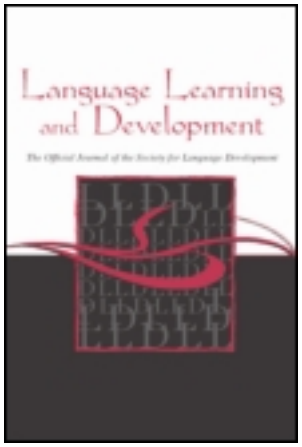

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No Fear of Commitment: Children's Incremental Interpretation in English and Japanese Wh-Questions

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Much work on child sentence processing has demonstrated that children are able to use various linguistic cues to incrementally resolve temporary syntactic ambiguities, but they fail to use syntactic or interpretability cues that arrive later in the sentence. The present study explores whether children incrementally resolve filler-gap dependencies, using Japanese and English ambiguous wh-questions of the form *Where did Lizzie tell someone that she was gonna catch butterflies?*, in which one could answer either the telling location (main clause interpretation) or the butterfly–catching location (embedded clause interpretation). Three story-based experiments demonstrate two novel findings on children's incremental interpretation of filler-gap dependencies. First, we observe that English-speaking adults and children generally prefer the main clause interpretation, whereas Japanese adults and children both prefer the embedded clause interpretation. As the linear order of main clause and embedded clause predicates differs between English (main first, embedded second) and Japanese (embedded first, main second), the results indicate that adults and children actively associate the wh-phrase with the first predicate in the sentence. Second, Japanese children were unable to inhibit their embedded clause interpretation bias when the sentence was manipulated to syntactically block such analyses. The failure to inhibit the preferred interpretation suggests that the wh-phrase was incrementally associated with the embedded clause. On the other hand, when the sentence was manipulated to semantically block a plausible interpretation for the embedded clause wh-association, children were able to overcome their strong embedded clause interpretation bias and favored the main clause interpretation. These findings suggest that syntactic and interpretability cues may have distinct impacts on children's sentence comprehension processes.

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INTRODUCTION

How do children parse strings of words and assign interpretations to them? The substantial evidence for children's early grammatical sophistication (e.g., Crain, 1991; Guasti, 2002) may lead one to think that this is a straightforward question; children must be able to parse sentences as do adults. However, a growing body of work on the development of sentence processing mechanisms has found that children show striking non-adult-like behaviors despite the early development of linguistic knowledge. Children's immature sentence comprehension mechanisms raise important questions for developmental research. First, it is unclear how children's parsing mechanisms develop into adult-like systems, given that children cannot directly inspect adults' minds to observe how they parse sentences. Second, the development of sentence processing mechanisms could affect the process of language development as well. Children must be able to assign correct structures to the sentences they hear in order to acquire target-like linguistic knowledge; if they are unable to successfully parse the input due to its linguistic complexity or cognitive limitations, then this could significantly impact the course of language development. In this sense, understanding the constraints on children's parsing success and failures is critical for understanding how linguistic development happens (Fodor, 1998; Omaki, 2010; Trueswell & Gleitman, 2007; Valian, 1990; for a review, see Omaki & Lidz, manuscript submitted).

This paper presents a cross-linguistic exploration of children's incremental sentence interpretation and (in)sensitivity to syntactic and interpretability cues for resolution of filler-gap dependencies. Specifically, we report how adults and children comprehend ambiguous wh-questions in English and compare these findings to their Japanese counterparts, where the linear order of verbs and their associates is the opposite of English. Based on this cross-linguistic comparison, we present two pieces of evidence for children's active interpretation of filler-gap dependencies. First, we demonstrate that children show a strong bias to associate the fronted wh-phrase with the first verb that they encounter, independent of the canonical word order of the language. Second, we show that children fail to respond to syntactic cues that should block this first verb association of the wh-phrase, which provides further evidence for incremental resolution of filler-gap dependencies.

CHILDREN'S INTERPRETIVE BIASES AND NON-ADULT-LIKE COMPREHENSION BEHAVIORS

Sentence processing mechanisms must assign a correct structural representation to the input despite the pervasiveness of ambiguities in natural language (Altmann, 1998; Kimball, 1973). For example, sentences such as (1) illustrate an example of temporary structural ambiguity: when listeners hear the sentence up to the first prepositional phrase (PP) *on the towel,* this PP can serve either as a modifier of the noun phrase (NP) *the apple* that specifies its location, or as a verb phrase (VP) argument specifying the destination for the apple-moving event.

(1) Put the apple on the towel in the box.

It may seem plausible for the parser to wait on deciding how to interpret the ambiguous PP until disambiguating information arrives later in the sentence. For example, if this sentence is presented with an array of objects, such as an apple on a towel, an empty towel, a pencil on a

plate, and an empty box, then the meaning of (1) becomes clear: the final PP *in the box* must refer to the destination, and *on the towel* must be a modifier of the NP *the apple*. However, an eye-tracking experiment by Tanenhaus, Spivey-Knowlton, Eberhard, and Sedivy (1995) showed that adult listeners do not wait for later information in sentences such as (1) but rather incrementally interpret them by integrating multiple sources of information. In a 1-referent context with only one apple in the scene, adult participants initially looked toward the empty towel as soon as the first PP *on the towel* was presented. This suggests that the PP was immediately analyzed as a destination PP. However, in a 2-referent context, in which one apple was on a towel and another apple was on a napkin, it was pragmatically more likely that the definite NP *the apple* would be followed by a modifier (Crain & Steedman, 1985). In this condition the PP *on the towel* led adults to fixate on the towel with an apple rather than on the empty towel, suggesting that they immediately analyzed the first PP *on the towel* as an NP modifier (though see Novick, Thompson-Schill, & Trueswell, 2008). These findings corroborate earlier observations that adult listeners make PP attachment decisions according to the verb bias (e.g., Britt, 1994; Carlson & Tanenhaus, 1988; Spivey-Knowlton & Sedivy, 1995), but that referential information and pragmatic inferences can be quickly integrated to override the verb bias and select a NP-modifier analysis (for related findings on incremental parsing, see Altmann & Kamide, 1999; Frazier & Rayner, 1982; Marslen-Wilson, 1973; Pickering, Traxler, & Crocker, 2000; Staub & Clifton, 2006; Trueswell, Tanenhaus, & Garnsey, 1994). The study by Tanenhaus and colleagues also highlights that sometimes an incrementally assigned interpretation can be wrong, as observed in the 1-referent context where participants initially interpreted *on the towel* as the destination. In other words, listeners must sometimes flexibly retract their early analyses when they are disconfirmed by subsequent information. Such revision processes could be cognitively taxing and affect comprehension success even for adults (Christianson, Hollingworth, Halliwell, & Ferreira, 2001; Ferreira & Patson, 2007; Sturt, 2007; for a review, see Fodor & Ferreira, 1998). In other words, the ability to make incremental syntactic and interpretive commitments is a double-edged sword: it incrementality allows efficient processing at the risk of incurring reanalysis costs.

Given that children are more limited than adults in both their linguistic knowledge and their processing resources, children might be less likely to make incremental processing decisions in favor of reducing the risk of sentence revision. However, it has been demonstrated that children are willing to make incremental syntactic and interpretive commitments, and that when they encounter later information that disconfirms their initial analyses, children tend to perseverate and struggle to revise them. For example, Trueswell, Sekerina, Hill, and Logrip (1999) measured the eye movement and act-out performance of adults and 4- and 5-year-olds during presentation of a garden-path sentence such as, *Put the frog on the napkin in the box,* which closely resembled (1). Whereas the adult participants showed the same behavior as in Tanenhaus and colleagues' study, the children's data diverged in interesting ways. First, the eye movement measures revealed that regardless of the number of relevant objects in the scene (1-referent vs. 2-referent), the children entertained the destination interpretation of the first PP *on the napkin*. More importantly, on more than 60% of trials the children moved the object (frog) to the location described by the first PP (napkin), despite the presence of the second PP *in the box* that signals the need for revision of the initial syntactic analysis. These findings suggest that children incrementally analyzed the ambiguous PP using the verb information that arrived early in the sentence, whereas they were less sensitive to late-arriving cues that should effectively determine the final interpretation of the sentence.

