A processing-based analysis on the observation of isomorphism*

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Kang, Chorong and Eunjeong Oh. 2020. A processing-based analysis on the observation of isomorphism. *Linguistic Research* 37(3): 581-616. Since Musolino's (1998) influential work, studies on children's acquisition of scope interpretation have investigated children's grammatical knowledge and processing mechanisms that derive the difference between children and adults in their interpretation of scopally ambiguous sentences. In the current work, we propose a processing-based account for the fundamental question of why children do not get some interpretations among alternative interpretations. Being inspired by the argument intervention in the acquisition of A-movement, proposed by Orfitelli (2012), we suggest that children's parsing mechanism has difficulties in correctly filling the gap (i.e. the base position of the displaced element) with a scope bearing element that undergoes movement if there is another scope bearing element between the filler-gap dependency. We discuss how the current proposal can account for many observations reported in previous works. Furthermore, to show that such an argument intervention effect in the domain of scope acquisition is a matter of configuration, we conducted an experiment on Korean. Korean is a language where an object undergoes movement over negation, which is the argument intervention configuration. We found that Korean-speaking children show the argument intervention effect in learning scope interpretation. This result supports the idea that children's interpretation of scopally ambiguous sentences is configurationally determined and the immature parser is susceptible to the argument intervention effect. **(Seoul National University · Sangmyung University)**

Keywords acquisition of scope, argument intervention effect, observation of isomorphism, immature parser, Korean scope ambiguity

1. Introduction

Since Musolino's (1998) influential work, studies on children's acquisition of

scope interpretation have investigated children's grammatical knowledge and processing mechanisms that derive the difference between children and adults in their interpretation of scopally ambiguous sentences. Zooming into the issue of learning ambiguous sentences with a quantifier and a negation, the most outstanding characteristic of children's behavior is called the *observation of isomorphism* (Musolino 1998). This phenomenon can be illustrated with the example in (1). The sentence in (1) is ambiguous in adults' grammar. If the subject quantifier scopes over negation, the scope relation matches with the syntactic c-command relation, so is called the isomorphic reading. If the subject quantifier is interpreted under the scope of negation, their syntactic hierarchy is reversed in semantics, so is called the non-isomorphic reading. The observation of isomorphism refers to the phenomenon that children readily accept the isomorphic reading, but not the non-isomorphic reading in a neutral context.

(1) Every horse didn't jump over the fence.
   a. *Isomorphic reading:* None of the horse jumped over the fence.
                                                              (every > not)
   b. *Non-isomorphic reading:* It is not the case that every horse jumped over the fence.   *(not > every)*

Over the past years, there has emerged a consensus view that the observation of isomorphism is a matter of processing rather than children's lack of grammatical knowledge. If children's grammar cannot generate the non-isomorphic reading, that particular reading is expected to be unaccepted in any context. However, Musolino and Lidz (2006), Gualmini (2008), Viau, Lidz and Musolino (2010) show that children's acceptance of the non-isomorphic reading increases if a pragmatic condition can support the non-isomorphic reading. This indicates that the non-isomorphic interpretation can be generated in children's grammar, but for some processing issues, it is rejected in neutral context. Thus, the question needs to be answered is why children prefer the isomorphic reading over the non-isomorphic reading even though both interpretations are available in their grammar. There is a call for studies that investigate children's scope interpretation to probe into their processing mechanism.

The current paper proposes a new perspective focusing on the syntactic structure of low-accepted readings and children's late acquisition of A-movement. Throughout the discussion, we argue that the observation of isomorphism is the consequence of children's immature parsing mechanism that struggles to associate a filler-gap dependency created by movement. Section 2 reviews two processing accounts for children's preference for the isomorphic reading and summarizes important observations reported in previous studies, which must be accounted for in any approach. Section 3 proposes a new processing account for the observation of isomorphism and how the proposed account can explain the important observations discussed in section 2. Section 4 provides experimental evidence that supports the current proposal. In section 5, we will discuss the implication of the proposal on the interwoven relation between grammar and processing in the domain of acquisition of scope ambiguity.

2. The role of grammar and processing in the acquisition of scope

2.1 Word order-based approach

One interesting processing-based idea is what is proposed by O'Grady (2013). O'Grady adopts the two pervasive assumptions below in (2):

(2) a. Sentence processing is incremental in word-by-word, left-to-right basis.
    b. When a word is encountered, the word is processed then dismissed from active working memory.

Since the processor works word-by-word fashion, when a child hears a sentence in (3), negation is encountered and processed before the object quantifier. According to O'Grady, there are two possible interpretive options when the object quantifier is encountered. One is that the quantifier is interpreted in the scope of negation and the other is that the interpretation of the quantifier is free from the effect of negation, leading to the quantifier wide scope reading. O'Grady argues that a child who is less experienced in language use than adults

would be balanced in either of the two grammatically possible interpretations.

(3) Mike didn't eat every banana.
   a. *Isomorphic reading*: It is not the case that Mike ate every banana.

   (not > every)

   b. *Non-isomorphic reading*: Mike did not eat any of the bananas

   (every > not)

However, the two alternatives are not the same in its processing cost. If one interpretation is more frequently used over the other, the more frequent interpretation is more likely to be activated than the other. If we consider adults' interpretation of the sentence, English speakers more frequently use such type of sentences for the negation wide scope reading (Musolino et al. 2000; Musolino and Lidz 2006), so that the negation wide scope reading is the easy-to-access interpretation (or "route" following the term used by O'Grady). O'Grady argues that children would have acquired the "preference" as he grows.[1]

The analysis proposed by O'Grady furthermore well accounts for the low acceptability of the non-isomorphic reading of sentences in (1) by children. In this case, the quantified subject precedes negation. Since the processor goes word-by-word, when the quantifier is encountered, it is assigned to its usual "full-set" interpretation not acknowledging the information about the upcoming negation.[2] Since the quantifier-wide scope reading matches with the "full-set" interpretation of the universal quantifier, the isomorphic reading does not require an extra burden on processing. On the other hand, the negation wide scope reading requires a revision of the first hypothetical interpretation of the universal quantifier when negation is encountered. For the subject quantifier to be interpreted in the scope of negation, the processor discards the previous "full-set" interpretation of *every*. This procedure asks for extra cost in processing under the assumption in (2b). This account predicts that children prefer the isomorphic reading over the non-isomorphic reading when they interpret negated

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1   However, as O'Grady noted, this processing account faces a fundamental problem of how the frequency of use is differentiated to begin with.

2   O'Grady calls the *every > not* reading the "full-set" interpretation. We adopt the terminology here for explanatory convenience.

sentences with a subject quantifier and the prediction is borne out, as shown in many previous studies including Musolino and Lidz (2006).

However, there seems to be some issues that must be elaborated. First, it is somewhat mysterious how adults can overcome the processing penalty and get the non-isomorphic interpretation for the same sentences. English speaking adults can get both interpretations of the sentence in (1) and in actuality, adults prefer the non-isomorphic interpretation over the isomorphic interpretation (Musolino and Lidz 2006). One possibility is that children can adjust their hypothesis based on the frequency of use in their input as they grow up. However, it is still unclear how this developmental breakthrough has been accomplished favoring the less attractive option from the perspective of processing.

