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Resolution of Wh/Quantifier Scope Ambiguity in Native and Nonnative Language Processing*

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An, Youngjae. (2021). Resolution of wh/quantifier scope ambiguity in native and nonnative language processing. *The Linguistic Association of Korea Journal*, *29*(1), 93-113. This study makes an attempt to identify how and when native (L1) and nonnative (L2) speakers of English make use of syntactic knowledge and nonsyntactic contextual information to resolve wh/quantifier scope ambiguity during online sentence processing. The question addressed in this research is investigated in the context of weak crossover phenomena (Chiercia, 1993). 19 native speakers of English and 32 Korean speakers of English participated in a self-paced reading experiment; the Korean speakers are further divided into advanced and intermediate group. The results show that L1 and L2 speakers are able to integrate the syntactic information with the contextual information in resolving wh/quantifier scope ambiguity online, suggesting that the ambiguity is influenced by the contextual information (Villalta, 2003). The findings also show that L2 proficiency is not a predictor of L2 speakers' use of the target syntactic knowledge online. More importantly, the results indicate that L1 and L2 speakers employ similar strategies in resolving wh/quantifier scope ambiguity online, supporting the view that L2 processing is not fundamentally different from L1 processing (An 2019; Dekydtspotter et al., 2006).

Key Words: wh-word, universal quantifier, scope ambiguity, sentence processing, self-paced reading

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1. Introduction

This study investigates how and when native (L1) and nonnative (L2) speakers of English associate syntactic representations to the process of resolving scope ambiguity in questions with universal quantifiers. In English, questions with a wh-object and a universally quantified subject (henceforth Wh-obj/Qu-subj questions), such as (1), allow a single answer (SGA) and a pair-list answer (PLA) whereas questions with a wh-subject and a universally quantified object (henceforth Wh-subj/Qu-obj questions), such as (2), allow an SGA only (Aoun & Li, 1993; Chierchia, 1993; Hornstein, 1995; May, 1985, among others).

(1) Who did everyone say he met at the party?
  a. Single answer: Yanf.
  b. Pair-list answer: Mary met Yanf, Peter met Sue, and Julio met Yengmi.
(2) Who said he met everyone at the party?
  a. Single answer: Yanf.
  b. *Pair-list answer: Mary met Yanf, Peter met Sue, and Julio met Yengmi.

From an L2 acquisition point of view, this interpretive difference poses an interesting learnability problem for speakers whose L1 does not allow the PLA reading: the question of whether or not L2 acquisition differs fundamentally from L1 acquisition (Bley-Vroman, 1990; Schwartz & Sprouse, 1996). This is because the language input that L2 speakers receive is almost never sufficient to indicate that questions such as (1) are ambiguous.

From an L2 processing perspective, the issue proceeds in a similar vein: the question of whether or not L2 processing utilises syntactic knowledge in the same way as L1 processing (Clahsen & Felser, 2006; Dekydtspotter et al., 2006). The processing routines applied in the current experimental study will help determine how and when the scope ambiguity is resolved during online comprehension as well as whether L2 speakers are able to associate the target syntactic knowledge to the target language online.

In the meantime, it is necessary to provide an appropriate context that induces a felicitous interpretation of the target structure. Previous processing research supports the idea as such; that is, the resolution of structural ambiguity is influenced by the interaction with the context (Crain & Steedman, 1985; Kuno, et al., 1999; Villalta, 2003).

The parsing mechanism behind this argument is that the resolution of quantifier scope ambiguity derives from the interaction of syntactic and nonsyntactic principles. As a result, when multiple factors, such as syntax and context, compete with each other, processing difficulties arise in the resolution of wh/quantifier scope ambiguity. It is another aim of this study to examine how the contextual information guides the construction of syntactic representations during online comprehension. The underlying assumption is that a context with more than one possible antecedents for a wh-word delays the construction of syntactic representations necessary for semantic interpretations; that is, reference to the context is called for resolving wh/quantifier scope ambiguity.

The following section briefly outlines two theoretical accounts of wh/quantifier scope ambiguity, which follows the view adopted in generative grammar where it is assumed that such ambiguity is a case of structural ambiguity.

2. Weak Crossover and Wh/Quantifier Scope Relations

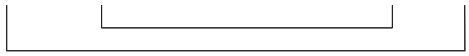
May (1985) observes that Wh-obj/Qu-subj questions such as (3a) is ambiguous, allowing an SGA or a PLA reading whereas Wh-sub/Qu-obj questions such as (3b) is unambiguous, allowing only an SGA reading. Consider the following sentences from May (1985, p. 45).

