The Online Processing of Ambiguous Sentences with a Focus Particle *only*

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Kim, Soyoung. 2012. Eye Movements during the Processing of Ambiguous Sentences with a Focus Particle *only*. *The Linguistic Association of Korea Journal. 20*(1). 85-107. This study investigates how English-speaking children (5-6 years old) interpret, in real time, scope ambiguous sentences with a preverbal *only* as in

Charlie is only walking the dog. --> Charlie is walking [only the dog] (NP Scope)
--> Charlie is [only walking the dog] (VP Scope).

Prior research suggests adults favor NP scope while children prefer VP scope (Crain et al. 1994). An eye-movement-during-listening paradigm was employed in which participants heard a description of a picture and their eye movements were video-recorded. Also the task used a context-based methodology in which contextual information was provided to help children compute contrast information. The results show that like adults capable of accessing NP scope interpretation, children exhibit a NP scope interpretation. In contrast to previous reports of children's failure to use contrast information (Paterson et al. 2003), the present study found that children employed contrast information and resolve focus ambiguity by assigning NP scope. This suggests that children, despite presumably less-developed pragmatic knowledge, have the ability to mentally compute a contrast set for sentences with *only* and access an NP scope interpretation in an adult-like way with the help of contexts.

Key Words: child language acquisition, pragmatic inferencing, focus particle, scope, on-line processing, eye fixations

1. Introduction

Most psycholinguistic research into adult comprehension of focus operators has been concerned with effect of a focus on structural ambiguity resolution (e.g., Fodor, 1982; Frazier, Pacht, & Rayner, 1999; Ioup, 1975; Johnson-Laird, 1969; Kurtzman & MacDonald, 1993; Micham, Catlin, Van Derveer, & Loveland, 1980). In contrast to the active discussion on adults' processing of sentences containing *only*, there has been little research on children's on-line comprehension of it and if any, there was a relative scarcity of psychological processing account. In this study, I attempt to propose the processing that children will be expected to have pertaining to a focus particle *only*. This suggestion will be made based on experimental investigation into how children understand sentences containing preverbal *only*.

Sentences with preverbal *only* involve ambiguity in terms of the assignment of focus as shown in example (1) below. In other words, *only* that can be associated with more than one entity allows us to access two different types of scope analyses. One analysis, called the VP scope analysis, is made in sentences with *only* restricted to the verb phrase as a whole (e.g., washed a dog) while in the other called the NP scope analysis, *only* is circumscribed to the direct object (e.g., a dog). In (1a), with the VP scope analysis, the interpretation is that John didn't do anything other than wash a dog. With the NP scope analysis, however, the sentence means that John didn't wash anything other than a dog as illustrated in (1b).

(1) John only washed a dog.
  a. John didn't do anything other than wash a dog. (VP scope)
  b. John didn't wash anything other than a dog. (NP scope)

Crain et al. (1994) provided a theoretical baseline for how adults and children can process the scope ambiguous sentences. He claimed that the NP scope analysis for sentences with preverbal *only* is favored by adults, while VP scope analysis is preferred by children. According to Crain et al. (1994), adults' preference to the NP scope reading comes from a parsing strategy by which they make the fewest presumptions about information that is not given in the

sentence in order to minimize risk of revising the initial parsing later. However, their claims were disconfirmed by the results by Paterson et al. (2006), who were the first to empirically investigate the resolution of focus ambiguity of preverbal *only* in children and adults. Paterson et al. (2006) reported the findings that not only children aged from 6 to 7 but also adults preferentially adopt VP scope reading, which is not in line with what Crain et al. (1994) had claimed.

This study attempts to revisit an issue of how children resolve focus ambiguity in sentences containing preverbal *only,* using a context-based methodology. Prior studies concerning *only* are lack of discourse contexts in which the use of *only* is reasonable, which led to an abnormally high rate of erroneous responses. In the current study, in order to supplement the previous methodological limitation, the task provided referential contexts within which children are readily accessible to both NP-based and VP-based information. This experimental setting has an advantage that participants are laid to select either of scope reading out of their own parsing principle alone.

For the detail examination into their processing, this study also employed a DIY eye-tracking paradigm (Shin, 2004). Previous studies simply demonstrated the result of children's interpretation processes might be influenced by different kinds of linguistic or non-linguistic factors. In order to provide information about the processing of these sentences, there is a need to employ the visual world-eye-tracking paradigm (Cooper, 1974; Tanenhaus, Spivey-Knowlton, Eberhard & Sedivy, 1995). This online paradigm allows us to collect data from unconscious gaze movements on a picture, while the child is listening to a sentence that describes aspects of the scene. This on-line method contribute a deeper insight into the issue of how children resolve focus ambiguity.

This study outlines theoretical backgrounds and reviews previous studies on *only* in Chapter 2. After then, Chapter 3 presents the experiment along with procedures and results. Lastly this study is concluded with the discussion and processing implication in Chapter 4 and 5 respectively.

