THE USE OF SENTENCE STRUCTURE AND PRAGMATIC CUES IN NOVEL VERB LEARNING: A CROSS-LINGUISTIC STUDY OF MANDARIN CHINESE AND ENGLISH

By

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Abstract

As children hear a novel verb in a NOUN-VERB-NOUN (i.e., NVN) structure, they generally infer that the verb is transitive, like the verb "hit" (Naigles, 1990; Yuan, Fisher, & Snedeker, 2012). However, the relationship between sentence structure and a verb's transitivity status is not straightforward. Particularly, in typologically pro-drop languages, such as Mandarin Chinese, the object in a sentence is often dropped, so that transitive verbs commonly appear in the NOUN-VERB (i.e., NV) structure. Transitive verbs thus appear in variable sentence structures in Mandarin. On the other hand, though English also allows object dropping, object dropping does not occur as frequently and freely as in Mandarin.

Discourse studies show that speakers' uses of object-dropping are closely related to the discourse-pragmatic principle of NEWNESS/OLDNESS, which is linguistically universal. Therefore, this study compared Mandarin-speaking and English-speaking children's interpretation of a novel verb in an object-dropping context, specifically testing whether children in both language groups could utilize the NEWNESS/OLDNESS cue in the context of object omission, then interpret a verb as still being transitive in the NV structure.

Children from both language groups participated in a verb-learning experiment, in which novel verbs were presented in the object-dropping context, an NV-only, and an NVN-only context. After learning the novel verbs, children decided whether the novel verbs were transitive or intransitive. Results suggest that for both language groups, when novel verbs were presented in the object-dropping context (i.e., NVN sentence followed by a NV sentence), children gave more transitive/causative interpretations than when these verbs were presented in the NV-only context. This suggests that children from both language groups used the pragmatic cue of NEWNESS/OLDNESS in the object-omission context. The results also show that across

languages, children interpreted a verb as transitive very frequently when it was presented in the NVN-only context, suggesting the universality of the use of the NVN structure cue. In the NV-only context, Mandarin-speaking children were more likely to give a causative interpretation than English-speaking children did. This discrepancy reflects the fact that object dropping is much more common in daily conversations in Mandarin than in English. In sum, this study found that children across languages used the NVN syntactic cue in novel verb learning. English-speaking children used the pragmatic cue of NEWNESS/OLDNESS to learn novel verbs. Mandarin-speaking children most likely did the same.

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Chapter 1: Introduction

Verb Learning

As children encounter a novel word, they undergo a "fast mapping" process (Carey & Bartlett, 1978) that involves identifying and linking the form of the word to its referent and storing an initial representation in memory. During fast mapping, the initial lexical representation that children construct for a novel word lacks details and can even be erroneous. Later, children refine their initial interpretation of the word as the exposure to the word increases over time (e.g., extended mapping, Carey & Bartlett, 1978), or as the exposure to the word occurs across different situations (e.g., cross-situational mapping, Siskind, 1996). Despite the preliminary nature of lexical representation gained from fast mapping, fast mapping is the initial process that serves as the gateway to robust and rich learning of a word. This study focused on the initial lexical representation children construct for a novel verb under the circumstance in which word exposures are minimal.

Learning a word is not simple. However, children learn words rapidly starting at the age around 19 months (Clark, 1973). How can children successfully learn words so quickly? The key lies in children's ability to use multiple cues instead of a single cue to help them learn words. The use of multiple cues can account for why children can quickly perform fast mapping, successfully linking a word to its referent among infinite candidates. There are several models that emphasize the use of multiple cues in word learning (e.g., Bloom & Margulis, 1996, the Intentionality Model; also see Woodward, 2000, for a review of multiple cues; Yu & Ballard, 2007). One example is the "emergentist coalition model" raised by Hollich, Hirsh-Pasek and Golinkoff (2000). This model speculates that every time a novel word is encountered, children are "tuned in" to the relevant cues available in the learning episode. For example, when a child

hears a novel verb "*FO*" in the sentence "*I am FO-ing",* if the child tunes into the morphosyntactic cue of this sentence, then the child may correctly infer that the word *FO* is a verb rather than a noun. Following the hypothesis that the use of multiple cues facilitates word learning, this study specifically examined how children may use **syntactic** cues and the **discourse-pragmatic** cue of NEWNESS/OLDNESS in novel verb learning.

Syntactic Cues

The use of syntactic cues to aid verb learning has been well discussed in the verb learning literature (Gleitman & Landau, 1985; Naigles, 1990; Yuan, Fisher, & Snedeker, 2012). Specifically, the discussion in the previous literature centers on whether the syntactic structure of a sentence implies the transitivity status of the verb used in the sentence. The transitivity status of a verb refers to whether a verb takes an object or not. An object is a noun that undergoes the action of a verb. For example, the English verb "hit" requires an entity that performs the hitting action (e.g., "Mary" in "*Mary hits Bob*"), and an entity that undergoes the action of hitting (e.g., "Bob"). Verbs that require both the "do-er" (the "AGENT" thematic role) and the "do-ee" (the "PATIENT" thematic role) are called "transitive verbs". On the other hand, verbs that do not take objects, but only require the subject, are called intransitive verbs. The subject of a verb in English is typically the AGENT or the "EXPERIENCER[1]" of the verb action. The English verb "jump" is an example of an intransitive verb. It only requires the entity that performs the jumping action. When a novel verb is presented in a NOUN-VERB-NOUN structure (henceforth NVN frame), that structure is a potential cue to infer that this novel verb is a transitive verb. In contrast, hearing a novel verb in the NOUN-VERB structure (i.e., the NV frame) is a potential

[1] An experiencer is the entity that receives the sensory input. For example, "Mary" in the sentence "Mary saw a picture on the wall" is an experiencer.

cue that this novel verb is an intransitive verb (according to Naigles, 1990). See Table 1 for examples. The hypothesis that children use syntactic cues to learn verbs is called "syntactic bootstrapping" (Gleitman & Landau, 1985). Empirical evidence has supported this hypothesis (Landau & Gleitman, 1985; Naigles, 1990; Yuan et al., 2012).

