L2 Learners' Sensitivity to Strong and Weak Subjacency-Violations in Online Processing

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1. Introduction

Cross-linguistically, languages differ with respect to whether or not they instantiate overt WH-movement. For example, in WH-questions in languages such as Chinese and Korean, there is no overt WH-movement and a WH-phrase can remain in situ, in the same position as it appears in the declarative counterpart. This is illustrated by the examples in (1-2) from Korean and Chinese.

(1) ku-nun mues-ul coa-ha-ni?
He-TOP what-ACC like-PRES-Q
What does he like?'

(2) ni xiangxin ta hui shuo shenme
you think he will say what
'What do you think he will say?'

English, on the other hand, instantiates overt WH-movement. As illustrated by the example in (3), the WH-phrase (*who*) has moved overtly from the object position of the embedded clause to the Spec(ifier) position of the matrix CP. The standard analysis of the apparently 'long-distance movement' illustrated in (3) is that the WH-movement is cyclic; that is to say, the WH-phrase moves in a step-wise fashion from its underlying position through the SPEC of the embedded clause CP, before reaching its landing site in the SPEC of the matrix CP, rather than moving in one full swoop.

(3) [CP Who$_i$ does [IP Mary think [CP that [IP Bill likes t_i]]]]?

The ungrammaticality of the WH-questions in (4-5) indicates that WH-movement is cyclic, is constrained and not freely operative.

(4) *[CP Who$_j$ does [IP Jack wonder [CP when$_i$ [IP Mary saw t_j t_i]?

(5) *[CP Which book$_i$ did [IP Mary meet [DP the man$_j$ [CP who$_j$ [IP t_j wrote t_i]]]]]?

Both (4) and (5) violate the principle of Subjacency, a proposed Universal constraint on WH-movement, according to which, WH-movement may not cross more than one bounding node (or barrier) in each cycle, where the bounding nodes, in the case of English, are DP and IP (Chomsky, 1981a, 1981b, and 1986a).

However, it has been observed that not all violations of the subjacency principle result in equally strong judgments of ungrammaticality. For example, although both (6) and (7) violate the subjacency

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principle, (6) appears far worse than (7). In (6), the WH-extraction is from a CP that is a relative clause (i.e. where the relative clause is an adjunct to the head noun). In (7), on the other hand, the WH-extraction is from a noun-complement clause (i.e. from a CP that is a complement to the head noun). Thus, although both (6) and (7) violate subjacency, the violation in (6) represents a strong subjacency-violation whereas the one in (7) represents a weak-subjacency violation.

(6) Which painting did John forgive the boy that ruined _____ ?
*[CP Which painting$_i$ did [IP John forgive [DP the boy$_j$ [CP *Op*$_j$ that [IP t$_j$ ruined t$_i$]]]]]?

(7) ??*Which contract did George emphasize the fact that the company lost _____ ?
??*[Which contract$_i$ did [IP George emphasize [DP the fact [CP t$_i$ that [IP the company lost t$_i$]]]]]?

Within second language acquisition research, an issue that has generated considerable debate is the status of Universal Constraints on WH-movement, in particular, the principle of subjacency, in adult L2 grammars of English. In their seminal article, Johnson and Newport (1991) investigated age effects on Chinese speakers' accessibility to the subjacency principle in their L2 acquisition of English. Based on their findings, they argued that the Chinese participants' L2 performance on the UG principle of subjacency over age of arrival in the US underwent a gradual decline with increasing age. Johnson and Newport proposed that the human biological endowment for language acquisition, undergoes a very broad deterioration as learners become increasingly mature. Crucially, according to them, the failure on the part of the late arrivals to consistently reject ungrammatical WH-questions involving subjacency violations is evidence that UG is not accessible for the acquisition of a second language in adulthood.