2. Theoretical Backgrounds and Previous Studies

2.1. Computation of a contrast set in unambiguous focus of *only*

The basic semantic function of a focus particle *only* is to signal the relation of the extension of some linguistic constituent to a set of alternatives (Crain et al., 1994; Paterson et al., 2003). For example, for a sentence *Only John bought a balloon,* the resulting discourse model involves a more complex representation than for the corresponding sentence without the focus particle. The contrast is made between John, identified as a constituent in focus of this whole sentence, and other people who did not buy a balloon with respect to John. Here, the psychologically salient set (i.e. John) is referred to as a focus set and the information that is not asserted but inferred with respect to the focus is called an alternative set or a contrast set (i.e. the other people who didn't buy a balloon).

From psycholinguistic perspectives, the comprehension of a sentence with *only* involves a complicated path of processing, which emerges as a consequence of determining a focus set and costly computation of a contrast set in the parsers' mental representation (Johnson-Laird, 1983). This leads to a general consideration about how contrast information is mentally represented. The set of alternatives is inferred from the common background of a speaker and a listener. This shared information between them can be based on either world knowledge, if there is no piror discourse context, or a referential context given (e.g., Frazier, 1999; Sedivy, 2002). For instance, for a sentence *Only John walked a dog,* readers or listeners compute unspecified people who did not walk a dog from their own pragmatic knowledge when no specific referent is provided except for John. However, given a referential context in which John and Mary went to the park, it can be inferred that Mary did not walk a dog in contrast to John. In this sense, the selection of alternatives is highly context-dependent.

According to Reinhart (2004), the computation of a contrast or alternative set comes with processing cost. While adults are able to readily infer contrast information even without prior discourse contexts, children are expected to be hard because they are responsible for the computation of an alternative set

using their non-adult-like pragmatic knowledge.

Paterson et al. (2003) posed the possibility that children's non-adult-like semantic interpretation of sentences with *only* might derive from a failure to generate contrast information. With the introduction of *only* to a sentence, the computation of contrast sets becomes crucial for parsers to be able to reach the intended interpretation of the sentence containing it. However, given that children are not adult-like in their employment of pragmatic knowledge required to infer contrast information, it is highly probable that they would process *only* sentences without this set computation. This lack of computation could lead to *only*-deletion errors.

To address this issue, Paterson et al. (2003) tested whether 4- to 7-year-old English-speaking children were capable of managing a mental model that necessarily included a contrast set as well as a focus set. The main result drawn from this study is that children aged 4 to 5 years made substantial *only*-deletion errors over 50 percent of the time. The same kind of error was witnessed 36 percent of the time even in older children aged 6 to 7 years. In contrast to the results of Crain et al. (1992), the children principally made errors by neglecting contrast information rather than by misanalyzing scope. These findings reported by Paterson et al. (2006) indicate that while they can perceive a focus set, children tend not to take account of contrast information.

2.2. Focus ambiguity of preverbal *only*

As mentioned earlier, sentences with preverbal *only* raise focus ambiguity between a VP scope with focus assigned to the verb phrase and an NP scope with focus restricted to the direct objection. There are two contrasting parsing strategies that account for how adults and children prefer a scope reading for an ambiguous sentence containing preverbal *only*.

Crain and Steedman (1985) proposed that adults are more likely to prefer an NP scope reading in a preverbal *only* sentence, following the "principle of parsimony". According to this principle, if there is a reading that carries fewer unsatisfied but consistent presuppositions than any other, then that reading will be adopted by adults. (p.333). The advantage of such a least effort strategy for ambiguity resolution is to reduce the risk of making commitments that will need

to be changed later. So, to avoid unnecessary commitment, the parser selects that interpretation of an ambiguous sentence that makes it true in the largest set of circumstances. This principle pursues processing simplicity, so that adults don't have to alter analysis at later point.

Consider the sentence like *John only washed a dog* again. There are two accessible scope readings, according to which two possible contrast sets for the preverbal *only* are computed in the sentence. One is the entire VP set, *washed a dog*; the other is the set of NP, *a dog*. On the VP-based interpretation, John didn't do anything other than wash a dog, so if he involves another action such as throw a ball, other than wash a dog, the sentence should be judged to be false. The main point in the semantic relation between the NP scope and the VP scope is that for John not to do anything other than wash a dog entails that he also did not wash anything other than a dog whereas the reverse does not hold (Paterson et al. 2006). Thus, the analysis with the focus on the VP is true in a subset of the circumstances in which the analysis with the focus on the NP is true. Here, the NP scope analysis costs less than the VP scope analysis because it is true in a larger set of circumstances than the VP scope analysis. This is because the NP scope analysis requires a minimum revision if an initial analysis needs to be changed to an alternative analysis. Adults, who tend to employ efficient interpretative strategies for focus ambiguity, therefore associate preverbal *only* with the direct object rather than the verb phrase.