The second issue is more serious. The account does not refer to a syntactic hierarchy, but the linear word order plays a primary role. Thus, the account predicts that children do not accept the negation wide scope reading in languages that has SO(quantifier)-V(negation) word order because negation linearly comes after the object quantifier. However, as Lidz and Musolino (2002) show that children whose native language is Kannada, a SOV word order language, not only accept the negation wide scope reading but also prefer that interpretation over the quantifier wide scope reading. Thus, the prediction of the account does not turn out to be true.

Even though the linear word order seems to be a likely cause of the observation of isomorphism, it appears that children are not simply misled by the linear sequence of linguistic input. Rather, as argued by Lidz and Musolino with Kannada, children might seriously take the syntactic hierarchy into consideration for scope interpretation. Therefore, a linear order-based account does not seem to be much promising. We will discuss another possible processing-based account suggested in literature in the next section.

2.2 Pragmatics and resistance to modification

Musolino and Lidz (2006) provide an observation that children readily accept the non-isomorphic interpretation of sentences in (1) if those sentences are provided with an affirmative sentence preceding them, as in (4). For the

sentences without a preceding affirmative sentence as in (1), they replicate the results of Musolino et al. (2000) confirming that children rarely accept the non-isomorphic reading. However, the increase of acceptability in the sentences like (4) shows that children's grammar can generate the non-isomorphic reading, otherwise there should be no effect of context on the acceptability.

(4) Every horse jumped over the log but every horse didn't jump over the fence.

Pointing out that adults prefer the non-isomorphic reading over the isomorphic reading in (1), Musolino and Lidz argue that adults can incorporate pragmatic principles along with syntactic information for interpretation while children do not. The two interpretations in (1) is in a semantic entailment relation. Every situation which is compatible with the *every*-wide scope reading (i.e. *every > not*) is also compatible with the *not*-wide scope reading (i.e. *not > every*). It means that the *every*-wide scope reading entails the *not*-wide scope reading. English has an alternative word *none* to express the *every*-wide scope reading and it is only compatible with that reading. Thus, *none* is a stronger term than *not-every* sequence. According to the scalar implicature (Horn 1972, 1989), using a less stronger expression (*every-not* sequence) implicates that the stronger expression (*none*) is not possible. Thus, adults, as experienced language users, can instantly incorporate the pragmatic factor that *every-not* sequence is not the pragmatically best expression to refer to the "none" reading, so they prefer to interpret *every-not* sequence as the negation wide scope reading. However, children are not sensitive to such a pragmatic factor, so they prefer to interpret *every-not* sequence as the quantifier-wide scope reading primarily cued by its surface syntax.

Lidz and Musolino (2002) and Musolino and Lidz (2006) further argue that children have difficulty in revising their first hypothesis they made primarily based on the surface syntax. This approach is supported by independent studies that show that children are reluctant to revise their wrong first hypothesis. For example, Trueswell et al. (1999) investigate whether children can use referential context in ambiguity resolution through an eye movement experiment. Adults and children were given a sentence like (5) and asked to move objects. There

were two conditions. One is the one-referential condition where the visual context has just one frog. The other is the two-referential condition where two frogs were provided in the visual context. In the one-referential condition, adults looked at the wrong destination (*napkin*) when they listened to the ambiguous part (*on the napkin*). This means they misinterpret "on the napkin" as the goal PP. On the other hand, adults do not look at the wrong destination (napkin) in the two-referential condition. This indicates that adults immediately use the referential context so that they interpret "on the napkin" as the noun modifier that is added to the sentence to distinguish between the two (same-looking) frogs. In contrast, five-year-old children were not sensitive to the referential condition looking at the wrong destination regardless of the experimental manipulation. Moreover, many children put the frog on the napkin and then put it in the box. This indicates that they interpret the sentence in (5) as the sentence "put the frog on the napkin and in the box". The result tells us that children are reluctant to revise the (wrong) first hypothesis (i.e. interpreting *on the napkin* as the goal PP) even after they realized that there is another PP (*in the box*) that must be interpreted as the destination.

(5) Put the frog on the napkin in the box.

The experiment by Trueswell et al. provides two important points. One is that it is hard for children to incorporate referential condition which is one of the non-syntactic cues. The other is their stubbornness to revise their first parsing. The results well support the idea that the observation of isomorphism is a consequence of children's immature parsing: Children first parse a scopally ambiguous sentence based on its surface syntactic structure ignoring non-syntactic factors including pragmatics or referentiality. Then, they resist to revise their first hypothesis. This idea can also account for the increase of acceptability in the presence of a pragmatic context in (4). The additional pragmatic context helps children to have access to pragmatic factors so that the non-isomorphic reading becomes more acceptable.

However, there is still a remaining fundamental question why children's first hypothesis should be the isomorphic reading, rather than the non-isomorphic reading. Lidz (2018) argues that the only acceptable interpretation by children

corresponds to adults' preferred interpretation. However, this idea does not seem to be supported by many experimental results. First, children accept interpretations that adults do not accept. For example, children easily accept the non-isomorphic reading of (3) (we repeated it below) while adults do not prefer that reading.

(3) Mike didn't eat every banana.
   a. *Isomorphic reading*: It is not the case that Mike ate every banana.
      Children: Accepted   Adults: Accepted   *(not > every)*
   b. *Non-isomorphic reading*: Mike did not eat any of the bananas
      Children: Accepted   Adults: Not accepted   *(every > not)*

Musolino and Lidz argue that since adults well incorporate pragmatic factors (in this case, scalar implicature), they are reluctant to interpret *not-every* sequence as the "none" reading because there is a more proper alternate expression, *nothing*, for that reading. Thus, adults prefer to have the negation wide scope reading for (3), which means that it is not the case that Mike eats ate every banana. On the other hand, they found that children do not hesitate to accept the non-isomorphic reading (i.e. *every > not* reading). Musolino and Lidz argue that this is because children are sensitive to the semantic entailment relations. Every situation that satisfies the "none" reading satisfies the "not-all" reading as well because "none" entails "not all". According to Musolino and Lidz, children accept the "not-all" reading which is the isomorphic interpretation and infer the non-isomorphic reading (*every > not* reading) from the isomorphic reading by the semantic entailment relation. That is, when the non-isomorphic reading entails the isomorphic reading, as in (3), children can also obtain the non-isomorphic reading through the semantic entailment relation, not even referring to the syntactic information. If this is the case, the low acceptability of "not-all" reading in (1) can be accounted for (we repeated it below).

(1) Every horse didn't jump over the fence.
   a. *Isomorphic reading*: None of the horse jumped over the fence.
                                                              (*every > not*)
      Children: Accepted   Adults: Accepted (but less preferred)

b. *Non-isomorphic reading:* It is not the case that every horse jumped over the fence.   (*not > every*)

Children: Not accepted   Adults: Accepted

Unlike (3), in (1), the non-isomorphic reading ("not-all" reading) does not entail the isomorphic reading ("none" reading). Thus, some situation that satisfies the non-isomorphic reading ("not-all" reading) does not satisfies the isomorphic reading ("none" reading), so children cannot accept the non-isomorphic reading just relying on the semantic entailment relation alone.

