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The effect of lyrical and non-lyrical background music on different types of language processing - An ERP study

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People read in different settings, including when music is playing in the background. Whether the presence of music facilitates, hinders, or does not affect language processing is an on-going debate in the current literature. The present study used ERPs to examine the influence of music on orthographic, semantic, and syntactic processing by inspecting P2, N400, and P600 responses, respectively. A total of 60 participants judged the correctness of visually presented sentences while listening to music with lyrics, music without lyrics, or in silence. The results showed that the P2 and P600 effects were larger in the silent condition than in the music-with-lyrics condition, while there were no N400 differences among the conditions. This indicates that only lyrical music interferes with orthographic and syntactic language processing, while it has no, or minimal, effect on semantic processing. The results are discussed in relation to the background music interference effect.

Key words : language processing; background music; Event-Related Potentials (ERPs); N400; P600

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1. Introduction

Nowadays, many people read in the presence of music, whether it is by personal choice, such as listening to music while reading a book on the way to work, or due to external settings, like being exposed to background music being played in coffee shops. The question of whether the presence of background music affects language processing, positively, negatively, or not at all, has been of interest to many researchers from the early 20th century and has continued to be a popular topic up to today.

Despite its great interest, the answer to the question remains controversial; studies that examined the influence of music on language processing present inconsistent findings. Some show evidence of music facilitating language processing or even foreign language learning (e.g., Brandt et al., 2012; Schön et al., 2008), while others report that music hinders performance on language-related tasks such as reading comprehension, sentence recall, and writing (e.g., Ransdell & Gilroy, 2001; Thompson et al., 2012). There are also studies that found no significant effect of the presence of music on reading (e.g., Freeburne & Fleischer, 1952; Miller, 1947; Mitchell, 1949). The diverging findings make it difficult to draw strong conclusions about the effect of background music on language processing.

The present study, therefore, examined the influence of background music, with and without lyrics, on different levels of visual sentence processing. EEG/ERPs was used to directly observe brain responses to three different types of sentence anomalies (i.e., orthographic, semantic, and syntactic), in three different music conditions (i.e., no music, lyrical music, non-lyrical music) to investigate the effect of background music on real-time sentence processing.

Ⅱ. Literature Review

In the wide spectrum of studies that explored the influence of background music on different kinds of cognitive abilities, a large portion of the literature focuses on the question of whether the presence of music affects performance on reading comprehension (e.g., Anderson & Fuller, 2010; Avila et al., 2012; Cauchard et al., 2012; Crawford & Strapp, 1994; Gillis, 2010; Hall, 1952; Kallinen, 2002; Kiger, 1989; Martin et al., 1988; Miller, 2014; Perham & Currie, 2014; Stroupe, 2005; Thompson et al., 2012). A typical method used to probe this question is to manipulate the different aspects of music (e.g., genre, tempo, loudness) and observe how these traits, as well as the presence of music itself, modulate performance on a concurrent language-related task, and one particular aspect of music that has gained a large amount of attention is whether it contains lyrics or not.

Earlier studies have found different degrees of interference from background music depending on whether the music is lyrical or non-lyrical. For example, Crawford and Strapp (1994) observed participants' performances on reading and on a spatial scanning task in different music conditions and found that popular music with lyrics caused more distraction than instrumental music, or music without lyrics. Stroupe (2005) went further and compared the accuracy and reaction times in a reading task among three background music conditions (i.e., lyrical music, non-lyrical music, and no music). The results showed that participants were equally accurate and fast in responding to comprehension questions in the non-lyrical music and silent conditions, while they were significantly less accurate and slower in the lyrical music condition (Stroupe, 2005). Similar results were found in Perham and Currie's (2014) experiment, in which participants read short passages in one of four background music conditions: liked lyrical music, disliked lyrical music, instrumental music, and quiet. While there was no difference in performance between liked and disliked music, both types of lyrical music produced significantly lower scores on the reading comprehension task than the non-lyrical music and quiet conditions, corroborating Stroupe's (2005) results (Perham & Currie, 2014). Miller (2014) also found the same pattern with lyrical and non-lyrical music, while there was no effect of music genre (i.e., classical vs. rock). Perham and Currie's (2014) and Miller's (2014) results suggest that the presence of lyrics may be a stronger factor in determining the extent of background music interference, compared to others like music genre or preference. Likewise, in a recent meta-analysis of 65 studies that examined the influence of auditory distraction (i.e., background noise, speech, music) on reading, lyrical music tended to be more distracting than non-lyrical music, as much as unattended intelligible speech was (Vasilev et al., 2018).

Some theories have been proposed to explain why many studies tend to find lyrical music more distracting than music without lyrics. The Semantic-Interference Hypothesis, which was first introduced to account for the findings in Martin et al.'s (1988) experiments[1], suggests that the semantic properties in the lyrics negatively influence semantic processing involved in reading, more than non-lyrical music with no semantic information does. A similar explanation is provided by advocates of the "interference

1) In their series of experiments, Martin and his colleagues (1988) found that English speakers were worse at comprehending passages in the presence of intelligible speech (i.e., English) compared to unintelligible speech (i.e., Russian). They concluded that "the semantic properties of the irrelevant speech can interfere with building the semantic representations of the text that is being read" (Vasilev et al., 2018: p. 571), which led to the proposal of the Semantic-Interference Hypothesis.

by process" theory (Hughes, 2014; Marsh et al., 2008, 2009; Marsh & Jones, 2010), which assumes that greater distraction occurs when the same kind of processing is involved in handling two concurrent stimuli. According to this view, lyrical music hinders reading performance more than non-lyrical music, because the same kind of semantic processing is required for both reading texts and listening to lyrical music, which causes interference and hinders performance. While the two theories present slightly different underlying reasons for the difference between lyrical and non-lyrical music, they both suggest that the processing of semantic information of lyrics interferes with the semantic processing of language in the main reading task.