In contrast to adults, the Crain and Steedman (1985) suggested that Language Acquisition Device (LAD) permits children to attain their target grammar solely on the basis of positive evidence. Since children lack negative evidence, it is possible to propose that children avoid making semantic errors in the first place. So, children are proposed to follow a so-called semantic subset principle. According to their claim, based on only positive evidence, children are more likely to employ a parsing strategy that makes sentences true in the narrowest possible set of circumstances. Children thus will exhibit the preference of VP scope analysis in focus ambiguity of preverbal *only*.

A recent study conducted by Paterson et al. (2006) has extended previous studies on pre-subject or pre-object *only* to preverbal *only*. Paterson et al. examined how 7- to 8-year-olds determine scope ambiguity for preverbal *only* using a picture verification task. In their experiment, children were asked to

verify whether sentences with preverbal *only* (e.g., *The woman is only walking a dog.*) described pictures that contained either an NP-based contrast set (e.g., walking a cat) or a VP-based contrast set (e.g., throwing a ball). The results demonstrated that children were more likely to employ the VP scope analysis than the NP scope analysis in line with the semantic subset principle. As shown in this study, children, who want to have minimal commitment, tend to resolve scope ambiguity following the semantic subset principle.

However, all these parsing strategies have been discussed given that there is not prior referential context available. The picture verification tasks as in Paterson et al. (2006), are characterized by the presentation of a static picture to children. Based on the depicted information, children are required to compute alternative sets to interpret target sentences. However, the process might require children, with less pragmatic knowledge than adults, to have the computation of a set of alternatives and extralinguistic factors to reach to the intended interpretation. Notley et al., (2009) claimed that such task demand can be attributed to a high rate of erroneous responses in children's performance. To fill out this methodological gap, the current study provide referential context in which the use of *only* is natural and reasonable and revisits children's and adults' parsing strategies in focus ambiguity. Furthermore, the contexts contain information on not only NP-based but also VP-based information in detail, so that participants can adopt either of scope analysis by their own strategy.

3. The Current Study

The study aims to examine how children resolve the ambiguity of focus in preverbal *only* sentences with the help of a context. There has been little research that takes an approach using a method in which a context assists children's performance in understanding sentences with *only* in the preverbal position. The study combines a Truth Value Judgment Task (Crain & Thornton, 1998) with an eye-tracking paradigm (Shin, 2007). Using this experimental setting, it is possible to investigate not only how children resolve the scope ambiguity of *only* off-line, but also whether they compute a contrast

set contingent on scope analysis on-line, assuming that children's preferential scope analysis is reflected in their eye movement patterns. The two primary research questions are as follows:

- How do children and adults resolve focus ambiguity of preverbal *only*? Do they prefer to adopt NP scope reading or VP scope reading?
- Does contextual help play a role for participants to determine scope reading between NP and VP?

3.1. Participants

A total of 14 English-speaking children aged 5 to 6 (mean 5;2) with normal hearing and normal vision were recruited at the University of Hawai'i at Mānoa (UHM) children's center. As a control group, 5 English adult speakers who were undergraduate students of UHM also participated in the experiment. All of the participants were naive with respect to the purpose of the experiment. Parental consent was obtained prior to conducting the experiment. Children were given a small bag of snacks in compensation for their participation, and adults participated in exchange for a small bag of snacks or for credit in an introductory course in linguistics or psychology.

3.2. Procedures

Participants were placed in a leaned back chair in front of the screen made by a white board hanging on the wall of the laboratory. To video-tape participants' eye movements and fixations on objects described in visual stimuli, a digital camcorder was placed in front of participants.

Before listening to a story, children were introduced a puppet (i.e. Smurf) on the screen. And then they were asked to listen to a story along with him. Each participant was instructed to view a series of pictures on the screen via a projector[1] while listening to the story prerecord by an English native

1) A projector played a crucial role in blowing up objects described in visual stimuli. This type of DIY eye-tracking methodology (Shin, 2004) made it possible for an experimenter to easily analyze eye movements and fixations of participants

speaker with linguistic training. To reduce children's memory burden, the last picture always provided a summarized description of what happened in the story. At the end of the story, prerecorded verbal stimuli, which are preverbal *only* sentences, were spoken by the puppet in a child-directed manner.

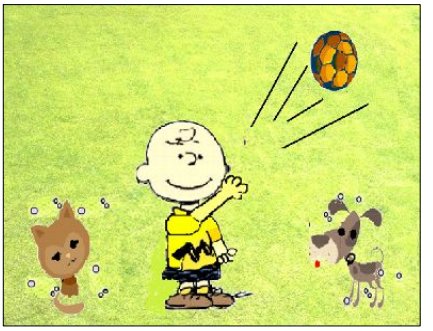
Participants were asked to judge whether the puppet's statement containing *only* correctly matched the depiction of the summary picture. They were asked to answer 'yes' (=true) when what the puppet said was right, and 'no' (=false) otherwise. They were also asked to justify their responses when answering 'no' to the puppet's statement.