(3) a. Who do you think everyone saw at the rally? [SGA, PLA]
b. Who thinks everyone saw you at the rally? [SGA, *PLA]

May attributes this subject-object asymmetry to c-command relations between the wh-word and universal quantifier at LF, which contributes the difference scope ordering of the two elements. In order to capture the scope ambiguity in (3), May proposes quantifier raising (QR) that enables the quantifier to undergo movement to take its scope at LF. May suggests that in order for the SGA to be achieved, the wh-word takes scope over the quantifier (i.e. the wh-word c-commands the universal quantifier); in order for the PLA to be achieved, on the other hand, the quantifier takes scope over the wh-word (i.e. the universal quantifier c-commands the wh-word). In addition to this, May claims that QR respects the empty category principle (ECP) of Chomsky (1981). Since QR is an instance of movement, its trace must be properly governed at LF. In order to ensure the

well-formedness of LF representation, May further adopts Pesetsky's (1982) path containment condition (PCC), which states that "intersecting Ā-categorial paths must embed, not overlap" (p. 118). Let us see how QR, ECP and PCC account for the contrast between (3a) and (3b). The LF representations of (3a) and (3b) are given in (4) and (5), respectively.

(4) Who do you think everyone saw at the rally?
[$_{CP}$ who$_i$ [$_{IP}$ everyone$_j$ [$_{IP}$ you think [$_{CP}$ [$_{IP}$ t_j saw t_i at the rally]]]]]



(5) Who thinks everyone saw you at the rally?
a. [$_{CP}$ who$_i$ [$_{IP}$ t_i thinks [$_{CP}$ [$_{IP}$ everyone$_j$ [$_{IP}$ t_j saw you at the rally]]]]]

b. [$_{CP}$ who$_i$ [$_{IP}$ everyone$_j$ [$_{IP}$ t_i thinks [$_{CP}$ [$_{IP}$ t_j saw you at the rally]]]]]

The LF representation of (4) is well-formed since QR satisfies both ECP and PCC: the wh-trace and Qu-trace are properly governed, and the wh-path and Qu-path do not overlap. Since the wh-word and universal quantifier c-command each other, the relevant scope ordering is achieved. In the lower IP, the Qu-trace can take scope over the wh-trace, yielding the PLA reading. In the higher IP, the wh-word can take scope over the universal quantifier, giving the SGA reading.

The LF representation of (5a) is well-formed, satisfying both ECP and PCC. Unlike (4), the wh-word c-commands the universal quantifier, but not vice versa. As a result of this, the wh-word can take scope over the universal quantifier; thus, the SGA reading only available. The LF representation of (5b), however, is ill-formed because QR does not meet neither ECP nor PCC. In (5b), the wh-trace and Qu-trace are not properly governed, and the wh-path and Qu-trace cross each other. Consequently, the universal quantifier cannot take scope over the wh-word; thus, the PLA reading is not available.

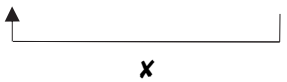
Chierchia (1993) develops a different approach from May's (1985) scope ordering mechanism. Chierchia proposes that the subject-object asymmetry maninfested in the scope relation between the wh-word and universial quantifier is an instance of weak crossover (WCO) phenomena (Wasow, 1972). For Chierchia, the availability of the PLA reading is due to the presence of two functional traces of the wh-word: a functional

trace and an argument trace. Their functions are to specify the semantic value of a coindexed binder. Consider the following question-answer pairs from Chierchia (1993, pp. 194-195).

(6) Who$_i$ does everyone love [$_{NP}$ e_j t_i]$_i$?
  a. His mother
  b. Giovanni, Maria; Paolo, Francesca; ... where the first member of each pair is a person and the second his mother.

In (6), the wh-traces are marked with two indices: the f(unctional)-trace is marked as t_i and the a(rgument)-trace is marked as e_j. Chierchia argues that the f-trace t_i serves as an ordinary wh-trace and denotes an entity that individual arguments share, yielding a functional answer (6a), whereas the a-trace e_j behaves like a pronominal element bound by the quantifier and specifies a pair of individuals based on the functional answer; thus, the PLA readign (6b) is available due to the functional answer. The binding relation between the universal quantifier and the a-trace e_j is then a crucial factor that determines the (un)availability of the PLA reading. Let us examine how the WCO effect is induced on the subject-object asymmetry in wh/quantifier scope relation (based on Chierchia, 1993, p. 214).