These observations led to a number of developmental psycholinguistic studies on the extent to which children are able to use various linguistic and nonlinguistic cues in incremental resolution and final (re-)interpretation of PP attachment ambiguity (e.g., Choi & Trueswell, 2010; Hurewitz, Brown-Schmidt, Thorpe, Gleitman, & Trueswell, 2000; Kidd & Bavin, 2005, 2007; Kidd, Steward, & Serratrice, 2011; Meroni & Crain, 2003; Snedeker & Trueswell, 2004; Snedeker & Yuan, 2008; Weighall, 2008; Felser, Marinis, & Clahsen, 2003; for a review, see Snedeker, 2009; Trueswell & Gleitman, 2007). The current paper extends this line of investigation to incremental processing of long-distance dependencies between distant constituents in a sentence. As explained below, this parsing problem presents a qualitatively different challenge than PP attachment ambiguity, and serves as a further empirical test of incrementality and cue sensitivity in children's sentence comprehension.

ACTIVE DEPENDENCY COMPLETION IN FILLER-GAP DEPENDENCY PROCESSING

Much work in adult sentence processing research has investigated how the parser processes so-called filler-gap dependencies in sentences such as (2) and (3).

(2) My brother wanted to know **who** Ruth will bring us home to ____ at Christmas.
(3) We like **the city** / **book** that the author *wrote* unceasingly and with great dedication about _____ while waiting for a contract.

In these sentences, the complement of a preposition (2) or a verb (3) is dislocated to the left of its canonical syntactic position, and the parser must hold such constituents (called *fillers*) in memory and relate them to their original positions (called *gaps*, with no theoretical commitment as to their representational status). Although identification of late-arriving bottom-up information (e.g., the fact that the preposition *to* lacks its complement in (2)) could allow the parser to complete filler-gap dependencies accurately, it has been widely observed that the parser attempts to complete filler-gap dependencies as soon as possible, without waiting for late-arriving information. This mechanism is known as *active dependency completion* (Crain & Fodor, 1985; Fodor, 1978; Frazier, 1987; Frazier & Flores D'Arcais, 1989). For example, Stowe (1986) observed a *filled gap effect* in (2), that is, slower reading times at the direct object position *us* in the wh-fronting condition than in a control condition that did not involve wh-fronting. This suggests that the parser had already posited the object gap before checking whether the direct object position was occupied (for related findings, see also Aoshima, Phillips, & Weinberg, 2004; Lee, 2004). Converging evidence comes from an eye-tracking experiment by Traxler and Pickering (1996), who manipulated the semantic fit between the filler and the potential verb host, as in (3). Traxler and Pickering found a *plausibility mismatch effect* at the critical verb *wrote*: the eye gaze duration at the optionally transitive verb *wrote* increased when the filler was an implausible object of the verb *(wrote the city*), compared to when the filler was a plausible object of the verb *(wrote the book*). This suggests that at the verb the parser immediately postulated a gap and analyzed the filler as the object of the verb (for related findings, see Boland, Tanenhaus, Garnsey, & Carlson, 1995; Garnsey, Tanenhaus, & Chapman, 1989; Omaki & Schulz, 2011; Phillips, 2006; Pickering & Traxler, 2003; Wagers & Phillips, 2009). There is ample time course evidence for

active dependency completion from a variety of dependent measures and across languages with different grammatical properties, suggesting that active completion of filler-gap dependencies is a robust phenomenon that presents a good testing ground for incremental interpretation (for review see Phillips & Wagers, 2007).

As this survey indicates, for adults the resolution of filler-gap dependencies and PP attachment ambiguities in sentences like *Put the frog on the napkin in the box* both involve incremental interpretation. However, it is important to note that they involve qualitatively different processes, such that children's incremental parsing of PP-attachment ambiguities may not extend to incremental resolution of filler-gap dependencies. First, PP attachment ambiguity is a case of structure selection: the parser incrementally chooses between two (or more) potential attachment positions that have already been made available (e.g., the VP containing *put the frog* or the NP *the frog*). On the other hand, filler-gap dependency resolution involves a structure building decision, as the parser incrementally decides whether to complete a dependency at a potential gap position, or whether to wait to complete the dependency at a subsequent structural position that may become available later. Second, given that having all options available before making a decision may reduce the risk of making errors, it is possible that children only make incremental commitments after relevant structural options have become available, as in PP attachment ambiguity resolution. If children were to pursue this strategy, they might avoid active dependency completion and wait to see all potential gap sites, even though filler-gap dependencies can span a very long distance (e.g., *What did John say that Bill thought that Mary bought ___ ?*). Third, filler-gap dependency processing may involve unique memory operations and associated costs. For example, it has been argued that storing the filler in memory is costly and disrupts processing until the dependency is completed (e.g., Chen, Gibson, & Wolf, 2005; Fiebach, Schlesewsky, & Friederici, 2002; Gibson, 1998; Grodner, Gibson, & Tunstall, 2002). Moreover, retrieval of the filler at the gap position could also consume extra memory resources (Gibson, 1998; Grodner & Gibson, 2005) or cause memory interference from previously encountered words with related features (e.g., Van Dyke & McElree, 2006; Van Dyke, 2007). Given these additional costs in filler-gap dependency processing, children may prefer to decrease the risk of incorrect analyses and sentence revision by simply avoiding active dependency completion.

Little work has so far investigated children's filler-gap dependency processing, but cross-modal picture priming findings from 5-year-old children have been offered as evidence that children actively complete filler-gap dependencies. For example, Love (2007) presented sentences such as *The zebra that the hippo had kissed ___ on the nose ran away*, and found that children made an alive versus nonalive decision more quickly when a picture of the filler noun (e.g., zebra) was presented at the onset of the verb, relative to trials that presented a picture of an animal that has not been mentioned in the sentence (e.g. camel; for a related study, see also Roberts, Marinis, Felser, & Clahsen, 2007). These results were taken to indicate that the head of the relative clause (*zebra*) was reactivated at the verb. However, it is important to note that reactivation does not necessarily involve an active interpretation of the filler as the theme of the verb, and moreover, the observed facilitation effect might not reflect reactivation of the filler. For example, it could be taken to indicate that a locally coherent continuation such as *the hippo had kissed the zebra* was contextually easier than *the hippo had kissed the camel* due to a previous mention of *zebra*.

The Present Study: Cross-Linguistic Investigation of wh-question Interpretation

The present study explores incrementality in children's filler-gap dependency processing by using story-based comprehension experiments and ambiguous bi-clausal wh-questions in English and Japanese, as shown in (4):[1]

(4) a. Where did Lizzie tell someone that she was gonna catch butterflies?

b. Doko-de Yukiko-chan-wa choucho-o tsukamaeru-to itteta-no?

where-at Yukiko-Dim-Top pro butterfly-Acc catch- Comp was telling-Q

"Where was Yukiko telling someone that she will catch butterflies?"

These sentences are globally ambiguous, because the fronted wh-filler *where* can be associated with one of two potential gap sites, namely, the locative adjunct position for either the main clause VP (*tell someone*) or the embedded clause VP (*catch butterflies*). Wh-fronting is generally required in English wh-questions. Japanese is known as a wh-in-situ language, because wh-phrases can generally stay in their thematic positions, but (4b) shows that the wh-phrase *doko-de* ('where-at') can also be fronted to the beginning of the sentence via scrambling, a process by which syntactic constituents can be fronted within and across clauses in Japanese (Harada, 1977; Saito, 1985). This allows us to construct closely matched sentence pairs as in (4), in which the English and Japanese sentences both begin with a wh-phrase and are followed by two clauses. Importantly, however, due to the verb-final property of Japanese, the order of the main clause and embedded clause verbs is the opposite in the two languages. In English the main clause verb (*told*) occurs before the embedded clause verb (*catch*), and in Japanese this order is reversed.

The experiments reported here use a Question-after-Story task (de Villiers, Roeper, & Vainikka, 1990; de Villiers & Roeper, 1996) to examine the interpretation of wh-questions such as (4) in English-speaking adults and children (Experiment 1) as well as Japanese-speaking adults and children (Experiments 2 and 3). None of the experiments uses a time course measure such as eye movement data, but we present two forms of interpretation evidence that support the incrementality of filler-gap dependency processing in children. The first step of the argument is based on a cross-linguistic investigation of wh-association preferences. For example, active dependency completion has been observed across many languages despite differences in the structural position of the first available gap. As discussed above, in bi-clausal sentences in Japanese such as (4) the embedded clause predicate linearly precedes the main clause predicate; in this context, reading time studies with adult Japanese speakers have shown that the parser actively associates a scrambled wh-phrase with the first verb in the sentence (Aoshima et al., 2004; Nakano, Felser, & Clahsen, 2002). Thus, if children actively complete filler-gap dependencies in (4), it is predicted that children should prefer an interpretation in which the wh-phrase is associated with the first VP in the sentence. Specifically, in Japanese they should favor an interpretation in which *where* is associated with the embedded clause VP and consider the location of the butterfly-catching event as the answer to the question, rather than the location of the telling event. In contrast, if children engage a similar active dependency completion mechanism in English, where the order of

[1] The gloss abbreviations used in Japanese examples in this paper: Acc = accusative case marker, Comp = complementizer, Dim = diminutive marker, Gen = genitive case marker, Q = question particle, Top = topic marker.

verbs is the opposite of Japanese, then we predict that English-speaking children should prefer to associate *where* with the main clause VP *tell someone*.