Although semantic interference would predict differing degrees of distraction from lyrical and non-lyrical music, it is important to note that not all studies show this fine contrast between the two types of background music and their effect on language processing. In some studies, no significant difference between the two music conditions is observed. Avila and his colleagues (2012) had their participants take three different types of "job selection" tests which included one that measured reading performance. The background music conditions included vocal music, instrumental music, and no music, and unlike some previous studies, the songs used were controlled so that the same songs in the lyrical music condition were used for the instrumental music condition, just without their lyrics. The results showed that the presence of background music (regardless of whether it included lyrics or not) hindered performance in the reading section, indicating significant distraction from the background music itself, while the difference between the two music conditions (lyrical vs. non-lyrical) did not reach significance (Avila et al., 2012). Similarly, Gillis (2010) found no significant difference between lyrical and non-lyrical background music regarding college students' ability to solve reading comprehension questions, although both music conditions did not differ from the silent condition either.

Thus, there seems to be an inconsistency in the findings regarding the effect of lyrical and non-lyrical background music on language processing. One possible reason is that previous studies mostly relied on behavioral methods which have limitations in measuring participants' reading performance. The outcome measures that were typically used in these studies include reading comprehension, sentence recall, and proofreading accuracies. Although tasks like answering reading comprehension questions and recalling previously encountered sentences are relatively easy to administer, they introduce various external factors that can influence experimental results. For example, in the studies that used reading comprehension accuracy as the outcome measure, the type of text used varied across experiments in terms of difficulty, length, and topic, and these factors could have led to diverging results regarding the music interference effect. Miller (2014) and Avila et al. (2012) used private reading comprehension tests (i.e., the Nelson-Denny Reading Test and Saville Consulting's Verbal test, respectively), while Perham and Currie (2014) used SAT reading passages which were potentially more familiar to their participants. It is possible that the type of reading text influenced the extent to which background music, lyrical and non-lyrical, interfered with comprehension. Moreover, the format of questions and responses varied across studies; the most common form was multiple choice (e.g., Avila et al., 2012; Perham & Currie, 2014), though with different numbers of answer choices, while some also included true-or-false questions (e.g., Gillis, 2010). The disadvantage of using multiple-choice tests is that it cannot control for the probability of guessing, which can produce misleading results that do not reflect actual reading performance. All of these factors should be considered when determining the degree of distraction from background music, which is why using behavioral tests may not be the best way to investigate the reasons for the conflicting findings across studies.

The current accounts that try to explain the music interference effect were also mostly formed based on these studies that used behavioral tasks, which cannot tease apart the different types of processing involved in reading, including semantic processing. In other words, since the outcomes reflect general reading accuracy, it is difficult to conclude from these results that it is specifically the concurrent semantic processing that leads to greater interference from lyrical than non-lyrical music. While much of the discussion on the effect of background music on reading so far has focused on semantic interference, it is possible, for example, that background music hinders the processing of other types of information during sentence processing, such as syntactic or orthographic information.

The present study, therefore, is focused on observing the more specific effects of background music on different types of visual sentence processing, including orthographic, semantic, and syntactic processing. In order to overcome the limitations of using behavioral methods, EEG/Event-Related Potentials (ERPs), a more sensitive tool, was used to measure neural responses during online sentence processing to more directly investigate the background music effect.

The present study presents EEG/ERPs as an effective tool to observe the influence of background music on different levels of visual sentence processing. It has become a widely used research method in the field of cognitive linguistics as it enables the direct observation of brain responses to given stimuli (Friederichi, 2002). In an ERP paradigm, target amplitudes of specific components are compared between set conditions. In the present study, ERP components each associated with orthographic, semantic, and syntactic processing were observed.

The ERP components that are proposed to be involved in orthographic processing vary across studies that observe different types of word and letter-level processing. Most studies observing visual word recognition and processing looked at the ERP components that appeared in the early time window, about 150ms to 300ms after stimulus presentation (e.g. Barber, Vergara, & Carreiras, 2004; Holcomb & Grainger, 2006; Mitra & Coch, 2009). Out of the various ERP components, this study focused on the P200 (i.e., P2), which has been identified as a positivity peaking around 200ms post-stimulus that represents lexical and orthographic processing (Carreiras, Vergara, & Barber, 2005; Christoffels et al., 2013; Costa et al., 2009, Kong et al., 2012). Specifically, Kong et al.'s (2012) study showed that the P2 appeared in high amplitudes during the identification and processing of Chinese characters, indicating clear relations of the P2 with the visual recognition of orthographic traits. As the present study focused on the processing of Korean individual characters, the P2 was selected as the target component to observe brain responses of processing orthographic information.

The N400 is a commonly discussed ERP component suggested to reflect the processing of semantic information or word predictability (Kutas & Federmeier, 2011); generally, in response to a semantic error or a semantically unpredicted word, a peak in negativity appears at about 400ms after a given stimulus, compared to a semantically plausible or predicted word. Previous studies that used the N400 in examining music and language processing include the examination of semantic priming in both music and language (Daltrozzo & Schön, 2008; Koelsch et al., 2004; Steinbeis & Koelsch, 2008), the influence of melodic familiarity on music processing (Daltrozzo et al., 2010), the influence of musical training on semantic word learning (Dittinger et al., 2016), and independent versus interactive processing of melody and lyrics (Gordon et al., 2010). Following these works, the N400 was used in the present study as an index of semantic processing of visually presented sentences.

