No fear of commitment: Children’s incremental interpretation in English and Japanese wh-questions

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We thank Hiromu Sakai for assisting with data collection for Japanese adults, as well as the staff, parents and children at Ibaraki University Kindergarten, Mito Kindergarten, and the Center for Young Children at the University of Maryland. This work was supported in part by a Wylie Dissertation Fellowship to AO, a Japan Society for the Promotion of Science Grant-in-Aid for Young Scientists #20820009 to TG, NSF BCS-0954651 to CP, and AO and JL, and NSF BCS-0848554 to CP.
Abstract

Much work on children’s PP attachment ambiguity resolution has demonstrated that children can use syntactic and semantic cues for sentence comprehension when the cues appear before structural ambiguities arise, but not when the cues appear after an ambiguity has been resolved (the ‘kindergarten-path effect’). The present study extends this line of research to filler-gap dependency processing and investigates to what extent syntactic and semantic cues guide adults’ and children’s comprehension of Japanese and English ambiguous wh-questions of the form *Where did Emily tell someone that she hurt herself?* Four story-based experiments demonstrate two novel findings on children’s incremental interpretation of filler-gap dependencies. First, we observe that adults and children actively associate the wh-phrase with the first VP in the sentence regardless of the canonical word order of their language: English-speaking adults and children generally prefer the main clause interpretation, whereas Japanese adults and children both prefer the embedded clause interpretation. Second, Japanese children were unable to revise their embedded clause interpretation bias even when the gap position was occupied by an overt constituent that should syntactically block wh-association. On the other hand, when the cues were based on semantic properties of the verb, children were able to overcome their strong embedded clause interpretation bias and entertain the main clause interpretation. These findings suggest that syntactic and semantic cues may have a different impact on children’s interpretation and sentence revision processes.
NO FEAR OF COMMITMENT: CHILDREN’S INCREMENTAL INTERPRETATION IN ENGLISH AND JAPANESE WH-QUESTIONS

1.1. Introduction

How do children parse strings of words and assign interpretations to them? The substantial evidence for children’s early grammatical sophistication (Crain 1991; Guasti, 2002) may lead one to think that this is a straightforward question – children must be able to parse sentences like adults do. 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 and 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; however, if children are unable to successfully parse the input due to cognitive limitations or the linguistic complexity of the input, then this could significantly impact the time 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; Trueswell & Gleitman, 2007; Valian, 1990).

This paper presents a cross-linguistic exploration of one sentential environment that causes so called kindergarten-path effects, in which children incrementally assign an interpretation to a temporarily ambiguous sentence, and struggle to revise this early commitment
based on subsequent disambiguating information. Specifically, we report how adults and children comprehend ambiguous complex 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. This cross-linguistic comparison allows us to test the robustness of incremental interpretation that does not depend on the canonical word order of the language. In addition, this comparison allows us to determine the effectiveness of syntactic and semantic cues that are critical for assigning a correct interpretation, which, as reviewed below, have not been systematically studied in a controlled linguistic environment. Based on the observation of children’s interpretive biases and their comprehension successes and failures in wh-questions, we discuss the implications for the linguistic and cognitive conditions that constrain children’s (re-)parsing of the input.

1.2. Children’s interpretive biases and sentence revision difficulties

Sentence processing mechanisms must assign the correct structural representation to the input despite the pervasiveness of ambiguities at multiple levels of linguistic representation (Altmann, 1998; Kimball, 1973). It may seem plausible for the parser to postpone structure building decisions in order to avoid misanalyses and maximize accuracy, but adult language comprehension research to date has demonstrated the opposite: the sentence processing mechanism does not wait for later information in the sentence, but rather draws upon a variety of linguistic and non-linguistic information in the environment in order to make incremental hypotheses about possible syntactic structures and interpretations as the sentence unfolds (e.g., Altman & Kamide, 1999; Frazier & Rayner, 1982; Marslen-Wilson, 1973; Pickering, Traxler & Crocker, 2000; Staub & Clifton, 2006; Trueswell, Tanenhaus & Garnsey, 1994). The resolution
of temporary prepositional phrase (PP) attachment ambiguity is one example of incremental integration of multiple sources of information that has drawn much attention in both adult and child sentence processing research. For example, an adult eye-tracking study by Tanenhaus, Spivey-Knowlton, Eberhard, and Sedivy (1995) presented instructions like (1) while adult participants viewed an array of objects, such as an apple on a towel, an empty towel, a pencil on a plate, and an empty box.

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

In the sentence shown in (1), the first PP on the towel presents a temporary structural ambiguity as it can serve as a noun phrase (NP) modifier specifying the location of the NP the apple, or as a verb phrase (VP) argument specifying the destination for the apple-moving event. Here, the verb put can only accommodate one destination PP, and therefore the only contextually appropriate destination must be in the box. However, at the point of hearing the ambiguous PP on the towel, listeners do not have access to the disambiguating information from the second PP, and could potentially adopt the destination interpretation.

Tanenhaus and colleagues measured moment-by-moment eye fixations on the objects in the scene, which can be used to infer the time course of interpretive processes. There were two main findings in this study. First, in a one-referent context where there was only one apple in the scene, adults initially looked toward the empty towel as soon as the first PP on the towel was presented, suggesting that this PP was immediately analyzed as a destination PP. However, in a two-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
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(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 did not analyze the first PP *on the towel* as a destination PP but rather as an NP modifier. These findings corroborate earlier observations that English-speaking adults 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 this VP-attachment bias and select a NP-modifier analysis.

This visual world study illustrates how lexical and contextual information can be used to generate sentence interpretations very efficiently, but it also highlights the fact that sometimes an incrementally assigned interpretation can be wrong, as observed in the one-referent context where participants initially interpreted *on the towel* as the destination. In other words, listeners must sometimes flexibly retract their incremental commitments when the selected hypothesis is disconfirmed by subsequent information. Such reanalysis processes could be cognitively taxing, and can affect the success of the comprehension mechanism even for adults (Christianson, Hollingworth, Halliwell, & Ferreira, 2001; Ferreira & Patson, 2007; Sturt, 2007). In other words, the ability to make incremental syntactic and interpretive commitments is a double-edged sword: 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, it is possible that children might be less likely to make risky incremental processing decisions in favor of reducing the risk of incurring reanalysis costs. However, the past decade of child sentence processing research has demonstrated that children are in fact willing to make incremental syntactic and interpretive commitments, and that when they encounter later information that disconfirms such incrementally constructed representations,
children tend to perseverate and struggle to revise their earlier analyses. 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 like *Put the frog on the napkin in the box*, which closely resembled (1). Whereas the adult participants showed the same behavioral response as in Tanenhaus and colleagues’ study, the children’s data diverged in interesting ways. First, the eye movement measures revealed that the children only entertained the destination interpretation of the first PP *on the napkin*, regardless of the number of relevant objects in the scene (1-referent vs. 2-referent). More importantly, on more than 60% of trials the children moved the object (‘the frog’) to the location described by the first PP (‘the napkin’), despite the presence of a syntactic error signal, i.e., the second PP ‘in the box’, which indicated that *on the napkin* cannot be the destination. The fact that the fixation on the napkin corresponds to the destination for moving the object suggests that the children failed to revise the initial destination interpretation.

Children’s inability to use contextual information for ambiguity resolution as well as their perseveration on early commitments have led to a number of studies that investigated what type of linguistic and non-linguistic information children are able to exploit for ambiguity resolution and sentence revision (Arnold, Brown-Schmidt, & Trueswell, 2007; Choi & Trueswell, 2010; Hurewitz, Brown-Schmidt, Thorpe, Gleitman, & Trueswell, 2000; Kidd & Bavin, 2005, 2007; Kidd, Steward, & Serratrice, 2011; Meroni & Crain, 2003; Novick, Trueswell, & Thompson-Schill, 2005; Sekerina, Stromswold, & Hestvik, 2004; Snedeker & Trueswell, 2004; Snedeker & Yuan, 2008; Weighall, 2008; for a review, see Trueswell & Gleitman, 2007; Snedeker, 2009). Here, we focus on three critical factors that appear to condition children’s interpretation biases and sentence revision difficulties, namely, cognitive control capacity, the timing of
disambiguation cues (early vs. late), and the type of disambiguation cues (syntactic vs. lexical semantic).