In addition to the cross-linguistic comparison, the present study also probes the incrementality of children's filler-gap dependency processing by presenting linguistic cues that should block the association of the wh-filler and the first VP. Recall from the discussion of Trueswell and colleagues' studies on PP-attachment ambiguities (Trueswell et al., 1999) that when children incrementally assign interpretations, they also often fail to inhibit this interpretation bias despite the availability of relevant cues. If a wh-filler is incrementally associated with the first VP in the sentence, it is predicted that children might not be able to incorporate cues that disconfirm such interpretations. This is explored in Experiment 3 by manipulating the syntactic and semantic content of the first VP in Japanese wh-questions.

We should note that de Villiers and colleagues have previously investigated children's comprehension of sentences like (4a) (de Villiers et al., 1990; de Villiers, Roeper, Bland-Stewart, & Pearson, 2008; Roeper & de Villiers, 1992). For example, a large-scale study with 703 typically developing children (age range 4–9 years) revealed that children showed an 82% preference for the embedded clause interpretation of the sentence *How did the boy say he hurt himself?* (de Villiers et al., 2008). This is a strong demonstration of an embedded clause bias, although de Villiers and colleagues did not provide an account of this preference. However, these studies tested few tokens of this type of wh-question, and the findings may have been driven by properties of the specific items used. In particular, the previous studies by de Villiers and colleagues mostly used the verb *say* without modifiers in the main clause VP. Experiment 1 of the current study explored the possibility that the previously reported embedded clause preference (de Villiers et al., 2008) may be tied to the use of this particular main clause VP. In order to test this question, we manipulated the main clause VP content by using the bare verb *say*, and the more complex predicates *tell someone* and *say to someone*. If the embedded clause interpretation bias in previous work was driven by the use of bare *say*, then we predict that different interpretive biases should arise with *tell someone* or *say to someone*.

EXPERIMENT 1: ENGLISH QUESTION-AFTER-STORY TASK WITH VERB MANIPULATION

Experiment 1 used a Question-after-Story task with English-speaking adults and children to investigate their comprehension of globally ambiguous bi-clausal wh-questions, such as (4). If they have an active dependency completion bias, we predict a main clause interpretation preference because the main clause VP provides the first available position for interpretation.

Method

Participants

We recruited 36 adult native speakers of American English from the University of Maryland community. Forty-five children aged 4;7 to 6;5 were recruited at a preschool at the University of Maryland and from surrounding communities. The age range was determined based on two

factors: a) the ability to sit patiently through the study and listen to the relatively complex stories used in our experiment and b) similarity with the age range used in previous studies on PP-attachment ambiguity (e.g., Trueswell et al., 1999) and filler-gap dependency processing (e.g., Love, 2007), such that children's behaviors in the current study could be readily compared to the previous findings. Data from nine children were excluded due to fussiness (n=2) or providing more than two incorrect or irrelevant answers for the filler questions (n=7), and the remaining 36 children were included in the final sample (mean age; 5;5). The adult participants were given course credit or $10 for their participation in a one-hour experiment session that included other experiments unrelated to the present study.

Materials

Story design

The same eight stories were used in all three experiments reported in this paper, so we elaborate on the details of the story design here. The story stimuli were cartoon movies made from a sequence of clipart image animations, and these movies incorporated features used in an earlier visual world eye-tracking study (Sussman & Sedivy, 2003), so that the same stimuli could also be used in future eye-tracking studies. Each story display contained similar-sized images of four locations that were familiar to children (e.g., a playground). A sample story and a target question is given in (5) (see below for details of the question design), and a sample sequence of events in the visual display is shown in Figure 1.

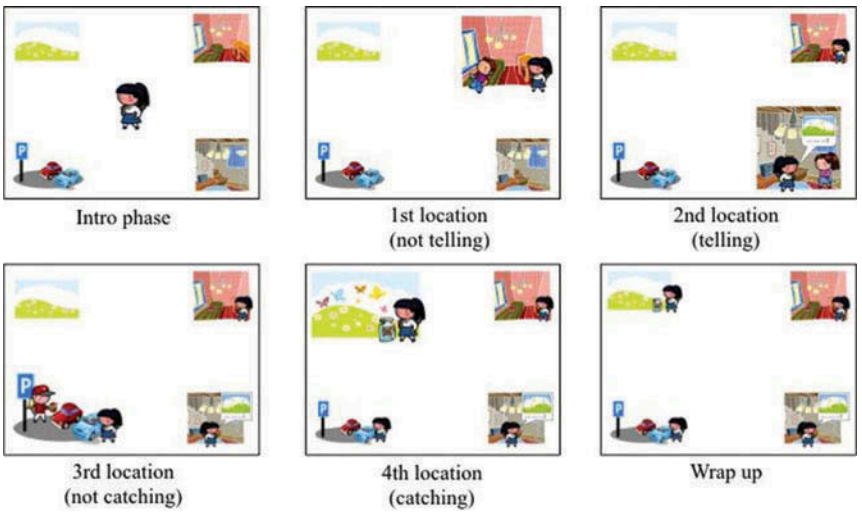

FIGURE 1 A sample sequence from the scenes used to accompany the stories in Experiments 1–3. (Color figure available online.)

(5) **[Introductory phase]** It was a beautiful day in spring so Lizzie decided she was going to go catch some butterflies in the park.

[1st location] Her Mom and Dad weren't home, so Lizzie thought she should tell her brother or sister about going to the park, so that Mom and Dad would know where she was when they got back. She first went to her brother's room, but he was taking a nap and she couldn't tell him about catching butterflies.

[2nd location] Instead, Lizzie looked for her sister. She looked all over the house but didn't see her sister anywhere! When she was about to give up, Lizzie heard her sister's voice in the basement! She went to the basement and said to her sister: "I'm gonna catch butterflies in the park!"

[3rd location] Then, on her way to the park, Lizzie passed by a parking lot and saw a butterfly near it! She walked slowly towards the butterfly, but before Lizzie could get there, another girl came along and caught the butterfly! Lizzie didn't see any more butterflies there, so she kept walking towards the park.

[4th location] There were lots and lots of butterflies in the park, and she caught one in a jar and took it home with her. She liked the one that she caught, but she wished she could have caught more butterflies.

[Question] Where did Lizzie tell someone that she was gonna catch butterflies?

In each story, a main character visited the four locations, and during the character's visit, the relevant location was magnified so that the event that happened in that location was clearly visible to participants. The stories consisted of six phases. In the introduction phase the main character appeared in the center of the display and the theme of the story was introduced. In the next four phases the main character visited each location and encountered a mix of failure and success in achieving the intended activities. After the story ended, the fourth location shrank to its original size (wrap-up phase) and the target question was presented.

The first two locations and the last two locations were relevant for either the main clause event or the embedded clause event. In the first location, the relevant event almost occurred but eventually failed; it was only in the second location that the relevant event actually occurred. For example, in the sample story Lizzie almost talked to her brother first but failed in the first location, and in the second location Lizzie was able to talk to her sister. This feature was introduced to make the location-event paring for each target event more memorable for children. Moreover, having two relevant locations for each event also makes the *where* questions more felicitous. In order to further help children to remember what happened in each location, we also left visual traces of events. In the locations in which the intended activity successfully occurred, the visual trace of that event remained on the display (e.g., the butterfly in the jar, or the speech bubble with an image of the park in Figure 1), but in the "failed attempt" locations, only the image of the character remained.

In order to control for possible event recency bias in participants' answers (i.e., they might only provide an answer that related to the last event in the story), in half of the stories the first pair of locations described the embedded clause event, and in the other half the first pair described the main clause event. In either sequence, the first set of events provided an important motivation for the next set of events. For example, in the story in (5) above, the telling events were motivated by Lizzie's need to tell her family member where she was going.

The quadrants in the display where relevant events occurred were randomized across stories to prevent participants from predicting which quadrant would correspond to which type of event.

The list of story scripts and questions used in Experiments 1 through 3 can be found on the first author's webpage (http://mind.cog.jhu.edu/∼lpad/papers.html).

Question design. For each of the 8 stories, we constructed bi-clausal wh-questions with *where* as shown in (6).

(6) Where did Lizzie {say | tell someone | say to someone} that she was gonna catch butterflies?