Recently, however, some researchers (e.g. Ma, Kim and Schwartz, 2007; Martohardjono, 1993; Pérez-Leroux and Li, 1998), have argued (contra, Johnson and Newport, 1991) that adult L2 learners of English, whose L1s lack overt wh-movement, do in fact "pattern" very similar to native-speakers in their acceptance of grammatical WH-extraction and rejection of ungrammatical WH-extraction (subjacency violations), i.e., even though they may differ from native-speakers of English in terms of absolute accuracy. Like native-speakers, the adult L2 learners in these more recent studies, also exhibited a differential sensitivity to the different subjacency-violation types. Their judgments were most accurate on "strong- violations" (e.g., WH-extraction out of relative clauses) and least accurate on "weak-violations" (e.g., WH-extraction from DPs with clausal complements). Pérez-Leroux and Li, (1998) also found developmental trends in relation to their Chinese L2 participants' differential sensitivity to strong and weak violations of subjacency in English. In their study, only the learners at the Intermediate level of proficiency exhibited differential sensitivity to strong and weak violations, rejecting WH-extraction out of a relative clause significantly more often than WH-extraction out of a noun-complement clause. The L2 learners at the advanced level of proficiency performed similar to the native speakers in their study, rejecting strong and weak subjacency-violations equally. The findings of these previous L2 studies, based on offline methods, bolster the position that adult L2 acquisition is indeed constrained by Universal Grammar.

We report the results of a small-scale study that addressed the issue of adult L2 learners' sensitivity to "strong" and "weak" subjacency-violations from an online-processing perspective. Specifically, our study investigated whether L2 speakers of English, whose L1s lack overt WH-movement, and who pattern similar to native-speakers of English in their offline grammaticality judgment of "strong" and "weak" violations of subjacency, would also pattern similar to native-speakers of English in their real-time processing of such violation types. Our research question was, 'Will Korean and Chinese L2 speakers of English, whose L1s do not have overt WH-movement, show native-like sensitivity to strong and weak subjacency-violations in WH-questions in English in an offline and an online task?'.

2. Methodology

2.1. Participants

Information about the participants, including information about their language background and language use, was obtained through a questionnaire. The participants consisted of two groups: an

experimental group consisting of 11 adult second language speakers of English and a control group of 5 adult native speakers of English (3 males and 2 females). The L2 group comprised 6 native speakers of Korean (3 males and 3 females) and 5 native speakers of Chinese (2 males and 3 females). The mean age of the Korean speakers of English was 24 years and the mean age of the Chinese speakers of English was 27 years. The mean age of the native speakers of English was 27 years. The mean age at onset of exposure to English for the Korean and the Chinese participants was approximately 13 years. All the L2 participants reported that they used their L1 (Korean/Chinese) and their L2 (English) on a daily basis. The mean length of residence in the U.S for the Korean speakers of English was 2 years and 6 months. The mean length of stay in the U.S for the Chinese speakers of English was 4 years. One of the Chinese participants had lived longer in the U.S. than the others (i.e. for 10 years). When that person is excluded, the mean number of years in the U.S for the Chinese participants in the L2 experimental group drops to 3 years. All the participants were undergraduate or graduate students at a mid-western university in the U.S at the time the study was conducted. One of the 5 native speakers of English was a graduate student and the remaining 4 were undergraduate students. The L2 group consisted of 8 undergraduate students and 3 graduate students.

2.2. Materials and Procedures

As stated above, a written questionnaire was used to obtain information about the language history of the participants. Besides the questionnaire, the instruments used in this study consisted of the following: an Offline grammaticality judgment task, a word-by-word, self-paced online moving window reading task using the program *Linger* (Rohde, 2001), controlled by custom software on Mac computers, and a forced choice semantic judgment task following each item in the online task.

The Offline task contained a total of 15 experimental sentences to judged, with 5 items in each of the three conditions: Grammatical WH-movement out of an embedded clause, Ungrammatical WH-movement out of a noun complement clause (i.e. Weak violation) and Ungrammatical WH-movement out of a relative clause (Strong violation). The participants were asked to rate each sentence on a 4-point rating scale (1=incorrect; 2=somewhat incorrect; 3=somewhat correct; 4=correct).

The Online task contained 30 experimental items, with 10 items in each of the three conditions: Grammatical WH-movement out of an embedded clause, Ungrammatical WH-movement out of a noun complement clause (i.e., Weak violation) and Ungrammatical WH-movement out of a relative clause (i.e., Strong violation). Examples of the experimental items in the offline and online tasks are shown in (8-10). The WH-extraction site is indicated for the example in each condition.

(8) Condition 1: Grammatical WH-movement out of an embedded clause
Which cat did Jack say that the dog chased -----?

(9) Condition 2: Ungrammatical (Weak Violation) WH-movement out of a noun complement clause
Which patient did Sally make the claim that the doctor cheated ------?