Another frequently used ERP component in the language processing literature is the P600, which is generally proposed to reflect the processing of syntactic information or syntactic reanalysis: a positivity peak appearing near the 600ms range after stimulus onset indicates evidence for the activation of syntactic processing in the brain (Hoeks et al., 2004). Previous studies found that syntactic violations in music and language both elicit the P600 (Fitzroy & Sanders, 2013; Patel et al., 1998) and also reported different degrees of P600 effects between musicians and non-musicians when processing harmonic incongruities (Featherstone et al., 2013). For the purpose of the present study, the P600 was selected as a target component representing the response to syntactic anomalies in different background music conditions.

With these considerations, the present study set out to investigate the influence of background music on specific types of language processing (i.e., orthographic, semantic, and syntactic), using ERPs as measures of efficient processing of linguistic information. The potentially different effect between lyrical and non-lyrical music was examined by including three types of background music conditions: no music, music with lyrics, and music without lyrics. For the main language task, participants read sentences that contained different types of anomalies that would elicit corresponding ERPs, which would indicate whether the music conditions interferes with the different types of language processing.

Ⅲ. Method

1. Participants

A total of 60 undergraduates from Seoul National University participated in the experiment (34 males; mean age 23.4, SD = 2.68) and were divided into three groups according to the experiment conditions: 20 participants who did not listen to background music during language processing (condition 1), 20 participants who listened to background music with lyrics (condition 2), and 20 participants who listened to background music without lyrics (condition 3). All participants were right-handed, native Korean speakers using the standard Korean language with no experience of learning another dialect of Korean. None of the participants reported having any form of reading, hearing, or neurological problems. All participants signed an agreement on the necessary information regarding the present study, approved by the Seoul National University Review Board (SNUIRB), and were paid after completing all experimental procedures.

2. Visual Stimuli

A total of 30 sentences were initially created for the visual stimuli to be used in the main acceptability judgment task. The same kind of structure with the same number of words were used for the sentences: they all started with a noun, the subject, followed by two adverbs (indicating time and location), a direct object, and ended with a transitive verb, following the natural word order of the Korean language. The number of characters per word was limited to three to four characters. For each of these grammatically correct sentences, three incorrect versions were created: orthographically incorrect (misspelling of Korean past tense inflection, "-ess"; e.g., "문서를[document-ACC] 작성*햇다[creat*id]"), semantically incorrect (unacceptable match between the transitive verb and its object; e.g., "문서를 [document-acc] *입었다[*wore]"), and syntactically incorrect (incomplete NP containing possessive noun; e.g., "문서의[document's] *작성했다[created]"). An example of a group of a correct sentence (control) and its incorrect versions (targets) is presented below (Table 1). Note that for all the incorrect types, the errors were to be detected at the last word of the sentence (at the transitive verb), for comparable observation of ERP responses to the different anomalies. In total, 30 groups of four sentences (120 sentences), were created for subsequent pretests.

With the initially created stimuli, two pretests were conducted with subjects who did not participate in the EEG experiment: one pretest to confirm the familiarity of the sentences for the correct sentence

Table 1. Example of a group of sentences used for visual stimuli

Sentence Type	Example				
Correct	직원이	어젯밤에	회사에서	문서를	작성했다.
	jikwon-i	eojessbam-ey	hwesa-eyse	munseo-lul	jakseonghay-essta
	employee-NOM	last night-TIME	work-LOC	document-ACC	create-PST
	Last night, at work, the employee created a document.				
Orthographically Incorrect	직원이	어젯밤에	회사에서	문서를	*작성햇다.
	jikwon-i	eojessbam-ey	hwesa-eyse	munseo-lul	jakseonghay-***ess**ta
	employee-NOM	last night-TIME	work-LOC	document-ACC	create-PST
	*Last night, at work, the employee "creatid" a document.				
Semantically Incorrect	직원이	어젯밤에	회사에서	문서를	***입었다**.
	jikwon-i	eojessbam-ey	hwesa-eyse	munseo-lul	***~~ib-essta~~**
	employee-NOM	last night-TIME	work-LOC	document-ACC	wear-PST
	*Last night, at work, the employee wore a document.				
Syntactically Incorrect	직원이	어젯밤에	회사에서	문서의	*작성했다.
	jikwon-i	eojessbam-ey	hwesa-eyse	munseo-~~uy~~	~~jakseonghay-essta~~
	employee-NOM	last night-TIME	work-LOC	document-GEN	create-PST
	*Last night, at work, the employee created a document's.				

type and another to confirm the incorrectness of the sentences for the incorrect sentence types. For the familiarity pretest, a total of 23 native Korean speakers (mean age 21.0, SD = 1.68) were given a list of 100 sentences, including sentences in the correct sentence type stimuli, and asked to rate each sentence on a Likert scale (1: very unfamiliar, 7: very familiar) based on whether the sentences sounded natural to them. Sentences with familiarity rated above 6 on average were selected for the final correct sentence type stimuli (M = 6.78, SD = 0.20). Another pretest was conducted with 20 subjects (mean age 20.7, SD = 1.99) with a list of 100 sentences that included the sentences in the incorrect sentence types. Subjects were asked to determine the correctness of each sentence (correct: 0, incorrect: 1), and only the sentences that were considered incorrect by more than 90% of all subjects (at least 18 out of 20) were selected for the final stimuli (M = 0.89, SD = 0.19).

In total, 80 sentences (20 sets of the four sentence types: correct, orthographically incorrect, semantically incorrect, syntactically incorrect) were counterbalanced across four different lists so that each participant only viewed one of the four sentences in a set and saw different sentences for each type. Along with the target sentences, 100 filler sentences were included in the final stimuli in order to prevent participants from recognizing the target stimuli of the study. The filler sentences consisted of 20 correct sentences and 80 incorrect sentences: correct sentences included instances where the direct object of the sentence that was manipulated to be syntactically incorrect was put in the front of sentences with correct form and incorrect sentences included sentences that were incorrect in terms of the use of classifiers, honorific forms, and possessives. With a total of 180 sentences, the order of the sentences was randomized and presented as visual stimuli for the EEG experiment.