This construction is globally ambiguous and allows two possible interpretations, one in which *where* is associated with the main clause VP, and one in which it is associated with the embedded clause VP. All target sentences contained the overt complementizer *that*, as our pilot work with adult English speakers showed that the presence of an overt complementizer is critical for making main clause and embedded clause interpretations equally accessible. We manipulated the VP content (*say, tell someone, say to someone*) as a between-participants factor instead of a within-participants factor, so as to avoid any potential priming effects from one verb type to another. There were 12 children in each verb condition, and the resulting mean age range for each VP condition was 5;4 for *say*, 5;7 for *tell someone*, and 5;3 for *say to someone*. There was no reliable difference in mean age across the three conditions ($F < 1$).

For each of the eight stories, we also constructed unambiguous filler wh-questions using *why.* Fillers were designed such that they could be used for the same set of stories as the target sentences. We chose *why* questions because these questions were slightly more challenging than *where* questions, since in the latter case there were visual cues on the display that participants could use to find where certain events occurred, whereas there were no direct visual cues that would help participants remember why certain events occurred or failed to occur in the story. In order to balance the type of locations that were asked about, all *why* questions targeted locations that were not questioned in the *where* questions (e.g., the filler question for the story illustrated in Figure 1 was "why couldn't Lizzie catch the butterfly in the parking lot?").

The target and filler questions were distributed across two lists, such that half of the participants saw items 1 to 4 in the target *where* question form and items 5 to 8 as filler *why* questions, and the other half of the participants saw items 5 to 8 in target question form and items 1 to 4 in filler question form. Each list had two versions with a different order of stories, but in each version the target question trials were interspersed with filler question trials.

Procedure

Children were told that they were going to play a quiz game with a puppet, and that they were going to watch cartoon movies and hear a question after each story. They first saw two short practice trials to make sure they understood the task, and then saw four target and four filler trial movies. The stories were presented through a speaker attached to the computer. An experimenter presented the movies using digital media player software, and the movie presentation was paused at the end of each story, at which point the experimenter asked a question using the puppet and noted the answer. The experimenter was trained to produce the questions with a neutral prosody that would not bias the hearers to one interpretation or the other. During the story phase the experimenter provided brief comments on the events happening in each location to make the task more interactive and to help maintain children's attention. The comments were made in each

location so as to balance the degree of saliency across the four locations. After a child answered a question, a brief positive feedback movie was played on the computer to encourage children to keep paying attention. The experiment took approximately 20 minutes.

For adult participants, an experimenter explained the task using one practice trial, and the rest of the experiment was automated in a single movie file. For adult participants, the experimenter stayed outside the testing room during the experiment. In this version, the computer presented a question auditorily after each story, and after listening to the question participants had six seconds to write down the answer in a short phrase (e.g., (at the) park) on an answer sheet. With this procedure, the experiment took approximately 15 minutes.

Data Coding

The off-line responses were classified as a) main clause interpretation, b) embedded clause interpretation, and c) others, including failures to provide an answer or providing answers that corresponded to neither the correct main clause or embedded clause locations. For the main clause and embedded clause interpretations, answers varied in form from simply providing the name of the location or the PP (e.g., (at the) park) to answering the question with a clause (e.g., she caught the butterfly at the park). All of these responses were collapsed together as either main or embedded clause answers. Pointing occurred rarely, but whenever children answered by pointing the experimenter encouraged them to answer the same question verbally.

The dependent measure was the proportion of main clause responses, for example, answering '(in the) basement' to the example scenario in (5). Generally, we observed few responses of the "others" category, and there was no systematic pattern among the participants who produced such responses. We thus excluded those trials as outliers before calculating the proportion of main clause responses. In Experiment 1, each verb condition had two lists of items such that each story could be used with target or filler questions, but the data from the two lists were collapsed in the analyses, as there was no significant difference across two lists of stimuli ($F < 1$).

Results

Responses in the target and filler items that belonged to the "others" category accounted for 8.0% of responses for children and 2.1% for adults. These trials were removed from further analyses. The proportion of main clause responses for all conditions is summarized in Figure 2.

Overall, children provided more main clause responses than adults, but children and adults showed the same general pattern of responses in each VP condition. In the *say* condition, children and adults produced few main clause answers (children: 24%; adults: 0%), but both groups preferred the main clause interpretation in the *tell someone* and *say to someone* condition (children: 86% for *tell someone*, 81% for *say to someone*; adults: 63% for *tell someone*, 71% for *say to someone*). To assess the reliability of this pattern, the mean proportion of main clause responses were submitted to an ANOVA with age group (children vs. adults) and verb type (*say* vs. *tell someone* vs. *say to someone*) as between-participants factors. We found that there was a main effect of age, $F(1, 66) = 6.12$, $p < .05$, as well as a main effect of verb type $F(2, 66) = 29.58$, $p < .001$, but there was no significant interaction of the two factors, $F < 1$. The main effect of age resulted from a slightly stronger main clause preference across the three conditions in children,

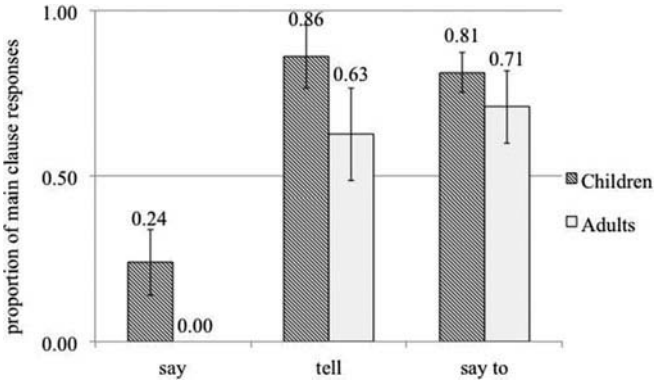

FIGURE 2 Mean proportion of main clause esponses in Experiment 1. Error bars indicate standard errors of the mean.

but the lack of interaction suggests that children and adults are alike in having similar interpretive biases across the different verb conditions.

Discussion

The results from Experiment 1 demonstrate that children and adults show very similar preferences in interpreting ambiguous wh-questions. Previous work by de Villiers and colleagues did not include adult participants, and this is therefore the first demonstration of children's adult-like interpretative preference in answering ambiguous bi-clausal wh-questions. Our results from the bare *say* condition showed the same pattern as the child data from de Villiers and colleagues (de Villiers et al., 2008) in that both adults and children preferred the embedded clause interpretation. However, we also found that when the main clause VP was changed to *tell someone* or *say to someone,* adults and children alike preferred the main clause interpretation.

Further support for a main clause preference comes from a Truth Value Judgment experiment with English-speaking adults reported in Omaki (2010). The experiment used the same story materials as Experiment 1 but replaced the questions with declarative sentences with a similar filler-gap dependency, for example, *The place where Lizzie said to someone that she was gonna catch a butterfly was the basement/park*. The ambiguity was identical to the one used in the present study, but the declarative sentence frame forced participants to judge the truth of either the main clause or embedded clause interpretation. Here, adult participants accepted the main clause interpretation (park) as true 100% of the time, while they accepted the embedded clause interpretation (basement) only 19% of the time. This strong judgment bias for the main clause interpretation is consistent with the main clause interpretation preference observed in the present experiment, and the rejection of the embedded clause interpretation highlights the robustness of main clause wh-association preference. (For a similar use of the TVJT method to examine parsing mechanisms, see Crain, Ni, & Conway, 1994; Viau, Lidz, & Musolino, 2010.)

These results have two implications for the filler-gap dependency resolution mechanism in adults and children. First, wh-interpretation decisions are strongly influenced by properties of the first VP in the sentence. Second, the main clause interpretation seems to be more broadly preferred, since the embedded clause interpretation preference was restricted to the bare *say* condition. This suggests that wh-association to the first VP in the sentence is preferred over association to the second VP. This may reflect active completion of filler-gap dependencies, although the present data alone do not provide decisive evidence that the main clause interpretation was assigned incrementally (see below).

The exceptional embedded clause interpretation bias in the bare *say* condition raises the question of what makes that condition different from the other two VP conditions. We tentatively suggest that the embedded clause interpretation preference in the bare *say* condition may result from the fact that the English verb *say* can be used as an evidential marker, especially when it appears without modifiers (Aikhenvald, 2006; Simons, 2007). If the verb *say* is treated as an evidential marker, the main clause would only serve as a description of the source of information (as in *According to Emily, where did she hurt herself?*), and not as a description of an event that contains a verbal report. In other words, under the evidential marker analysis of *say*, the main clause is treated like a parenthetical clause and hence it is no longer felicitous to ask about the location of the saying event (for evidence that children often adopt parenthetical analyses in similar bi-clausal sentences with *think*, see Lewis, Hacquard & Lidz, 2012). Under this view, the main clause interpretation is preferred in the *say to someone* condition because the addition of the recipient modifier *to someone* highlights the presence of a speech event and blocks the evidential interpretation. This explanation predicts a main clause preference with a bare *say* in wh-fronting languages that have an English word order and an evidential marker. We leave this question open for future research.