As the children were performing this task, their eye movements were video-recorded by a digital camcorder. The video-taped data was transferred to frame by frame software through which the eye fixations were divided into small frames by 30ms and analyzed by hand.

3.3. Materials and Design

For target sentences, which always included preverbal *only* (e.g., *Charlie only washed a dog*), I constructed a context comprised of a series of visual pictures, called *NP+VP contrast context* as illustrated in Figure 1. In this context, the main character (i.e. Charlie) carries out an action involving an object denoted in a sentence (i.e. washing a dog) in addition to another object implied by the sentence (i.e. washing a cat). Also, the agent performs a second action involving one object, which is implied in the sentences (i.e. throwing a ball). In this case, participants should consider preverbal *only* to be false regardless of whether any scope reading is preferred. In cases with the same false values between the two scope reading, children's justifications for why they answered false could indicate whether their negative responses were the result of correct reasoning. Therefore, all the explanations about their judgments were written by hand for the data analysis.

Figure 1. A sample of *NP+VP contrast contexts*



Target sentence: *Charlie only washed a dog.*
Story summary: Charlie washed a dog and then washed a cat, too. He also threw a ball.

For NP scope reading: focus set: a dog/contrast set: a cat --> No, because he also washed a cat.
For VP scope reading: focus set: wash a dog/contrast set: throw a ball --> No, because he also threw a ball.

In addition to the target sentences, two other kinds of sentences were presented with the *NP+VP contrast contexts*. First, sentences without *only*, as a control condition, were tested with the same contexts as sentences with preverbal *only* in order to ensure that participants knew the meaning of *only*. Second, sentences with pre-object *only* were also included. This condition is important in that eye fixation patterns on unambiguous sentences with pre-object *only* could be comparable to those for ambiguous sentences with preverbal *only*. Assuming that participants correctly analyze the scope of *only* with respect to the following constituents, sentences with pre-object *only* should allow them to make the NP scope analysis. If the similar patterns of eye fixation are observed for sentence with pre-object *only* and preverbal *only* in eye-tracking analysis, this would support the conclusion that participants prefer the NP scope analysis over the VP scope analysis. A total of three tokens for each sentence type were created, resulting in 9 target trials. To avoid any preferential looks toward any direction by participants, each objects described in pictures were counterbalanced, so that NP contrast sets and VP contrast sets were located in a different place. In sum, the three types of sentences as blow were constructed in this experiment.

(2) a. **control sentence**: sentences without *only*
John washed a dog.
b. **target sentences:** ambiguous sentence with preverbal *only*
John only washed a dog.
c. **filler sentence**: unambiguous sentences with pre-object *only*
John washed only a dog.

3.4. Predictions
-Truth Value Judgment task-

Participants should consider preverbal *only* to be false regardless of whether any scope reading is preferred. Ostensibly, if children say 'no' to the target sentence *Charlie only washed a dog,* providing *Charlie washed a cat* as the reason for their 'no', it can be taken to mean that they interpret preverbal *only* as having NP scope. On the other hand, if they said 'no' because *Charlie threw a ball,* it can be interpreted as their adoption of a VP scope reading.

However, consider the semantic relationship between the NP scope and the VP scope mentioned in Chapter 2. For the VP scope reading, Charlie must not do anything else other than wash a dog. Put it in another way, if he does something other than wash a dog such as wash a cat or throw a ball, the target answer should be judged to be false. According to this logic, although participants interpret the preverbal *only* as having VP scope, they can say 'no' because *Charlie washed a cat.* Following the reasons, only the case where subjects answer 'no' because of throwing a ball would indicate that they adopt a VP scope reading rather than its counterpart.

Although it is not feasible to clearly distinguish between the NP scope and the VP scope for these reasons, a piece of evidence for the NP scope reading might be found through the comparison between target sentences and filler sentences. For a filler sentence (i.e. *John washed only a dog),* participants should answer 'no' for the reason that the agent involves two objects such as a dog and a cat. This justification for the answer 'no' provides a conclusive evidence that they adopted the NP scope reading. At this point, I hypothesize that children, who prefer an NP scope analysis to its counterpart, are likely to exhibit the same truth value and justification between prevebal *only* sentences and pre-object *only* sentences. On the other hand, children, who adopt a VP scope reading, are hypothesized to be inconsistent in their justifications between two sentence types albeit the same truth answer. So, as illustrated in Table 1, those who persistently justify their answers 'no' due to a cat in response to a target sentence as well as a filler sentence are likely to assign *only* to the NP. In contrast, those who respond 'no' to a filler sentence switch their reasoning due to a ball can be taken to adopt a VP scope reading.