(7) Wh-object/Qu-subject questions
  a. SS: Who did everyone meet?
  b. LF: [$_{CP}$ who$_i$ [$_{IP}$ everyone$_j$ [$_{VP}$ t_j meet [$_{NP}$ e_j t_i]$_i$]]]
(8) Wh-subject/Qu-object questions
  a. SS: Who met everyone?
  b. LF: [$_{CP}$ who$_i$ [$_{IP}$ [$_{NP}$ e_j t_j]$_i$ [$_{VP}$ met everyone]]]



In (7b), *everyone* can be an antecedent for the a-trace e_j since it is c-commanded by the Qu-trace t_j; hence, the PLA reading obtains. In (8b), on the other hand, *everyone* cannot be an antecedent for the a-trace e_j since it is not c-commanded by the quantifier. In order for *everyone* to bind the a-trace e_j, it will have to cross over that trace, resulting in the WCO violation. Recall that the a-trace in Chierchia's system is considered as a

pronominal element. Consequently, the PLA reading cannot be obtained in (8); only the SGA reading is available. The upshot of Chierchia's system is that the PLA reading depends on whether a quantifier that has a distributive property c-commands a wh-trace left by overt movement.

In Korean, however, the odds are that no wh/quantifier scope ambiguity is observed; that is, the PLA reading is reported to be unavailable (Ahn, 1990; Choi, 2003; Kim, 2003).[1)]

(9) a. Nwu(kwu)-ka motun salam-ul mannass-ni? [SGA, *PLA]
who-NOM every person-ACC met-Q
'Who met everyone?'
b. Motun salam-i nwukwu-lul mannass-ni? [SGA, *PLA]
every person-NOM who-ACC met-Q
'who did everyone meet?'
c. Nwukwu-lul motun salam-i mannass-ni? [SGA, *PLA]
who-ACC every person-NOM met-Q
'Who did everyone meet?'

The wh-subject/Qu-object question (9a) allows only the SGA reading like English. However, the wh-object/Qu-subject question (9b) is not ambiguous. In other words, the PLA reading is not available in (9b) unlike English. Even though scrambling is applied to the wh-object as in (9c), the PLA reading is still unavailable. With respect to this, Kim (2003), following Beck (1996), argues that such unambiguity is due to intervention effects; that is, a quantifier blocks LF movement. In (9b), for example, the intervening quantifier *motun salam* 'everyone' blocks the LF movement of *nwukwu* 'who' to a clause-initial position where the scope is marked. In order for (9b) to be interpreted as a question, *motun salam* 'everyone' cannot thus act like a quantifier; rather, it should be analysed as a noun referring to a group. That being so, the PLA reading is not allowed

1) Note that *motun salam* 'everyone' sounds more natural than *nwukwu-na* 'everyone' in wh-questions and has been widely used as a universal quantifier in the literature to describe the quantifier scope relations in Korean (Choe, 2005). It should be also noted that the judgement is not as robust as one would expect. It has been claimed that in Korean wh-questions such as (9b) can receive a PLA reading (Suh, 1990; Yang, 1991). However, my own judgement does not allow the PLA reading in (9b). I thus take my judgement to be exemplary.

in Korean.

In order to process wh/quantifier scope relations in English, the parser must not only identify filler-gap dependencies in wh-questions, but also determine scope relations between the filler and the universal quantifier at the same time. This definitely imposes a heavy processing load, which in turn results in slow processing of the target structure. It is thus hypothesised that if Korean speakers of English have not acquired genuine wh-movement, they will not be able to construct the LF representation that yields the PLA reading in the Wh-object/Qu-subject question, resulting in different processing patterns compared with native speakers of English.

3. Previous Studies

Related to the issue of whether L2 speakers make use of the target syntactic knowledge during online sentence processing, several studies have investigated this in the context of wh-filler-gap constructions. Some studies suggest that higher-proficiency L2 speakers can integrate the fronted wh-word into its gap position as early as possible while lower-proficiency L2 speakers cannot (An, 2019; Williams et al., 2001). For example, An (2019) investigated, using a self-paced reading task, processing of the wh-filler-gap identification in strong crossover configurations (Postal, 1971; Wasow, 1972). Consider the following sentences from An (2019, p. 90).

(10) a. Which waitress$_i$ did the busboy say she$_{*i/j}$ had blamed t_i for slow service?
b. Which salesman$_i$ t_i said the chairwoman had flattered him$_{i/j}$ on talents for sales?

In (10a) *which waitress* and *she* cannot be interpreted as coreferential whereas in (10b) *which salesman* and *him* can be interpreted as coreferential. This contrast is argued to be reducible to condition C because in (10a) the pronoun c-commands the wh-trace (Chomsky, 1981), which is not the case in (10b). If the strong crossover constraint is obeyed, a reading time slow-down is expected at or after the pronoun in (10a). In (10b), however, no slow-down is predicted at or after the pronoun because the wh-phrase must be processed before the pronoun.