One may object that the main clause interpretation preference in the *tell someone* and *say to someone* conditions might reflect pragmatic biases that are derived from the choice of the sentence form. If the speaker had intended to ask for the location of the embedded clause event, then the speaker could have just asked a mono-clausal question (*Where was Lizzie gonna catch butterflies*?). Therefore, the fact that the bi-clausal sentence was used might suggest that the speaker wanted to gather information about the event described by the main clause predicate. However, the contrast between the bare *say* condition and the *tell someone* or *say to someone* conditions casts doubt on this explanation, because this account predicts that bi-clausal questions should always engender a main clause interpretation preference. The Japanese study reported in Experiment 2 can also be used to test this alternative account. If the main clause preference seen in English reflects active dependency completion, then we predict the opposite preference in Japanese, since the first VP in Japanese is the embedded clause VP. If it instead reflects a pragmatic bias, then we predict an identical main clause preference in Japanese.

EXPERIMENT 2: JAPANESE QUESTION-AFTER-STORY STUDY WITH AMBIGUOUS SENTENCES

This experiment examined Japanese children's interpretation preference in Japanese versions of the English stimuli used in Experiment 1.

Method

Participants

We recruited 16 adult native speakers of Japanese from the Hiroshima University community in Japan. Fourteen children who were between the ages of 4;9 and 6;4 and acquiring Japanese as their native language also participated in the study. The children were recruited at Ibaraki University kindergarten and Mito kindergarten in Mito, Japan. Two children were excluded due to providing more than two incorrect or irrelevant answers, and the remaining 12 children were included in the final sample (mean age: 5;9). The adult participants were paid 1000 yen for their participation in a one-hour experiment session that consisted of the present study and other unrelated experiments.

Materials and Procedure

The stories, target questions and filler questions in Experiment 1 were translated into Japanese sentences like (7), while ensuring that the resulting materials contained words and expressions that are familiar to Japanese children.

(7) Doko-de Yukiko-chan-wa [*pro* choucho-o tsukameru to] itteta-no?

where-at Yukiko-Dim-Top she butterfly-Acc catch Comp was telling-Q

"Where was Yukiko telling someone that she will catch butterflies?"

This example is translated from the English example (6) in Experiment 1, and here the wh-phrase *doko-de* ('where at') is scrambled to the beginning of the sentence. In all items, the pronominal subject in the embedded clause was replaced by a null pronoun. Some sentences were slightly modified to adjust for lexical and grammatical differences between English and Japanese. For example, the main clause recipient *someone* was not overtly mentioned in (7) because the most natural translation in an argument-drop language like Japanese is to keep such indeterminate expressions implicit.[2] Note also that the Japanese main clause verb *itteta* ('was telling') cannot be used as an evidential marker in Japanese, because there is a distinct evidential morpheme in Japanese (e.g., *rashii, -yooda, -sooda;* Aoki, 1986). Typologically, there is a complementary distribution between languages that use a lexical strategy of evidential marking (e.g., English) and languages that use a distinct verbal morpheme for evidential marking as in Japanese (Aikhenvald, 2006). Note that the main clause predicate was presented in the past progressive form *itteta* (was telling) rather than the regular past tense form *itta* (told) in order to avoid confusion with the homophonous embedded clause verb *itta* (went). It is important to note, however, that the aspectual choice does not affect interpretive preferences in (7).

[2] We also note that the Japanese counterpart of *someone* (i.e. *dare-ka*) carries the additional requirement that the speaker is uncertain about the identity of the referent in context. For example, in English one could naturally say "I'm going to meet someone at five" when the speaker knows exactly who he is meeting, whereas the Japanese version of that utterance would be completely infelicitous in this context. Thus, using *dare-ka* in our task would be inappropriate, because it is quite obvious from the screen who was involved in the speech event.

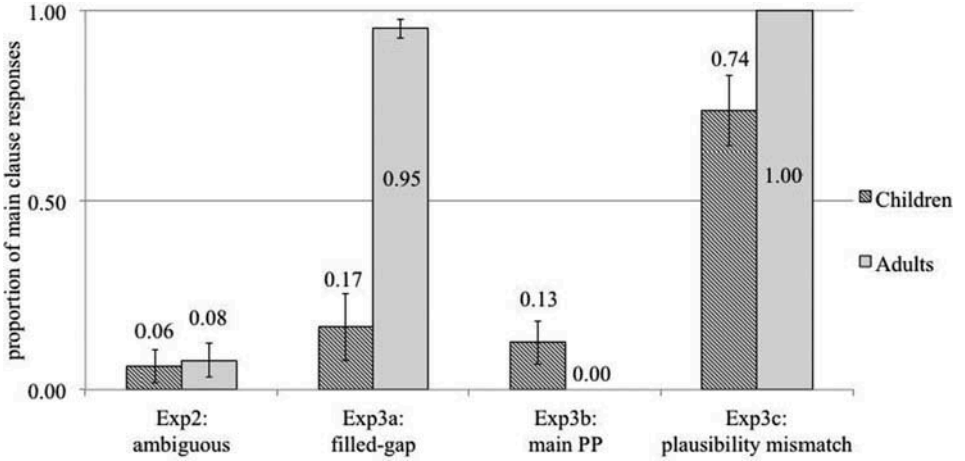

FIGURE 3 Mean proportion of main clause responses in the Japanese Question-after-Story experiments (Experiments 2 and 3a–c). The error bars indicate standard errors of the mean.

These items were distributed across two lists in the same manner described in Experiment 1. The experiment and data coding procedures were identical to those of Experiment 1, and the experiment took approximately 15 minutes for adults and 20 minutes for children.

Results

Responses in the target and filler items that belonged to the "others" category comprised 5.2% of trials for children, and these trials were removed from further analyses. Adults provided either main clause or embedded clause interpretation responses only. The mean proportion of main clause answers is shown in Figure 3. Children showed a clear embedded clause preference (mean = 6%, $SE = 4$), as did adults (mean = 8%, $SE = 4$). An ANOVA with age (child vs. adult) as a between-participants factor revealed no reliable difference between the two groups, $F < 1$.

Discussion

The results of Experiment 2 demonstrate that Japanese adults and children preferred the embedded clause interpretation of the ambiguous sentences, in stark contrast to the English-speaking adults and children in Experiment 1. Given that this experiment used the same story stimuli as Experiment 1, the results indicate that the interpretive biases observed in the Japanese or English Question-after-Story experiments are unlikely to be due to properties of the story design. Moreover, the embedded clause interpretation preference in Japanese cannot be due to the evidential use of the main clause predicate, because Japanese has an evidential marker that is morphologically distinct from the main clause predicate *itteta* ('was telling') that we used in our stimuli. These results are compatible with findings from online sentence processing studies

with Japanese adults (Aoshima et al., 2004; Nakano et al., 2002), which showed time course evidence for a bias to associate a fronted wh-phrase with an embedded clause predicate. The fact that the preferred interpretation corresponds to the initial structural analysis suggests that our off-line interpretation measure reflects what happens in the real-time parsing of the sentences. Taken together, the present findings suggest that the Japanese child and adult sentence processing mechanisms actively associate the fronted wh-adjunct with the first VP in the sentence and incrementally assign the embedded clause interpretation.

It is important to note, however, that the present study provides no time course evidence that the first VP association occurs incrementally as soon as the first VP is encountered. The data are compatible with a non-incremental mechanism that waits until seeing all the VPs in the sentence and choosing the first VP for wh-association. Experiment 3 aims to tease apart the predictions of these hypotheses.

There is also an alternative explanation for the robust embedded clause preference. Recall that our target sentence (7) included a null subject *pro* in the embedded clause subject position. This null subject in Japanese is the closest counterpart to the overt pronoun that served as the subject of the embedded clause in the English target sentences. It was necessary to use a null subject pronoun to make the Japanese stimuli natural while keeping the content of the target items constant across English and Japanese. However, if the embedded subject is silent, there is no overt signal to indicate the presence of an embedded clause until the overt complementizer *-to* is encountered. This raises the possibility that the listeners may have mistakenly analyzed the target sentence as mono-clausal ('Where did Yukiko catch butterflies?') and effectively ignored the main clause VP. This is unlikely to be the cause of adults' embedded clause bias: our pilot work with Japanese adults also presented bi-clausal sentences with two distinct overt (non-pronominal) subjects, and in this case participants still demonstrated an embedded clause interpretation preference. However, children may have ignored the main clause predicate for exactly this reason. We return to this point below in Experiment 3.