Table 1.
Inferences about the Transitivity Status based on Syntactic Frames According to Naigles (1990)

Syntactic structure of a novel verb	Example	Inferences about the verb's transitivity status
NVN	John is FO-ing Bob	Transitive verb
NV	John is FO-ing	Intransitive verb

There is no doubt that transitivity inferences based on syntactic cues may lead to errors. Sometimes a transitive verb is used without an object under specific contexts (See Goldberg, 2001 for a review). However, some researchers believe that even if syntactic cues do not lead to the correct inference in all cases, the strength of syntactic cues is still hypothesized to be strong and reliable enough for children to use (Lidz, Gleitman, & Gleitman, 2003). Empirical evidence supports this claim (Lidz et al., 2003; Naigles & Hoff-Ginsberg, 1995). In the study of Naigles (1990), two-year-old English-speaking children watched videos in which two characters performed a causative[2] (e.g., character A bent character B's arm) and a non-causative action

[2] In a causative action, the AGENT performs an action that causes the PATIENT to do something, or change its state. For example, the verb *"trip"* in the sentence "*Mary tripped Bob*" refers to a causative action, in which the AGENT Mary did something to make the PATIENT Bob stumble. Transitive verbs do not have to be causative. However, a causative verb must be transitive. On the other hand, an intransitive verb must be non-causative. To maximize the differences between the visual representation of a transitive and an intransitive verb, previous studies often used videos showing causative actions to represent transitive verbs, and videos showing non-causative actions to represent intransitive verbs.

(e.g., character A waved his own hand) simultaneously. While watching each video, children also heard a novel verb presented in either a NVN structure (e.g., *Duck is FO-ing Frog*) or a NV structure (e.g., *Duck is FO-ing*). Using a preferential-looking paradigm, children's eye fixation on each video was recorded. The results of Naigles (1990) showed that when the verb was presented in the NVN structure during the video, children had longer eye fixation on the causative video than on the non-causative video, indicating that they interpreted the novel verb as a transitive verb. In contrast, when the novel verb was presented in a NV structure, children looked longer at the non-causative video than on the causative video, indicating that they interpreted the verb as an intransitive verb. Taken together, the result suggested that children interpreted the meaning of a novel verb based on the sentence structure in English.

Although it is widely agreed upon that children use the NVN structure as a cue (Arunachalam & Waxman, 2010; Naigles, 1990; Yuan et al., 2012), the use of the NV structure did not produce consistent results across studies. While some studies found the NV structure was used by children as an indicator for an intransitive verb (Naigles, 1990; Noble, Rowland, & Pine, 2011), some studies found children selected videos at chance when a novel verb was presented in the NV structure (Arunachalam & Waxman, 2010; Yuan et al., 2012). Nevertheless, it is clear that the differences in sentence frames (NVN vs. NV) indeed impacted which video children selected.

To date, almost all syntactic bootstrapping studies in the literature only presented novel verbs in highly reliable cues. That is, child participants in their studies heard the novel verb in only one type of frame, either the NVN or the NV frame. In reality, children hear verbs used in varying frames. For example, a transitive verb can be presented in a sentence in which an object is dropped. In English, it is okay to say, "*Tigers kill at night*" (borrowed from Goldberg, 2001),

omitting the object. In Mandarin, object dropping occurs extensively (Lee & Naigles, 2005). If children stick to the inferences laid out in Table 1, they may produce erroneous interpretations when a novel verb is presented in varying structures, such as in the object dropping situation.

Potential Problems Caused by Object Dropping

As mentioned above, in Mandarin Chinese, the syntactic cues may be less reliable than the ones in English. The reason is that Chinese is a pro-drop language that permits argument omission (i.e., omitting the arguments of a verb, such as the object or the subject of a verb). When an argument, such as the object of a sentence, is omitted, it poses a challenge for children when using syntactic cues, because argument omission allows a verb to be used in variable syntactic structures, decreasing the reliability of the syntactic cues. For example, the transitive verb in Mandarin, qin 'kiss', can be used in the NVN structure, as in sentence (1). However, when the object is omitted, this verb can also appear in the NV structure, as in (2)[3].

(1) **Transitive** verb used in the **NVN** structure

ta qin le[4] ni

HE KISS PFV YOU

'He kissed'

(2) **Transitive** verb used in the **NV** structure

ta qin le _____[5]

[3] Note that like English, the typical word order in Mandarin Chinese is also Subject-Verb-Object.
[4] Le is a perfective aspect marker (PFV) in Mandarin.
[5] The symbol "____" represent a trace, which is an unpronounced placeholder to indicate the position of a constituent before it is moved.