Table 1. Prediction on children's responses in TVJT

context type / scope reading	pre-object *only*	preverbal *only*
if NP scope is preferred	'no' because of a cat	'no' because of a cat
if VP scope is preferred	'no' because of a cat	'no' because of a ball

-DIY (Do It Yourself) eye-tracking paradigm-

In the eye-tracking paradigm, if children know the function of *only*, that is, they know how to compute contrast sets, they will exhibit different eye gaze patterns between control sentences without *only* and sentences with preverbal *only*. For a control sentence (i.e. *John washed a dog*), children's eye fixations will be predominately placed on the direct object, namely, a dog. To check the denoted information by the sentence, *John washed a dog*, a possibility rises that the looks of participants are toward a cat to some extent, however, the rate of eye fixations on a cat would be much less than the one of eye fixations on a dog.

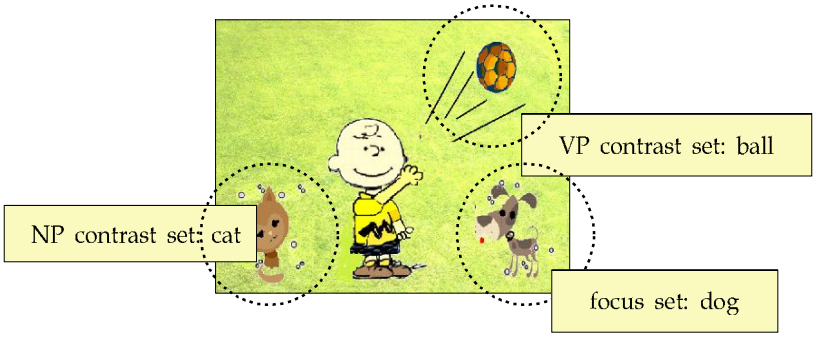
In contrast, given children have the ability to compute NP contrast sets and VP contrast sets, if they assign the scope of *only* to the NP, there should be looks to NP contrast sets (i.e. washing a cat). However, as shown in the prediction of TVJT, the same hold true even when they assign the scope of *only* to the VP. The point is that the looks on the NP contrast sets alone cannot provide any compelling clue to identify their scope preference. However, the looks on the VP can clearly indicate that participants resolve focus ambiguity biasing toward the VP scope reading. From the filler sentences (i.e. *John washed only a dog)*, children will look at a cat when computing the NP contrast set.

Table 2. Predicted eye fixation on objects in visual stimuli

sentence type / scope reading	pre-object *only* (filler)	preverbal *only* (target)
if NP scope is preferred	a cat	a cat
if VP scope is preferred	a ball	a cat

To calculate the proportion of eye fixations across a sentence with ambiguous focus of *only*, each picture context was divided into three regions of interest on which the eye fixations of participants could possibly be placed. For the sentence *Charlie only washed a dog*, children would look at the asserted information denoted in the sentence such as a dog. In addition, the eye fixations of the children might be on the NP contrast sets such as a cat or on the VP contrast sets such as a ball, depending on which scope analysis they preferred. Taking these into consideration, three regions in each picture were set up as below: (1) an entity denoted by an object constituent, (2) an NP contrast set, and (3) a VP contrast set. All the data video-taped by a digital camcorder was digitized and transferred to *Frame by Frame software*. In the eye data divided into 30 ms segments, the eye fixations on each region of interest were recorded by hand. I use a windows movie maker for digitizing video stimuli and editing video clip.

Figure 2. Three regions for eye fixations



3.5. Results

3.5.1. Truth Value Judgment data

In the *NP+VP-contrast contexts* including both the NP-contrast entity (e.g., washing a cat) and the VP-contrast action (e.g., throwing a ball) in the pictures, the rate of rejection for the statements with preverbal *only* was high for both children (84.4%) and adults (100%). In this context, since target answers should be false regardless of which scope analysis was made, the participants' justifications for their negative answers were important in understanding how both groups resolved the scope ambiguity of *only* in the

target sentences. Also, their justifications for target sentences is compared with the ones for pre-object *only* sentences. It was found that the children's reasoning behind most of their negative responses to preverbal *only* sentences derived from their access to the NP-contrast entity. That is, children rejected preverbal *only* sentences by pointing out that the agent in the picture carried out a single action but involving two objects (in the case of Charlie's story, a dog and a cat). These children also negatively answered to pre-object *only* sentences for the same reason, so those who exhibit consistent reasoning between two sentence types were treated to adopt the NP scope reading. It turned out that two third of the children are of this case. On the other hand, the rest of children seemed to employ the VP scope reading 15.6% of the time. They responded negatively to target sentences because of a ball but did so to filler sentences because of a cat. The adults' negative responses were also mainly caused by the NP-contrast entity but one adult participant was found to be predominately biased toward the VP-contrast action. This suggests that children as well as adults are able to access an NP scope analysis.