(10) Condition 3: Ungrammatical (Strong Violation) WH-movement out of a relative clause
Which bank did Bob see the thief that robbed -------?

As can be seen from the examples in (8-10), the sentences in Condition 1 and Condition 3 were of the same length (9 words per sentence) and the sentences in Condition 2 consisted of 11 words each. The Online task also contained 30 grammatical declarative counterparts of the WH-questions in the three experimental conditions. Examples of these declaratives are shown in (11).

(11) Jack said that the dog chased the yellow cat.
Sally made the claim that the doctor cheated the cancer patient.
Bob saw the thief that robbed the Central Bank.

In the Online self-paced reading task, each participant read sentences presented on the computer screen. The words in every sentence appeared one by one on the screen by pressing the space bar. With

every press of the space bar, a new word appeared, and the previous one disappeared from the screen. *Linger* recorded the time between each press of the space bar (i.e., the time spent reading each word) in milliseconds. For the purpose of the statistical analysis, the reading times in three regions (i.e. in the target WH-questions) in each experimental condition were considered. The critical region for the sentences in the three conditions were, the first three words in the leftmost edge of the complex NP in the ungrammatical WH-questions (e.g., *the claim that* in (9) and *the thief that* in (10)) and the first three words in the leftmost edge of the embedded CP in the grammatical WH-question (e.g., *that the dog* in (8)). The reading times for the final word (i.e. embedded clause verb) in the sentences in all three conditions (e.g. *chased/cheated/robbed* in (8-10)), which immediately precedes the site of WH-extraction, as well as the reading times for the question mark at the end of every sentence, was also measured.

When the participants finished reading each sentence, a Yes/No question ("Does the sentence you just read make sense?") appeared on a new screen. The participants were asked to indicate their semantic judgment by pressing the "F" key on the keyboard for YES and the "J" key for NO. The time (in milliseconds) taken to indicate their response to the Yes/No question was also recorded.

The Offline and the online tasks also contained 10 filler sentences, consisting of grammatical WH-questions (monoclausal WH-questions and WH-extraction from the matrix clause) and ungrammatical monoclausal WH-questions (involving errors in subject-auxiliary inversion), and grammatical Yes/No questions. In addition, the Online task also included 5 sentences where the words in each sentence were in a jumbled-up order and which did not make sense. The sentences in the jumbled-up order were included in order to ensure that the participants were indeed reading the sentences on the screen. Participants who failed to respond in the negative to 4 of the 5 sentences in the jumbled-up order were excluded from further consideration. Accordingly, one of the Korean participants was excluded from the online (and the offline) data analysis, as he responded in the affirmative (yes, the sentence makes sense) to all five jumbled-up sentences on the online task. One Chinese participant was also excluded from the offline and the online data analysis as he rated all the offline target WH-questions, including the grammatical WH-questions as incorrect (=1 on the rating scale), indicating that WH-movement was probably not operative in his L2 grammar. This resulted in reducing the number of participants in the L2 speaker group from 11 to 9.

2.3. Predictions

In relation to the offline grammaticality judgment task, we hypothesized that the degree of well-formedness of the target sentences will be reflected in the participants' grammaticality rating scores for them. Our expectation (based on the findings of recent L2 research in the area) was that the native speakers and the L2 speakers would pattern alike in the domain of WH-Questions. Specifically, we predicted that they would judge grammatical WH-extraction out of an embedded clause as "correct" and reject both types of ungrammatical WH-extraction (i.e., Weak violation and Strong Violation). At the same time, we also predicted that both the native speakers of English and the L2 speakers would distinguish between the WH-questions in the two ungrammatical conditions, namely Weak Violation WH-questions and the Strong violation WH-Questions. We predicted that their Mean rejection rate of the Strong Violation WH-questions would be significantly higher than their Mean rejection rate of the Weak Violation WH-questions.

As for the online self-paced reading task, we hypothesized that the degree of well-formedness of the targets will be reflected in the online Reading Times (RTs) of them. Our expectation was that if the L2 speakers behave like the native speakers in the offline task, their online results would also resemble that of the native speakers. Specifically, our prediction was that the sentences in condition 1 (Grammatical WH-movement) will have the shortest Reading Times (RTs) and that the sentences in condition 3 (Ungrammatical [Strong Violation] WH-movement) will have the longest RTS for all of the three regions.