An found that the higher-proficiency Korean speakers, like the native speakers of

English, slowed down in the strong crossover questions such as (10a) and that no (or minimal) slow-down was incurred in the non-strong crossover questions such as (10b). The lower-proficiency Korean speakers, on the other hand, did not slow down in any question. An concludes that L2 proficiency, rather than L1, affects whether L2 speakers actively build a filler-gap dependency online, respecting the strong crossover constraint.

Other studies, however, have shown that L2 speakers do not construct a filler-gap dependency online. For instance, Marinis et al (2005) investigated, using a self-paced reading task, processing of the wh-filler-gap dependency at each trace position in (11) with higher-proficiency L2 speakers of English. The L2 speakers consisted of L1 Chinese, German, Greek and Japanese. Consider the following sentences from Marinis et al. (2005, p. 61).

(11) a. The nurse who$_i$ the doctor argued t_i that the rude patient had angered t_i is refusing to work late.
b. The nurse who$_i$ the doctor's argument about the rude patient had angered t_i is refusing to work late.

In (11), the filler-gap dependency is resolved at or after the subcategorising verb *angered*. However, in (11a), the parser can utilise the intermediate gap to identify the filler-gap dependency. In (11b), by contrast, no intermediate gap is present. As a result of this, the parser has to process every element between the filler and gap. A higher processing cost is then expected at or after the verb *angered* in (11b) than in (11a).

Marinis et al. found that when processing sentences such as (11b), the processing cost was higher for the native speakers and L2 groups. However, when processing sentences such as (11a), the processing cost was relatively lower for the native speakers, but not for the L2 groups, regardless of whether or not their L1s involve wh-movement. Marinis et al. conclude that L2 speakers' ability to use syntactic information online is different from L1 speakers.

4. The Experiment

In accordance with the logic and assumptions of previous studies (An, 2019; Clahsen & Felser, 2006; Dekydtspotter et al., 2006; Marinis et al., 2005; Villalta, 2003; Williams et al., 2001), the following research questions are formulated:

- Does L1 influence the process of resolving wh/quantifier scope ambiguity online?
- Does L2 proficiency affect the process of resolving wh/quantifier scope ambiguity online?
- Does the context guide the parser's structural decision on the resolution of wh/quantifier scope ambiguity online?

If the findings provide affirmative answers to the questions, this would convey the implication that nonnative processing is not fundamentally different from native processing and that context helps establish the correct mapping of syntactic dependencies onto semantic relations during online processing.

4.1. Participants

51 participants participated in the experiment: 19 monolingual native speakers of English and 32 monolingual Korean speakers of English. At the time of testing, they were enrolled either in undergraduate or postgraduate programmes at UK universities. All participants received financial compensation for their time spent on participating in the experiment. The participants' background information is provided in Table 1.

Table 1. Participants' Background Information

Group	Age		Gender		*OE*		*LOR*	
	M	Range	Male	Female	*M*	Range	*M*	Range
Korean	33.1	18–52	11	21	11.4	7–14	3.1	0.9–16
English	23.9	20–41	14	5	N/A	N/A	N/A	N/A

Note. Korean (n = 32); English (n = 19); *OE* = onset of English learning in year; *LOR* = length of residence in English-speaking countries in year.

Table 2. Mean Scores on the QPT

			95% CI			
Group	*M*	*SD*	*LB*	*UB*	Min	Max
Advanced	52.3	3.4	49.9	54.7	48	57
Intermediate	42.4	2.3	41.4	43.4	38	46

Note. Advanced (n = 10); Intermediate (n = 22); *CI* = confidence interval; *LB* = lower bound; *UB* = upper bound.

Korean speakers were further divided into two subgroups based on their performance on the Quick Placement Test (QPT, Oxford University Press, University of Cambridge & Association of Language Testers in Europe, 2001): intermediate and advanced group.[2] The results of the QPT are present in Table 2.

The data in Table 2 show that the advanced group (mean score = 52.3) achieved relatively a higher level of competence than the intermediate group (mean score = 42.4). An independent-samples *t*-test confirms that the advanced group's proficiency differs significantly from the intermediate group's, $t(30) = 9.63$, $p < .05$.