3.5.2. DIY (Do It Yourself) eye-tracking data

Figures 3, 4 and 5 show the children's proportion of eye fixations on the three regions of the picture contexts across sentences used in the experiment, such as the reference of the subject, in other word, focus sets (e.g., Charlie), an NP contrast set (e.g., a cat), and a VP contrast set (e.g., a ball).

Figure 3 plots the fixation probability of three objects over time with separate graphs for each of them. The red circles in these graphs indicate the probability of fixations on contrast sets (e.g., a cat). The red X in these graphs indicates the probability of fixations on focus sets (e.g., a dog). And the yellow triangles indicate the probability of fixations on the VP contrast sets (e.g., a ball). These data were generated from the video records, by noting which object was fixating during each video fame.

The vertical lines appearing below the y-axis indicate the proportion of looks to objects while the horizontal lines appearing below the x-axis indicate the onset of each content word in a sentence (e.g., *Charlie, only, washed, dog).* These graphs show the observed averaged fixations of the NP contrast set and VP contrast set for each of the three sentence conditions, namely, preverbal

only sentences, pre-object *only* sentences and control sentence without *only*. The graphs cover a time-window of 2500 ms starting from the onset of the sentence containing preverbal *only* with the offset of the focus particle *only* from 1500ms and the end of the sentence at 2400 ms. Since gaze information is obtained every 30 ms, the graphs entail 80 successive datapoints that represent the mean proportion of fixations in the specific target regions such as NP or VP contrast set across subjects.

In the adult group, as shown in Figure 3a, we found a higher probability of fixations for the NP contrast sets while listening to target sentences with preverbal *only* in the time spans between 1000–2300ms after the onset of *only*. As illustrated in Figure 3b, for the experimental group, a similar eye fixation pattern was also observed with a high proportion of looks toward the NP contrast sets. In contrast, there was a low probability of eye fixations on the VP contrast sets from the onset of *a dog* in both groups. This is evidence that children as well as adults resolve focus ambiguity at an early point, that is, after the onset of *only*, by adopting the NP scope reading.

Figure 3a. Proportion of eye fixation for preverbal *only* by adults

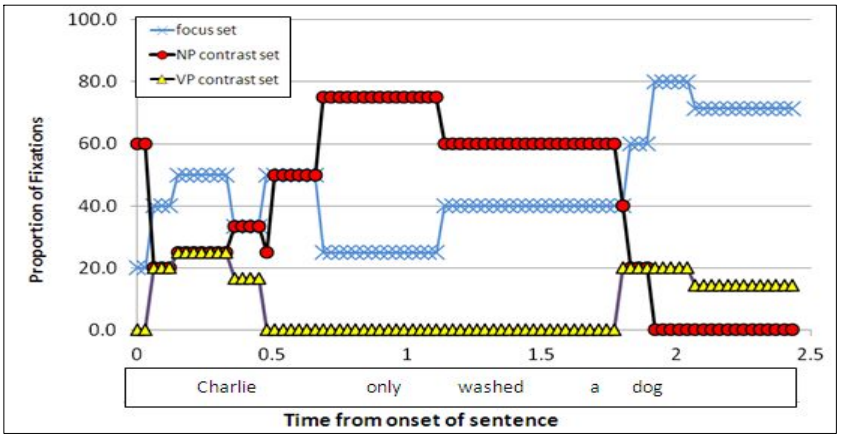
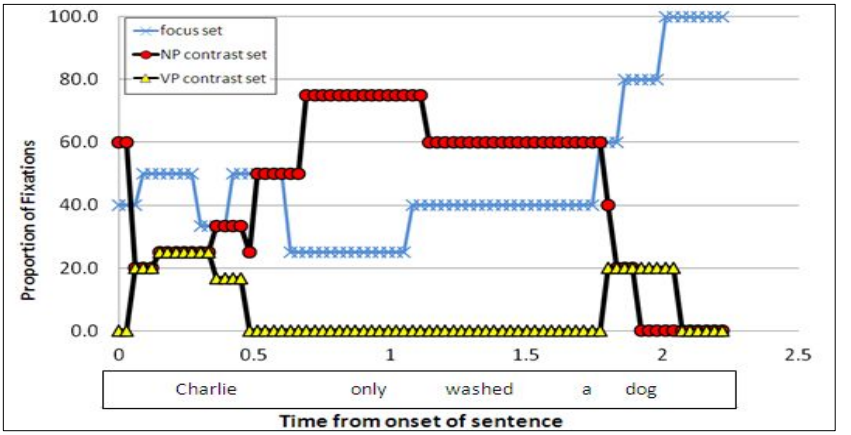
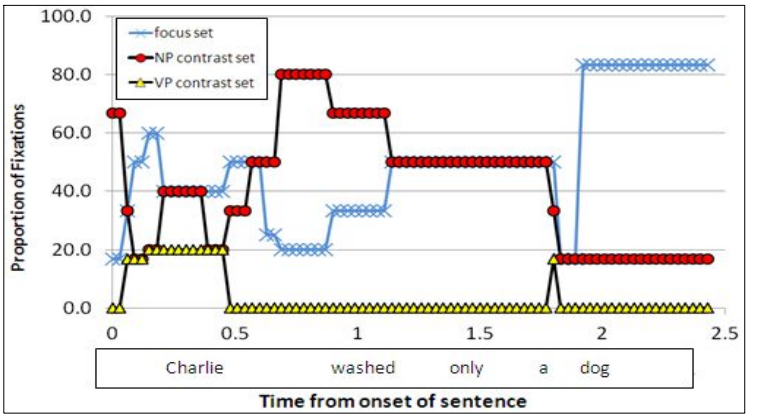