3. Auditory stimuli (background music)

For the background music stimuli, unfamiliar songs were used in order to control the familiarity to the music which could alter the results of the experiment. A total of 14 songs of various genres including ballad, rock, and pop, that were released in the same year and did not receive any “likes” were selected from the most widely used online music service in South Korea. In order to confirm the unfamiliarity of the songs, another pretest was conducted with 29 subjects who did not participate in the EEG experiment (13 males; mean age 23, SD = 2.78). On average, subjects reported that they listen to about four hours per day. All 14 songs were combined into one audio file using the Adobe Soundbooth CS5 software and played to the subjects while they determined whether they recognized each song.

None of the subjects recognized any of the songs presented in the pretest. In order to cover the running time of the EEG recording session, a total of nine songs and their instrumental counterparts that do not contain any lyrics were selected for the final background music stimuli. The songs were combined into two separate audio files: one containing nine songs with lyrics (for condition 2) and another containing the same nine songs, but without lyrics (for condition 3). When combining the songs into each audio file, the intro and accompaniment of songs, which do not contain any lyrics, were removed to ensure that participants in condition 2 (with lyrics) were always presented with background music that contained lyrics. A dissolve effect was added in-between each song to avoid artificial shifts, and both versions played for a total of 28 minutes and 30 seconds during the experiment.

4. Procedure

The experiment was carried out in a quiet, soundproof EEG booth that blocks electromagnetic waves. Participants were seated in a comfortable chair in front of a 24-inch screen and were instructed to determine the correctness of the presented sentences at the end of each sentence.

Experimental sentences were visually presented to the participants on the computer screen. For each sentence, a fixation point ("+") appeared on the screen for 500ms, followed by a word-by-word

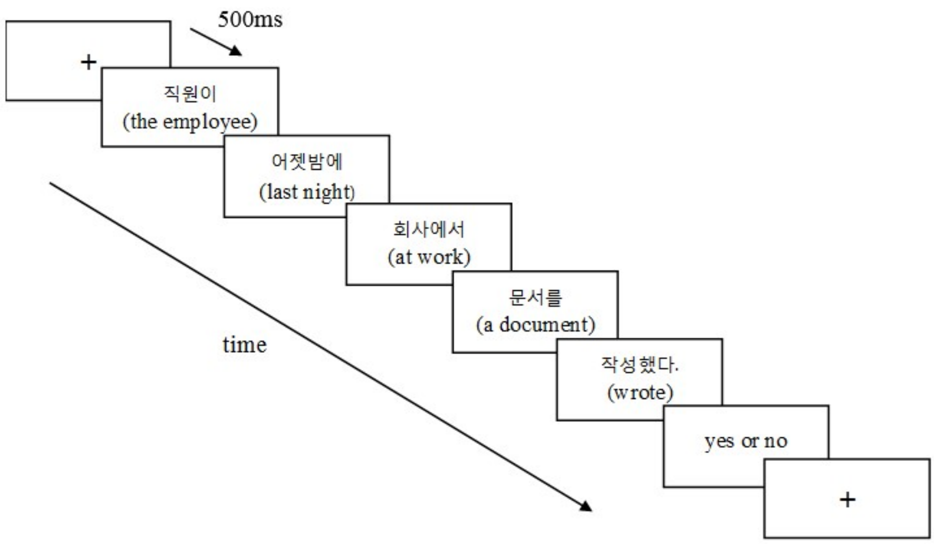

Figure 1. Representation of visual stimuli

* Only the Korean characters were presented in the actual experiment.

presentation of the sentence, with a 500ms duration per word and an interstimulus interval of 200ms. At the end of each sentence, the phrase, "yes or no" appeared on the screen, at which the participants had to determine the correctness of the presented sentence by pressing either the "A" key (yes) or "L" key (no) on the keyboard. This was to ensure that the participants were paying attention throughout the experiment. Figure 1 shows an example of the presentation of the visual stimuli.

During the presentation of visual stimuli, for participants in condition 2 (background music with lyrics) and condition 3 (background music without lyrics), the background music stimuli were played concurrently with a fixed volume using a BOSE Companion 2 Series 3 2-channel speaker installed 4 feet behind where the participants were seated.

5. EEG Recording and Analysis

The EEG was recorded from 32 electrodes (ActiCHamp, Brain Products, Germany) using BrainAmp EEG amplifier with a bandpass filter of 0.1-100 Hz and sampling rate of 500 Hz. The electrodes were arranged according to the international 10-20 system. An electrode was placed on the left mastoid as reference and then re-referenced offline to the average of the left-and-right mastoid activity. Impedances of electrodes were controlled below 10kΩ, and electrooculograms (EOGs) were recorded from two electrodes, each placed horizontally and vertically to the left eye, in order to monitor blinks and other eye movements. The BrainVision Recorder© v.1.21 software (Brain Products, Germany) was used for EEG recording.

For data analysis, the Brain Vision Analyzer© v.2.0 (Brain Products, Germany) was used. After ocular corrections were conducted based on ICA mechanisms with the Meaned Slope Algorithm, the data were epoched and artifacts with amplitudes exceeding ±100 μV were rejected. The data of each participant was then segmented separately among the four sentence types, followed by a baseline correction (from -100 to 0 ms) and average calculation for each type. By subtracting the baseline (correct type) from violations (orthographically, semantically, syntactically incorrect types), three difference waves and the grand average values were obtained for each participant's data. Through visual inspection of the control condition (no-music) amplitudes, the time windows for each difference wave were selected based on the grand average peak points (after the onset of the critical word) and the areas where the associated components are usually elicited (Christoffels et al., 2013; Dittinger et al., 2016; Fitzroy & Sanders, 2013): 130-230ms for orthographically incorrect sentence type (P2), 350-450ms for semantically incorrect sentence type (N400), and 640-740ms for syntactically incorrect sentence type (P600). The participants' individual difference waves in each of their corresponding time windows were exported for final analysis. Data from seven participants were excluded from analysis due to excessive noise in the individual EEG data. Therefore, data from 53 participants (16 for condition 1, 18 for condition 2, 19 for condition 3) were included in the final analyses.