HE KISS PFV

'He kissed (someone)'

Prevalence of Object Dropping in Mandarin Chinese

A corpus analysis of Mandarin child-directed speech (Lee & Naigles, 2005) suggests that, Mandarin caregivers used transitive verbs in the NVN structure only 39% of the time. That is, when children heard a verb in the NV structure, as high as 61 % of the time the verb could actually be a transitive verb. In the case of novel verb learning, when the novel verb is used in the NV structure, the verb can either be a transitive or an intransitive verb, as shown in Table 2. If Mandarin-speaking children act like English-speaking children in Naigles (1990) and use the NV structure as a cue to infer that a verb in the NV structure is an intransitive verb, they may make a mistake in this prediction as high as 61% of the time.

Table 2.
Possible Transitivity Status for Syntactic Structures in Mandarin

Syntactic structure of a novel verb	Example	Possible transitivity status of a verb
NVN	*Wo FO le ni* I – FO – ASP- you **'I have FO-ed you'**	Transitive verb
NV	*Wo FO le* I – FO – ASP **'I have FO-ed'**	Intransitive verb

Wo FO le (ni)[6] I – FO – ASP (you) **'I have FO-ed you'**	Transitive verb

(The case of object omission)

Syntactic Mechanism of Object Dropping in Mandarin Chinese

The phenomenon of object dropping in Mandarin has accumulated substantial theoretical discussions (Li, 2014; Shi, 1992; Tsao, 1977). Among the discussions, the concept of "topic chaining" has been proposed (Huang, 1984; Tsao, 1977) as the underlying syntactic mechanism to account for object dropping. In order to understand the concepts of "topic chaining", it is necessary to know what a "topic" is in terms of discourse. Simply put, a topic is "what the sentence is about" in discourse (Li & Thompson, 1981, p. 15), which "refers to something about which the speaker assumes the person listening to the utterance has some knowledge." As Li and Thompson (1981) pointed out, Chinese is a topic-prominent language and has the topic-comment structure. Sentence (3) is a good illustration of a topic-comment structure. Zhangsan is the topic of the sentence and is what the speaker intends to talk about. The pronoun "I" is the subject. The referent of the object, which is Zhangsan, is moved from the object position to the very beginning of the sentence.

(3)

Zhangsan wo yijing jian ____ guo le

Zhangsan I already see ____ EXP[7] PFV

[6] Words in parenthesis are not realized phonetically (i.e., not pronounced).
[7] Experiential aspect marker

The topic-comment structure is a typological feature of Mandarin Chinese (Li & Thompson, 1981) compared to other languages. Other pro-drop languages have this topic-comment structure as well, such as Korean and Japanese. In contrast to the topic-comment structure, languages that are not pro-drop languages, such as English, usually have the subject-predicate structure. Following the idea of the topic-comment structure of Mandarin, Huang (1984) proposed that an argument, such as an object in the sentence, could be raised to the position of a topic (in Chinese the sentence-initial position), leaving a trace as an empty object *e*. Within the framework of the Government and Binding theory (Chomsky, 1981), this means that the empty object is now a trace that is bound[8] by the discourse topic, and its reference must be the discourse topic[9]. Topics can be linked across sentences in discourse to form a "topic chain." When the topic is already presented in the preceding sentence, it can be dropped in the following sentence. The conversation in (4) illustrates topic chaining and object dropping. In (4), the topic *suiguo* "fruit" in speaker B's utterance is raised to the topic position and then deleted, given that it has already been explicitly expressed by speaker A.

(4)

Speaker A: Zhou sang DE suiguo ne?

Table on DE fruit Q[10]

"What happens to the fruit on the table?"

Speaker B: (That fruit$_i$[11]) Wo chi le e_i

[8] See Chomsky (1981) for the concept and principles on binding.
[9] Huang (1984) further discussed the syntactic property of an empty object in Mandarin, and concluded that based on its syntactic features, an empty object is not an empty pronoun or anaphora, rather, an empty entity.
[10] Question marker

(That fruit) I eat PFV

"I ate (it)"

As a consequence of object dropping, the NV structure in (4) contained a transitive verb "eat". Therefore, the NV structure in Mandarin is tricky because it sometimes contains an intransitive verb and sometimes a transitive verb with omitted object(s).

Children's Use of Syntactic Cues in Mandarin Chinese

Due to object dropping, syntactic structures for a verb may be less reliable in Mandarin than they are in English. Two novel-verb learning studies (Cheung, 1998; Jiang & Haryu, 2014) were conducted to examine whether Mandarin-speaking children nevertheless use syntactic cues to infer verb transitivity. Jiang and Haryu used a paradigm similar to the one from Naigles (1990). In Jiang and Haryu's study, two videos were presented side-by-side on a screen. While watching the videos, children aged two to four heard a novel verb used either in the NVN (e.g., "*Uncle is FO-ing Auntie*" in Mandarin) structure or in the NV structure (e.g., "*Uncle is FO-ing*" in Mandarin). Children were asked to select the video that matched the sentence. The results in Jiang and Haryu's study suggest that when children heard the novel verb in the NVN structure, they selected the causative action almost all the time (94% of the time), implying that they might interpret the verb as a transitive verb. On the other hand, when children heard the novel verb in the NV structure, they chose the causative video at chance (47% of the time), indicating

[11] The symbol "i" represents co-indexation, meaning the two elements refer to each other.

equivalent transitive and intransitive interpretations for the novel verb. This result seems to imply that the NV structure in Mandarin might not be a reliable cue for inferring verb transitivity, so children in Jiang and Haryu's study were not strongly guided by this cue in inferring the meaning of a novel verb.