However, Szendrői et al. (2017) challenge this idea. In their experiment, children whose native language is German were asked to act out the events corresponding to their interpretation of the test sentences. The example of a test sentence is represented in (6). The capital letter represents that the quantifier modifying the object is pronounced with main stress. The sentences were pre-recorded and adults and children listened to the same pre-recorded sentences. Interestingly, adults who listened to the sentence in (6) rarely acted out the object universal quantifier wide scope reading (2%). On the other hand, 5-year-old children who listened to the same sentence acted out the object wide scope reading over 50% in their responses. 6-year-old children showed the lower percentage of acting out the object wide scope reading (42%) than the 5-year-old children's responses, but still significantly higher compared to adults' behaviors. Crucially, the non-isomorphic reading does not entail the isomorphic reading. The entailment relation in this case is reversed.

(6) Ein Tierpfleger füttert JEDE Giraffe.   (Szendrői et al. 2017: (7))
    'A zookeeper feeds EVERY giraffe.'
    a) *Isomorphic reading:* There is a zookeeper that fed every giraffe.
    b) *Non-isomorphic reading:* For every giraffe there is a zookeeper that fed it.

Yamakoshi and Sano (2007) show a similar fact. Adults in their experiment did not allow the non-isomorphic reading (i.e. the object-wide scope reading) while children who listened to the same sentence accepted the non-isomorphic reading.

(7) Dareka-ga   dono-ringo-mo   oisii-to   it-tayo.
    someone-Nom   every-apple   delicious-Comp   say-Past
    'Someone said that every apple was delicious.'

What these experiments show is that children open to the non-isomorphic reading even when the non-isomorphic reading does not entail the isomorphic reading. Thus, it seems to be premature to conclude that the high acceptability of the non-isomorphic reading in English sentence (3) by children reflects their knowledge of semantic entailment and the prompt use of the knowledge in the interpretation of sentences with scope ambiguity. There could be another reason for the high acceptability of the non-isomorphic reading of (3) by children. Such cases that children readily accept the interpretation that is not acceptable to adults indicate that adults' preference does not guarantee what would be the first hypothesis for children. Furthermore, children's high acceptability of the non-isomorphic reading in (6) and (7) also tells us that the surface syntactic hierarchy might not coincide with children's first hypothesis. Thus, the question as to how children decide their first hypothesis is left unresolved.

2.3 Interim summary

Studies on children's acquisition of scope interpretation have revealed many important aspects of children's processing mechanism. Children can utilize a syntactic hierarchy not simply being misled by linear word order (Lidz and Musolino 2002). However, children have difficulty utilizing pragmatic factors in the absence of a supporting pragmatic context (Musolino and Lidz 2006; Gualmini 2008; Viau, Lidz and Musolino 2010). In addition, children do not readily revise their first parsing hypothesis (Trueswell et al. 1999). Even though the word-by-word processing based on the linear word order cannot account for the cross-linguistic differences, O'Grady's proposal also gives an insightful intuition that the working memory constricts the processing domain for scope interpretation. However, the fundamental question of how children choose the first hypothetical interpretation remains unresolved. In the next section, we will propose an alternative account for this question.

3. Processing strategies

In this section, we will introduce how syntax and semantic theories have understood scopes. Focusing on the syntax of the non-isomorphic interpretation and hinted by the studies on children's late acquisition of A-movement, we will propose an alternative account for the fundamental reason of the observation of isomorphism.

3.1 The syntax of scope

We hope to take a brief detour to review syntax of sentences with scope ambiguity. The two distinct interpretations in (8) are generated by a hierarchical structure at *Logical Form* (hereafter, LF) or in the semantics.

(8) Every frog didn't jump into the water.
    a. $\forall x$ [frog (x) $\rightarrow$ ¬jump into the water (x)]
    b. $\neg \forall x$ [frog (x) $\rightarrow$ jump into the water (x)]

Within the generative grammar, the difference in hierarchy is calculated by the notion of 'c-command'. Thus, scope taking has been defined with the c-command relation. We adopted Aoun and Li's proposal as in (9).

(9) The Scope Principle (Aoun and Li 1993: 88)
    An operator A may have scope over an operator B iff A c-commands a member of the chain containing B.

The quantifier wide scope reading in (8a) is generated because the sentence has a LF representation in which the subject quantifier *every* c-commands negation. Likewise, the negation wide scope reading in (8b) is generated because the sentence has a LF representation in which negation c-commands the subject quantifier. The LF representation of the quantifier wide scope reading in (8a) corresponds to the surface syntax, so the LF representation seems to be natural consequence of the surface syntax. However, the negation wide scope reading in (8b) does not match with the surface scope in its hierarchy. To reconcile this

discrepancy between the LF representation and the surface syntax, different types of "movement" has been proposed under the generative grammar, such as Quantifier Raising (May 1977, 1985; Aoun and Li 1993) or movements for an independent reason (e.g. case or agreement) (Hornstein 1995; Beghelli and Stowell 1997).[3]

For the current discussion, it does not seem important to clarify which type of movement plays a role in scope ambiguity. Nevertheless, there is one important point we would like to bring up. One possible syntactic structure for the sentence in (8) is shown in (10). The subject quantifier is base-generated in the specifier position of *v*P and moves to the specifier position of TP for EPP or Case valuation (depending on theoretical perspectives).

(10) Every frog didn't jump into the water.
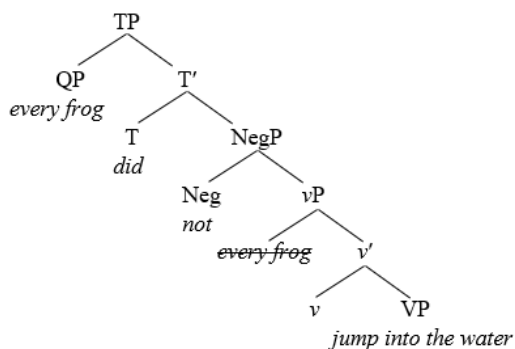
The isomorphic interpretation (the subject quantifier wide scope reading) is calculated between the subject in Spec.TP (or in a higher Spec.TP due to a quantifier raising) and the negation head. If we assume this theoretical assumption is true, we might say that English native speakers who get the isomorphic interpretation are able to use the surface structure where the subject movement has taken place for scope interpretation. On the other hand, the non-isomorphic reading where negation scopes over the subject quantifier is generated by the scope interaction between the negation and a copy of the

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3   There is also a non-movement approach like semantic operations (Choice function depending on the property of quantificational element, see Reinhart 1995).

subject quantifier in its base position Spec.*v*P, which is deleted at *Phonetic Form* later (so as not to be pronounced).[4] This means that people who get the non-isomorphic reading can calculate scopes using either the base structure where the subject movement has not occurred yet or the copy left in the base position.[5]

Based on the discussion, we assume that children primarily have access to the information of the surface structure rather than the base structure when they interpret scopally ambiguous sentences. However, the acceptability of the non-isomorphic reading by children in (6) and (7), repeated below, indicates that the surface syntax is not the only possibility for children to utilize for scope interpretation. Rather, children can also have access to the LF syntax that does not match with the surface syntactic hierarchy.

(6) Ein Tierpfleger füttert JEDE Giraffe.
'A zookeeper feeds EVERY giraffe.'
a) *Subject quantifier wide scope reading:* There is a zookeeper that fed every giraffe.
b) *Object quantifier wide scope reading:* For every giraffe there is a zookeeper that fed it.

(7) Dareka-ga   dono-ringo-mo   oisii-to   it-tayo.
someone-Nom   every-apple   delicious-Comp say-Past
'Someone said that every apple was delicious.'