4.2. Materials

A self-paced reading task was used to find out participants' parsing strategies for resolving wh/quantifier scope interactions online, employing a sentence of the type discussed in Sloan (1991). Each test stimuli comprised a question and a brief story with pictures and words. Each question was manipulated by the position of a quantifier and by the position of a wh-extraction: the weak crossover (WCO) questions (i.e. Wh- subject/ Qu-object questions) and the non-weak crossover (NWCO) questions (i.e. Wh-object/ Qu-subject questions). In addition to this, each story was manipulated in terms of ambiguity to see whether the context would have an effect on the process of each question type.

For the NWCO questions, six items were constructed including the stories that support the SGA only as in Figure 1.

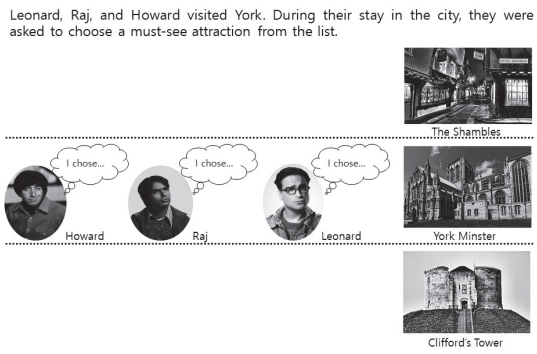


Figure 1. Unambiguous Context for NWCO Questions.

2) Proficiency levels were determined by the following score ranges, which corresponds to the Common European Framework Reference: elementary (18-29 out of 60); intermediate (30-39 out of 60); upper intermediate (40-47 out of 60); lower advanced (48-54 out of 60); upper advanced (55-60 out of 60).

(12) Sample stimulus

What did everyone say he chose for a must-see attraction?

In Figure 1, the parser can easily identify a set of antecedents for (12) within the context given; thus, a lower processing cost would be incurred during comprehension, bearing only one possible LF representation.

Another six items were created for the NWCO questions involving the stories that favour both the SGA and PLA equally as in Figure 2

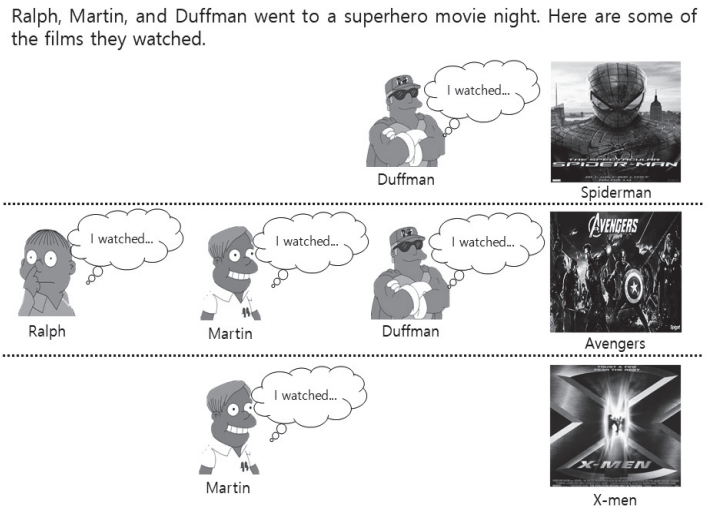


Figure 2. Ambiguous Context for NWCO Questions.

(13) Sample stimulus

What did everyone say he watched at the movie night?

In Figure 2, by contrast, a higher processing cost would arise since the context contains more than one possible set of antecedents for (13), bearing at least two possible LF representations. Thus, when processing NWCO questions such as (13), higher reading times would be expected at or after the embedded verb position in the ambiguous context than in the unambiguous context.

For the WCO questions, six tokens accompanied the stories favour both the SGA and PLA as in Figure 3.

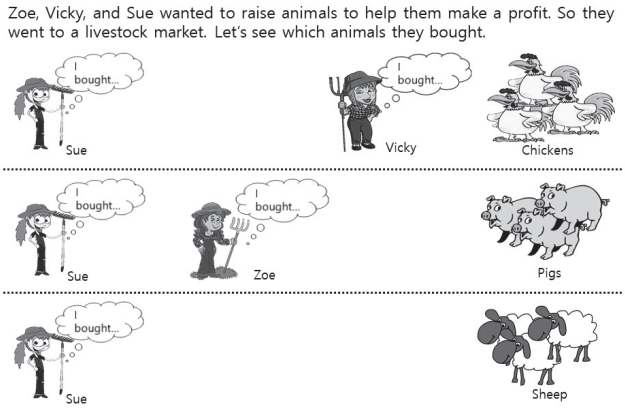


Figure 3. Ambiguous Context for WCO Questions.

(14) Sample stimulus

Who said she bought every animal at the livestock market?