It has been proposed that children’s revision difficulties may result from their immature cognitive control mechanism (Choi & Trueswell, 2010; Novick et al., 2005, 2010). Cognitive control refers to a set of cognitive processes that are necessary for inhibiting automatic attention or responses to stimuli and controlling adaptive and efficient responses to novel or difficult situations. Children’s ability to execute these processes is typically measured by tasks that force children to flexibly inhibit and shift their attention between conflicting features of the stimuli. For example, in a Dimensional Change Card Sorting Task (Zelazo, 2006) children were first instructed to sort two cards according to their color feature (e.g., blue vs. red), but later in the experiment children were instructed to ignore the color feature and sort the cards according to their shape (e.g., rabbit vs. boat). Novick et al. (2005) pointed out that the attention inhibition of the type required in the second block of this task resembles processes that are required during recovery from garden-path sentences. In garden-path sentences, children incrementally assign a certain structural analysis and interpretation to a partial sentence, and must then inhibit their initial commitment and adopt an alternative structural analysis and interpretation. Although the exact nature of the cognitive control mechanisms is still debated, various studies have reported that it does not fully develop until late adolescence (e.g., Carlson & Moses, 2001; Diamond & Kirkham, 2005; Davidson, Amso, Anderson, & Diamond, 2006; Kirkham, Cruess, & Diamond, 2003; Zelazo, Muller, Frye, Marcovitch, Argitis, Boseovski, Chiang, Hongwanishkul, Schuster, & Sutherland, 2003; for a review, see Diamond, 2006). Thus, it is possible that kindergarten-path effects arise from children's inability to inhibit early, erroneous syntactic and interpretive commitments (for discussion, see Mazuka, Jincho, & Onishi, 2009).
This proposal predicts that even if linguistic information could potentially guide children’s subsequent parsing decisions, children should struggle to use it if the information is presented later in the sentence, and critically after they have made an initial commitment to the interpretation of an ambiguity. Supporting evidence for this view has been found in studies that investigated children’s ability to use early and late verb information to resolve PP-attachment ambiguity. For example, in an act-out during eye-tracking study similar to Trueswell et al. (1999), Snedeker and Trueswell (2004) presented English sentences like Tickle/choose the frog with the feather, in which the PP with the feather could be analyzed as a VP-modifier (specifically, an instrument) or as an NP modifier (the location of the frog). A number of different verbs were used, which were shown in a norming study to vary in their probabilistic biases for one of the structural analyses (e.g., tickle has a VP-modifier bias, whereas choose has a NP-modifier bias). The study also manipulated the referential context, presenting the target sentence in contexts with one or two referents for the critical NP (i.e., one frog vs. two frogs). The eye-movement patterns revealed that adults’ and children’s attachment decisions were immediately influenced by the verbs’ probabilistic biases, whereas the referential manipulation still did not significantly influence children’s ambiguity resolution preferences. This suggests that verb information is an effective and somewhat privileged cue that children can exploit to guide their initial commitments in sentence comprehension.

However, evidence from a verb-final language like Korean suggests that even such privileged verb information is not effectively used to revise early interpretive commitments. Choi and Trueswell (2010) examined adults’ and children’s interpretation of Korean sentences like (2).
(2) naypkhin-ey kaykwuli-lul {nohu-sey-yo | cipu-sey-yo}
napkin-{Loc/Gen} frog-Acc put-Hon-SE pick up-Hon-SE¹

“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 on the napkin, and a genitive case marker, which leads to an NP modification interpretation, specifying the location of the following NP (i.e., frog on the napkin). Therefore, unlike in ambiguous English PP-attachment sentences like (1), the structural ambiguity in Korean arises as soon as the first and second NPs are processed, and before the verb information becomes available. This study further tested the accessibility of verb semantic cues by manipulating the semantic fit between the verb and the first NP to disambiguate the sentence in (2) to the destination analysis (e.g., nohu-sey-yo ‘put’) or NP modifier analysis (e.g., cipu-sey-yo ‘pick up’). The eye movement data revealed that children and adults alike fixate on the empty napkin in the scene as soon as the ambiguous PP naypkhin-ey (napkin-Loc/Gen) is presented, suggesting the presence of a bias towards the locative analysis of the -ey particle, which in turn led to the VP attachment of the ambiguous PP. In other words, children and adults had a bias for the destination interpretation. However, when the verb was incompatible with the destination analysis of the ambiguous phrase (e.g., pick up), adult and child performance diverged. Adults were able to incorporate the verb information to revise this initial analysis and perform the correct actions. For example, they would pick up the frog that was sitting on the napkin and hold it in the air. But children were unable to revise the initial destination interpretation of the first NP; Regardless of the number of frogs in the scene,

¹ The gloss abbreviations used in this paper are as follows: Acc = accusative case marker, Comp = complementizer, Dim = diminutive marker, Gen = genitive case marker, Hon = honorific, Loc = locative postposition, Q = question particle, SE = sentence end particle, Top = topic marker.
they typically coerced the destination interpretation and performed an incorrect action, such as picking up the frog and then placing it on the napkin.

The English and Korean findings together illustrate that children fail to use either syntactic cues (e.g., Trueswell et al., 1999) or verbal semantic cues (Choi & Trueswell, 2010) when they appear late in the sentence, despite the fact that children are able to use verb information to guide their initial parse when it is presented in advance of the structural ambiguity. These observations lend support to the view that early sentential information is generally more potent than later-arriving information (Choi & Trueswell, 2010), and they are compatible with the proposal that children’s non-adult-like sentence revision capacity results from their immature cognitive control mechanism. It is important to note, however, that these observations might not constitute evidence for the primacy of early sentential information. For example, the contrast in the use of verb information between the English and Korean studies (Snedeker & Trueswell, 2004; Choi & Trueswell, 2010) could reflect the fact that the PP attachment in the two studies had different interpretive consequences. The English PP ambiguity examined by Snedeker and Trueswell (2004) involved a contrast between a PP as an instrument or a PP as the location of the NP object, whereas the PP-attachment ambiguity examined in most studies of kindergarten-path effects instead contrasted a destination interpretation with a location interpretation (Choi & Trueswell, 2010; Hurewitz et al., 2000; Trueswell et al., 1999; Weighall, 2008). It is possible that the destination interpretation could be particularly prone to kindergarten-path effects, or that verbs like *pick up* provide a weak verb-based revision cue, especially in an act-out task in which the scene contains an empty destination (e.g., a napkin with no object on it), making it tempting to move an object to the empty destination (for discussion, see Meroni & Crain, 2003).

Moreover, Choi and Trueswell’s findings are amenable to an alternative interpretation.
The observation that the locative analysis of the –ey particle in a Korean sentence like (2) influenced PP-ambiguity resolution could be taken as evidence that children’s word recognition mechanism could only access the locative particle in their lexicon. This is a plausible explanation given that cross-linguistically the most common use of an adnominal genitive case marker is to indicate a possessor (Blake, 1994), which is most often associated with animate nouns in many languages (Rosenbach, 2002). It is thus possible that children used the inanimacy of the –ey marked noun as a plausibility cue to only access the locative version of the ambiguous –ey particle. Under this view, the sentence in (2) may not have been ambiguous for children.