EXPERIMENT 3: JAPANESE QUESTION-AFTER-STORY STUDY WITH CUE MANIPULATION

The results from Experiments 1 and 2 showed that adults and children preferentially resolve filler-gap dependencies by associating the wh-phrase to the first VP in the sentence, regardless of the canonical word order of the language. However, the off-line interpretation evidence for first-VP association does not prove that the association was incrementally formed upon encountering the first VP. Experiment 3 provides a further empirical test of active completion of filler-gap dependencies by exploring Japanese adults' and children's sensitivity to various cues that should attenuate the first-VP association bias. Developmental psycholinguistic studies have shown that children often fail to incorporate cues that are incompatible with incrementally assigned interpretations. For example, Trueswell and colleagues (1999) found that in comprehension of *Put the frog on the napkin in the box,* children's final interpretation of the sentence still indicated that *napkin* was interpreted as the destination, despite the fact that the presence of another PP *in the box* disconfirms this interpretation. Extending this logic to the wh-questions in our current study, if children incrementally associate the wh-filler to the first VP, then children (unlike adults) might fail to incorporate cues that block this association. On the other hand, if the first-VP

bias in Experiments 1 and 2 arises because children wait until the second VP and then select the first VP for wh-association, then we expect different outcomes once additional cues are introduced to block the first VP association. In that case children should favor the second VP association because they make their interpretation decision at a point when the second VP is the only interpretation that is grammatically compatible with the input.

Much evidence for active dependency completion in adult sentence processing comes from measures of processing difficulties upon encountering cues that disconfirm the first VP association. The present study adopts the two most widely used cues in research on filler-gap dependency processing. The first is a syntactic cue provided by a so-called *filled-gap* (Crain & Fodor, 1985; Stowe, 1986). In filled-gap sentences the first potential gap position turns out to be an unavailable gap position as it is actually filled by an overt phrase (*What did John eat **the cake** with __?*). The second cue is an interpretability cue. In this case the semantic or pragmatic fit between the filler and the first verb of the sentence is manipulated to be incompatible (*The **city** that the author **wrote**. . .*, as opposed to *the **book** that the author **wrote**. . .*), such that the association of the filler and the verb yields no plausible interpretation. Either type of cue effectively forces the filler to be integrated in a later part of the sentence. Here we verify the effectiveness of these cues in Japanese using adult interpretation data.

Three conditions were created by modifying the target sentences used in Experiment 2. The first condition contained an overt PP headed by *-de* ('at') that specified the location of the embedded clause event, thereby syntactically blocking the embedded clause interpretation. The second condition contained an overt locative PP that specified the location of the main clause event. This condition was included as a control for the first condition to ensure that children would not just provide an answer that corresponded to the overtly mentioned location in the sentence. The third condition manipulated the interpretability of the wh-phrase in the embedded clause by using an embedded clause predicate that did not yield a plausible interpretation for wh-association in the embedded clause. An example sentence for each condition is shown in (8).

(8) a. filled-gap condition

Doko-de Yukiko-chan-wa [*pro* kouen-de choucho-o tsukameru to] itteta-no?

where-at Yukiko-Dim-Top she park-at butterfly-Acc catch Comp was telling-Q

"Where was Yukiko telling someone that she would catch a butterfly at the park?"

b. main clause PP condition

Doko-de Yukiko-chan-wa [*pro* choucho-o tsukameru to] monooki-de itteta-no?

where-at Yukiko-Dim-Top she butterfly-Acc catch Comp storage-at was telling-Q

"Where was Yukiko telling someone at a storage space that she would catch a butterfly?"

c. plausibility mismatch condition

Doko-de Yukiko-chan-wa [*pro* kouen-ni iku to] itteta-no?

where-at Yukiko-Dim-Top she park-to go Comp was telling-Q

"Where was Yukiko telling someone that she would go to the park?"

The filled-gap condition was designed to test the effectiveness of a syntactic cue. This condition was created by taking the ambiguous wh-question used in Experiment 2, and adding an overt PP headed by the postposition *-de* ('at') that specified the location of the embedded clause event (e.g., *at the park*). In other words, the overt PP corresponded to the embedded clause response in the ambiguous wh-questions used in Experiment 2. The fronted wh-adjunct *doko-de* ('where-at') was also headed by the locative postposition *-de*, but because the locative PP position for the embedded clause VP was occupied by an overt PP, attachment of the wh-phrase to the embedded clause predicate was syntactically blocked. Thus, the only grammatically possible interpretation should be the main clause interpretation. If children are able to use the syntactic cue to inhibit their bias for an embedded clause interpretation, then they are predicted to only allow the main clause interpretation in this condition. On the other hand, if children are unable to use the syntactic cue, then they are predicted to give an embedded clause answer (e.g., *at the park*) despite the fact that it was overtly mentioned in the sentence.

It is possible, in principle, to attach *where* to the embedded clause VP in sentences such as the filled-gap condition (8a) if there is appropriate contextual information that meets the following three conditions. First, a larger environment that contains the target location (e.g., park) needs to be specified in the story, such that a part-whole relationship for the target location is made clear (e.g., a park in Baltimore). Second, there needs to be another large environment that contains a counterpart of the target location (e.g., a park in College Park), such that the two larger environments can be contrasted (e.g., butterfly-catching happened at the park in Baltimore, but not at the park in College Park). Third, the protagonist must explicitly mention the target location as well as the larger environment ("I will catch a butterfly at the park in Baltimore!"). However, none of these three conditions was met in our story design: each location was described as an independent location without specifying a larger environment; the target location (park) appeared only once in the story; and the protagonist never mentioned a larger environment that contained the target location. Moreover, even if these felicity conditions were met, in Japanese it would be more natural to use *where* with a genitive marker *-no* that directly selects the target locative PP (e.g., *doko-no kouen-de,* which roughly translates as "at which park"). It is thus pragmatically infelicitous to attach *where* to the embedded clause VP, and this is why the overt locative PP in the embedded clause can be considered as an effective filled-gap cue for inhibiting wh-association to the first VP.

The main clause PP condition (8b) was included to examine whether the mere presence of *-de* marked PPs causes children to provide a non-adult-like response. In the filled-gap condition in (8a) children could plausibly exhibit a non-adult-like behavior and provide an embedded clause response, corresponding to the locative PP overtly mentioned in the embedded clause. When this form of non-adult-like response is observed, however, it could reflect a task-induced strategy to treat overtly mentioned locative PPs as the relevant answer to *where* questions. The main clause PP condition (8b), in which the location of the main clause event was overtly expressed with a locative PP (e.g., in the storage space), allowed us to address this concern. If children used this strategy and treated the overtly mentioned locative PP as the answer to *where* questions, we expected that they would answer the main clause event location which was overtly mentioned. However, if embedded clause answers in (8a) reflected children's inability to revise the active wh-association to the embedded clause VP, then we expected to see an embedded clause response for (8b) as well.

The plausibility mismatch condition (8c) was designed to test the effectiveness of an interpretability cue. It was constructed by changing the embedded clause predicate of the original

ambiguous sentences in Experiment 2 in such a way that no plausible interpretation would be available if the wh-phrase was associated with the embedded clause VP. In (8c), for example, associating the wh-phrase to the embedded clause VP would essentially constitute a question like "Where did Yukiko go to the park?" This question could receive a plausible interpretation if the context specified two larger locations in which a park-visiting event could happen (e.g., going to a park in Baltimore vs. College Park). However, given the absence of such information in our stories, the embedded clause association was simply impossible. The eight predicates that we used in this condition included change-of-location verbs (*iku/itta* "go/went" × 5, *ochita* "fell" × 1), a change-of-state verb (*naru* "become" × 1), and an individual-level predicate (*oishikatta* "was yummy" × 1). The change-of-state verb and individual-level predicate were presented together with a theme argument NP. The change-of-location verbs were presented with a PP argument that described the origin or the end point of the change-of-location event (e.g., falling off a tree, going to a park). This was not expected to syntactically block the attachment of the wh-adjunct as it occupied a different structural position. In this condition, if children were able to recognize the interpretability cue to inhibit the embedded clause association, then a preference for the main clause interpretation was predicted. If children were unable to use the interpretability cue, then based on observations by Choi and Trueswell (2010), we predicted that children should coerce non-adult-like interpretations and answer with the location that was related to the embedded clause VP (e.g., the park in (8c)).