6. Statistical Analysis

Data from seven ROIs, three for midline and four for lateral, were collected for analyses. For the midline analysis, electrodes Fz, Cz, and Pz were collected, while for lateral analysis, two electrodes representing each region were observed: F3, FC5 (left anterior); P3, CP5 (left posterior); F4, FC6 (right anterior); P4, CP6 (right posterior). Repeated measures analyses of variance (ANOVA) were used to examine the EEG results for midline and lateral electrodes separately, each having the Condition (Cond; condition 1: no music, condition 2: music with lyrics, condition 3: music without lyrics) as the between-subject factor as well as Electrode (Elec; Fz, Cz, Pz) for midline, and Hemisphere (Hem; left, right) and Anteriority (Ant; anterior, posterior) for the lateral analysis within-subject factors. When there was a main effect or interaction, post-hoc analyses were conducted through pairwise comparisons, and Bonferroni correction was used for adjustment for multiple comparisons (i.e., the reported p-values are the adjusted p-values). The ultimate degree of freedom was corrected with the Greenhouse-Geisser epsilon when the variance sphericity assumption was violated.

Ⅳ. Results

1. Orthographic Processing (P2: 130-230ms)

For the midline analysis, a main effect in the Condition factor was found [$F(2, 50) = 3.23, p = .048, \eta_p^2 = .114$]; there was a significant difference between the background music with lyrics and no background music conditions, where the no-music condition elicited a greater amplitude difference than the with-lyrics music condition ($p = .044$). There was no main effect in the Electrode factor [$F(1.6, 81.9) = .46, p = .595, \eta_p^2 = .009$] nor a significant interaction of Elec*Cond [$F(3.3, 81.9) = .50, p$

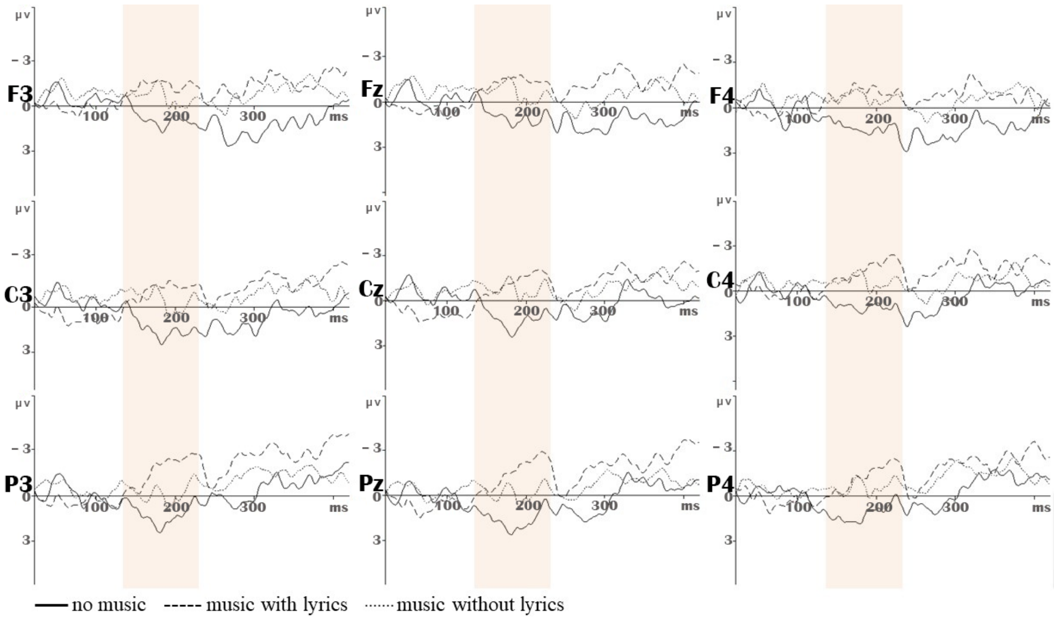

Figure 2. Grand averaged difference waves (incorrect - correct) in orthographic processing: P2

= .697, ηp^2 = .020].

The analysis of the lateral regions also showed a Condition main effect [$F(2, 50) = 4.12$, $p = .022$, $\eta p^2 = .142$], where the amplitude difference was greater in the no music condition compared to the music with lyrics condition ($p = .018$), similar to the pattern observed in the midline analysis. This was regardless of hemisphere or anteriority as there were no main effects nor interactions observed.

2. Semantic Processing (N400: 350-450ms)

In terms of semantic processing, there was an Electrode main effect [$F\ (1.7, 85.5) = 12.58$, $p < .001$, $\eta p^2 = .201$], while the difference between conditions did not reach significance [$F\ (2, 50) = 2.84$, $p = .068$, $\eta p^2 = .102$]. There was no significant interaction of Elec*Cond [$F\ (3.4, 85.5) = 1.63$, $p = .182$, $\eta p^2 = .062$].