Finally, under the hypothesis that representational conflicts are responsible for sentence revision difficulties, it need not be the case that all information that appears after initial ambiguity resolution should be inaccessible for children, because the difficulty of revision could be modulated by the nature of the commitment that was made in earlier parts of the sentence. In both the Korean and the English kindergarten-path studies, revision of the garden-path sentences required the parser to retract both syntactic and interpretive commitments. Revision of the PP-attachment decision had an immediate interpretive consequence not only for the overall interpretation of the sentence, but also on the interpretation of the ambiguous PP itself, because the interpretation of the PP had to be changed from a destination interpretation to a location interpretation. Even for adults, it has been argued that the parser is more willing to make syntactic revisions that do not involve revision of interpretive commitments (Aoshima, Phillips & Weinberg, 2004). However, there are other sentential contexts in which syntactic or semantic cues that appear relatively late in the sentence require revision of early syntactic analysis without changing the interpretation of the structurally ambiguous phrase. In such linguistic contexts, the demands of sentence revision should be smaller and may even be manageable for children with
immature cognitive control capacity. As we illustrate below, wh-attachment ambiguity in complex questions presents an ideal syntactic environment for addressing this possibility.

In summary, the PP attachment ambiguity resolution studies reviewed above have examined the type of information that children can use to resolve syntactic ambiguity resolution, as well as the timing of the information that is critical for successful sentence interpretation. The existing findings have been taken to show that children are generally able to exploit early syntactic and verb semantic information better than later-arriving information, but differences in the designs of these studies leave open the possibility that some effects that have been attributed to timing might instead be due to information type.

1.3. The present study: Cross-linguistic investigation of wh-question interpretation

The present study explores children’s sensitivity to syntactic and verb semantic information by using a different task and syntactic environment than the previous studies on PP-attachment ambiguity, namely, story-based comprehension experiments and ambiguous bi-clausal wh-questions in English and Japanese, as shown in (3):

(3) a. Where did Emily tell someone that she hurt herself?

b. Doko-de Emily-chan-wa pro ashi-o kegasrita to itteta-no?  
   where-at Emily-Dim-Top she foot-Acc hurt Comp was telling-Q

These sentences are globally ambiguous, because the fronted wh-phrase where (also called the filler) can be associated with one of two possible thematic positions (also called the gaps), namely, either the main clause VP (tell someone) or the embedded clause VP (hurt herself).
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 (3b) 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 a closely matched sentence pair as in (3), in which the English and Japanese sentences both begin with a wh-phrase and are followed by two clauses. Importantly, however, the verb-final property of Japanese has the effect that 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 (hurt), and in Japanese this order is reversed.

Three features of this construction make these sentences an appropriate testing ground for children’s sensitivity to syntactic and verb semantic information. First, adult psycholinguistic research on wh-dependencies has provided clear evidence for incremental syntactic processes, namely, the parser actively creates gap sites (in a theory neutral sense, i.e., regardless of whether the gaps correspond to phonologically empty categories) before there is sufficient evidence to confirm the accuracy of the gap assignment (active gap creation: Crain & Fodor, 1985; Fodor, 1978; Frazier & Flores D’Arcais, 1989). For example, Stowe (1986) observed a filled gap effect in (4), i.e., slower reading times at the direct object position us in the wh-fronting condition (4a) than in a control condition that did not involve wh-fronting (4b). This pattern of reading times suggests that the parser had already posited the object gap before checking whether the direct object position was occupied.

(4) a. My brother wanted to know who Ruth will bring us home to ____ at Christmas.
b. My brother wanted to know if Ruth will bring us home to Mom at Christmas.

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 (5).

(5) We like the city / book that the author wrote unceasingly and with great dedication about ____ while waiting for a contract.

Traxler and Pickering found a *plausibility mismatch effect* at the critical verb in (5), i.e., 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 position the parser postulated a gap and analyzed the filler as the object of the verb. There is ample time course evidence for active gap creation using a variety of dependent measures such as reading time and eye-fixation measures (Crain & Fodor, 1985; Frazier, 1987; Frazier & Clifton, 1989; Lee, 2004; Omaki, Lau, Davidson White, Dakan, Lidz & Phillips, submitted; Omaki & Schulz, 2011; Phillips, 2006; Pickering & Traxler, 2001, 2003; Schlesewsky, Fanselow, Kliegl & Krems, 2000; Wagers & Phillips, 2009), the stop-making sense task (Boland, Tanenhaus, Garnsey & Carlson, 1995), cross-modal priming (Nicol, 1993; Nicol & Swinney, 1989), the visual world paradigm (Omaki, Trock, Wagers, Lidz & Phillips, 2009; Sussman & Sedivy, 2003) as well as event-related brain potentials (Garnsey, Tanenhaus, & Chapman, 1989; Gouvea, Phillips, Kazanina, & Poeppel, 2010; Hestvik, Maxfield, Schwartz, & Shafer, 2007; Kaan, Harris, Gibson, & Holcomb, 2000; Phillips, Kazanina, & Abada, 2005). Moreover, active gap creation has been observed across many languages despite
differences in the structural positions of the first available gap site, such as embedded clause argument positions in verb-final languages like Japanese (Aoshima et al., 2004; Nakano, Felser, & Clahsen, 2002), suggesting that active gap creation is driven by the need to assign a thematic interpretation to the fronted wh-phrase as soon as possible.

These observations suggest that active gap creation is a very robust property of the adult sentence comprehension mechanism, and that active filler-gap processing effects present a good testing ground for incremental integration of syntactic and semantic cues. A filled-gap as in (4) is a good syntactic cue for reducing the number of possible gap locations, whereas the semantic fit manipulation paradigm in (5) allows us to test whether the semantic information of the verb can be used effectively to locate the correct gap position.

Evidence from cross-modal picture priming studies suggests that 5-year-old children also actively process filler-gap dependencies. For example, Love (2007) presented sentences like The zebra that the hippo had kissed ___ on the nose ran away, and found that children made an alive vs. non-alive 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). This pattern of results was taken to show that the head of the relative clause was reactivated at the verb, but it is important to note that evidence for reactivation does not necessarily indicate an active interpretation of the filler as the theme of the verb. The current study aims to shed light on both the incremental analyses and ultimate interpretation of wh-dependencies. If children actively complete filler-gap dependencies, and children have difficulty with revision, then in the context of sentences like (3) it is predicted that children should favor wh-association to the first VP in the sentence. Specifically, in English they should favor an
interpretation of *where* in which it modifies the main clause VP *tell someone*, i.e., it is the location of the telling event, rather than the location of the hurting event. In contrast, if children engage a similar active gap creation mechanism in Japanese, where the order of verbs is the opposite of English, then we predict that Japanese children should favor an interpretation of *where* as modifying the embedded clause VP *hurt herself*. Although it might seem surprising that children should favor an interpretation of the fronted wh-phrase in which it is interpreted with the most deeply embedded verb, this would be consistent with a parallel cross-language contrast that has been found in adult reading time studies on English and Japanese. Whereas active gap creation in English leads comprehenders to favor a main clause interpretation of ambiguous wh-phrases, Japanese speakers preferentially interpret scrambled wh-phrases with the first verb in the sentence, which corresponds to the most deeply embedded clause (Aoshima et al., 2004; Nakano et al., 2002). Thus, by testing whether children show a similar contrast in interpretive preferences between English and Japanese we can obtain a further measure of whether children actively processes filler-gap dependencies (Experiments 1 to 3).

A second attractive feature of the construction in (3) is that the VP region can be manipulated in a variety of ways to investigate the effectiveness of different syntactic and semantic cues (Experiment 4). In particular, the Japanese version (3b) provides an ideal testing ground because the embedded clause VP can be manipulated to induce a filled-gap effect (4) or a plausibility mismatch effect (5). This is more feasible in Japanese than in English, where the first verb selects a clausal complement, and hence the range of verbs is more limited. Note that the gap position in Japanese is pre-verbal, and for this reason the syntactic and verbal semantic cues could be considered to appear after the actively created gap (see below). This order also resembles the temporal order of the ambiguity and the disambiguating verb information used in
Choi and Trueswell’s study of Korean PP-attachment (Choi & Trueswell, 2010).