In relation to the semantic judgment task, our prediction was that the results for the participants in both groups would be in line with the results for the Online reading task as well as that of the Offline grammaticality judgment task, both in terms of their semantic acceptability response as well as in terms of the Response time to the Yes/No questions.

2.4. Procedures for Data Analysis

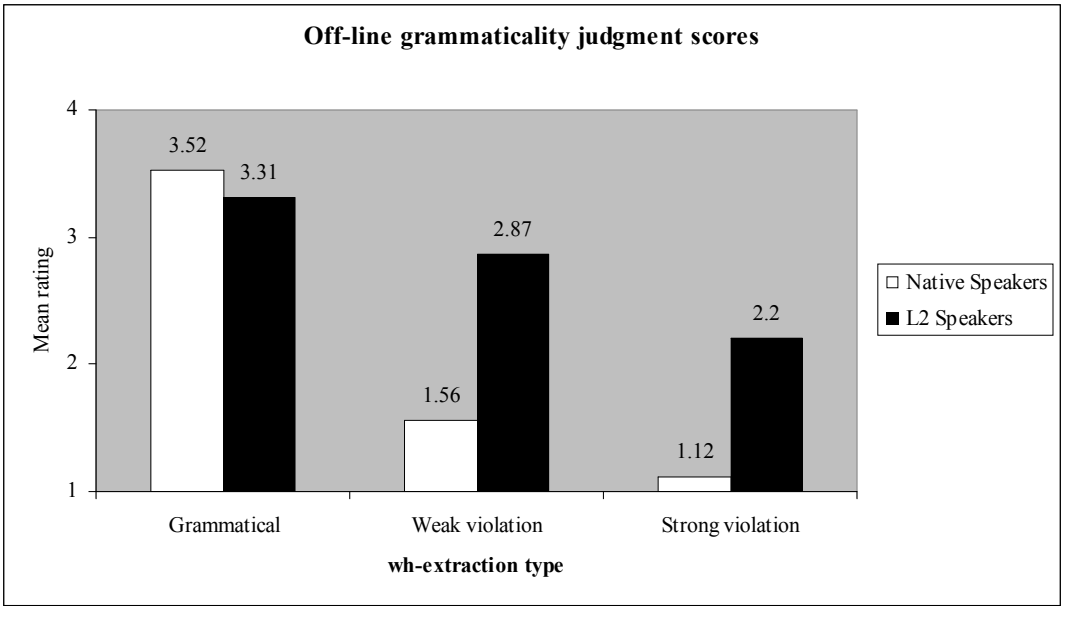
In order to test our predictions in relation to each of the three tasks, One-Way Repeated Measures ANOVAs, followed by paired samples T-tests, were performed for the L2 experimental group and the native-speaker control group, to test for significant Main Effects, with WH-Condition as a factor (with three levels, namely, grammatical, ungrammatical Weak-Violation, and Ungrammatical Strong-Violation). Alpha was set at the 0.05 level. In the Offline grammaticality judgment task, the dependent variable was the participants' Mean rating score for the sentences in each experimental condition. In the case of the Online task, the dependent variables were the reading times for each of the three regions, namely, the critical region in each condition (e.g. *that the dog*; *the claim that*; *the thief that*), embedded clause verb (which was also the final word), and the question mark immediately following it, and which marked the end of the sentence. For the semantic judgment task, the dependent variable was the participants' semantic acceptability Response Accuracy; our prediction was that the participants will judge the grammatical WH-extraction type items as semantically acceptable and the ungrammatical WH-extraction type items, particularly the items in the strong violation condition, as semantically unacceptable. In addition, the effect of WH-condition type on the participants' Response time to the Yes/No questions in the semantic judgment task was also examined.

3. Results

3.1. Off-line grammaticality judgment task

Figure 1 shows the results of the off-line grammaticality judgment task.

Figure 1: Results of the Off-line Grammaticality Judgment Task



Note: 1=Incorrect; 2=somewhat Incorrect; 3=somewhat correct; 4=Correct

There was a Main effect of WH-*extraction type* for the Native control group in the off-line grammaticality judgment task, $F(1,4) = 46.379$, $p < .0001$. Paired–samples T-tests revealed that there was a significant difference in their off-line rating scores between the grammatical condition and the weak violation condition, ($t(4) = 6.699$, $p=.003$), as well as between the grammatical condition and the strong violation condition, ($t(4) = 9.487$, $p=.001$). However, there was no significant difference in their rating scores between the weak violation condition and the strong violation condition, ($t(4) = 1.773$, $p=.151$). The results indicate that the native speakers accepted grammatical WH-extraction and rejected both types of ungrammatical WH-extraction (strong violation and weak violation types).