Thus, a more accurate generalization for the current phenomenon can be stated focusing on the syntactic structure that children do not have access to, rather than structures that children easily have access to. We argue that children

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4   Following the copy theory of movement, we assume that the entity left in the base position of the subject quantifier is a copy of it rather than a trace. Thus, the (movement) chain in (9) can be reinterpreted as the set of copies of a movement.

5   The system proposed by Beghelli and Stowell (1997) does not allow for a quantifier to scope in its base position (e.g. Spec.*v*P for the subject quantifier). However, they judged sentences with a subject universal quantifier (*every*) and negation ungrammatical even when the sentence is spoken in a neutral, non-focused intonation (Beghelli and Stowell 1997: 27), which is contrary to the results of many experiments cited here. Thus, we do not follow Beghelli and Sowell's system here.

hardly have access to the base structure as the first hypothesis when they interpret scopes. We suspect that the base structure is more difficult to have access to than the other structures because it requires a decoding processing looking for the origin of the displaced element. This idea is supported by the observations that children have difficulty with the processing of the dependencies created by so-called A-movement, for example, subject raising and passives. Many experimental works have shown that children (age 4 to 6) show non-adult interpretation of subject-to-subject raising sentences as in (11). For example, Hirsch, Orfitelli, and Wexler (2007) showed that children under age six say "true" to the sentence (11) even when they were looking at a situation where Ken was seeing Barbie wearing a hat.

(11) Ken seems to Barbie to be wearing a hat.

The incorrect "yes" response tells us that children have difficulty in finding the subject of the predicate be wearing. In this case, the subject of the predicate undergoes A-movement to the matrix clause, via subject-to-subject raising. Thus, to be properly interpreted, the displaced subject, *Ken*, must be interpreted in its base position. Developing previous studies, Orfitelli (2012) argues that children under age six have difficulty with A-movement across an intervening argument, not just A-movement by itself. In other words, children have difficulty in associating the filler-gap dependency created by A-movement if there is an intervenor between them. In (11), the intervenor, *Barbie*, could play a role as another candidate for the filler of the embedded subject gap. We would like to point out that the situation is parallel to the scope interpretation. In raising construction, the subject needs to be interpreted in its base position, but the experiencer which is closer to the gap (i.e. the silent subject of the infinitive clause) than the correct filler (the matrix subject), plays as an intervenor being a more attractive candidate for the filler. In other words, children feel difficult to associate a filler and its gap when there is another element that shares relevant properties (in the case in (11), a human noun phrase that can wear a hat) in-between. Similarly, in scopally ambiguous sentences as in (1), we repeated below, the subject quantifier needs to be interpreted in its base position to get the non-isomorphic reading. Although negation is not an argument, they share

the same property of being scope bearing elements. Thus, in terms of scope taking, the negation which is closer to the gap than the subject quantifier intervenes the subject's way back to its base position. In other words, we argue that the observation of isomorphism is a consequence of locality constraints in language acquisition.

(1) Every horse didn't jump over the fence.

Applying the Argument Intervention Hypothesis proposed by Orfitelli (2012) to the domain of scope interpretation, we assume that children are delayed in acquiring scope interpretation that is read off from the LF representation generated by lowering a scope bearing element across another scope-bearing element. In addition, we follow the idea that children resist to reanalyze their first hypothesis in syntactic analysis, proposed by Trueswell et al. (1999). The combination of the argument intervention hypothesis and the resistance to modification results in the observation of isomorphism by children. This proposal predicts that the isomorphic reading is always acceptable to children because the isomorphic reading is the reading that corresponds to the surface syntax. On the other hand, the non-isomorphic reading can or cannot be available depending on the syntactic structure from which the reading is read off. If the non-isomorphic reading is read off from the LF representation generated by (covert) upward movement (e.g. quantifier raising for scope interpretation), that particular reading would be available to children. However, if the non-isomorphic reading corresponds to the base structure after lowering (or reconstruction) of a scope bearing element over another scope bearing element, children would hardly accept the reading. We will discuss how the predictions are borne out in the next section.

3.2 Base structure is the matter

In the previous section, we proposed that the observation of isomorphism is a by-product of the children's immature parser that brings about difficulty in interpreting the filler-gap dependancy created by syntactic movement. When a

scope-bearing element undergoes syntactic movement, the following two situations are logically possible.

(12) Two logical possibilities
  a. A scope bearing element α undergoes movement over another scope bearing element β.
  b. A scope bearing element α undergoes movement to a position still lower than another scope bearing element β.

The first hypothetical situation (12a) is what happens between a subject quantifier and negation. Subjects are base generated in a position lower than negation and move over negation to SpecTP. Thus, the negation wide scope reading is predicted to be unacceptable to children and the prediction is borne out, as we have discussed. The second situation (12b) appears in between negation and an object quantifier in English. Objects are base generated in a position lower than negation and do not undergo movement over negation. Thus, the negation wide scope reading can be derivable from the syntactic structure. This is why the negation wide scope reading (the isomorphic reading) is readily acceptable to children using English. However, unlike negation, object quantifiers can undergo a further movement (as a type of quantifier raising for scope interpretation). Our proposal does not have a specific prediction on such a case. We suggest the possibility that children bear quantifier raising type movement in their grammar and freely utilize it. This is why children accept some instances of non-isomorphic readings which are not acceptable to adults, as shown in (3), (6), and (7).

However, one might wonder whether the difference between the two possibilities in (12) can be subsumed under a subject-object distinction because (12a) applies to the Subject quantifier-Negation sequence and (12b) applies to the Negation-Object quantifier sequence in many languages including English. To prove that the generalization has nothing to do with the subject-object distinction, we will introduce an experiment on Korean in the next section. In Korean, the situation described in (12a) applies to object as well and we will show that this is a matter of configuration, but not a matter of the subject-object distinction. Before jumping into the experiment, we hope to discuss one more

interesting prediction of this proposal.

If the observation of isomorphism is a consequence of the immature parser that has a trouble with a structure created by movement, it is predicted that we could find the observation of isomorphism from those who have a difficulty in understanding syntactic displacement due to a brain impairment. A number of studies have reported that individuals with Broca's aphasia show a poor performance when they interpret sentences with a syntactic movement including passives. Kennedy et al. (2019) found that individuals with Broca's aphasia show the observation of isomorphism when they interpret a scopally ambiguous sentence (with a subject quantifier and negation, corresponding sentence to (1)). As Kennedy et al. argue, such a result supports the idea that the observation of isomorphism is not just a learnability problem, but a by-product of the deficit in processing. Furthermore, given that Broca's aphasia is well known to impact syntax specifically, we take Kennedy's experiment as the evidence for the idea that difficulties in processing syntactic configuration causes the observation of isomorphism.

As a final remark, we wish to point out that the current proposal is not a competence-based account, but a process-based account. Thus, we assume that other non-syntactic cue can predispose children to have access to the base structure by facilitating the correct filler-gap dependency. Thus, this approach is well compatible with the results reported in Musolino and Lidz (2006) where a pragmatic context helps children to have access to the non-isomorphic reading.[6]

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6   In Musolino and Lidz (2006), a pragmatic context shown in (4), we repeated here in (i) helps children to have the non-isomorphic reading. One alternative account for the observation under the current proposal is as follows. When children heard the first conjunct of the sentence *every horse jumped over the log,* they might assign the usual "full-set" interpretation to the universal quantifier. However, the following sentence is conjoined by a negative conjunction *but* and this gives an impression that a contrasting event would happen in the second conjunct. Thus, when children listened to the same subject universal quantifier *every horse* and the following negation in the second conjunct, children might actively search an alternative scope interpretation (i.e. *not > every* interpretation) not just being satisfied with the subject quantifier wide scope reading (i.e. *every > not reading*)

(i) Every horse jumped over the log but every horse didn't jump over the fence.