A third useful feature of the construction in (3) is that any potential syntactic reanalysis does not change the interpretation of the locative interpretation assigned to the wh-phrase: Even when the syntactic analysis of the wh-phrase changes from the first VP to the second VP, thereby changing the overall interpretation of the sentence, the interpretation of the wh-phrase as a wh-locative remains unchanged. This contrasts with the PP-attachment ambiguities tested by Choi and Trueswell (2010) and Trueswell et al. (1999), where revision of the PP attachment also changed the interpretation of the PP itself.

The experiments reported here use two types of story-based interpretation tasks that are suitable for probing the ultimate interpretation that listeners adopt. Experiments 1, 3, and 4 use a Question-after-Story task (de Villiers, Roeper, & Vainikka, 1990; de Villiers & Roeper, 1996) and examine whether English-speaking adults and children (Experiment 1) as well as Japanese-speaking adults and children (Experiments 3 and 4) show evidence for active gap creation, i.e., a bias to attach the wh-phrase to the first VP in ambiguous wh-questions like (3). Experiment 2 uses a Truth Value Judgment Task with adult English speakers to examine whether the results from question-answering responses reflect parsing biases rather than question-answering strategies.

We should note that children’s comprehension of sentences like (3a) has been tested in studies by de Villiers and her colleagues (de Villiers et al., 1990; de Villiers, Roeper, Bland-Stewart, & Pearson, 2008; Roeper & de Villiers, 1992). Regarding children’s main clause vs. embedded clause interpretation preference, somewhat mixed results were found in earlier small-scale studies that tested various wh-question structures with different main clause verb types and contextual manipulations (de Villiers et al., 1990; Roeper & de Villiers, 1992). However, a large-
scale study with 703 typically developing children (age range 4 to 9-years-old) 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. This evidence may call into question whether children actively process filler-gap dependencies, or whether this task is even appropriate for probing incremental wh-attachment. However, the fact that de Villiers and colleagues tested very few tokens of this type of wh-question raises the possibility that this may have been driven by properties of the specific items. In particular, the previous studies by de Villiers and her colleagues mostly used the verb *say* as the main clause verb.

Based on Snedeker and Trueswell’s demonstration that children’s PP attachment decisions are affected by verb biases (Snedeker & Trueswell, 2004), Experiment 1 explored the possibility that the previously reported embedded clause preference (de Villiers et al., 2008) may be tied to the use of the English verb *say*. In this experiment we constructed a series of stories that were designed to make the main clause and embedded clause interpretations equally available and further manipulated the verb type. We used the bare verb *say*, and the more complex predicates *tell someone* and *say to someone* (6), and examined whether adults and children’s wh-attachment is sensitive to properties of the main clause VP.

(6) Where did Emily { say | tell someone | say to someone } that she hurt herself?
If the embedded clause interpretation preference observed in de Villiers and colleagues’ study was driven by properties of the main clause verb *say*, then we predict that different interpretive preferences should arise with *tell someone* or *say to someone*.

### 2.1. Experiment 1: English question-after-story task with verb manipulation

Experiment 1 uses a Question-after-Story task to investigate English-speaking adults’ and children’s interpretation preferences in comprehension of globally ambiguous bi-clausal wh-questions like (6). If both adults and children have an active gap creation bias, we predict that they would prefer the main clause interpretation as the main clause VP provides the first available thematic position.

**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. Data from 9 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 this experiment and other experiments unrelated to the present study. The age range for children 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.,
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Trueswell et al., 1999) and filler-gap processing (e.g., Love, 2007), such that children’s behavior in the current study could be compared to the previous findings.

**Materials**

*Story design.* The same 8 stories were used in all four experiments reported in this study, so we will 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 on-line eye-tracking measures. 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 (7) (see below for details of the question design), and a sample sequence of events in the visual display is shown in Figure 1.

(7)  

[**Intro phase**] Emily likes to play outdoors.  

[1st location] One day she was swinging on the swings, and she jumped off the swings from really high up! She balanced herself really well on the landing, so she didn't fall.  

[2nd location] When Emily got bored with the swings, she decided to climb a really tall tree. She got up pretty high, but suddenly one of the branches broke, so she fell off the tree and hurt herself! But Emily was a brave girl, so she got back up right away and didn't cry at all. Emily wanted to tell her friends how pleased she felt about not crying after hurting herself, so she went to find some of her friends at the library.  

[3rd location] She found a friend of hers there, but the librarian came out and told her that in the library they have to be very quiet! So Emily was disappointed that she couldn't
talk to her friend. But then she had a good idea: she could go to the swimming pool to see more friends, because at the pool she can talk as much as she wants.

[4th location] When Emily got to the pool and found her friends, she said to them, “I hurt myself falling out of the tree, but I didn't cry at all!” Emily was happy she could finally tell someone about her day, and her friends were impressed by how brave she was.

[Question] Where did Emily tell someone that she hurt herself?

Figure 1. A sample sequence from the scenes used to accompany the stories in Experiments 1-4.

In each story, a main character visited the four locations on the computer display, 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 of each pair of locations the relevant event almost occurred but eventually failed. For example, in the sample story Emily almost talked to her friend at the library but failed. It was only in the second location in each pair that the relevant event occurred. For example, in the sample story Emily finally was able to talk to her friends at the pool. This feature was introduced to make the location-event paring for each target event more memorable for children, and it was also expected that having two potential locations for each event would make the where questions more felicitous. In order to further help children to remember what happened in each location, we also left visual traces of what happened in each location. In the locations in which the intended activity successfully occurred, the visual trace of that event remained on the display (e.g., the hurting scene or the speech bubble with an image of the tree in Figure 1), but in the ‘failed attempt’ locations, only the image of the character (and no visual trace of the event) remained.

In order to control for the possibility that participants' answers might reflect a recency bias (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 of the stories the first pair of locations 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 (7) above, the ‘telling’ events were motivated by how brave Emily felt when she hurt
herself and did not cry. In stories that started with ‘telling’ events, the story was constructed in such a way that ‘telling’ was a pre-requisite for the next set of events. For example, an astronaut needed to first consult a scientist for advice before embarking on a space mission to find aliens.

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 story scripts and questions used in the experiments reported in this paper as well as a sample movie file can be found on the first author’s webpage (http://www.cog.jhu.edu/~lpad/).

Question design. For each of the 8 stories, we constructed 8 bi-clausal wh-questions with where as shown in (6), which is repeated below for convenience.

(6) Where did Emily {say | tell someone | say to someone} that she hurt herself?

This construction is globally ambiguous and allows two possible interpretations, one in which the wh-adjunct where is associated with the main clause VP, and one in which the wh-phrase is associated with the embedded clause VP. All target sentences contained the overt complementizer that, as our pilot work with adult native speakers of English showed that the presence of an overt complementizer is critical for making main clause and embedded clause interpretations equally accessible. We manipulated the verb type (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 verb condition was 5;4 for say, 5;7 for tell someone, and 5;3 for say to someone, respectively. There was no reliable difference in mean age across the three conditions ($F < 1$).
For each story of the 8 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 as fillers 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 in the story. In order to balance the type of locations that were asked about, all of the 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 Emily talk to her friends at the library?”).

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 4 target and 4 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 automatically after each story, and participants had roughly 6 seconds to write down the answer in a short phrase (e.g., at the pool) on an answer sheet. With this procedure, the experiment took approximately 15 minutes.