As for the L2 group, there was a Main effect of WH-extraction type in the off-line grammaticality judgment task, $F(1,8) = 12.338$, $p = .001$. Follow-up Paired –samples T-tests revealed that there was a

significant difference in the off-line rating scores between the grammatical condition and the strong violation condition, (($t(8) = 4.490$, $p=.002$), and between the weak violation condition and the strong violation condition, ($t(8) = 3.050$, $p=.016$). In contrast to the native-speaker group, there was only a marginal difference in the off-line rating scores between the grammatical condition and the weak violation condition, ($t(8) = 2.141$, $p=.065$). The results indicate that the L2 group was most accurate in their judgment (i.e. acceptance) of grammatical WH-extraction and least accurate (i.e. in rejecting) in the case of the items in the weak violation condition.

3.2. Online self-paced reading task

Tables 1 to 3 present the Mean Reading Times and the Standard Deviations for the critical region, final verb, and the question mark for each of the three WH-question types for the native speakers of English and the L2 speakers.

Table 1. Reading Times (RT) for the critical region across the three conditions

Participant group	**Native speakers**		**L2 Speakers**	
Condition	RT (ms)	SD	RT (ms)	SD
Grammatical	1337	397	1966	608
Weak violation	1470	392	1773	565
Strong violation	1468	349	2744	825

Table 2. Reading times for the final verb across the three conditions

Participant group	**Native speakers**		**L2 Speakers**	
Condition	RT (ms)	SD	RT (ms)	SD
Grammatical	469	178	777	463
Weak violation	511	221	640	298
Strong violation	474	106	860	401

Table 3. Reading times for the question mark across the three conditions

Participant group	**Native speakers**		**L2 Speakers**	
Condition	RT (ms)	SD	RT (ms)	SD
Grammatical	988	514	1822	1647
Weak violation	1113	811	2220	1642
Strong violation	669	146	2648	2050

In relation to the critical region, there was no Main effect of WH-extraction type for the native English speaking control group ($F(1,4)=1.870$, $p =.242$). In the case of the L2 group, a Main effect of WH-extraction type was observed for the critical region, $F(1,8) = 11.208$, $p = .003$. Follow-up Paired – samples T-tests revealed that the L2 group's reading times for the strong violation WH-extraction condition (2744 ms) were significantly longer than the reading times for the weak violation WH-extraction condition (1773 ms), $t(8) = -3.884$, $p=.005$). The results also showed that the L2 group's reading times for the critical region in the strong violation condition (2744 ms) was also significantly longer than the reading times for the critical region in the grammatical WH-extraction condition (1966 ms, ($t(8) = -5.721$, $p<.0001$). In contrast, the differences between the reading times for the grammatical WH-extraction and the weak violation WH-extraction conditions was not found to be statistically significant.

In relation to the reading times for the final verb, there was no Main effect of WH-extraction type for the native speaker control group ($F(1,4)= .387$, $p = .667$) or for the L2 group ($F(1,8)= .893$, $p = .391$). Likewise, in relation to the reading times for the question mark, there was no main effect of WH-extraction type on the reading time of the question mark for either the native control group ($F(1,4)= .846$, $p = .423$) or for the L2 group ($F(1,8)= .914$, $p = .400$).

3.3. Semantic Judgment task

Table 4 shows the participants' semantic acceptability Response Accuracy for each of the three WH-extraction conditions. The percentages shown in Table 4 represent the proportion of trials where the participants responded in the affirmative in the case of the items in the grammatical WH-extraction type and in the negative in the case of the items in the ungrammatical WH-extraction type (both strong violation and weak violation). It is relevant to state here that whether a sentence makes sense or not may not necessarily be tied to its grammaticality, and for this reason, the label "Accuracy" may be misleading. However, our use of the term "Accuracy" in this context, is solely for ease of comparison across the three WH-extraction types. .