In a similar method, Cheung (1998) taught children novel verbs by showing action videos and presenting novel verbs in sentences with either the NVN or the NV structure. Children were asked to give their interpretation of the verbs verbally. When a novel verb was taught in the NVN sentence structure, five-year-old children were more likely to give a causative interpretation (72% of the time). For a novel verb taught in the NV structure, children were less likely to give a causative interpretation (39% of the time). Results in Cheung's study were similar to those of Jiang and Haryu's study. In sum, these two studies suggest that Mandarin-speaking children used the NVN structure reliably. However, the NV structure was ambiguous and did not lead children toward the non-causative interpretation.

However, a study by Lee and Naigles (2008) found conflicting results, using an act-out paradigm. In their study, children acted out sentences that were presented verbally to them. Half of the transitive real verbs were presented in the NV structure. For example, the transitive verb dai4 'bring' was presented in the sentence "Xiao3 gou3 dai4 ('The dog brings)", without an object. This was the transitive verb - NV frame conflict. Under this condition, children enacted the sentence causatively 30-60% of the time. This range of percentage was significantly lower than the 80-90% of causative enactment when the transitive verb was presented in the NVN structure (e.g., "The dog brings the lion"). Lee and Naigles (2008) concluded that the NV structure strongly biased children toward the intransitive interpretation. Furthermore, the bias was so strong that it overrode the original meaning of the transitive verb. The different findings

in previous Mandarin studies centered on the NV structure, which formed a complicated issue due to the object dropping feature in Mandarin. This warrants a need to examine object dropping in Mandarin more closely.

An important limitation of the past studies comes from the fact that these studies did not test conditions in which the object is omitted. In the past studies, each novel verb was only presented in one sentence. It was either presented in the NVN or the NV structure. Object-omission interpretation was not allowed in this single-sentence paradigm. That is, when a novel verb was presented in a single sentence with the NV structure, like "Ma3-li4 zai4 fo4" (Mary is FO-ing) in Mandarin, it was pragmatically unacceptable to interpret the sentence as "Mary is FO-ing (something/someone)" based on the sentence alone. As a result, presenting the NVN or the NV structure in a single sentence did not set up the context for object dropping. As such, what children heard in the single-sentence paradigm used by previous studies differed markedly from the input that Mandarin-speaking children hear in the naturalistic environment, which includes extensive argument dropping. Therefore, multi-sentence paradigms in which a verb is presented in various syntactic structures are needed so that the empirical evidence is drawn from scenarios that are closer to what children hear in the real world. The later section on experimental design presents how this study taught novel verbs in a multi-sentence paradigm in which a verb was presented in variable syntactic structures.

Using Pragmatic Cues in Mandarin Chinese

How would a multiple-sentence paradigm assist a child in inferring that an object has been omitted? Luckily, object omission does not occur freely but happens only under certain discourse contexts. Borrowing Greenfield and Smith's (1976) *principle of informativeness*, Allen

(2000) listed several discourse-pragmatic factors that influence how a referent in a discourse is realized, such as with a lexical form, a pronoun, or a null form (i.e., omission). The principle of informativeness suggests that " children tend to encode those aspects of the event that are most informative ... and children tend not to encode those aspects of the event that are presupposed" (Allen, 2000, p. 485). Presupposed information is of low informative value. For a referent that carries low informative value (e.g., already presented in the physical context), children tend to realize it with a pronoun or completely drop it from the discourse. For a referent that carries high informative value (e.g., the referent is absent from the physical context), children tend to realize it with a lexical form. The principle of informativeness has been investigated in many languages and is mostly agreed to be language universal (see Allen, Skarabela, & Hughes, 2008 for a review).

This study focused on the discourse-pragmatic factor of NEWNESS/OLDNESS in Allen (2000)'s framework (following the terminology used in Allen, Skarabela, & Hughes, 2008; also known as the "giveness" principle, as in Graf, Theakston, Lieven & Tomasello, 2014). The NEWNESS/OLDNESS principle in a discourse context refers to the fact that an overt argument (i.e., arguments that are phonologically realized) usually refers to a *new* referent that has not been introduced in the discourse earlier, whereas an omitted argument usually refers to an *old* referent that has already been mentioned in discourse (Allen, 2000; Allen et al., 2008; Clancy, 2003). The example below in sentence (6) shows how an object is omitted in Mandarin because it refers to an old referent. The verb used in (6) is *da* 'hit', which takes *Xiao-Ming* as the object. However, *Xiao-Ming* is omitted in (6) because he has been mentioned earlier in (5). It is clear to both speakers that the omitted object in (6) refers to *Xiao-Ming*.

(5) Speaker1: Ni da le Xiao-Ming ma?

You hit ASP Xiao-Ming Q[12]

'Did you hit Xiao-Ming?'

(6) Speaker 2: Wo3 da3 le5 _____ .

I hit ASP (Xiao-Ming)

'I hit (Xiao-Ming).'

This NEWNESS/OLDNESS terminology should be distinguished from the idea of new/old information raised by Chafe (1976) or Prince (1981). According to Chafe (1976), "given/old" information is "the knowledge which the speaker assumes to be in the consciousness of the addressee at the time of the utterance" (p.30). Old information could be inferred or evoked textually (from the context), as suggested by Prince (1981). Old information discussed in the NEWNESS/OLDNESS principle used by Allen and other researchers specifically refers to the latter category (i.e., evoked textually) in Prince's taxonomy. That is, whether a referent carries new or old information depends on whether such information has been mentioned earlier in the discourse.

Huang (2011) analyzed Mandarin-speaking children's conversations with mothers and found that children were sensitive to this NEWNESS/OLDNESS pragmatic principle and omitted object arguments only when they referred to referents that were mentioned in prior discourse. This suggests that Mandarin-speaking children are sensitive to this pragmatic factor and have the potential to use this principle as a cue to facilitate novel verb learning. Nevertheless, studies examining the pragmatic effect on argument structure were limited to production tasks.