Results

The dependent measure was the proportion of main clause responses, e.g., answering ‘at the pool’ to the example scenario in (7). 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 analysis, since there was no significant difference across two lists of stimuli ($F < 1$). The proportion of main clause responses for all conditions is summarized in Figure 2.
Overall, children provided more main clause responses than did adults, but children and adults showed the same general pattern of responses in each verb-type condition. In the *say* condition, children and adults produced few main clause answers (children: 24%; adults: 0%), but they 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 lack of interaction...
suggests that the main effect of age is not due to qualitative differences in their wh-attachment preferences, but rather due to the quantitative difference that results from a slightly stronger main clause preference in children.

Discussion

The results from this experiment demonstrate that both 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 replicated the previous finding from de Villiers and colleagues (de Villiers et al., 2008) in that adults and children alike preferred the embedded clause interpretation when the main clause verb was the bare predicate *say*. 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. These results have two implications for adults and children’s wh-attachment ambiguity resolution mechanism. First, wh-attachment decisions are strongly influenced by properties of the first VP in the sentence. Our finding thus extends the previous demonstration of verb primacy in PP-attachment ambiguity resolution (Snedeker & Trueswell, 2004) to the domain of wh-attachment ambiguity resolution, suggesting that this is a robust property of the sentence processing mechanism in adults and children.

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-attachment to the first VP in the sentence is preferred over attachment to the second VP. This may reflect active gap creation processes for the fronted constituent, although the present data do not provide decisive evidence that the main clause interpretation was assigned
incrementally (see below for further discussion). The exceptional embedded clause interpretation in the bare *say* condition raises the question of what makes that condition different from the other two verb conditions. We do not have a definitive answer to this question, but 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 in isolation (Aikhenvald, 2006; Simons, 2007). If the verb *say* is analyzed as an evidential marker, the main clause VP 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 the verb *say*, it would be no longer felicitous to ask about the location of the saying event. This explanation predicts a main clause preference with a bare *say* in verb-medial, wh-fronting languages which use an evidential marker that is morphologically distinct from the verb *say*. We leave this question open for future research.

One may instead argue that the main clause interpretation preference in the *tell someone* and *say to someone* conditions reflects 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 did Emily hurt herself*?). 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 below (Experiment 3) can also be used to test this alternative account. If the main clause preference seen in English reflects
active gap creation then we predict the opposite preference in Japanese, but if it instead reflects a pragmatic bias, then we predict an identical preference in Japanese.

It is important to note that the current evidence for a main clause interpretation preference does not necessarily indicate that children’s and adults’ interpretive preferences are due to active association of the wh-phrase with the main clause VP. For example, it is possible that adults and children initially gave equal consideration to both interpretations of the ambiguous questions, and that they then used verb biases to select among the two possible answers. If this were the case, then the Question-after-Story task might not provide an appropriate measure of the actual sentence comprehension processes, because the dependent measure would only reflect biases in deciding which answer is more appropriate in the particular Question-after-Story experiment setting. We address this question in Experiment 2.

2.2 Experiment 2: English truth value judgment study with adults

Experiment 2 examined whether the main clause wh-attachment preference observed in Experiment 1 simply reflected biases in selecting a possible answer to a question. To this end, two methodological changes were made: First, we tested adult native speakers, who are presumably much more competent at retracting incremental commitments, in order to examine how robustly the early interpretative commitment remains in their ultimate comprehension of the target sentence. Second, we used a Truth Value Judgment Task (TVJT) in which participants were forced to judge the truth of one of the two possible interpretations (Crain & Thornton, 1998). An example target sentence is shown in (8).

(8) The place where Emily said to someone that she hurt herself was the {pool | tree}.
This sentence is derived from the target questions used in Experiment 1, and it involves a relative clause *the place where...* which contains the same wh-attachment ambiguity that can be resolved by association with the first VP (*said to someone*) or the second VP (*hurt herself*). At the end of the sentence, one of the two locations that correspond to the possible interpretations is provided (e.g., *pool* for the saying event, *tree* for the hurting event), such that participants are forced to evaluate whether the first or second VP interpretation was true in the story. If the participants in Experiment 1 entertained both possible interpretations and then selected one of them as the more plausible answer using the verb information, then we predict that in sentences like (8) participants should accept both statements as true. On the other hand, if the main clause preference seen in question-answering responses in Experiment 1 truly reflected active commitments to the main clause interpretation, then we predict that a sentence that forces participants to evaluate the truth value of the embedded clause interpretation should be rejected. (for a similar use of the TVJT method to shed light on child and adult parsing mechanisms, see Crain, Ni, & Conway, 1994; Leddon & Lidz, 2006; Musolino & Lidz, 2006; Viau, Lidz, & Musolino, 2010).

**Method**

**Participants**

We recruited 32 adult native speakers of American English from the University of Maryland community. The participants were given course credit or $10 for their participation in a one-hour experiment session that consisted of the present study and other unrelated experiments.

**Materials**
This experiment used the same 8 stories as Experiment 1, but instead of presenting questions, declarative sentences like (8) were presented after each story. In the target sentences, we only used one verb type, *say to someone*, for which we had seen the clearest main clause preference in Experiment 1. For fillers items we constructed unambiguous relative clause sentences about locations other than the ones that the target sentences described, e.g., *The place where Emily couldn’t talk to her friends is the library*. Half of the fillers were manipulated to be true descriptions of the stories, and the other half were manipulated to be false descriptions of the stories.

We treated the main clause vs. embedded clause description as a between-participants factor in order to avoid any priming effects between the two sentence types. The target sentences and fillers were distributed across two lists in the same way as in Experiment 1.

Procedure

The same overall procedure as in the adult version of Experiment 1 was used, the only difference being that participants circled TRUE or FALSE written on the answer sheet instead of writing down answers to the questions. The experiment took approximately 15 minutes.

Results

No participant provided more than one incorrect answer for the 4 filler trials, and hence all 36 participants were included in the data analysis. The mean acceptance rate for the main clause description condition was 100%, whereas the mean acceptance rate for the embedded clause description condition was 19% (*SE* = 9), and there was a significant difference in acceptance rate between the two conditions, $F(1, 30) = 87.41, p < .001$. 
Discussion

We found that the adults’ acceptance rate was consistent for the main clause description condition, whereas in the embedded clause description condition, adults accepted the grammatically permissible embedded clause interpretation on only 19% of trials, despite the fact that all of the statements were true. These results indicate that the TVJT replicated the first-VP preference found in the Question-after-Story experiment (Experiment 1). In fact, the rate of embedded clause interpretation rejection in Experiment 2 (81%) was similar to the rate of main clause interpretation response in Experiment 1 (71%). This parallel suggests that the same mechanism underlies the question-answer responses in Experiment 1 and Truth Value Judgment responses in Experiment 2, and this mechanism may reflect the active gap creation bias. This possibility will be explored further in Experiment 3.

These results also present an important methodological implication for Truth Value Judgment Tasks. It has been argued that participants in TVJT experiments show a bias to accept any grammatically permissible interpretations that are true and pragmatically felicitous in the given context (Principle of Charity: Gualmini, Hulsey, Hacquard, & Fox, 2008). Since both the main clause and the embedded clause interpretations were not only grammatically possible but also pragmatically felicitous in our story design, the Principle of Charity predicts that both main clause and embedded clause interpretations should have been accepted. On the contrary, our adult participants mostly rejected the embedded clause interpretation. This implies that the Principle of Charity should not be taken for granted in a TVJT experiment (for related findings, see Conroy, Takahashi, Lidz & Phillips, 2009; Musolino & Lidz, 2006; Syrett & Lidz, 2011). As Crain and Thornton (1998, p. 211) note, interpretation preferences in a TVJT can be derived from a variety of factors such as parsing strategies, frequency or complexity of the intended
interpretation. Thus, to the extent that children do not perform as the Principle of Charity predicts, the response pattern we observed is likely to be due to some of these other factors. In this case, the effects of active gap creation and a general tendency to avoid sentence revision may be strong enough to swamp any effects of the Principle of Charity.