The lateral analysis showed that there was a Hemisphere main effect [$F\ (1, 50) = 6.10$, $p = .017$, $\eta p^2 = .109$]; the left hemisphere had a significantly higher amplitude difference than the right hemisphere throughout the three conditions ($p = .017$). A Hem*Ant*Cond interaction was also discovered [$F\ (2, 50) = 3.66$, $p = .033$, $\eta p^2 = .128$], but there were no significant Condition main

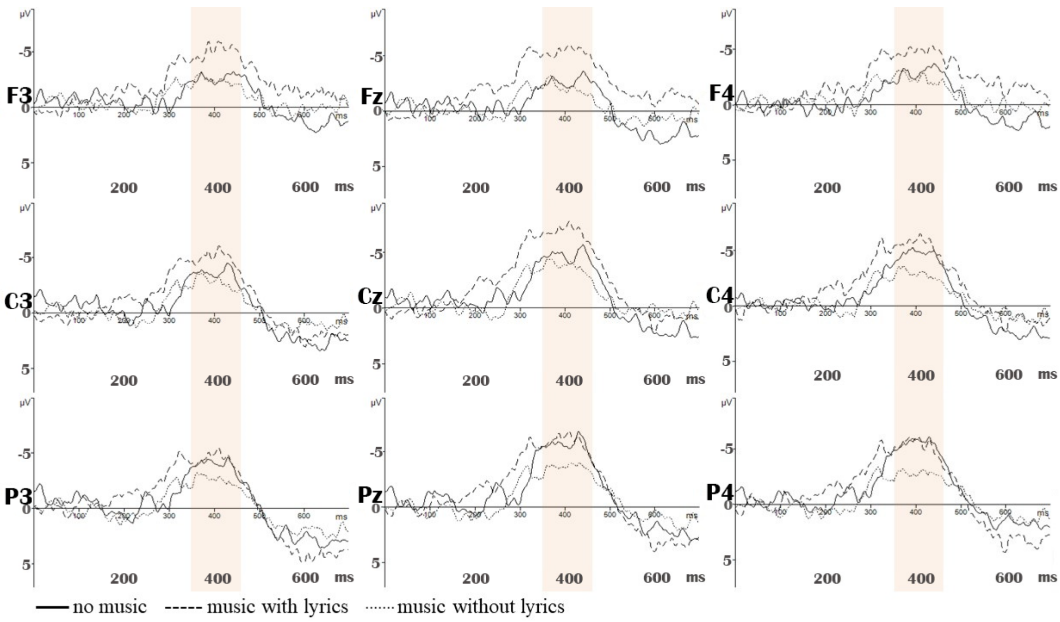

Figure 3. Grand averaged difference waves (incorrect - correct) in semantic processing: N400

effects or interactions with Anteriority and Hemisphere, when each variable was held constant (all $p > .05$).

3. Syntactic Processing (P600: 640-740ms)

In the midline analysis, a main effect in the Electrode factor was found [F (1.4, 67.7) = 28.02, $p < .001$, $\eta p^2 = .359$], while there was no main effect in the Condition factor [F (1, 50) = 1.78, $p = .18$, $\eta p^2 = .066$]. There was a significant interaction of Elec*Cond [F (2.7, 67.7) = 3.15, $p = .035$, $\eta p^2 = .112$], and to examine the electrode(s) that caused the interaction with the Condition factor, a post-hoc analysis was conducted in which each electrode was analyzed individually. The examination of the differences among the Condition factor at each electrode site revealed a significant difference between the two conditions was found at the Fz electrode[2]. The P600 amplitude in condition 1 (no music) was

2) Although the P600 is well known to appear in the posterior regions of the brain, there are studies showing that the component sometimes has an anterior position (Friederici et al., 2002; Hagoort et al., 1999; Kaan & Swaab, 2003b). Similarly, we found clearer P600 effects in the anterior region, and we leave the reason for such distribution for further exploration in future studies.

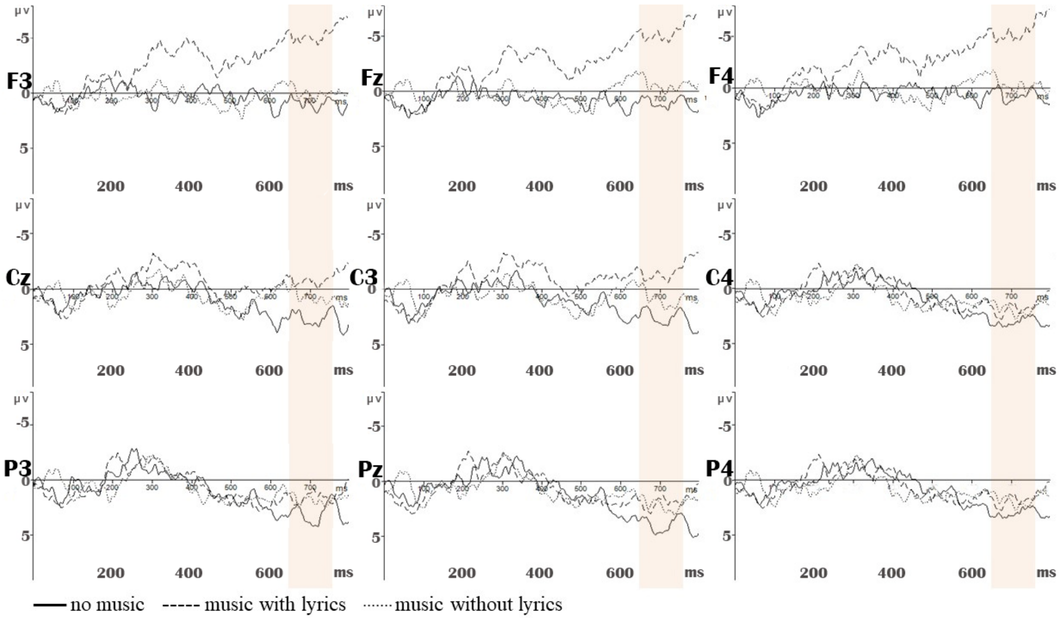

Figure 4. Grand averaged difference waves (incorrect - correct) in syntactic processing: P600

higher than in condition 2 (music with lyrics) (p = .039).