[12] Question marker in Mandarin.

Particularly, this line of research looked at the preferred argument structure that children used with familiar verbs. Specifically, they examined children's preference of using the null form, pronominal form, or full lexical form for the subject/object in their sentences. To date, it has not been shown whether children can use discourse-pragmatic cues to infer the transitivity status of novel verbs.

In conclusion, the object-drop feature in Mandarin Chinese provides an interesting case for us to investigate how syntactic structure cues interact with the pragmatic cue of NEWNESS/OLDNESS. Moreover, the interaction between syntactic cues and pragmatic cues might differ across languages. A cross-linguistic comparison enables us to examine the language-specific and language-general properties in this syntactic–pragmatic cue interaction. For the current study, English was chosen to compare with Mandarin. The reason was that object dropping in English is regulated by some language-general as well as some language-specific rules, and the latter rules differ quite a lot from Mandarin.

Object Dropping in English

Unlike Mandarin Chinese, in English the NV syntactic cue is more reliable in indicating an intransitive verb. Based on the corpora analyses of maternal speech, the NV structure in Mandarin was used for transitive verbs (i.e., the case of object dropping) as high as 28% of the time (Lee & Naigles, 2005). In contrast, in English, the NV structure is used for transitive verbs as little as 13% of the time (Naigles & Hoff-Ginsberg, 1995). To summarize, this means that object dropping does not occur as often in English as it does in Mandarin.

Goldberg (2001) discussed the contexts that permit object omission in English. Some of them also apply to Mandarin, but some of them do not. English differs from Mandarin in that the

dropped object has to refer to *indefinite* entities[13]. If the object argument refers to a particular entity or a definite set of entities, the object argument must be overtly expressed in English. The case is illustrated in sentence 7 and 8. In sentence 7, the referents of the object are some types of food that are indefinite. In sentence 8, the referents specifically refer to a definite set of food. The referents were not any kind of tomatoes or onions, but were the specific set that were in the fridge last night. Therefore, in sentence (8), the referents must be expressed overtly.

(7) The chef-in-training chopped ∅ and diced ∅ all afternoon (∅= "some type of food")

(Goldberg, 2001, p.506)

(8)

Speaker A: What did the chef-in-training do to the tomatoes and onions in the fridge last night?

Speaker B: #[14] The chef-in-training chopped ∅ and diced ∅ all afternoon (∅= "the tomatoes or the onions")

On the other hand, Mandarin does not have this restriction. Entities that are definite can also be dropped, as illustrated in sentence (5) and (6). The proper name Xiao-Ming is a definite entity, and is dropped in (6). This specific requirement of indefiniteness in English may account for why object dropping is less frequent in English than in Mandarin.

Another difference between English and Mandarin is that English does not allow a topical[15] referent to be dropped. By contrast, in Mandarin, referent that is at the topic position can be dropped, via the aforementioned "topic chaining" mechanism as illustrated in sentence

[13] Goldberg (2001) discusses a very unique context for object to be dropped for definite referent. It is the verb pair context. See p.515 for discussion.

[14] The symbol # indicates semantic anomaly.

[15] The following sentence pair illustrates violation to this non-topical restriction. In speaker A's utterance, "those cans" is put on the topic position. As a consequence, they cannot be omitted, as speaker B does.

A: What should we do with those cans?

B: #You crush and I'll stuff.

(4). This difference of "topicality" is also related to the fact that object dropping is more frequent in Mandarin than in English.

Nevertheless, some contexts that permit object dropping are language-universal and shared by both English and Mandarin. These contexts are related to the aforementioned "informativeness" principle. Referents that are highly informative in the discourse cannot be dropped, whereas those that are low in terms of informativeness can be dropped.

For example, in both English and Mandarin, the referents that are typical or predictable can be dropped (see Goldberg, 2011, for the discussion for English; Li & Thompson, 1981, for the discussion for Mandarin). Take sentence (7) in English as an example, it is assumed that the objects of the verb "chopping" and "dicing" are some types of food that are typical for cooking. Given that these referents are typical, they carry low informative value, and they are not worth mentioning in discourse.

The target context that was of interest in this study was when a referent carried old information as a result of being mentioned earlier in discourse. This context is also language-universal and applies to both Mandarin and English. According to the NEWNESS/OLDNESS principle, arguments that carry *old* information are underinformative and can be dropped, while arguments carrying *new* information are highly "informative" and dropping it violates the pragmatic principle.

Empirical evidence suggests that just like Mandarin-speaking children, English-speaking children are sensitive to this NEWNESS/OLDNESS factor in terms of how they realize the subject and/or the object in sentences (See Serratrice, Sorace, & Paoli, 2004, for the discussion on the object argument; See Paradis & Navarro, 2003, for the discussion on the subject argument). Like Mandarin-speaking children, English-speaking children showed a tendency to

use lexical forms to express a referent that was newly introduced to the discourse, and tended to express an aforementioned referent in the discourse with a pronominal or null form. However, as is the case in Mandarin, it has not been demonstrated whether English-speaking use the NEWNESS/OLDNESS pragmatic cue in novel verb learning.

The object dropping phenomenon in Mandarin and in English are like the two ends of a continuum. Object dropping is pervasive and quite free in Mandarin, whereas it is less frequent and more restricted in English. For this distinct property of object dropping, it is beneficial to compare Mandarin and English in this study, to further our understanding in how language-general factors (i.e., NEWNESS/OLDNESS) work relative to language-specific characteristics.