To provide a further test of whether the ultimate interpretation of the target sentences with wh-dependencies reflects active gap creation at the first potential thematic position, Experiment 3 used the Japanese counterpart of the stimuli in Experiment 1 and examined Japanese children’s and adults’ interpretive biases. As reviewed above, the order of verbs in a verb-final language like Japanese is the opposite of English (Japanese: embedded-main, English: main-embedded). If children actively create a gap and incrementally assign an interpretation to the Japanese counterpart of the English sentences tested in Experiment 1, then we predict that Japanese children should prefer wh-attachment to the embedded clause VP (hurt herself).

2.3 Experiment 3: Japanese question-after-story study with ambiguous sentences

This experiment examined Japanese children’s interpretation preference in the Japanese counterpart 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 (9), while ensuring that the resulting stories and sentences contained words and expressions that are familiar to Japanese children.

(9) Doko-de Emily-chan-wa [ pro ashi-o kegashita to ] itteta-no?
    where-at Emily-Dim-Top she foot-Acc hurt Comp was telling-Q

“Where was Emily telling someone that she hurt herself?”

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. Some sentences were slightly modified to adjust for grammatical differences between English and Japanese. For example, hurt herself was changed to hurt her foot in Japanese because the Japanese verb for hurt does not select a reflexive pronoun. The overt pronoun she in the English version was replaced by a null subject pronoun. 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 (-sou), and 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), which was used in Experiment 4. It is important to note, however, that according to Japanese adult native speakers’ intuitions the aspectual choice does not affect the interpretive preferences in (9).

These items were distributed across two lists in the way described in Experiment 1. The procedure was identical to that of Experiment 1, and the experiment took approximately 15 minutes for adults and 20 minutes for children.

**Results**

The mean proportion of main clause answers for children and adults 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, $F < 1$.

![Figure 3. Mean proportion of main clause responses in the Japanese Question-after-Story experiments (Experiments 3 and 4). The error bars indicate standard errors of the mean.](image-url)
Discussion

The results of Experiment 3 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 Experiments 1 and 2. Given that this experiment used the same story stimuli as Experiments 1 and 2, 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 (e.g., -rashii, -yooda, -sooda; Aoki, 1986) that is morphologically distinct from the main clause predicate itteta (‘was telling’) 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 active gap creation in an embedded clause predicate region. The fact that the preferred interpretation corresponds to the one that results from 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 lead us to believe that the Japanese child and adult sentence processing mechanism actively associates the fronted wh-adjunct with the first VP in the sentence and incrementally constructs the embedded clause interpretation.

However, there is an alternative explanation for the robust embedded clause preference. Recall that our target sentence (9), which is repeated here for convenience, included a null subject pro in the embedded clause subject position.

(9) Doko-de Emily-chan-wa [pro ashi-o kegashita to ] itteta-no?
where-at Emily-Dim-Top she foot.Acc hurt Comp was telling-Q

“What was Emily telling someone that she hurt herself?”

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 thus necessary to use a null subject pronoun in order 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 misanalyzed the target sentence as mono-clausal (‘Where did Emily hurt herself?’) 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. This is consistent with the real-time evidence from Aoshima and colleagues (Aoshima et al., 2004) that Japanese adults actively associate the fronted wh-phrases with an embedded clause VP. However, it is possible that children may have ignored the main clause predicate for exactly this reason. We will return to this point below in Experiment 4.

2.4 Experiment 4: Japanese question-after-story study with cue manipulation

The results from Experiments 1 to 3 showed that adults and children alike resolve the wh-attachment ambiguity by attaching the wh-phrase to the first VP in the sentence, regardless of the canonical word order of the language. The next experiment takes advantage of this behavior to examine whether the active gap creation process would lead to kindergarten-path
effects in the presence of additional syntactic and semantic cues.

Recall that in previous work on Korean and English PP-attachment ambiguities, neither syntactic nor semantic cues saved children from kindergarten-path effects. This may only reflect difficulties in retracting the interpretive commitments that children made upon analyzing the ambiguous PP (e.g., on the napkin) as a destination, because changing the VP argument analysis to the NP modifier analysis results in a change in the interpretation of the PP itself. However, for the wh-attachment ambiguity in Japanese complex questions, the interpretation of the ambiguous wh-phrase itself remains the same whichever attachment option is adopted. Using this construction, Experiment 4 examined the interaction of interpretation perseveration and the timing of syntactic and semantic cues in a controlled linguistic environment.

Method

Participants

Forty eight children aged 4;6 to 6;5 and acquiring Japanese as their native language participated in the study. The children were recruited at Ibaraki University Kindergarten and Mito Kindergarten in Mito, Japan. Six children did not complete all the trials and were not included in the data analysis, and another 6 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 also recruited 16 adult native speakers of Japanese from the Hiroshima University community in Japan. 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 experiment used three conditions that were created by modifying the target sentence used in Experiment 3. The first condition contained an overt PP headed by -de (‘at’) that specified the location of the embedded clause event, thereby 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, in order to ensure that children would not just provide an answer that corresponded to the overtly mentioned location in the sentence. The third condition contained an embedded clause verb that blocked felicitous embedded clause interpretations due to lexical properties of the verb. An example sentence for each condition is shown in (10).

(10)  a. embedded clause PP condition
Doko-de Emily-chan-wa [ pro ashi-o ki-no-shita-de kegashta to ] itteta-no?
where-at Emily-Dim-Top she foot-Acc tree-Gen-below-at hurt Comp was telling-Q
“Where was Emily telling someone that she hurt herself by the tree?”

b. main clause PP condition
Doko-de Emily-chan-wa [ pro ashi-o kegashta to ] puuru-de itteta-no?
where-at Emily-Dim-Top she foot-Acc hurt Comp pool-at was telling-Q
“Where was Emily telling someone at the pool that she hurt herself?”
c. selectional mismatch condition

Doko-de Emily-chan wa [pro ki-kara ochita to] itteta-no?

where-at Emily-Dim-Top she tree-from fell Comp was telling-Q

“Where was Emily telling someone that she fell off the tree?”

The embedded clause PP condition was designed to test the effectiveness of syntactic cues. This condition was created by taking the ambiguous wh-question used in Experiment 3, and adding an overt PP headed by the postposition -de (‘at’) that specified the location of the embedded clause event (e.g., by the tree). In other words, the overt PP corresponded to the embedded clause response in the ambiguous wh-questions used in Experiment 3. The fronted wh-adjunct doko-de (‘where-at’) is 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 should be syntactically blocked. Thus, the only possible interpretation for adults is the main clause interpretation. This condition uses a logic similar to the Filled Gap Effect paradigm (see (4) above; Crain & Fodor, 1985; Stowe, 1986). If children are able to use the syntactic cue to inhibit their bias for an embedded clause interpretation, then they are predicted to behave like adults and only allow the main clause interpretation in this condition. On the other hand, if children are unable to use the syntactic cue to inhibit their embedded clause interpretation bias, then they are predicted to give an embedded clause answer (e.g., by the tree) despite the fact that it was overtly mentioned in the sentence and that this interpretation is highly unnatural for Japanese adults.

It should be noted here that it is possible, in principle, to attach where to the embedded clause VP in sentences like the filled-gap condition (10a) if there is appropriate contextual
information that meets the following three conditions. First, a larger environment that contains the target location (e.g., the tree) needs to be specified in the story, such that the part-whole relationship for the target location is made clear (e.g., the tree in the park). Second, there needs to be another large environment that contains a counterpart of the target location (e.g., the tree in the backyard), such that the two large environments can be contrasted (e.g., hurting happened by the tree in a park, but not by the tree in the backyard). Third, the protagonist must explicitly mention the target location as well as its larger environment (“I hurt myself by the tree in the park!”). However, none of these three conditions was met in our story design: each location was described as an independent location without specifying the larger environment; the target location (tree) 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 ki-no-shita-de, which roughly translates as “at which tree”). It is thus pragmatically infelicitous and grammatically dispreferred 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 error signal for active wh-attachment.