In the lateral analysis for the P600, an Anteriority main effect was discovered [F (1, 50) = 15.06, p < .001, η_p^2 = .231] as well as an Ant*Cond interaction [F (2, 50) = 3.38, p = .042, η_p^2 = .119]. The amplitude difference was higher in the posterior region compared to the anterior region of the brain (p < .001). In order to further analyze the interaction between anteriority and condition factors, a post-hoc analysis was conducted by observing the differences among conditions in both anterior and posterior regions. Although there was a difference between the conditions in the anterior region, it did not reach significance (p = .066).

A summary of the main comparisons across the three music conditions is presented in Table 2.

Ⅴ. Discussion

The main purpose of the present study was to examine whether the presence of background music, with and without lyrics, interferes with different types of language processing. Participants were situated in one of the three background music settings (music with lyrics, music without lyrics, and no music)

Table 2. Summary of main results

Type & ERP component	Analysis	Condition main effects / interactions	Cond.	Mean	Std. Error	95% Confidence Interval	
						Lower bound	Upper bound
orthographic processing P2 (130-230ms)	midline	Condition main effect NO > WL	NO	1.146	.693	-.246	2.539
			WL	-1.207	.653	-2.519	.106
			NL	-.573	.636	-1.850	.705
	lateral	Condition main effect NO > WL	NO	1.038	.571	-.109	2.184
			WL	-1.209	.538	-2.290	-.128
			NL	-.298	.524	-1.350	.755
semantic processing N400 (350-450ms)	midline	N/A	NO	-4.407	.934	-6.282	-2.532
			WL	-6.127	.880	-7.895	-4.359
			NL	-3.211	.857	-4.932	-1.491
	lateral	N/A	NO	-3.435	.826	-5.093	-1.777
			WL	-4.473	.778	-6.036	-2.909
			NL	-2.298	.758	-3.819	-.776
syntactic processing P600 (640-740ms)	midline	Condition x Electrode Fz: NO > WL	NO	2.527	1.524	-.535	5.588
			WL	-1.405	1.437	-4.292	1.481
			NL	.750	1.399	-2.059	3.560
	lateral	N/A	NO	2.001	1.327	-.664	4.666
			WL	-1.334	1.251	-3.846	1.179
			NL	1.017	1.218	-1.429	3.462

Note: Values are in µV; Cond. = Condition; NO = no-music; WL = music with lyrics; NL = music without lyrics

and were asked to judge the acceptability of visually presented sentences while their ERP responses to orthographic, semantic, and syntactic anomalies were recorded. According to the results, there were no differences between the no music and music without lyrics conditions, while the music with lyrics condition decreased neural sensitivity to orthographic and syntactic errors compared to the no music condition. The results are discussed below in relation to previous studies on the music interference effect.

One important finding from the present study is that the music without lyrics condition did not influence orthographic, semantic, or syntactic processing. That is, participants were equally sensitive to linguistic errors when there was instrumental music playing in the background and when there was no auditory stimuli at all. This is in contrast to the case where participants listened to background music with lyrics, which hindered online sentence processing. The pattern corroborates the majority of previous studies (e.g., Miller, 2014; Perham & Currie, 2014; Stroupe, 2005; but c.f., Avila et al., 2012; Gillis, 2010). While those studies mostly relied on behavioral methodologies and indirect measures of language processing ability, such as using multiple-choice reading comprehension questions, the present study used ERPs and measured sensitivity to different kinds of sentence anomalies in online sentence processing. The results thus provide more direct, neural evidence for the account that the presence of lyrics plays a significant role in determining the effect of background music on reading performance.

While there was no effect of non-lyrical background music, the music with lyrics condition yielded a significant difference in performance on orthographic and syntactic processing, but not semantic processing. In terms of orthographic processing, the positivity peak near 180ms after stimulus presentation, which can be recognized as a P2, revealed significantly larger amplitudes in the condition where participants did not listen to any music than when they listened to music with lyrics. This difference in P2 effects between the no-music and the music-with-lyrics conditions was found both in the midline and lateral regions of the brain, suggesting a strong, general distribution. A similar pattern was found with the P600, reflecting syntactic processing. The midline and lateral analyses revealed that the P600 effect was larger when participants were processing sentences in silence, compared to when they were listening to lyrical music being played in the background. That is, listening to music with lyrics interfered with the syntactic structure building process required in the acceptability judgment task. Interestingly, the same kind of pattern was not observed in semantic processing; the N400 effects did not differ between the no music and music with lyrics conditions. These are novel findings regarding the effect of background music on reading, as no previous study, to our knowledge, has examined and found different music interference effects according to the type of sentence processing involved in reading.

The difference between the music with and without lyrics conditions also supports the account that lyrics and melody in music are processed independently. Some previous studies (e.g., Serafine et al., 1984) have proposed that the lyrical and melodic information in music are integrated in memory. However, if this was the case, there should have been no significant differences between the music with and without lyrics conditions in the present experiment. The finding that different degrees of interference occurred according to the presence of lyrics in the songs suggests that lyrics and melody are not integrated, but rather processed separately, resulting in additive distraction from the lyrical and melodic information combined in the with-lyrics condition. These findings are in agreement with previous results indicating independent processing of lyrics and tunes, at least in online processing (e.g., Besson et al., 1988).