In Figure 3, the wh-word takes part in a scope relation with the quantifier, forming only one possible LF representation that has the same order as the surface structure due to the WCO constraint. It is thus predicted that the processing cost of the WCO question (14) in Figure 3 would be lower than that of the NWCO question (13) in Figure 2. Note that in (14) the singular pronoun *she* is intentionally inserted to fix a set of referents in the discourse, which in turn removes the availability of a PLA reading.

In addition to the 18 target stimuli, there were 18 fillers to mask the test sentences, giving a total of 36 items. The filler items consisted of declarative sentences that create scope ambiguity such as doubly quantified constructions. Half of the items, including the fillers, comprised yes/no comprehension questions.

4.3. Procedure

The experiment was run on a laptop PC, using PsychoPy (Pierce, 2007). Participants read the story first, and then they were able to read the corresponding question or statement. Each sentence was presented in a centre noncumulative format with word-by-word segmentation. Participants were able to read a sentence one word at a time, by pressing the space bar on the keyboard. Each press of the space bar disclosed a new word, and at the same time the previous word disappeared from the screen.

Participants were instructed to read each sentence at their own speed for comprehension. Half of the trials, including the fillers, were presented with a yes/no questions, asking about information of the sentence. Prior to the actual test, participants were also given four practice items in order to familiarise them with the task.

5. Results and Discussion

Prior to the data analysis, reading times (RTs) that were below 200ms or above 6000mswere eliminated. Furthermore, RTs that were 2.5 standard deviations above or below the group mean were removed. This affected less than 3.5% of the trial in each group. Participants were also screened based on the comprehension question accuracy; that is, participants whose score that was below two standard deviations from the mean were removed from data analysis. Due to the outlying participants, one native English speaker and two intermediate Korean speakers were excluded. Thus data from 18 native English speakers, 10 Korean advanced speakers and 20 Korean intermediate speakers entered into the data analysis. Table 3 provides comprehension question results by conditions.

Table 3. Mean Accuracy on Comprehension Questions

Group[a]	WCO with ambiguous context	NWCO with ambiguous context	NWCO with unambiguous context	*M*	*SD*
NC	96%	93%	100%	96%	4
KA	100%	87%	100%	97%	4
KI	92%	88%	95%	93%	6

Note. [a]NC = native controls (n = 18); KA = Korean advanced (n = 10); KI = Korean intermediate (n = 20).

The data in Table 3 show that the NWCO question with the ambiguous context appears to be relatively less accurate on average than the NWCO question with the unambiguous context and the WCO question with the ambiguous context, indicating that the NWCO question with the ambiguous context elevated computational burden. This pattern of accuracy confirms that the Korean speakers of English are sensitive to the WCO and NWCO configuration in English. The mean comprehension question accuracy did not differ significantly across the group.

In order to see whether the context guide the parser's structural decision on the

NWCO questions, the Repeated Measures (RM) ANOVAs were conducted on the critical region and post critical region with context (ambiguous vs. unambiguous) as within-subject variables and group (English, Korean advanced and Korean intermediate) as a between-subjects factor for each of the two regions of interest. Note that in the NWCO question, the wh-word is assumed to take part in the scope relation with the universal quantifier at or after the embedded verb; therefore, they are assumed to be regions of interest during online comprehension.

For the critical region, the RM ANOVA shows a main effect of context, $F(1, 46) = 6.95$, $p = .011$). The pair-wise comparison reveals a significant difference between the ambiguous and unambiguous context ($p < .05$). For the post-critical region, there appears a two-way interaction between the context and group, $F(2, 46) = 3.29$, $p = .047$. The relevant data are given in Table 4.

Table 4. Mean Reading Times of NWCO with Context Factor in Milliseconds

		Region[c]									
Group[a]	Context[b]	WH	AUX	QU	MAV	PRON	EMV	P	MOD_1	MOD_2	N
NC	AMB	464	344	359	358	380	401	447	390	482	1021
	UNA	504	353	319	349	337	380	395	357	404	614
KA	AMB	619	396	422	454	498	581	485	422	775	1337
	UNA	543	403	441	387	403	481	462	473	506	854
KI	AMB	505	376	427	464	395	482	446	407	809	1374
	UNA	554	411	492	400	431	459	426	416	514	830

Note. [a]NC = native control (n = 18); KA = Korean advanced (n = 10); KI = Korean intermediate (n = 20), [b]AMB = ambiguous; UNA = unambiguous, [c]WH = wh-word; AUX = auxiliary; QU = quantifier; MAV = main verb; PRON = pronoun; EMV = embedded verb; P = preposition; MOD = modifier; N = noun.

