093/cercor/bhm149.
[19] P. Hagoort, C. Brown, J. Groothusen, The syntactic positive shift (SPS) as an ERP measure of syntactic processing, Lang, Cognit. Process. 8 (4) (1993) 439–483, https://doi.org/10.1080/01690969308407585.
[20] E. Kaan, A. Harris, E. Gibson, P. Holcomb, The P600 as an index of syntactic integration difficulty, Lang, Cognit. Process. 15 (2) (2000) 159–201, https://doi.org/10.1080/016909600386084.
[21] L. Osterhout, P.J. Holcomb, Event-related brain potentials elicited by syntactic anomaly, J. Mem. Lang. 31 (6) (1992) 785–806, https://doi.org/10.1016/0749-596X(92)90039-Z.
[22] A.D. Patel, E. Gibson, J. Ratner, M. Besson, P.J. Holcomb, Processing syntactic relations in language and music: an event-related potential study, J. Cognit. Neurosci. 10 (6) (1998) 717–733, https://doi.org/10.1162/089892998563121.
[23] S. Koelsch, W.A. Siebel, Towards a neural basis of music perception, Trends Cognit. Sci. 9 (12) (2005) 578–584, https://doi.org/10.1016/j.tics.2005.10.001.
[24] A.D. Patel, Music, Language, and the Brain, Oxford University Press, New York, 2008.
[25] S. Koelsch, Towards a neural basis of processing musical semantics, Phys. Life Rev. 8 (2) (2011) 89–105, https://doi.org/10.1016/j.plrev.2011.04.004.
[26] S. Koelsch, E. Kasper, D. Sammler, K. Schulze, T. Gunter, A.D. Friederici, Music, language and meaning: brain signatures of semantic processing, Nat. Neurosci. 7 (3) (2004) 302–307, https://doi.org/10.1038/nn1197.
[27] J.G. Painter, S. Koelsch, Can out-of-context musical sounds convey meaning? An ERP study on the processing of meaning in music, Psychophysiology 48 (5) (2011) 645–655, https://doi.org/10.1111/j.1469-8986.2010.01134.x.
[28] Y. Sun, X. Lu, H.T. Ho, B.W. Johnson, D. Sammler, W.F. Thompson, Syntactic processing in music and language: parallel abnormalities observed in congenital amusia, Neuroimage-Clin. 19 (2018) 640–651, https://doi.org/10.3389/fpsyg.2018.00038.
[29] E. Gibson, The dependency locality theory: a distance-based theory of linguistic complexity, in: Y. Miyashita, W. O'Neil (Eds.), Image, Language, Brain, MIT Press, Cambridge, Massachusetts, 2000, pp. 95–126.
[30] Y. Zhang, J. Zhang, B. Min, Neural dynamics of animacy processing in language comprehension: ERP evidence from the interpretation of classifier–noun combinations, Brain Lang. 120 (3) (2012) 321–331, https://doi.org/10.1016/j.bandl.2011.10.007.
[31] X. Zhou, X. Jiang, Z. Ye, Y. Zhang, K. Lou, W. Zhan, Semantic integration processes at different levels of syntactic hierarchy during sentence comprehension: an ERP study, Neuropsychologia 48 (6) (2010) 1551–1562, https://doi.org/10.1016/j.neuropsychologia.2010.02.001.
[32] W. Klein, P. Li, H. Hendriks, Aspect and assertion in Mandarin Chinese, Nat. Lang. Ling. Theor. 18 (4) (2000) 723–770, https://doi.org/10.1023/A:1006411825993.
[33] I. Peretz, A.S. Champod, K. Hyde, Varieties of musical disorders: the montreal Battery of evaluation of amusia, Ann. N. Y. Acad. Sci. 999 (1) (2003) 58–75, https://doi.org/10.1196/annals.1284.006.
[34] X. Guo, Dictionary of Classifier Usages in Contemporary Chinese, Yuwen Press, Beijing, 2002.
[35] Q. Cai, M. Brysbaert, SUBTLEX-CH: Chinese word and character frequencies based on film subtitles, PLoS One 5 (6) (2010), e10729, https://doi.org/10.1371/journal.pone.0010729.
[36] C.C. Hsu, S.H. Tsai, C.L. Yang, J.Y. Chen, Processing classifier–noun agreement in a long distance: an ERP study on Mandarin Chinese, Brain Lang. 137 (2014) 14–28, https://doi.org/10.1016/j.bandl.2014.07.002.
[37] A. Delorme, S. Makeig, EEGLAB: an open source toolbox for analysis of single-trial EEG dynamics including independent component analysis, J. Neurosci. Methods 134 (1) (2004) 9–21, https://doi.org/10.1016/j.jneumeth.2003.10.009.
[38] J. Lopez-Calderon, S.J. Luck, ERPLAB: an open-source toolbox for the analysis of event-related potentials, Front. Hum. Neurosci. 8 (2014) 213, https://doi.org/10.3389/fnhum.2014.00213.
[39] G. Zhang, X. Li, F. Cong, Objective extraction of evoked event-related oscillation from time-frequency representation of event-related potentials, Neural Plast. 2020 (2020) 1–20, https://doi.org/10.1155/2020/8841354.
[40] N. Kwon, P. Sturt, P. Liu, Predicting semantic features in Chinese: evidence from ERPs, Cognition 166 (2017) 433–446, https://doi.org/10.1016/j.cognition.2017.06.010.
[41] M.P. Roncaglia-Denissen, F.L. Bouwer, H. Honing, Decision making strategy and the simultaneous processing of syntactic dependencies in language and music, Front. Psychol. 9 (2018) 38, https://doi.org/10.3389/fpsyg.2018.00038.