The finding that lyrical music did not hinder performance on processing semantic information, but rather interfered with handling orthographic and syntactic information during reading is also an important contribution to the literature on the background music interference effect. Currently existing accounts that attempt to explain the interference from lyrical music, including the Semantic-Interference hypothesis (Martin et al., 1988) and the interference-by-process account (e.g., Marsh et al., 2008), propose that the semantic information in the lyrics of background music hinders the semantic processing required in reading. Yet, the phrase "semantic processing" was used as a broad term to refer to the general processing of linguistic information in the texts being read, as these theories are based on behavioral measures that cannot tease apart the different types of processing involved in reading. One of the aims of the present study was to specifically examine the music effect on different types of linguistic processing separately, using a more sensitive tool, EEG/ERPs. In this regard, the results are particularly informative in that lyrical music did not influence semantic processing but instead interfered with the visual processing of orthographic information and the reanalysis of syntactic structure. These results provide important pieces of empirical evidence that could be used to further refine current theories explaining the effect of lyrical background music on reading. Although the present study focused on measuring neural responses to scrutinize the effect of background music on different types of language processing, it is encouraged that future studies measure both behavioral and neural data in the same experiment and compare them to provide a more comprehensive understanding of the background music effect and also highlight the potential advantage of using more sensitive measures like EEG/ERPs. Moreover, the current results would benefit from further replications that include a greater number of participants and trials, in order to confirm that the effects hold in a higher-powered experiment.

Due to the lack of previous research on the music interference effect on different types of language processing, it is difficult to speculate why lyrical music interfered with orthographic and syntactic processing, but not with semantic processing. One potential reason is that the semantic anomaly typically used to elicit N400 effects, which was also used in the present study, is very robust and that it is not easily modulated by the interference from lyrical or non-lyrical background music. That is, the effect of lyrical music on language processing may not be strong enough to influence strong, immediate responses to semantic anomalies. Another possible explanation, particularly for the difference found in syntactic processing, lies with the account that supports the interactive processing of music and language. The current literature on music and language processing seems to support the idea that music and language have similar syntactic properties that are processed interactively in common areas in the brain, which leads to interference when burden is imposed due to completing concurrent tasks that require attention to both music and language syntax (Fiveash & Pammer, 2012; Maess et al., 2001; Patel et al., 1998; Sammler et al., 2011; but c.f. Saito et al., 2012; Samson & Zatorre, 1991). If music and language syntax are processed together, it is possible that the syntactic information in both the lyrics and the melody in lyrical music causes more processing load than the melodical information alone in non-lyrical music, and therefore, lyrical music places more burden on the brain that is concurrently processing the syntax in the language in the acceptability judgment task at hand. Further investigation of whether melodic syntax is processed even outside the focus of attention, during a main language-related task, is needed to support this explanation. It is also important to note that given that there were only effects of the different music conditions shown as the interactions with the electrode or anteriority main effects, there is a possibility that the effect of background music is not as robust, not enough to show an overall effect of the conditions independent from the electrode or anteriority effects. Thus, further replications using experimental designs to specifically test the effect of background on syntactic processing is encouraged.

As the focus of the study was on whether the presence of music affects different kinds of language processing, all the songs used in the background music stimuli were controlled to be unfamiliar to all participants. However, it is possible that the null effect found with the non-lyrical music is due to the novelty of the songs; since the songs were unknown, they could have caused minimal distraction compared to more familiar songs, although previous studies have found that the lyrics in background music are processed to the same extent when the songs are familiar to when they are unfamiliar (e.g., Chien & Chan, 2015). Another interesting avenue for future research would be comparing music with lyrics that are intelligible and not intelligible (in an unfamiliar language) and their effects on the types of language processing examined in the present study, using more direct measures like ERPs rather than behavioral measures (Herring & Scott, 2018; Martin et al., 1988). This comparison would allow us to tease apart the interference from the language-specific processing of lyrics from distraction from other non-language related properties of music that contains lyrics, such as the presence of human voice. While the familiarity and intelligibility of the music stimuli were controlled for the purpose of the current study, whether these factors as well as others, such as music genre, have varying effects on language processing would be an interesting avenue for future research.

Ⅵ. Conclusion

The present study examined the influence of background music, with and without lyrics, on different levels of visual sentence processing. By observing the sensitivity to orthographic, semantic, and syntactic anomalies in different background music settings using ERPs, it was discovered that the presence of lyrical music hinders orthographic and syntactic processing, while it has no effect on semantic processing. The presence of non-lyrical music did not have an effect on processing orthographic, semantic, or syntactic information. The findings indicate that the influence of background music on language processing can vary according to the type of language processing involved in reading.

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(국문요약)

배경음악 및 가사가 실시간 언어처리에 미치는 영향 - 사건 관련 전위 연구

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우리는 사람들이 음악을 들으면서 책을 읽거나 학습활동을 하는 경우를 자주 발견하게 된다. 이러한 배경음악이 언어처리 과정에 어떠한 영향을 미치는지에 대해 그동안 활발한 논의가 진행됐다. 하지만 음악의 언어처리에 대한 영향성은 아직까지 명확히 밝혀져 있지 않은 상황에 있다. 본 연구는 사건관련전위(ERP)를 활용하여, 각 언어의 처리 과정-표기 정보 처리, 의미 정보 처리, 통사 정보 처리에 따라 나타나는 배경음악의 효과를 분석하고 이를 통해 음악이 언어처리에 미치는 영향성을 규명하고자 하였다. 총 60명의 피험자를 세 가지 실험조건그룹(가사 있는 음악 조건, 가사 없는 음악 조건, 무 음악 조건)으로 구분하고, 각 언어처리 과정에 해당하는 문장 자극을 제시하고 이에 대한 뇌파를 측정하였다. 실험 결과, 무음악 조건에 비해 가사 있는 음악 조건에서 표기 처리를 반영하는 P2와 통사 처리를 반영하는 P600의 진폭이 유의미하게 낮게 나타났다. 이에 반해, 의미 처리 과정을 반영하는 N400은 조건 간의 차이가 발견되지 않았다. 이러한 결과는 가사 있는 음악이 표기 처리 과정과 통사 처리 과정을 방해하는 한편, 의미 처리 과정에는 영향을 미치지 않는다는 점을 시사한다.

주요어 : 언어처리; 배경음악; 사건관련전위; N400; P600