Figure 3b. Proportion of eye fixation for preverbal *only* by children



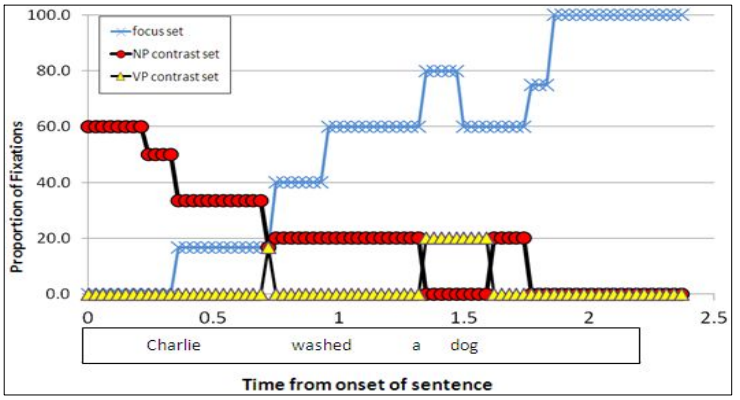
This high eye fixations at the NP contrast sets in the *NP+VP contrast contexts*, however, are quite similar with the ones when children respond to unambiguous sentences with *only,* that is, pre-object *only* sentences. If children correctly assigned scope of pre-object *only* to the object constituents, it should have been a high proportion of looks at the NP contrast sets given that they correctly assigned scope of pre-object *only* to the object constituents. As predicted, as in Figure 4, children looked at not only NP contrast sets as well as focus sets, which indicates that to correctly understand pre-object *only* sentences, their eyes moved back and forth between focus sets and NP contrast sets in the processing of these sentences. Also, combined with the results of Figure 3b (children's eye fixations for preverbal *only*), it suggests that children interpreted sentences with preverbal *only* as if they are pre-object *only* sentences. Therefore, this similarity in eye fixation patterns observed between preverbal *only* sentences and pre-object *only* sentences provided a piece of conclusive evidence that children assign scope of preverbal *only* to the object constituents.

Figure 4. Proportion of eye fixation for pre-object *only* by children



Lastly, in contrast to sentences with preverbal *only*, children did not show a high rate of eye fixations on any contrast sets related to neither NP nor VP in response to control sentences without *only*. In the absence of *only* in sentences, participants don't have to compute contrast sets based on NP nor VP, which leads to their eye fixations only on focus sets (i.e. a dog) after the offset of the verb *washed* as shown in Figure 5. This high rate of looks toward focus sets rather than contrast sets after the onset of the verb suggests that children at the age of 5 to 6 can distinguish between sentences without *only* and sentences with *only*, whose reflected an opposite eye fixation pattern on contrast sets between two sentence types.

Figure 5. Proportion of eye fixation for control sentences without *only*



4. Discussion

This study produced several novel findings. First, unlike the results Paterson et al. (2003) had reported that children are not able to generate contrast information, the current study showed their ability to compute it during the course of processing sentences with *only*. As mentioned earlier, with the introduction of *only* to a sentence, the computation of contrast sets becomes crucial for parsers to be able to reach the intended interpretation of the sentence containing it. As a results of the comparison between control sentences without *only* and sentences with preverbal *only*, they exhibited the opposite eye fixation patterns on contrast sets. The processing of control sentences led to a much higher proportion of looks toward focus sets than contrast sets after the onset of verbs. In contrast, the processing of target sentences with *only* led children to look at contrast sets to a higher degree.

Second, adults assigned *only* to the direct object – that is, the NP scope analysis – as shown in the *NP+VP contrast contexts*, which appeared to be compatible with Crain et al.'s (1994) proposal. In their study (1994), it was argued that adults, who make the fewest assumptions about the implied information for sentences with ambiguous *only*, are more likely to assign *only* in a preverbal position to the following object constituent than to the verb phrase as a whole. That is, adults preferentially adopt the NP scope analysis over the VP scope analysis. Surprisingly, children, like adults, preferred the NP scope analysis over the VP scope analysis in the same context, as shown in the eye-tracking analysis. My study provided a piece of evidence that supports this finding from the comparison with children's eye fixation patterns for filler sentences. As mentioned earlier, there was a high proportion of eye fixations on NP contrast sets for unambiguous sentences with pre-object *only*. Children also exhibited a quite similar preference toward contrast sets in eye fixations in response to ambiguous sentences involving *only*. This lends a support to conclusion that children assign preverbal *only* to the object constituents in resolving focus ambiguity, thus interpreting sentences with preverbal *only* as having the same meaning of pre-object *only* sentences. This finding was unexpected because Crain et al.'s study (1994) suggested that children tend to preferentially adopt the VP scope analysis.