In order to find out the main effect of context on reading, the mean RTs from each of the group has been explored on the basis of the context types. The NC group appears to process the post-critical region (i.e. P) more slowly in the ambiguous context than in the unambiguous context. For the post-critical region, a paired samples *t*-test confirms that a significant difference is found between the RT in the ambiguous context (447ms) and RT in the unambiguous context (395ms), $t(17) = 2.25$, $p < .05$. Both KA and KI group appear to read the critical region (i.e. EMV) more slowly in the ambiguous context than in the unambiguous context although the significant difference disappears.

Nonetheless, it is likely that the results of these groups are very much in line with

the prediction. As can be seen in Table 4, it is clear descriptively that RTs in the unambiguous context differ from those in the ambiguous context where the ambiguity arise from the context; that is, RTs at the critical region are longer in the ambiguous context than in the unambiguous context. This in turn manifests that the structural ambiguity is influenced by the interaction with the context given. In the ambiguous context, the parser has to establish a link between the wh-word and its antecedent from more than one possible set of antecedents. Upon encountering the embedded verb, it must incorporate the wh-word and universal quantifier that are kept in memory into the possible syntactic representations for the relevant semantic interpretations, considering two possible LF representations. After reanalysis of the alternatives, the parser might retain one of the LF representations or both, resulting in higher processing cost during online comprehension. In the unambiguous context, by contrast, no such operation is necessary since the parser immediately entertains its search for an antecedent for the wh-word and forms only one possible LF representation that has the same order as the surface structure, resulting in lower processing cost during online reading.

Additional evidence is found by examining the the end-of-sentence wrap-up effect at the final region (Just & Carpenter, 1980), which involves "a search for referents that have not been assigned, the construction of interclause relations and an attempt to handle any inconsistencies that could not be resolved within the sentence" (p. 345). This wrap-up effect reflects that the parser is more inclined to reevaluate its initial syntactic analysis for semantic plausibility in the context given. The data show that each of the groups reads the sentence final region (i.e. N) more slowly in the ambiguous context than in the unambiguous context ($p < .05$), which further supports the hypothesis that processing wh/quantifier scope ambiguity is influenced and facilitated by the context during L1 and L2 processing.

Another important thing to note is whether L2 processing is affected by L1 syntax since the interpretation of L2 English syntax (i.e. NWCO questions) is different from that of L1 Korean syntax. Looking at the data in Table 4, the parsing routine of each group is consistent with the hypothesis; that is, the scope ambiguity is resolved at or after the embedded verb of the NWCO question. The NC group demonstrates a slow-down at the critical region (i.e. EMV), and it is spilled over into the post-critical region (i.e. P). Both KA and KI group, on the other hand, display a slow-down at the crtical region, but it is not spilled over into the post-critical region. These data convey the implication that the Korean speakers of English, like the native speakers of English, construct the

filler-gap dependency actively upon reading the wh-word (An, 2019; Williams et al., 2001). In other words, they attempt to integrate a wh-filler immediately with a potential subcategoriser where the wh-word enters into a scope relation with the universal quantifier, thus indicating evidence in support of Clifton and Frazier's (1989) active filler hypothesis. The results confirm that L2 speakers are able to utilise the target syntactic knowledge (i.e. long-distance wh-movement) during online sentence processing, contrary to Clahsen and Felser's (2006) shallow structure hypothesis that states that L2 processing involves less syntactic details than L1 processing.

Turning to the results of the WCO questions, it is clear from Table 5 that during online sentence processing the native and Korean speakers of English are sensitive to the WCO contraint that blocks a c-command relationship between the universal quantifier and argument trace of the wh-word (Chiercia, 1993).

Table 5. Mean Reading Times of WCO with Ambiguous Context in Milliseconds

	Region[b]									
Group[a]	WH	MAV	PRON	EMV	QU	N_1	P	MOD_1	MOD_2	N_2
NC	557	356	342	355	392	551	520	385	448	648
KA	548	429	454	470	533	660	598	489	607	846
KI	604	454	435	440	524	590	532	448	557	827

Note. [a]NC = native control (n = 18); KA = Korean advanced (n = 10); KI = Korean intermediate (n = 20), [b]WH = wh-word; MAV = main verb; PRON = pronoun; EMV = embedded verb; QU = quantifier; N = noun; P = preposition; MOD = modifier.