The main clause PP condition (10b) was included to examine whether the mere presence of -de marked PPs causes children to provide a non-adult-like response. As discussed above, in the embedded filled-gap condition in (10a) children could plausibly exhibit a kindergarten-path effect 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 children’s revision difficulty, or it might plausibly reflect a task-taking strategy in which children treat overtly mentioned locative PPs as the relevant answer to where
questions. The main clause PP condition (10b), in which the location of the main clause event was overtly expressed with a locative PP (e.g., at the pool), allowed us to address this methodological concern. If children used this task-taking strategy and treated the overtly mentioned locative PP as the answer to *where* questions, we expected that children would answer the main clause event location ‘at the pool’ which was already mentioned in the sentence. However, if the kindergarten-path response (e.g., answering with the embedded clause location ‘tree’) in (10a) reflected children’s inability to revise the active association of the wh-phrase with the embedded clause predicate, then we expected to see an embedded clause response for (10b) as well.

The selectional mismatch condition (10c) was constructed by changing the embedded clause verb of the original ambiguous sentences in Experiment 3 in such a way that no felicitous embedded clause interpretation was available for the wh-phrase. For example, the verb *ochita* (“fell”) in (10c) is a change-of-location verb, and a PP modifier that is typically used for this type of verb specifies the beginning or the end point of the change-of-location event. The eight predicates that we used in this condition included change-of-location verbs (*itta* “went” × 5, *ochita* “fell” × 1), a change-of-state verb (*naru* “become” × 1), and an individual-level predicate (*oishikatta* “was yummy” × 1). We included more than one type of predicate in order to keep the same stories while ensuring verb incompatibility with the wh-phrase, but crucially none of these verb classes yield a felicitous embedded clause interpretation for adults. 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 direction of the change-of-location event (e.g., falling off a tree, going to a park, etc.), which 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 that the wh-phrase is semantically incompatible with the embedded VP and use this information to inhibit the embedded clause VP-attachment bias, then we predicted a preference for the main clause interpretation. On the other hand, if children were unable to use the verb semantic 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 tree in (10c)). It is important to note that the gap position precedes the verb, and for this reason the verb semantic cue could be regarded as a late-arriving cue with respect to gap creation, in the same sense that the verb semantic cue in Choi and Trueswell’s study was a late-arriving cue for PP-attachment ambiguity resolution.

Eight sentence sets with three conditions as shown in (10) were constructed. We treated each condition as a between-participants factor, and consequently 12 children were randomly assigned to each of the three conditions. The resulting mean age range for the three conditions was 5;7 for the embedded clause filled-gap condition, 5;8 for the main clause filled-gap condition, and 5;11 for the selectional mismatch condition, respectively, and there was no reliable difference in age across groups, $F(2, 33) = 1.70, p > .1$. The 12 adults were assigned to the embedded clause filled-gap condition, because as the results show, this is the condition in which children’s behavior contrasted with adult intuitions. For each condition the target items were distributed across two lists in the way described in Experiment 1, which resulted in 6 lists. The procedure was identical to that of Experiments 1 and 3, and the experiment took approximately 20 minutes for children and 15 minutes for adults.

**Results**

The mean proportion of main clause responses for each condition is shown in Figure 3. In
the embedded clause filled-gap condition (10a), we found a clear contrast between children and adults, as children demonstrated preference for the non-adult-like embedded clause response (17%, $SE = 9$), whereas adults strongly preferred the main clause response (95%, $SE = 3$) as expected. This difference was reliable, $F(1, 27) = 92.36, p < .001$.

In the main clause filled-gap condition (10b), children again showed a clear preference for the embedded clause interpretation (13%, $SE = 6$). In the selectional mismatch condition (10c), however, children showed a preference for the main clause interpretation (74%, $SE = 9$). Since we have no Japanese adult data for the main clause filled-gap and selectional mismatch conditions, we report comparisons between the three verb-type conditions among Japanese children. There was no significant difference in the proportion of main clause responses between the two filled-gap conditions (10a) and (10b), $F < 1$. The proportion of main clause responses in (10c) was above chance level, $t = 2.55, p < .05$ (2-tailed), and it was also significantly higher than in the embedded clause filled-gap condition (10a), $F(1, 23) = 19.65, p < .001$.

Discussion

This experiment examined the extent to which children are sensitive to verb semantic cues and syntactic cues in the interpretation of 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 the location for the embedded clause event (e.g., the tree), despite the fact that it is syntactically blocked by the locative PP that is overtly mentioned in the embedded clause. In the main clause PP condition, children again showed an embedded clause preference, but in this condition their preference corresponds to the adult preference. This suggests that the embedded clause preference observed in the embedded clause PP condition did not reflect a task-taking 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 3 that children actively associate the wh-phrase with the embedded clause VP, the embedded clause preference in the embedded clause PP condition indicates a failure to use the syntactic cue to constrain their wh-attachment decision. On the other hand, in the selectional mismatch condition, Japanese children demonstrated a clear 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 children were able to use the verb semantic information to recognize that there is no felicitous embedded clause interpretation available given the context, and adopt the main clause interpretation. We turn to the interpretation of these results and their implications for child sentence processing in the General Discussion.

In Experiment 3 we discussed the possibility that children’s preference for the embedded clause interpretation might be explained if children have a strong bias to misanalyze the target sentences as mono-clausal and simply ignore the main clause predicate. This is not implausible, given that bi-clausal sentences often include two overt subjects, whereas the embedded clause subject in our stimuli was a null subject, which may have made it difficult to recognize the presence of two clauses. However, the fact that children entertained the main clause interpretation in the selectional mismatch condition suggests that children are able to recognize these sentences as involving two clauses with two VPs. We cannot entirely rule out the possibility that for Japanese children to recognize the presence of the main clause predicate, the wh-phrase must be incompatible with the embedded clause verb. Future research is needed to further investigate this possibility.
3. General discussion

The present study used a series of story-based comprehension experiments to investigate adults’ and children’s interpretive biases in the processing of Japanese and English ambiguous wh-questions of the form *Where did Emily tell someone that she hurt herself?* Experiment 1 revealed that English-speaking adults and children prefer the main clause interpretation, with the exception of sentences in which the main clause verb is bare *say*. Experiment 2 used a Truth Value Judgment Task and replicated the main clause interpretation bias with English-speaking adults. Experiment 3 used the Japanese counterpart of the ambiguous wh-question 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, suggesting that in both English and Japanese, adults and children actively associate the wh-phrase with the first VP in the sentence. Finally, building on the finding in Experiment 3 that Japanese speakers actively attach the fronted wh-phrase to the embedded clause VP, Experiment 4 examined to what extent syntactic and verb semantic cues are able to constrain wh-attachment processes. The results showed that children still prefer the embedded clause interpretation when the embedded clause locative PP position was occupied by an overt PP to syntactically block wh-association with the embedded clause VP. On the other hand, when the cues were based on semantic properties of the verb, children were able to overcome their strong embedded clause interpretation bias and entertain the main clause interpretation. We now discuss broader implications of these findings for the child sentence processing mechanism.

Active gap creation in children
The observations above strongly suggest that children actively attach the fronted wh-phrase to the first VP in the sentence, and that this active commitment leads to kindergarten-path effects in the absence of suitable cues (see below). Our finding is thus consistent with the previous arguments from cross-modal picture priming studies that children actively complete the dependency between wh-phrases and their thematic positions (Love, 2007; Roberts et al., 2007). In fact, given that picture-priming results only indicate lexical activation of the filler and do not necessarily show that structural and interpretive commitments were made, the current finding provides important new evidence for active completion of filler-gap dependencies.