Experimental Design for Object Dropping

This study investigated whether Mandarin-speaking children and English-speaking children could use both the syntactic and pragmatic cues in novel verb learning, when object omission occurred. For example, a novel verb *FO* was presented in an object omission context using a multi-sentence paradigm as in Table 3.

Table 3.
An Example of the Multi-sentence Paradigm

	Object-omission condition	NVN-control condition	NV-control condition
Sentence 1	Bird is FO-ing Rabbit.	Bird is FO-ing Rabbit.	Bird is FO-ing.
Sentence 2	Dog is also FO-ing (Rabbit)[16].	Dog is also FO-ing Rabbit.	Dog is also FO-ing.
Question	Which video is FO-ing?		

[16] "Rabbit" in the parenthesis is not realized phonetically.

The same design was used for both the Mandarin and the English studies. For ease of explanation, sentence stimuli in Table 3 and below were presented in English. Participants for the Mandarin study heard the Mandarin version of the stimuli. In the object-omission condition, children heard two sentences in a row. Sentence 1 presented the verb *FO* in the **NVN** structure (e.g., *Bird is FO-ing Rabbit*), immediately followed by sentence 2, which presented the *FO* in the **NV** structure (e.g., *Dog is also FO-ing*). Each sentence was played simultaneously with two videos presented side-by-side. One of the videos displayed a causative action, while the other a non-causative action. As for the characters, the videos for sentence 1 and 2 had different subject/agent characters but the same object/patient character. According to the NEWNESS/OLDNESS principle, only the old referent can be dropped in a sentence. Therefore, maintaining the same object/patient characters across the sentences sets up the appropriate pragmatic conditions for dropping the overt marking of the object/patient.

Notice that in sentence 2 the conjunctive adverb *also* (*ye* in Mandarin) was used. The adverb of *also/ye* marks coordination (Paris, 1979). It emphasizes the sameness between propositions, which were sentence 1 and 2 in this study. For this function, using this conjunctive adverb in sentence 2 helped children to treat sentence 1 and 2 conjointly and view them as an integral context rather than two unrelated sentences. The use of *also/ye* is obligatory when the topics (in this study, the sentential subjects) of the consecutive sentences are different (Liu, 2009), as in this study.

In sentence 1, *FO* appeared in the NVN syntactic frame, which was a reliable cue that the action was causative. Thus, children might infer that *FO* referred to a causative action. In sentence 2, *FO* appeared in the NV syntactic structure. If children used the pragmatic cue of NEWNESS/OLDNESS, they would infer that the object has been dropped given that it referred

to an old referent (i.e., Rabbit). Thus, the exposure to sentence 2 would further reinforce the child's original inference that *FO* referred to the causative action, which indicates that they interpreted *FO* as a transitive verb. On the other hand, if the child did not use the cue of NEWNESS/OLDNESS, hearing *FO* in the NV structure in sentence 2 might lead children to infer that *FO* sometimes referred to the non-causative action and sometimes to the causative action, as found in past studies. As such, children might select the causative video at chance.

After children heard *FO* twice in sentence 1 and 2, they were tested. They watched a causative and non-causative video pair and simultaneously heard a question "*Which video is FO*?" Then they were asked to choose one video from the pair that corresponded to the verb FO.

Taken together, if children were able to use both the syntactic and discourse-pragmatic cues, they would be able to correctly infer the verb's transitivity status. In contrast, if children were not able to use the syntactic and discourse-pragmatic cues in the case of object omission, they might make erroneous inferences about a novel verb's transitivity status by choosing an action that contradicted the verb's true transitivity status.

Two control conditions, the NVN-control and the NV-control conditions in Table 3, were created to compare children's performance in the case without object omission. In the NVN-control condition, each novel verb was taught consistently in the NVN structure in both sentence 1 and sentence 2. This NVN-control condition should have supported a causative interpretation for the verbs. In contrast, the NV-control condition presented each novel verb only in the NV structure in both sentences. This condition should have boosted a non-causative interpretation or a neutral interpretation (i.e., sometimes non-causative and sometimes causative) for the verbs.

Research Questions and Predictions

This study aims to answer the following questions:

1. Do children, in either language, select the causative action for a novel verb, indicating that they interpret the novel verb as a transitive verb, more often in the **NVN-control** condition than in the **NV-control** condition?

Past studies using a single-sentence paradigm found that children select the causative action for a novel verb more often in the NVN structure than in the NV structure (English studies: Naigles, 1990; Yuan et al., 2012; Arunachalam & Waxman, 2010. Mandarin studies: Cheung, 1998; Jiang & Haryu, 2014). It is predicted that using a multi-sentence paradigm in this study will yield similar results. If this prediction is true, it implies that children across languages use the NVN structure to infer that a novel verb is causative.

2. Do children, in either language, select the causative action for a novel verb, indicating that they interpret the novel verb as a transitive verb, in the **object-omission** condition as frequently as in the **NVN-control** condition?