4. An experiment

This experiment is designed to investigate whether the two possible situations described in (12) can be subsumed under a subject-object asymmetry or it is a genuine configurational issue. Psycholinguists have revealed that speakers tend to mention more salient referents before less salient referents (Tannenbaum and Williams 1968). Thus, the subject of a sentence does not only take a grammatical function, but also a cognitive saliency. Due to the cognitive saliency of the subject, children might want to assign the wide scope to the subject quantifier than negation. On the other hand, a cognitively less salient referent appears as the object in many sentences. Thus, children have no hesitation to interpret the object quantifier under the scope of negation resulting in the preference of the negation wide scope reading. Since English and many languages share the same structure that the object quantifier is lower than negation in the surface structure, it is hard to distinguish the saliency-based account from the configuration-based account.

Fortunately, we have languages in which the object undergoes movement over negation. One of those languages is Korean. Korean has two types of negation. One is a short negation in (13a) and the other is a long negation in (13b). Following Han et al. (2007), we assume the syntactic structure of each negation type as in (14). In both structures, the object is base generated inside VP, which is lower than negation. However, it undergoes movement, presumably, for Case valuation, to a functional category higher than negation.
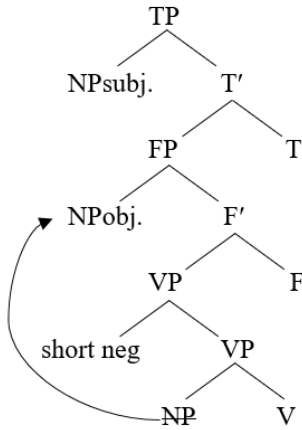
(13) a. Short negation

Yumi-ka   chayk-ul   sey-kwon   an   ilk-ess-ta.
Yumi-Nom   book-acc   three-classifier   Neg read-past-decl.
Yumi did not read three books.
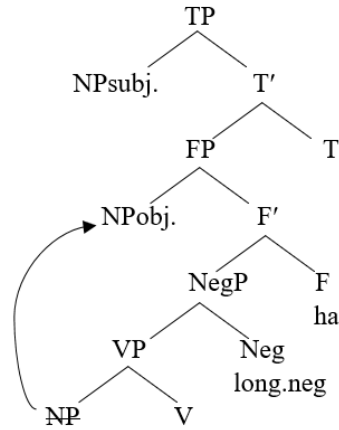
b. Long negation

Yumi-ka   chayk-ul   sey-kwon   ilk-ci anh-ess-ta.
Yumi-Nom   book-acc   three-classifier   read-CI-Neg-past-decl.
Yumi did not read three books.

(14) a. Short negation　　　　　　　　b. Long negation

TP
NPsubj.　T'
FP　T
NPobj.　F'
VP　F
short neg　VP
NP　V

TP
NPsubj.　T'
FP　T
NPobj.　F'
NegP　F
　　ha
VP　Neg
　　long.neg
NP　V

If the observation of isomorphism is a consequence of the difference between subjects and objects in saliency with respect to negation, Korean-speaking children are predicted to be more likely to accept the negation wide scope reading than the object wide scope reading when they listen to a sentence with object quantifier and negation (regardless of the negation types). On the other hand, if the problem is a genuine configurational issue, rather than the subject-object asymmetry, Korean-speaking children are expected to pattern different from Kannada-speaking children. Korean and Kannada are both SOV languages. However, in Kannada, the object does not undergo a movement over negation. Thus, the object is always situated lower than negation. Our proposal correctly predicts that Kannada speaking children prefer the negation wide scope reading when they listen to a sentence with a negation and an object quantifier because the object quantifier does not undergo syntactic movement. However, in Korean, since the object quantifier undergoes movement over negation, as shown in (14), the configurational proposal in (12a) predicts that Korean-speaking children have difficulty in associating the object quantifier with its base position, so they would not accept the object-narrow scope reading (i.e. the negation wide scope reading).

A number of studies have found that Korean children tend to prefer the isomorphic reading (Han et al. 2007; Kwak 2010, among many others). Many of

them use a universal quantifier *motun* 'every' as the object quantifier in their experiment. To be maximally equivalent to the experimental condition on Kannada by Lidz and Musolino (2002), we conducted an experiment investigating Korean-speaking children's understanding of scope interaction between an object numeral quantifier and negation, as exemplified in (13). Kwak (2010) conducted a similar experiment, but only short negation was tested. In this experiment, we include both types of negation so as to provide a more conclusive picture of the phenomenon showing that the phenomenon is not restricted to a certain type of negation.

4.1 Method

Subjects

We tested 53 Korean-speaking children (27 boys and 26 girls): 12 5-year olds (3 females, 9 males, mean age: 5;5, age range: 5;0–5;11), 17 6-year olds (9 females, 8 males, mean age: 6;5, age range: 6;0– 6;11), 24 7-year olds (14 females, 10 males, mean age: 7;6, age range: 7;0– 7;11). We also tested 40 adult native Korean speakers (26 females, 14 males; mean age: 21;1, age range: 18–30). The children were recruited and tested at Sangmyung University Elementary School and Kindergarten. The adults were all students at Sangmyung University.

Procedure

We performed a modified version of the Truth Value Judgment Task methodology (TVJT) (Crain and Thornton 1998). An experimenter showed videotaped short stories to participants. The video consists of two parts. One is the action part in which one actor performed a designed action and the other is the statement part in which a puppet (Momo) comes out to say what he thinks happened in the story. After watching the video, participants were asked to decide whether the puppet's statement is 'true' or 'false'. Children were asked to choose "a smiley face" if the statement is true, but "a crying face" if the statement is false. Adults were asked to provide a verbal response. After the evaluation, participants were asked to explain why they think that the statement was true or false. Children received a star sticker after every five trials for them

to stay focused on the task. Unlike the traditional TVJT, we did not act out stories in front of children. Instead, we used videotaped stories and puppet statements for the following three reasons. First, we could control any subtle differences that could happen between trials for the same item. Using the pre-recorded materials makes it easy to reduce any potential confounding factor like prosodic differences. Second, the puppet who made a statement showed up in the monitor so that children might be more likely to believe that the statement is spoken by the puppet, rather than by an adult who plays a role as a puppet. Although it does not seem to be a big issue in many works following the traditional TVJT, we designed to get rid of any possibility that children think that the statement might be true because it is spoken by the adult experimenter who mimics puppet's voice. Finally, we showed the same videotaped visual and auditory materials to both children and adults, so that we can make conditions maximally equivalent between groups.

Participants were individually tested in a quiet room. Before the main test, participants received three pretest items. Two pretest items were not ambiguous sentences. The puppet spoke a true statement for a story and a false statement for the other story. One pretest item was an ambiguous sentence with an adjunct that can modify either the subject or the object. Puppet's statement was true for the story. We included the ambiguous sentence in the pretest items for participants to understand that they should respond "yes" when only one of the interpretations of an ambiguous sentence matches with the story and the other interpretation does not match with the story.