Although the interpretation data reported in the current study does not reveal the time course of wh-attachment, our results demonstrate remarkable uniformity in wh-attachment preference across languages with different word orders and populations with differences in cognitive capacity. The uniformity in active gap creation 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). But to our knowledge, the present study is the first study in which the exact same stimuli were used to elicit cross-linguistic data that establish the link between the temporal order of verbs and wh-attachment preferences in children.

If the first-VP association preference reflects active gap creation processes, then the current findings also provide evidence that active gap creation is not restricted to argument wh-phrases. Most existing evidence for active gap creation in verb-medial or verb-final languages is based on filler-gap dependencies that involve argument fronting, and partly for this reason, it has been proposed that active gap creation processes are driven by the need to saturate the verb argument structure 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 gap creation processes are driven by the need to assign an interpretation to the fronted constituent itself. 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 gap creation generally applies to fronted wh-phrases, regardless of whether they are arguments or adjuncts.

It is important to note, however, that even though our results strongly suggest that gap creation occurs by the verb position at the latest, it is not clear whether gap creation occurs before or after the verb is recognized. Previous work on adult Japanese sentence processing has provided time course evidence for active gap creation in structural positions in advance of the verb (Aoshima et al., 2004; Nakano et al., 2002), and recently time course evidence in favor of pre-verbal active gap creation has been reported in verb-medial languages like English as well (Lee, 2004; Omaki, Lau, Davidson White & Phillips, submitted; Yoshida & Dickey, 2008). This suggests that pre-verbal active gap creation may be an architectural property of the parser that is independent of the canonical word order of the language. It is plausible that children in the current study also created gaps pre-verbally, but we cannot rule out the possibility that children’s gap creation is triggered only after the verb is recognized, because the current study does not provide time course data to precisely identify at which point in the sentence the gap was created. Future eye-tracking experiments are planned to address this question.

Use of syntactic and verb semantic cues to resolve wh-attachment ambiguity

One striking finding in the Japanese studies was that within the same structural environment of bi-clausal wh-questions, children’s interpretation success varied depending on
what type of cues were provided: children failed to use syntactic cues and provided non-adult-like embedded clause responses, whereas children were able to integrate the verb semantic information to generate an adult-like main clause response. We also saw evidence for verb sensitivity in the English ambiguous question, where the verb information modulated the wh-attachment preference. In light of our original goal to investigate the type and timing of cues that explain children’s syntactic and interpretive commitments, we next discuss the relevant implications of our findings for these questions.

The contrast between syntactic and verb semantic cues is compatible with the previous PP-attachment studies that demonstrated evidence for children’s sensitivity to verb information (Snedeker & Trueswell, 2004; Kidd & Bavin, 2007; Trueswell et al., 1999), but there are two ways in which our demonstration of verb sensitivity goes beyond the previous work. First, this is the first demonstration that verb information can be successfully used in making syntactic (re)analysis decisions for fronted constituents that precede the verb, as the previous demonstrations of verb sensitivity were based on English PP-attachment ambiguity resolution where the ambiguous constituent follows the verb. In other words, the current results suggest that the temporal order of verbs and ambiguous constituents does not change the privileged status of verb information. Second, the previous demonstration of verb sensitivity was restricted to contexts in which the verb information was relevant for deciding whether an ambiguous PP should attach to a preceding verb or to an NP, and this attachment decision had a direct consequence on the interpretation of the ambiguous PP itself, e.g., whether it should be analyzed as a modifier of the event (e.g., instrument) or a modifier of a participant in the event (e.g., location). In the present study, on the other hand, the interpretation of the PP itself remains as a locative modifier, and the verb information was relevant merely for deciding which event to
modify (embedded clause event vs. main clause event). This shows that ambiguity in the interpretation of the PP is not a necessary factor for the use of verb information.

With respect to the question of whether the timing of cues affected the effectiveness of syntactic and semantic cues in our study, the answer depends on whether the gap creation occurs pre-verbally or only after the verb is recognized, a time-course issue that remains unresolved in our studies. If children’s active gap creation occurs in advance of the verb, then in terms of the temporal order of the sentence, the filled-gap in the embedded clause as well as the incompatible verb semantics both followed the gap creation process. Under this view, the observed asymmetry in cue effectiveness indicates that the verb semantic error signal was a more effective corrective cue for sentence revision than the syntactic error signal. This may reflect a stricter constraint on the child parser to structurally integrate the fronted constituent and assign an interpretation to it as soon as possible. In the filled-gap condition the verb contained all the selectional features required by the fronted wh-phrase and it was therefore able to accommodate the structural integration of the filler, whereas in the selectional mismatch condition, the wh-requirement could not be satisfied on the embedded verb, and the parser therefore revised the initial gap assignment and searched for another verb in the remainder of the sentence.

Alternatively, we could interpret these data as evidence that active gap creation for Japanese children is triggered only upon processing the verb: no gap is created until the verb is reached, and when the verb semantics is compatible with the wh-phrase, a gap is created regardless of the presence of a filled-gap, whereas no gap is created when the verb does not meet the requirements of the wh-phrase. Under this view, the lack of main clause interpretation in the filled-gap condition implies that the syntactic cue did not serve as an effective preventive cue to block gap creation at the verb, whereas in the selectional mismatch condition the verb
information was used to effectively prevent the parser from creating a gap.

As pointed out above, the current study does not provide time course data that could be used to identify the trigger of gap creation, but on either account – whether the cues were corrective or preventive – it still holds that verb semantic cues are more accessible for children, even when they appear later than the potential gap position. This conclusion may appear to be in conflict with the results from Choi and Trueswell (2010), in which Korean children were unable to use later arriving verb information to adopt an adult-like interpretation. We argue, however, that there is no conflict, and in fact the present finding along with Choi and Trueswell’s results together suggest that late-arriving information is ineffective only in contexts where both early syntactic and semantic commitments must be retracted. In Choi and Trueswell’s stimuli, the critical ambiguity arose due to the morphological ambiguity of the -ey particle, which can be analyzed as a destination marker (forcing VP-attachment) or a genitive case marker (forcing NP-attachment). Here, resolving the morphological ambiguity leads children to make an interpretive commitment. In our stimuli, on the other hand, the interpretation of the fronted locative wh-phrase did not vary as a function of the attachment site. In this sense, the revision demands in our present study (i.e., syntactic revision) were smaller than in Choi and Trueswell’s study (i.e., syntactic and semantic revision), and this could explain why children were more successful at using the verb semantic information in our study. This account of the contrast is compatible with the view that children’s revision difficulties reflect their immature cognitive control mechanism, as this proposal does not predict a categorical failure in children’s ability to use late arriving information, but rather predicts that their performance should vary as a function of the actual cognitive control demands. Further studies are needed to investigate this suggestion, but this line of detailed comparative research on adult child reanalysis mechanisms promises to
further our understanding of the nature of kindergarten-path effects.

Finally, further studies are needed to investigate whether our demonstration of the ineffectiveness 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 less effective because the fronted wh-phrase was an adjunct. Adjuncts are not selected by verbs, hence there is no strict syntactic limit to how many adjuncts attach to VPs. This flexibility in VP-adjunction could be the reason why the filled-gap manipulation for wh-adjuncts was not effective. 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 is only a restricted number of argument positions available depending on properties of the verb. Thus, if the available argument positions are occupied by overt constituents, this might serve as a very clear error signal.

4. Conclusion

The results of the current study suggest that adults and children alike resolve wh-attachment ambiguities by actively associating a fronted wh-phrase with the first interpretive position in the sentence, regardless of the canonical word order of the language, and that children are able to use verb semantic cues more effectively than syntactic cues to modulate their active gap creation bias. This suggests that children can use verb semantic cues better than syntactic cues either in corrective or preventive ways to guide their wh-attachment decisions in an adult-like fashion, provided that these cues do not require the revision of an interpretation that has been assigned to the ambiguous constituent.
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