Method

Participants

Forty-eight children aged 4;6 to 6;5 learning Japanese as their first language participated in the study. The children were recruited at Ibaraki University kindergarten and Mito kindergarten in Mito, Japan. Six children were excluded as they did not complete all the trials, and another six children were excluded due to providing more than two incorrect or irrelevant answers. The remaining 36 children were included in the final sample (mean age: 5;9).

We recruited 34 adult native speakers of Japanese from Hiroshima University and Tsuda College in Japan. The participants at Hiroshima University were paid 1,000 yen for their participation in a one-hour experiment session with other unrelated experiments. The participants at Tsuda College participated in the experiment for course credit.

Materials and Procedure

Eight sentence sets with three conditions were constructed as shown in (8). We treated each condition as a between-participants factor, and consequently 12 children were randomly assigned to each condition. The resulting mean age range for the three conditions was 5;7 for the filled-gap condition, 5;8 for the main clause PP condition, and 5;11 for the predicate mismatch condition, respectively, and there was no reliable difference in age across groups, $F(2, 33) = 1.70$, $p > .1$. Sixteen adults were assigned to the filled-gap condition, eight adults were assigned to the main clause PP condition, and 10 adults participated in the predicate mismatch condition. For each condition the target items were distributed across two lists as described in Experiment 1,

which resulted in six lists. The experiment and data coding procedures were identical to those of Experiments 1 and 2, except that for adults who participated in the main clause PP condition and the predicate mismatch condition, the target sentences were presented in writing rather than auditorily due to constraints on the testing venue. The experiment took approximately 20 minutes for children and 15 minutes for adults.

Results

Responses to the target and filler items that were neither main clause nor embedded clause interpretations were 4.2% for children and 2.3% for adults in the filled-gap condition, 2.1% for children and 1.3% for adults in the main clause PP condition, and 10.4% for children and 6.3% for adults in the predicate mismatch condition. These trials were removed from further analyses. The mean proportion of main clause responses for each condition is shown in Figure 3.

In the filled-gap condition (8a) we found a clear contrast between children and adults, as children demonstrated a preference for the non-adult-like embedded clause response (main clause response 17%, $SE = 9$), whereas adults strongly preferred the main clause response (95%, $SE = 3$) as expected. In the main clause PP condition (8b), as in Experiment 2, children and adults showed a clear preference for the embedded clause interpretation (children's main clause response 13%, $SE = 6$; adults' main clause response 0%). In the plausibility mismatch condition (8c), in contrast to the filled-gap condition, children and adults were alike in showing a preference for the main clause interpretation (children's main clause response 74%, $SE = 9$; adults' main clause response 100%).

The mean proportion of main clause responses was submitted to an ANOVA with age group (children vs. adults) and structure type (filled-gap vs. main clause PP vs. plausibility mismatch) as between-participants factors. There was a main effect of age group ($F = 64.7$, $p < .001$), a main effect of structure type ($F = 71.2$, $p < .001$), and a significant interaction of age group and structure type ($F = 28.0$, $p < .001$). Planned comparisons were conducted to explore the structure type effect within each age group. Adults' data showed the expected pattern: the filled-gap and plausibility mismatch conditions both showed extremely high main clause response rates (filled-gap 95% vs. plausibility mismatch 100%), and these two conditions did not show a reliable difference ($t < 1.86$, $p = .082$). The main clause PP condition yielded no main clause responses and clearly diverged from the other two conditions. For children, the plausibility mismatch condition showed a significantly larger proportion of main clause responses than the filled-gap condition (74% vs. 17%: vs. $t = 4.43$, $p < .001$) or the main clause PP condition (74% vs. 13%: $t = 5.60$, $p < .001$), and the filled-gap and main clause PP conditions did not reveal a reliable difference (17% vs. 13%: $t = .40$, $p = .70$). In summary, the distribution of main clause preferences differed between adults and children: Adults showed a strong main clause preference in the filled-gap and plausibility mismatch conditions, whereas children showed a main clause preference only in the plausibility mismatch condition.[3]

[3] A reviewer raised the concern that the child-adult difference in the filled-gap condition may be partly due to the difference in the methodology: it might be easier to point to the filled-gap location and indicate it as an answer in the interactive procedure used with children, whereas adults in this experiment had to write down their answer on paper and hence could not use the same strategy. This concern was addressed in a follow-up experiment with 12 Japanese adults

Discussion

This experiment examined children's sensitivity to syntactic and interpretability cues in the interpretation of Japanese wh-questions. In the embedded clause PP condition, we found that children showed a non-adult-like preference for the embedded clause interpretation and answered with the location for the embedded clause event (e.g., the park), despite the fact that it is syntactically blocked by the locative PP in the embedded clause. In the main clause PP condition, children again showed an embedded clause preference, but in this condition their preference matched the adult preference. This suggests that the embedded clause preference observed in the filled-gap condition did not reflect a strategy of repeating the locative PP that was overtly mentioned in the sentence as an answer to *where* questions. Thus, taken together with the earlier observation in Experiment 2 that children actively associate the wh-phrase with the embedded clause VP, the embedded clause preference in the filled-gap condition indicates a failure to use the syntactic cue to inhibit their active dependency completion bias. However, in the predicate mismatch condition, Japanese children showed a preference for the adult-like main clause interpretation, unlike in all the other conditions, in which they showed a robust preference for the embedded clause interpretation. This suggests that they were sensitive to whether the wh-association to the embedded VP would yield a plausible interpretation. We turn to the interpretation and broader implications of these results in the General Discussion.

Finally, in Experiment 2 we discussed the possibility that children's preference for the embedded clause interpretation could potentially be attributed to a misanalysis of the target sentences as mono-clausal sentences. The fact that children entertained the main clause interpretation in the predicate mismatch condition suggests that they are able to recognize these sentences as involving two clauses. However, we cannot entirely rule out the possibility that Japanese children might recognize the presence of two clauses only when there is a plausibility cue; Future research is needed to further investigate this possibility.

GENERAL DISCUSSION

The present study used a series of story-based comprehension experiments with adults and children to investigate their processing of Japanese and English ambiguous wh-questions of the form *Where did Lizzie tell someone that she was gonna catch butterflies?* Experiment 1 revealed that English-speaking adults and children prefer the main clause interpretation, with the exception of sentences in which the main clause VP contained the bare verb *say.* Experiment 2 used Japanese translations of the ambiguous wh-questions to test a case in which the order of the verbs is the opposite of English (main-embedded in English, embedded-main in Japanese). We found that unlike English-speaking adults and children, Japanese adults and children both prefer the embedded clause interpretation. Finally, Experiment 3 examined whether filler-gap dependency processing could be guided by syntactic and interpretability cues. The results showed that children preferred the embedded clause interpretation when the embedded clause locative PP position

at Hiroshima University, using the same interactive procedure used with 5-year-olds. We found that after removal of two responses overall that involved an incorrect, distractor location, 100% of adults' responses were the main clause responses. Thus, the child-adult difference is unlikely to be due to task differences.

was occupied by an overt PP to syntactically block wh-association with the embedded clause VP. On the other hand, when the sentence was manipulated to block a plausible interpretation for the embedded clause association, children were able to overcome their strong embedded clause interpretation bias and entertain the main clause interpretation.

Although our studies did not collect time course measures, these interpretive biases provide evidence that children actively associate the fronted wh-phrase with the first VP in the sentence. The observation of wh-association with the first VP in both English and Japanese strongly suggests that regardless of its structural position, the parser is biased to complete the filler-gap dependency at the first possible integration site. While the first VP association could, in principle, happen after the second verb has been encountered, this is unlikely in light of the observation that children's first VP association persisted even in the presence of a filled-gap that should syntactically block the first VP association. If children waited until the second VP to decide where to complete the filler-gap dependency, it would be strange to choose a wh-association with a syntactically blocked position over the second VP, which would allow a grammatical integration of the wh-phrase. It is also important to note that this behavior resembles the sentence revision failures observed in children's processing of garden-path sentences (Trueswell et al., 1999), where both eye-movements and final interpretations provided evidence for incremental interpretation. Taken together, these observations lend support to the idea that children actively completed filler-gap dependencies at the first VP where the wh-phrases could be interpreted.