The data show that in the WCO questions the scope relation happens when the parser encounters the quantifier (i.e. QU) or the post-quantifier (i.e. N_1); therefore, they are assumed to be regions of interest during the process of WCO questions. The NC group displays an increase of 37ms at the critical region QU, and it is spilled over into the post-critical region N_1 with a slow-dwon of 159ms. The similar processing pattern is also observed in both KA and KI group. The KA group demonstrates an increase of 63ms at the critical region, and it is spilled over into the post-critical region with a slow-down of 27ms. The KI group shows an increase of 84ms at the critical region, and it is spilled over into the post-critical region with a slow-down of 66ms. The results suggest that both KA and KI group, like the NC group, employ the genuine wh-movement strategy online, thus respecting WCO constraint.

In the meantime, if the WCO constraint is a mechanism that minimises the

difference between the surface structure and LF, processing the WCO question may be overloaded with minimising a possible c-command relation between the wh-trace and the universal quantifier. This in turn leads to a question of whether processing cost of the WCO question is different from that of the NWCO question, and the assumption made in the current study was that a higher processing cost would be incurred in the NWCO question than in the WCO question. In order for this prediction to be confirmed, it is necessary to examine the wrap-up effect on each question type since it reflects increased processing cost associated with sentence complexity (Just & Carpenter, 1980). The regions of interest would be pre-final and final region of each question type. The relevant data are given in Table 6.

Table 6. Comparison of wrap-up effect on WCO and NWCO in Milliseconds

Group	Question type	Region of interest	
		Pre-final	Final
Native controls (n = 18)	WCO	448	648
	NWCO	482	1021
Korean advanced (n = 10)	WCO	607	846
	NWCO	775	1337
Korean intermediate (n = 20)	WCO	557	827
	NWCO	809	1374

The data show that the wrap-up effect is observed at the final region both in the WCO and NWCO question. And it is clear that the wrap-up effect on the NWCO question appears to be larger than the WCO questions. The native speakers demonstrate an increase of 200ms at the final region in the WCO questions while they show a slow-down of 539ms at the final region in the NWCO questions; a paired samples *t*-test conducted on the RTs at the final region reveals a significant difference between the WCO and NWCO questions, $t(17) = 3.33$, $p = 0.005$. And the Korean advanced speakers display a slow-down of 239ms at the final region in the WCO questions whereas they show an increase of 562ms at the final region in the NWCO questions; a paired samples *t*-test conducted on the RTs at the final region indicates a significant difference between the WCO and NWCO questions, $t(9) = 2.41$, $p = 0.019$. The Korean intermediate speakers exhibit an increase of 270ms at the final region in the WCO questions while they show a slow-down of 565ms at the final region in the NWCO questions; a paired samples

t-test conducted on the RTs at the final region shows a significant difference between the WCO and NWCO questions, $t(20) = 2.75$, $p = 0.029$. The results confirm that processing cost of the WCO questions is lower than that of the NWCO questions. This is because in the NWCO question with the ambiguous context, the parser, upon encountering the embedded verb, must incorporate the wh-word and universal quantifier that are kept in memory into the two possible LF representations for the semantic interpretations, showing the larger wrap-up effect at the final region. In the WCO question with ambiguous context, on the other hand, the parser has to construct only one possible LF representation that has the same order as the surface structure due to the WCO constraint. For this reason, the parser analyses the wh-word and universal quantifier one after the other as it encounters them, showing the relatively smaller wrap-up effect at the final region.

When taken together, the findings are in line with the predictions made in this study, providing affirmative answers to the research questions. It appears that wh/quanfier scope ambiguity is resolved by the interaction with contextual information, and this interaction can delay the resolution of wh/quantifier scope ambiguity. Furthermore, when processing WCO and NWCO questions, the native and Korean speakers of English appear to share similar parsing routines, which in turn provides the evidence that the Korean speakers of English have acquired the target syntactic knowledge that is applicable to the process of WCO and NWCO questions online although their L1 does not allow comparable LF representations for interpretations. In addition to this, L2 proficiency appears not to play a role in L2 processing of wh/quantifier scope interaction in real time, contrary to An (2019). The high level of accuracy on the comprehension questions further supports that the Korean speakers of English, regardless of their proficiency, behave similar to the native speakers of English at least in this experiment.

6. Concluding Remarks

The findings from the current experimental study suggest that the wh/quantifier scope ambiguity is influenced and facilitated by the contextual information. The native and Korean speakers of English are able to adjust their parsing strategies according to the contextual information when resolving the scope ambiguity. Furthermore, the native

and Korean speakers of English construct the target structure incrementally, displaying sensitivity to the c-command relation between the wh-word and universal quantifier. This conveys the implication that the Korean speakers of English, regardless of their proficiency, are able to make use of the target syntactic knowledge proper in real time. More importantly, these results suggest that the Korean speakers of English do not transfer their L1 when processing wh/quantifier scope ambiguity.

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