Table 4. Forced-Choice Semantic Judgment Task: Response Accuracy across the three WH-extraction types

Participant group Condition	**Native speakers**	**L2 Speakers**
Grammatical	62%	77%
Weak violation	90%	43%
Strong violation	100%	59%

Note: Percentages represent the Response Accuracy, that is, the proportion of trials where the participants responded, "Yes, the sentence makes sense" in the case of grammatical WH-extraction and 'No, the sentence does not make sense" in the case of the ungrammatical weak and strong violation WH-extraction types.

For the Native Control group, there was no Main effect of WH-extraction type on their Response Accuracy in the semantic judgment task, $F(1,4)=2.243$, $p = .207$. It is relevant to state there that the unexpectedly lower percentage of Response Accuracy for the grammatical WH-extraction (62%) was owing to one participant, who judged all 10 sentences in this category as semantically unacceptable. However, all the other native-speakers in the Control group overwhelmingly judged all the ten grammatical-WH extraction items as semantically acceptable (i.e. 90-100%). However, for the L2 group, a Main effect of WH-extraction type was observed, $F(1,8)=9.428$, $p = .004$. Follow-up Paired–samples T-tests revealed the following results: a significant difference in their Response Accuracy between the grammatical condition and the weak violation condition, ($t(8) = 3.714$, $p=.006$), and between the weak violation condition and the strong violation condition, ($t(8) = -2.589$, $p=.032$). A marginal difference was also observed in their Response Accuracy between the grammatical condition and the strong violation condition, ($t(8) = 2.276$, $p=.052$).

Table 5 shows the participants' Semantic Judgment Response Accuracy for the declarative counterparts of the target WH-questions in the three conditions in the self-paced reading task. There were no significant differences in the semantic acceptability responses across the three conditions for either the native-speaker group or the L2 group.

Table 5. Forced-choice Semantic Judgment task: Response Accuracy across the three grammatical declarative counterparts to the target WH-questions

Participant group Condition	**Native speakers**	**L2 Speakers**
Grammatical	100%	86%
Weak violation	98%	86%
Strong violation	98%	83%

Note: Percentages represent the proportion of trials where participants responded that the sentence made sense. All declarative counterparts were grammatical.

Table 6 shows the participants' Mean Response times to the Yes/No questions and their standard deviations for each of the three WH-extraction conditions. The differences between the Means were not found to be significant for either the native-speaker control group ($F(1,4)=.965$, $p = .398$) or the L2 group ($F(1,8)=2.531$, $p = .122$). Likewise, even in the case of the declarative counterparts to the target sentences, no significant differences between the Mean Response times for the three conditions were observed for either the native-speaker group or the L2 group.

Table 6. On-line Response Times (RSTs): Forced-choice semantic acceptability

Participant group	**Native speakers**		**L2 Speakers**	
Condition	RT (ms)	SD	RT (ms)	SD
Grammatical	1057	707	1522	857
Weak violation	775	482	1187	616
Strong violation	688	258	1784	1171

4. Conclusion

The offline grammaticality judgment task results indicated that the native speakers of English behaved as predicted. They accepted the grammatical WH-extraction sentences and rejected the items involving both strong and weak violations of the subjacency principle. The L2 speakers behaved similar to the native speakers, in that they accepted the grammatical WH-extraction items and rejected the strong violation items; however, unlike the native speakers, they also tended to accept (albeit weakly) the weak violation WH-items. In other words, unlike the native speakers, it was the L2 group that showed relative sensitivity to strong and weak violations of subjacency in the offline grammaticality judgment task, whereas the native speakers exhibited clear distinctions only between grammatical and ungrammatical WH-extraction.

The offline acceptability ratings of the target WH-question items were not reflected in the native speakers' reading times for the critical region, as there were no significant differences in the reading times for the critical region across the three conditions. In contrast, the L2 group's lowest acceptability rating in the offline grammaticality judgment task was reflected in their performance on the online reading task, as they took significantly longer to read the critical region in the case of the strong violation condition than in the case of the other two conditions. Crucially, the on-line task results indicated that the native speakers' and the L2 speakers' real-time processing of sentences involving grammatical WH-movement and ungrammatical WH-movement (i.e. strong and weak violations of subjacency) are somewhat different from each other. In sum, our overall findings, based upon the off-line and the on-line tasks, bolster the position that adult L2 acquisition is UG-constrained, and at the same time also suggest that L2 learners and native-speakers may use different processing "routes" to reach the same end. Future research, involving a larger number of participants, is needed to further explore the preliminary findings of this study.

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