It is predicted that the four-year-old children recruited in this study will select the causative action for a novel verb in the object-omission condition as often as in the NVN-control condition. Such a result indicates that children may use the discourse-pragmatic cue of NEWNESS/OLDNESS to detect cases when the object is omitted for a transitive verb, and then choose the causative action. Studies investigating the pragmatic effects on the realization of arguments suggest that children produce or omit an object of a verb in conversation in accordance with the discourse-pragmatic factors in discourse (English studies: Allen, 2000; Guerriero, Oshima-Takane, & Kuriyama, 2006. Mandarin studies: Huang, 2011, 2012). This

consistent finding across languages supports the postulation that both English-speaking and Mandarin-speaking children can use the pragmatic cue of NEWNESS/OLDNESS in novel verb learning in the case of object omission. If this postulation is false, children may choose the causative action for a novel verb less frequently in the object-omission condition than in the NVN-control condition. This finding would indicate that the pragmatic cue of NEWNESS/OLDNESS is not strong enough for children to infer that the object in sentence 2 is omitted in the object-omission condition. Instead, children may focus on the fact that the target verb no longer appears in the NVN structure and they may become more reluctant to select the causative action for the verb.

3. Do children, in either language, select the causative action for a novel verb more often in the **object-omission** condition than in the **NV-control** condition?

If the predictions in question (1) and (2) turn out to be true, then both the Mandarin-speaking children and the English-speaking children would choose the causative action more often in the object-omission condition than in the NV-control condition. This is an indication that, under the object-omission condition, the use of the pragmatic cue of NEWNESS/OLDNESS may reinforce children's initial transitive/causative interpretation of a novel verb based on the NVN cue in sentence 1. In other words, both the syntactic and pragmatic cues are used to learn a novel verb in the case when object omission occurs. However, if children do not use the pragmatic cue of NEWNESS/OLDNESS, then there may be no difference in children's selection of causative action between the object-omission and the NV-control condition (See Table 4).

Table 4.
Predictions for Pairwise Comparisons between Conditions across Language Groups

	Predictions on causative video selections	
	Mandarin-speaking children	English-speaking children
Question 1: NVN-control vs. NV-control conditions	NVN > NV	NVN > NV
Question 2: NVN-control vs. Object-omission conditions	NVN = Object-omission	NVN = Object-omission
Question 3: Object-omission vs. NV-control conditions	Object-omission > NV	Object-omission > NV

It is predicted that under the NV-control condition, English-monolingual children will select the causative action with lower percentage than Mandarin-monolingual children do. The NV structure is a reliable indicator for an intransitive verb in English (Naigles & Hoff-Ginsberg, 1995), whereas it may not be as reliable or may be neutral in Mandarin, if we take the findings from Jiang and Haryu (2013) and Cheung (1998), but not the findings from Lee and Naigles (2008).

Testing the Methodology

The experimental design for this study was the first one that directly incorporates a multi-sentence paradigm to examine the use of syntactic and pragmatic cues. For this reason, data

from Mandarin-speaking and English-speaking adults were collected to verify that the patterns predicted above were observed in the fully-developed system of adults regardless of language experience.

Chapter 2: Method

Study 1: Mandarin Study

Participants of adult study. A total of 12 undergraduate students participated the current study. All the participants were female. Participants were recruited from two universities in Taiwan. The mean age of adult participants was 19.8 years (SD = 0.8). A questionnaire was used to check eligibility for participation (see Appendix A). Based on the information provided in the questionnaire, participants were recruited if they met the following criteria: (1) spoke Mandarin Chinese as their native language, (2) did not speak English or any other language at a native-like proficiency, and (3) were exposed to Mandarin more than 10 hours daily. The results of the questionnaire showed that all participants rated their Mandarin proficiency as 7 in all areas of listening, speaking, reading and writing. A rating of 1 represented very poor proficiency, and a rating of 7 represented native-like proficiency. In terms of dialects of Chinese, 10 participants spoke only the dialect of Taiwanese, one participant spoke both the dialects of Taiwanese and Hakka and one participant only spoke the Mandarin dialect. Speakers of Taiwanese rated their Taiwanese proficiency from one to seven. The averaged Taiwanese proficiency rating was 4.9 (SD =1.4) in listening, and 4.2 (SD =1.9) in speaking. The Hakka speaker rated her listening proficiency in Hakka as 3, and her speaking proficiency as 2. The argument structure of Taiwanese and Hakka is not different from that of Mandarin Chinese. As a result, speaking a dialect of Taiwanese or Hakka was not expected to influence the processing of the Mandarin argument structure in this study. The averaged self-rating of English proficiency ranged from 4.0 to 4.8 across speaking, listening, reading and writing domains (SD range: 0.9 to 1.2). Participants on average started to learn English at the age of 7.8 years (SD =2.2). Five participants reported speaking at least one foreign language other than English. The averaged

rating of proficiency in other foreign languages was 3.2 (SD = 0.9). All participants reported that they were exposed to Chinese Mandarin for at least 12 hours every day.

Participants of child study. The data from a total of 42 children were included in the analyses. One child did not pass the language assessment, and thus was excluded from the analyses. Children were recruited from preschools in both the suburban and urban areas of Taiwan, with an approximately equal ratio. Dual-language schools were not considered in the recruitment process to avoid recruiting participants with native-like proficiency in English or in other languages. A questionnaire and a language assessment were administered to confirm children's eligibility to participate in the study. Children were recruited if they met the following criteria: (1) spoke Mandarin and only Mandarin as the native language, (2) spoke Mandarin at the native proficiency level, and (3) received linguistic input of Mandarin from birth. Children were excluded from participation if they (1) spoke English or any other language at the native proficiency level, (2) had a history of any language impairments or current language impairments, or (3) had any developmental or psychological impairments.