Materials

We manipulated two factors with two levels each: (i) Negation types (short-form negation, long-form negation) and (ii) scope (Obj.QP > Neg, Neg > Obj.QP), for a total of four conditions. 12 items were used in total. We used a Latin-square design so that each item has four different versions and each version of the item was rotated through the four experimental conditions. Thus, one participant saw one version of each video, and each version of each video was seen an equal number of times across participants.

An example of each scope condition is as follows:

Obj.QP > Neg context

See, it's Jia. Let's say hello to Jia. Hi Jia.

(An experimenter led children to say hello to the character in the story).

(Jia picked up three books one by one and showed that she has three books).

Jia has three books.

(Jia is holding the three books in her hands).

Oh, other kids are reading books, but Jia is just holding the books.

Momo watched this situation as well. Let's ask Momo to say what happened.

Picture 1. Obj.QP 〉 Neg context

Neg > Obj.QP context

See, it's Jia. Let's say hello to Jia. Hi Jia.

(An experimenter led children to say hello to the character in the story).

(Jia picked up three books one by one and showed that she has three books).

Jia has three books.

(Jia put down all the three books on floor. She picked up a book and started reading it. After reading that book, she put down the book on floor and picked the other two books. She did not read the two books, but held them in her hands.)

Oh, Jia read one book and she did not read two books.

Momo watched this situation as well. Let's ask Momo to say what happened.

Picture 2. Neg 〉 Obj.QP context

　　12 experimental items were video-taped and no same character appears more than one story. No single object head noun (in this case, *books*) is used more than one time. We recorded puppet's statement separately from the videotaped stories and pasted it to the end of each scope context-denoting videos. Each negation condition corresponding to the target examples is as follows:

(15)　a. Short-form negation

　　　　　Jia-ka　　　chayk-ul　　sey-kwon　　　　an　　ilk-ess-ta.
　　　　　Jia-Nom　　book-acc　　three-classifier　　Neg　read-past-decl.

　　　b. Long-form negation

　　　　　Jia-ka　　　chayk-ul　　sey-kwon　　　　ilk-ci anh-ess-ta.
　　　　　Jia-Nom　　book-acc　　three-classifier　　read-CI-Neg-past-decl.

　　　　　Jia did not read three books.

　　　　　Obj.QP > Neg reading: Jia did read eat any of the books.

　　　　　Neg > Obj.QP reading: It is not the case that Jia read every book.

　　We note that the story corresponding to the object quantifier wide scope reading does not follow the traditional methodology of the TVJT task. To follow the traditional method, the object wide scope reading context should be represented by the story to which the negation wide scope reading is false and the object wide scope reading is true. Thus, we can assure that participants' 'yes'

responses indicate that they interpret the sentence as to the particular reading. To be more specific, at the beginning of the story, an experimenter shows that the character in the story (e.g. *Jia* in (15)) has 6 books in total. However, the character reads only three books and does not read the other three books. This is an example of visual stimuli designed following the traditional TVJT task. In such a case, the negation wide scope reading is false (because Jia read three books), but the object wide scope reading is true (because there are three books Jia has not read). However, we found that such a story is very confusing, so children could happen to say 'no' because Jia read three books even though they understand that there are another three books Jia does not read. If children were to respond "no" because "Jia read three books" although they agree that there are three books left Jia has not read, the proportion of "yes/no" responses would be distorted by the unexpected reason. Therefore, focusing that our research question deals with the (im)possibility of the negation wide scope reading rather than the object wide scope reading, to reduce an unnecessary processing burden for children, we manipulated the object wide scope context as the situation to which both readings are true. Furthermore, this way of story-making has a benefit that we could infer how much the other factors affect participants' responses. Since both possible interpretations are true to the situation, the 'yes' responses are expected to reach almost 100% of the responses. If the 'no' answers appear, it may indicate the amounts of the effects that was not experimentally manipulated. On the other hand, we manipulated the negation wide scope reading context as the situation to which the negation wide scope reading is true, but the object wide scope reading is false. Thus, comparing the 'yes' responses between the two conditions shows us how much participants interpret the experimental sentences as the negation wide scope reading which is the main interest of the current work.

For the object quantifier, there are three ways to express the numeral quantificational expressions in Korean. The three ways are distinguished by the use of the accusative case marker: accusative case marker on the head noun, on the classifier, or no accusative case marker. Kwak (2010) shows that the negation wide scope reading is more available when the accusative case marker is attached to the head noun, as in (15). Our hypothesis predicts that the negation wide scope is not readily allowed by Korean children. To be more conservative,

we used object numeral quantifiers with the accusative case marker on the head noun, which is a counter-supportive against our prediction. In the numeral QPs, we used the numbers two and three (frequency and distribution of *two* and *three* among lists was counterbalanced). The reason we alternate numbers is to avoid any potential confounding effect caused by using a single number.

Picture 3. Video for puppet's statement

The puppet's statements were recorded by a female Korean native speaker who is naïve to the hypothesis and predictions of the experiment. She was instructed to read the list of 24 test sentences (12 items x two negation types) playing the role of puppet (see picture 3 above). There is no accented word in the sentence and the F0 contour decreases (like down-step) over the course of the sentence. We added a puppet video at the end of both scope-denoting videos of the same item, making 48 videos in total. Thus, there is no difference in the puppet statement between the two scope conditions. Each participant watched 12 target items and 12 filler items in total and no more than two targets or fillers were consecutive.

4.2 Results

For each condition, the dependent measure was the proportion of YES responses to the puppet's statements. Figure 1 shows the overall results. Both children and adults preferred the object wide scope reading in both negation types. To assess these results statistically, we conducted analyses of variance

(ANOVAs). A 2 (long-form vs. short-form) x 2 (Neg > Obj.QP vs. Obj.QP > Neg) ANOVA on children's responses shows that regardless of negation types, YES responses were significantly higher in the obj.QP > Neg context than in the Neg > Obj.QP context in both by-subjects analysis and by-items analysis (main effect of scope: $F1(1,52)=116.00$, $p<0.01$, $F2(1,15)=384.50$, $p<0.01$). There was no significant main effect of negation type nor significant interaction between the two factors. This means that children prefer the object wide scope reading over the negation wide scope reading and the type of negation has no effect. An ANOVA on adults' responses, however, shows main effect of both scope and negation type (main effect of scope: $F1(1,39)=14.24$, $p<0.01$, $F2(1,15)=37.52$, $p<0.01$, main effect of negation type: $F1(1,39)=9.75$, $p<0.01$, $F2(1,15)=14.03$, $p<0.01$). "Yes" responses occurred more in the long-form negation condition than in the short-form negation condition and more in the obj.QP > Neg context than in the Neg > obj.QP context. There was no significant interaction between the two factors. It indicates that adults prefer the object wide scope reading over the negation wide scope reading regardless of negation type. They prefer to use the long-form negation over short-form negation regardless of scope contexts. The results support the hypothesis of the configurational proposal in (12). The configurational proposal predicts that Korean-speaking children have difficulty in associating the object quantifier with its base position, so they would not accept the object-narrow scope reading (i.e. the negation wide scope reading). The prediction is borne out as follows: The Obj.QP > Neg story was to which both the negation wide scope reading and the object wide scope reading are true. In this case, the acceptance rate goes up to 90% in children's responses. This indicates children do not readily consider other factors than syntactic factors (comparing with adults' data, we will discuss this issue in more detail later). On the other hand, in the Neg > Obj.QP condition to which only the negation wide scope reading is true, the acceptance rate is lower than 40%. This is contrary to Kannada-speaking children's behavior and supports the idea that children rely on configurational information rather than the subject-object asymmetry regarding saliency. Furthermore, the results are comparable to Japanese children's responses on the subject quantifier-object quantifier sequence, observed by Yamakoshi and Sano (2007), discussed in the section 2.2. In that case, children readily accept the non-isomorphic reading even though adult speakers do not

accept the reading. Considering the Japanese data, it seems to be reasonable to say that the low acceptability of the negation wide scope reading by children in the current experiment is not just because the reading is not available in Korean adult speakers' grammar.