Our finding is consistent with the previous arguments from cross-modal picture priming studies that children actively complete filler-gap dependencies (Love, 2007; Roberts et al., 2007). In fact, given that the picture-priming results only indicate lexical activation of the filler at best and do not necessarily show that structural and interpretive commitments were made, the current finding provides important new evidence for active interpretation of filler-gap dependencies in children. Although the interpretation data reported in the current study do not reveal the time course of wh-association, our results demonstrate remarkable uniformity in wh-association preferences across languages with different word orders and different age groups. The uniformity in active dependency completion behaviors across verb-medial and verb-final languages has been attested in previous cross-linguistic work on wh-dependency processing with adults (Aoshima et al., 2004; Nakano et al., 2002). To our knowledge, however, this is the first study with any age-group in which the same stimuli were used to elicit cross-linguistic data that establish the link between the temporal order of verbs and wh-association preferences.

If the first-VP association preference reflects active dependency completion, then the current findings also provide evidence that active dependency completion is not restricted to argument wh-phrases. Most existing evidence for active dependency completion is based on filler-gap dependencies that involve argument fronting, and partly for this reason, it has been proposed that active dependency completion is driven by the need to saturate the argument structure of a verb as soon as possible (Pickering & Barry, 1991; Pritchett, 1992). However, since the locative wh-phrases used in our study are not selected by verbs, the present finding is more compatible with the view that active dependency completion processes are driven by the need to assign an interpretation to the fronted constituent itself (Aoshima et al., 2004). Relatedly, Yoshida and Dickey (2008) used a self-paced reading task and found evidence for filled-gap effects using manner adverbs (e.g., *The principal asked the students how/if the teacher carefully told him that. . .*),

further suggesting that active dependency completion generally applies to fronted wh-phrases, regardless of whether they are arguments or adjuncts.

We now discuss broader implications of these findings for child and adult sentence processing mechanisms.

Mechanisms of Active Filler-gap Dependency Completion in Children

Although we have argued that children actively complete filler-gap dependencies, there remain many questions about the mechanisms of filler-gap dependency completion. One open question is the role of clause boundaries. In most previous adult sentence processing studies, the first and second potential gap sites typically exist within a single clause (e.g., *The city that the author wrote about* __; but cf. Boland et al., 1995). In our stimuli, on the other hand, the first and second potential gap sites were always in different clauses, and for this reason, the first VP association could reflect a bias to complete dependencies within the clause that completes first as the sentence unfolds. There are many languages in which filler-gap dependencies never cross a clausal boundary (so called partial wh-movement languages; McDaniel, 1989), so it is possible that the active dependency completion bias is made stronger when the alternative choice is outside of the initial clause. This requires future research that explores filler-gap dependency processing within a single clause.

Another important question for future research is the exact timing of dependency completion, as the adult sentence processing literature has contrasted two possible ways for the parser to actively complete filler-gap dependencies. One way is to directly retrieve the wh-filler upon encountering the first VP in the sentence, with no prior expectation of where the gap is likely to be (verb-driven dependency completion: Pickering & Barry, 1991; McElree, Foraker, & Dyer, 2003). Under this account, no syntactic commitment is made prior to the arrival of verb information. The other way is to use probabilistic information to predict where the gap is likely to be, and complete dependencies in the predicted structure prior to the arrival of verb information (preverbal dependency completion: Aoshima et al., 2004; Lee, 2004; Nakano et al., 2002; Omaki et al., submitted; Yoshida & Dickey, 2008). Our interpretation data are compatible with either account. For example, with respect to the globally ambiguous wh-questions (Experiments 1 and 2), the filler-gap dependency can be completed before or after the information from the first VP has been accessed.

As for children's behaviors in Japanese sentences with syntactic or interpretability cues (Experiment 3), the two accounts provide very different explanations. In those sentences, the filled-gap syntactic cue is presented before the verb arrives due to the verb-finality of Japanese, whereas the interpretability cue is tied to the arrival of the verb itself. Here, the verb-driven dependency completion account would explain children's selective sensitivity to interpretability cues as indicating that wh-association to the first VP occurs only when it yields a plausible interpretation. In the predicate mismatch condition, the first VP association would yield no plausible interpretation, so children simply would not make this association. In other words, wh-association with the second VP becomes the very first wh-association. In the filled-gap condition, on the other hand, wh-association with the first verb would by itself yield a plausible interpretation, and children may ignore the earlier cues that conflict with this wh-association.

The preverbal dependency completion account is compatible with the data if we interpret the non-adult-like interpretation in the filled-gap condition as an instance of sentence revision failure: Under this account the filler-gap dependency is predictively completed as soon as the embedded clause begins, prior to encountering the filled-gap. In this case, the filled-gap should serve as a syntactic error signal that prompts sentence revision, but children fail to inhibit the incrementally assigned interpretation. Under this view, the behavior in the filled-gap condition would constitute another demonstration of kindergarten-path effects (Trueswell et al., 1999), On the other hand, the adult-like second VP association in the plausibility mismatch condition would indicate that children initially complete the filler-gap dependency before the interpretability cue arrives, and that they are able to use the cue to revise their initial interpretation. This would indicate that children are in fact able to revise their initial interpretations in the presence of appropriate cues, and also that such appropriate cues may have been missing in previous studies that demonstrated sentence revision failures (for discussions of revision cue sensitivity in adults, see Fodor & Inoue, 1994, 1998; Pickering & Traxler, 1998).

Previous studies that provided evidence for children's sentence revision failures have explored the effectiveness of syntactic and interpretability cues in revision of the initial PP attachment. For example, the error signal in *Put the frog on the napkin in the box* is the second PP *in the box*, and this is a syntactic revision cue that indicates that there is a syntactic incompatibility with the initial analysis of *on the napkin* as the destination (Trueswell et al., 1999; Weighall, 2008). Choi and Trueswell (2010) examined the effectiveness of interpretability revision cues in Korean sentences such as (9).[4]

(9) naypkhin-ey kaykwuli-lul {nohu-sey-yo | cipu-sey-yo}

napkin-{Loc/Gen} frog-Acc put-Hon-SE pick up-Hon-SE

"Put / pick up the frog on the napkin"

In this sentence, the *-ey* particle on the first NP is morphologically ambiguous between a locative postposition, which yields a destination interpretation of *napkin*, and a genitive case marker, which leads to an NP modification interpretation, specifying the location of the following NP *frog*. Therefore, unlike in English sentences with a temporary PP-attachment ambiguity, the structural ambiguity in Korean arises as soon as the first and second NPs are encountered. This study manipulated the semantic fit between the verb and the first NP *naypkhin-ey*: the verb *nohu-sey-yo* ("put") disambiguates the ambiguous *-ey* particle toward the destination analysis, whereas *cipu-sey-yo* ("pick up") is only compatible with the NP modifier analysis. The eye movement and action data revealed that children initially analyze *napkin* as the destination, but fail to revise this analysis when the verb is incompatible with this analysis (*pick up*).

This raises the possibility that children's ability to use interpretability cues is somehow restricted to filler-gap dependency processing. One possible reason is that the revision of PP attachment analyses requires a revision of the interpretation of the ambiguous phrase *on the napkin* itself, as the interpretation of the PP must be changed from a destination interpretation to a location interpretation. Even for adults, it has been shown that the parser is more willing to

[4] The gloss abbreviations used here are as follows: Acc = accusative case marker, Gen = genitive case marker, Hon = honorific, Loc = locative postposition, SE = sentence end particle.

make syntactic revisions that do not involve revision of interpretive commitments (Aoshima et al., 2004). However, in the revision of filler-gap dependencies, the analysis of the wh-phrase itself does not change regardless of which verb it is associated with. In such contexts, the demands of sentence revision may be smaller and more manageable for children.

Finally, further studies are needed to investigate whether the impact of syntactic cues could be modulated depending on the details of their syntactic properties. For example, the filled-gap cue in the present study may have been ineffective because the fronted wh-phrase was an adjunct. Adjuncts are generally not selected by verbs; hence, there is no strict syntactic limit to how many adjuncts attach to VPs. This syntactic flexibility in VP-adjunction could be the reason why the filled-gap manipulation did not serve as an effective revision cue. On the other hand, the filled-gap cue might be more effective when the fronted wh-phrase is an argument of the verb. Arguments are selected by verbs or prepositions, and there are only a restricted number of argument positions for a verb. Thus, if the argument positions are occupied by NPs, this might serve as a more effective revision cue.

CONCLUSION

The results of the current study suggest that adults and children alike resolve filler-gap dependencies by associating a fronted wh-phrase with the first VP in the sentence across languages with different canonical word orders and that children are able to use interpretability cues more effectively than syntactic cues to guide their processing of filler-gap dependencies. While further understanding of the details of dependency completion mechanisms and the timing of dependency completion requires future experiments using online measures such as eye-tracking, the cross-linguistically robust wh-association with the first VP as well as the failure to inhibit this bias despite the presence of syntactic cues lends support to the idea that children actively complete filler-gap dependencies by age 5.

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