As illustrated in the results, adults and children are found to be alike in their choice of scope of *only* when processing sentences with ambiguous focus for *only* when contextual information is provided. These findings are also consistent with the ones of TVJT. Recall that in the *NP+VP contrast contexts* that describe both NP (i.e. washing a cat) and VP contrast information (i.e. throwing a ball), participants are supposed to answer negatively due to either of the information. The reason for adults to answer negatively to the target sentences in the *NP+VP-contrast contexts* was their access to the NP-based contrast set in the TVJT, which is in line with the results of their high proportion of looks on NP contrast sets. Children also consistently answered negatively to the statement with preverbal *only* in this context, and their strong preference for scope assignment turned out to stem from their access to the NP-based contrast set, which was found in their justifications of the TVJT and the eye-tracking analysis. This indicates that children have the ability to access dispreferred scope reading in the resolution of focus ambiguity when NP contrast information is available to them.

The finding that children are able to adopt NP scope reading seems to be not compatible with the semantic subset principle mentioned earlier. However, before touching on this issue, it should be pointed out that this parsing strategy is discussed only under the condition that children interpret ambiguous sentences in the absence of referential contexts. In other words, without any prior referential context in which both NP and VP contrast information is accessible, children are more likely to resolve focus ambiguity such a way that makes sentences true in a narrowest circumstance, that is, the VP scope reading. However, the contexts used in my current study was characterized by containing combinatory contrast sets, which enabled children to access possible alternative analyses simultaneously. In this regard, it is worth noticing that the contexts supported their access to NP scope analyses.

Then, the question of why children showed such a strong preference toward the NP scope reading when they are able to access the VP scope reading in the *NP+VP contrast contexts* needs to be answered. There are largely two possibilities to account for this asymmetry between NP scope reading and VP scope reading. First, the strong NP-biased scope reading by the children poses a possibility that their performance was due to an animacy effect. The

picture always depict two animates (i.e. cat and dog) and one inanimate (i.e. ball). A cat is more salient than a ball in terms of animacy scale. This animacy saliency may be a clue to what made children bias one scope analysis over the other one. For a target sentence such as *Charlie only washed a dog*, the NP-contrast entity depicted in the story was an animate being such as cat while the VP-contrast action involve an inanimate object such as ball. The analysis involving two animates was usually an NP-scope analysis, which might possibly increase the choice of focus toward the NP rather than the VP. To what extent this animacy effect influence the resolution process of focus ambiguity in child group left unanswered at this point, however, there is an apparent need to control the animacy of alternative sets in future studies.

Second, the reason why children preferred the NP scope reading more than the VP scope reading might be that a computation of an entity or object (that is NP contrast sets) is easier than the one of an event involving a verb phrase (that is VP contrast sets). With the help of referential contexts, children don't have to stick to a default scope reading (VP scope reading) in resolving focus ambiguity, because there is other resource available that helps them to access a different scope reading. Therefore, their preference toward the VP scope reading, which should be adopted out of contexts according to the semantic subset principle, is nullified in the presence of referential contexts. When two scope readings are possible to them alternatively, they, who have limited cognitive resources, therefore can adopt a scope reading that is not costly in computation of contrast sets. Compared to the noun, the verb-based computation can be harder for them because it requires more complicated information for the computation, such as an agent who performed an action, and an event that takes place and an object influenced by the action. For this reason, children might select the VP-based computation, being less costly than the noun itself. For that reason, thye might exhibit a strong NP-based reading scope reading.

This study confirmed that referential contexts where both NP and VP based contrast information are accessible to them, children are able to adopt an NP scope reading.

5. Conclusion

This study examined how children comprehend sentences with ambiguous focus of *only* in a preverbal position. Some previous research had suggested that adults favor the NP scope analysis while children prefer the VP scope analysis (Crain et al., 1994), while other research showed a preference for the VP scope analysis in both adults and children (Paterson et al., 2006). In this study which made use of an eye-movement-during-listening analysis, the results showed that children aged 5 to 6 were able to assign the NP scope interpretation for ambiguous sentences with *only*. Even though this finding differs from previous accounts (Crain et al., 1994; Paterson et al., 2006), it is noteworthy that children exhibited the ability to prefer the NP scope analysis over the VP scope analysis with the help of contexts. The locus of children's non-adult like way of assigning scope should be further investigated in future work.

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