Table 1. Results (overall)

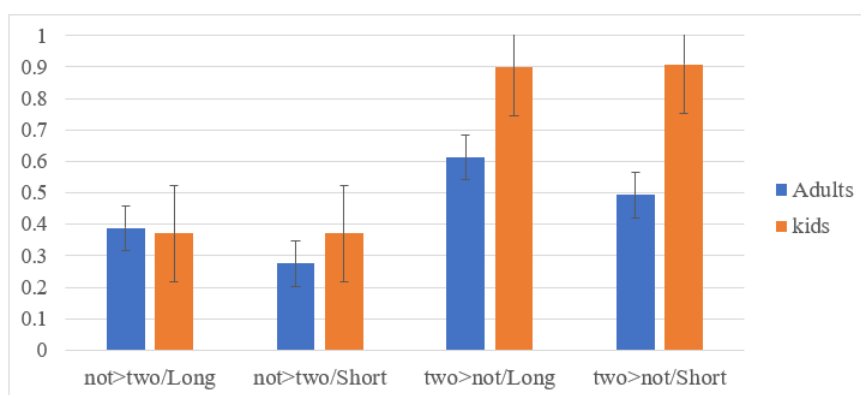| Mean (SD)	Neg > Obj.QP		Obj.QP > Neg	
	Long	Short	Long	Short
Kids	0.37 (0.48)	0.37 (0.48)	0.90 (0.30)	0.91 (0.29)
Adults	0.39 (0.49)	0.28 (0.45)	0.61 (0.49)	0.49 (0.50)

Figure 1. Results overall

Figure 2 shows the proportion of YES responses to the puppet's statement by children's age. 5-year-olds significantly more accepted the negation wide scope reading in both negation types than other groups do. We leave open the issue suggesting the following two possibilities for the difference. First, Kwak (2010) reports that the acceptance of the negation wide scope reading was about 50% when the number of participants was six, but it decreases to 12% when the number of participants was 29. In our experiment, the number of 5-year-olds participants was 12, which is the smallest number among groups (17 6-year-olds and 24 7-year-olds). Thus, the high acceptance rate observed in the 5-year-olds group could be a consequence of the low in the number of participants. Second, the last potential cause of the high acceptance of the negation wide scope

reading by the very young learners is simply their lack of understanding of experimental materials. Since the interpretation of a sentence with scope ambiguity is not easy even for adults, the youngest group possibly simply say 'yes' when they do not understand stories or sentences due to the 'Yes' bias proposed by Crain and Thornton. We find that three children in the 5-year-olds group could not provide a reason for their decision. Another 4 children raised 'good' or 'bad' face in all the trials. In addition, they felt hard to concentrate on the task compared to other groups. Thus, we suspect that this type of TVJT is not suitable to this young group. We leave this issue for future works.

To compare between adults and children, we conducted analyses of variance (ANOVAs). We did not include the results of 5-years-olds for the reasons described above. In addition, we exclude one 6-year-old child and one 7-year-old child because they were distracted and did not focus on the task. A 2(negation type) x 2(context) x 2 (kids vs. adults) ANOVA on responses show that a significant main effect of negation types ($F1(1,92) = 11.43$, $p < 0.01$, $F2(1,30) = 4.46$, $p < 0.01$), a significant main effect of context types ($F1(1,92) = 96.30$, $P < 0.01$, $F2(1,30) = 249.30$, $p < 0.01$) and a significant main effect of age groups ($F1(1,92) = 11.43$, $p < 0.01$, $F2(1,30) = 87.52$, $p < 0.01$)). A significant interaction between age groups and context types ($F1(1,92) = 16.32$, $p < 0.01$, $F2(1,20) = 41.73$, $p < 0.01$) and a significant interaction between age groups and negation types ($F1(1,92) = 8.94$, $p < 0.01$, $F2(1,30) = 5.27$, $p < 0.01$) were also observed. To better understand the source of interaction, we conducted an independent t-test. The results show that children's and adults' acceptance rates of the negation wide scope reading were not significantly different (long-form negation: $t(78) = -0.72343$, $P = 0.4716$, short-form negation: $t(78) = 0.53079$, $P = 0.5971$). This means that children do not accept the reading that adults do not accept. On the other hand, the acceptance rate of the object wide scope reading was significantly different between the two groups (long-form negation: $t(78) = 4.0545$, $P = 0.0001181$, short-form negation: $t(78) = 5.4824$, $P = 4.995e-07$). This indicates that adults are reluctant to use the experimental sentences to the given situations. Remember that the story we used for "the object wide scope reading" does not match only with the object wide scope reading, but also with the negation wide scope reading. Thus, adults do not accept the experimental sentence independent to the scope interpretation. We will discuss it in the discussion.

Table 2. The proportion of YES responses by age

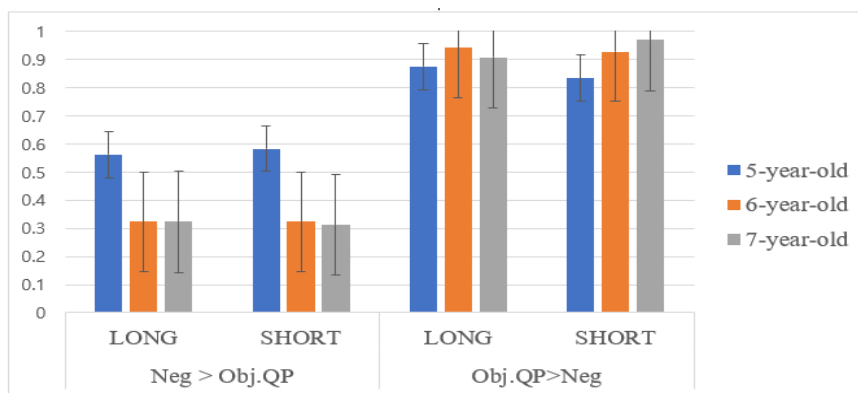| Mean (SD)	Neg > Obj.QP		Obj.QP > Neg	
	Long	Short	Long	Short
5 years old	0.56 (0.50)	0.58 (0.49)	0.88 (0.33)	0.83 (0.37)
6 years old	0.32 (0.47)	0.32 (0.47)	0.94 (0.24)	0.93 (0.26)
7 years old	0.32 (0.47)	0.31 (0.46)	0.91 (0.29)	0.97 (0.17)

Figure 2. The proportion of YES responses by age

4.3 Discussion

The experiment shows that Korean-speaking children, contrary to Kannada-speaking children, prefer the object wide scope reading when the object quantifier is a numeral quantifier. This is what is predicted by the configurational proposal in (12). If children's interpretation is based on the saliency, the subject-object asymmetry is expected to appear in both language groups. However, language learners of the two languages show different behaviors depending on the syntactic structures of their native language. In Kannada, the object does not undergo movement over negation, so as predicted by (12b), the negation wide scope reading is the preferred one. On the other hand, in Korean, the object undergoes movement over negation, so the syntactic hierarchy between the object and negation is the opposite between the base structure and the surface structure. We proposed that children have difficulty in linking filler-gap dependency created by movement. As predicted by (12a), the

negation wide scope reading that must refer to the base structure was less accepted. Assuming that the saliency of objects in Korean and Kannada is not different, the different behaviors between Kannada-speaking children and Korean-speaking children indicate that children's scope interpretation is more affected by the configurational properties of a sentence, rather than a simple subject-object asymmetry. The results can be comparable to the experiment reported in Szendrői et al. (2017) and Yamakoshi and Sano (2007). They show children can get interpretation that adults cannot when a sentence has two quantifiers; one is for subject and the other is for object. In that case, the non-isomorphic reading is obtained by a movement of object quantifier rather than referring back to the base position. In other words, children accepted the interpretation that can be construed by upward movement of the object. However, in the current experiment, the non-isomorphic reading (i.e. the negation-wide scope reading) cannot be obtained by upward movement, but by referring to the base structure (i.e. by lowering). Thus, as predicted, children do not accept the interpretation.

One more interesting point we want to discuss is the low acceptance rate of the object wide scope condition by adults. Adopting Musolino and Lidz's idea, we suggest that the low acceptability is caused by adults' ability to instantly incorporate pragmatic factors into interpretation. In Korean, the more natural expression for the object wide scope denoting situation might be the one including ta "all" as in (16). Thus, adults might think that there is a better expression for the situation. Contrary to adults, children more heavily rely on syntactic structures when they interpret scopes. This is why their acceptance rate of the same condition is high, up to 90%.

(16) a. Short-form negation

Jia-ka	chayk-ul	sey-kwon	ta	an	ilk-ess-ta.
Jia-Nom	book-acc	three-classifier	all	Neg	read-past-decl.

   b. Long-form negation

Jia-ka	chayk-ul	sey-kwon	ta	ilk-ci anh-ess-ta.
Jia-Nom	book-acc	three-classifier	all	read-CI-Neg-past-decl.

   Jia did not read all the three books.

One might wonder why the negation wide scope reading is not much available to adults as well. We suggest two potential reasons for it. First, Korean is a so-called scope-rigid language, so even adult speakers do not readily accept a scope interpretation that does not match with the syntactic hierarchy. However, it does not necessarily mean that children's responses simply reflect adults' ones. Han et al. (2007) show that the negation-object (universal) quantifier sequence in Korean is ambiguous for some speakers (but not every speaker). It means that the input children get from adults does not always bear scope rigidity. In addition, as reported by Szendrői et al. (2017) and Yamakoshi and Sano (2007), it is not rare that children accept the reading adults do not accept. Thus, it is premature to say that the low acceptance of the negation wide scope reading by children is a reflection of adults' use of the corresponding sentences. Second, the object-wide scope context condition in our experiment is compatible with both the negation wide scope reading and the object wide scope reading. As discussed above, for some non-syntactic reason, adults do not prefer to use the target sentences to refer to the object wide scope context. Such a low acceptance suggest that the target sentences might be interpreted in both readings equally. Given the observation, it could be the case that the reason why adults less accept the Neg > Obj.QP context is simply because that context is compatible with the negation wide scope reading, while the Obj.QP > Neg context is compatible with both readings. We leave this issue for future works.

5. Final remarks

We have proposed an immature parser account for the non-adult like behavior of children in their interpretation of scopally ambiguous sentences. The immature parser cannot properly incorporate various non-syntactic information into scope interpretation. Furthermore, the parser could not well have access to the base structure if movement takes place over a scope-bearing intervenor.

One of the most famous sentences in psycholinguistics is the one in (17) by Bever (1970). The sentence by itself is not ambiguous. To be a grammatically correct sentence, the verb in the middle of the sentence, raced, must be interpreted as "being raced" in the form of reduced relative clause, rather than

"doing racing". However, from the perspective of processing, the sentence is temporarily ambiguous at the point of listening to the word raced being able to be interpreted in two ways. If the processor (incorrectly) assigns the role of a main verb to the word raced and moves on, it will be perplexed when it faces the (correct) main verb, fell. The processor must revise its first hypothesis.

(17) The horse raced past the barn fell.

Psycholinguists call sentences with temporal ambiguities like (17) garden path sentences. To explain the garden-path effect, the garden path theory is proposed by Frazier and Fodor (1978) (and Frazier and Clifton 1996). Observing that people show a strong tendency to analyze a garden path sentence being consistent with the simpler syntactic structure, they argue that the parser is allured by the simplest syntactic structure in the early processing period. According to the garden path theory, when people listen to the sentence up to [the horse] [raced], people assign each phrase the role of subject and a main verb because the intransitive structure is simpler than the structure involving a reduced relative clause. Thus, when they face the actual main verb fell, they get lost. This kind of processing is somewhat error-prone heuristics, which supports fast and easy processing, but does not take all the relevant information into consideration. If the processor pursues a more efficient strategy in terms of reducing processing time or memory use (at least at the first round of processing), tendency to hire the simplest structure ignoring other information (e.g. semantic or pragmatic information) might be the best way to process an ambiguous sentence.

On the other hand, the constraint-based approach by MacDonald et al. (1994) argues that various types of relevant information for parsing affect processing of ambiguous sentences in the early processing as well. For example, MacDonald et al. (1994) show that the frequency of past-tense reading or past-participle reading of a verb can affect the way of interpreting garden path sentences. Specifically, under the constraint-based approach, the garden path effect in (17) can be accounted for as follows. Since the verb raced (in that particular morphological form) is more frequently used with the past-tense reading, rather than past-participle reading, people assign the past-tense reading to the verb raced,

misled by the frequency of the verb form. Supporting the constraint-based approach, many other studies have shown that semantic, pragmatic, and even visual information can affect the way of parsing ambiguous sentences in the early processing period (Trueswell et al. 1994; Spivey-Knowlton et al. 1993; Tanenhaus et al. 1995, among many others).

One might wonder why we have introduced the two approaches on parsing even though the current issue on scope interpretation concerns later processing. It might be obvious that adults can incorporate many relevant information when they interpret sentences in later processing but children might not due to limitations of immature cognitive mechanisms. Inspired by the two approaches on sentence processing, we suggest that children are more likely to use a garden path theory type strategy when they interpret a sentence with scope ambiguity so that they interpret the sentence matching with the simple syntax, which does not include the base structure.

Crucially we do not assume that children do not use non-syntactic factors in spoken language comprehension. Many experiments on children's comprehension show that children can take advantage of various cues for parsing even though they are less sensitive to those cues than adults (see Snedeker (2013) for a detailed discussion). What we would like to point out is that previous studies have shown that children tend to be led by a simple syntactic structure than any other factors. Therefore, it seems reasonable to assume that children's interpretation of sentence is heavily weighted on surface syntactic information. We believe that the observation of isomorphism is not an independent phenomenon that can be discussed without referring to children's parsing mechanism. Children may find the base structure more difficult to have access to so that they do not adopt the base structure as the primary resource for scope interpretation. Due to the immature parsing ability and short capacity of processing, children might use the garden-path type processing even in the later processing.

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