Questionnaire. The questionnaire is presented in Appendix B. Results of the questionnaire indicated the following information: The 42 child participants consisted of 22 female children and 20 male children. The mean age was 54.5 months (SD = 3.4 months). All of the children's Mandarin proficiency was rated at the native proficiency level. They had all received Mandarin input since birth. Children were exposed to Mandarin for 13 hours per day on average. As for the dialects of Chinese, 35 children received Taiwanese input at home or at school. On average, those children heard Taiwanese for 3.1 hours per day. In terms of Taiwanese proficiency, the majority of children received a proficiency label of "can converse in that language, but not native-like" (12 participants), or "can only say a few sentences or few words" (13 participants). A total of two participants received Hakka dialect input at home or at school. Both children received Hakka input less than one hour per day. Their Hakka proficiency ratings were both described as "only understand[ing] a few words or not understand[ing] at all." As mentioned earlier, rules of argument structure in Taiwanese and Hakka do not differ from those in Mandarin. Both Taiwanese and Hakka allow extensive dropping of verb arguments (e.g., subject/object). As for the exposure to English, 19 of the 42 child participants received English input at home or at school regularly. They heard English for an average of one hour every day. None of students had received English input from birth. The average age of initial exposure to English was 2.6 years old (SD = 1.2 years). English proficiency of these children ranged from "only understand a few words or do[es] not understand at all" (9 participants, 47%) to "can only say a few sentences or few words (10 participants, 53%)." The above information confirmed that none of the participants could be identified as English-Mandarin bilingual speakers.

Language assessment. A standardized language assessment tool, the Child Language Disorder Scale-Revised (Preschool version) (CLDS-R; Lin, Huang, Huang, & Hsuan, 2008) was administered to assess children's language ability. The CLDS-R was developed to test children aged 3;0 to 5;11. It has four subtests: Voice and Fluency, Language Comprehension, Expressive Vocabulary and Articulation, and Expressive Language. In this study, only the Language Comprehension subtest was administered because this study focused exclusively on understanding the meanings of novel verbs. The Language Comprehension subtest evaluated semantic comprehension, syntactic comprehension, and pragmatics. Comprehension was tested at the word, sentence, and paragraph level. The standard testing procedure was followed during testing. There were three types of questions. For the initial test items, children were presented with picture cards with multiple object items. The experimenter asked children to point to the objects after hearing their names (e.g., "Show me apple, milk and banana") or descriptions (e.g., "Which object is between the glove and the newspaper?). For the second type of question, children heard some sentences followed by questions. For example, they heard "The brother has three pencils, the sister has five pencils, which person has more pencils?" The child needed to provide responses like "the sister." At last, children heard two short passages and then answered several comprehension questions. Each passage was read aloud by the researcher twice. All the comprehension questions were expository/factual questions. Answers of expository questions were explicitly provided in the passages. There were 37 questions in total, and each was worth one point. This language assessment took about 5 to 10 minutes to complete.

The norming of the CLDS-R was based on 725 preschools from over 37 different regions of Taiwan. The sample included 81 four-year-old students. The Language Comprehension subtest had an internal consistency reliability of .88 for the four-year-old norming group,

calculated by the Kuder–Richardson Formula 20 (KR-20). Test-retest reliability was .93. The inter-rater reliability was .99. In terms of validity, the content validity of the Language Comprehension subtest ranged from .78 to .95. The discriminant validity was also calculated. The scores of 48 children that formally received a diagnosis of developmental delay were compared to that of the norm group. The group with developmental delay scored significantly lower than the norm group.

One participant scored below the 16th percentile. His data was excluded from the analysis. The remaining 42 children received a mean raw score of 27.7 (SD = 3.7) on the Language Comprehension subtest. The correspondence percentile score was 54.4 (SD = 19.9). There was a large variability in children's scores. The range was from 22 to 34 in raw scores, corresponding to a range of percentile scores from the 25% to the 97% percentile.

Verb Learning Experiment

The verb learning experiment used a game context to teach children novel verbs and elicit children's responses. The experiment had three parts: (1) The "real-word" practice. The purpose of the real-word practice was to train children to select the target video from a video pair by touching the video on the screen. (2) The novel verb practice. The novel verb practice was designed to familiarize children with the task of learning novel verbs. (3) The novel verb experiment. This part of the experiment presented the experimental trials.

Real verbs for the "real-word" practice. A total of eight verbs were selected for the response practice task. These eight verbs were real verbs and were familiar to children. Half of the verbs were causative verbs. The other half of the verbs consisted of non-causative verbs. These target verbs consisted of two syllables, such as *kan-shu* 'read a book'. Bi-syllabic words

are used more commonly than monosyllabic words in Mandarin. This response practice session focused on helping children practice how to make a response, so the most easily understood real words were chosen.

Causative verbs were defined as verbs that denote an action in which an entity causes another entity or entities to do or feel something. Examples of causative verbs are *open, close, irritate, melt*, etc. This type of verb often involves a change of state. For example, the verb *open* has the meaning of "*open the door to change its state from closed to open*". The most obvious case is the verb *melt,* which involves "*changing the physical state of the materials from solid to liquid"*. Appendix C has a list of the eight practice item verbs.

Novel verbs for practice trials and experimental trials. Novel verbs were used for the novel verb practice trials and experimental trials. Novel verbs were used for the purpose of avoiding real-word bias. The real-word bias exists when the meanings of the real words influence participants' verb interpretation. Each child received two novel verb practice trials and 15 experimental trials.

Mandarin syllable structure consists of onset and rime, as shown in Figure 1. The obligatory element in Mandarin syllables is the nucleus. The remaining elements are optional. The glide sounds /i/, /u/, /y/ can precede or follow a nucleus. The coda follows the nucleus and is usually /n/ or /ŋ/.

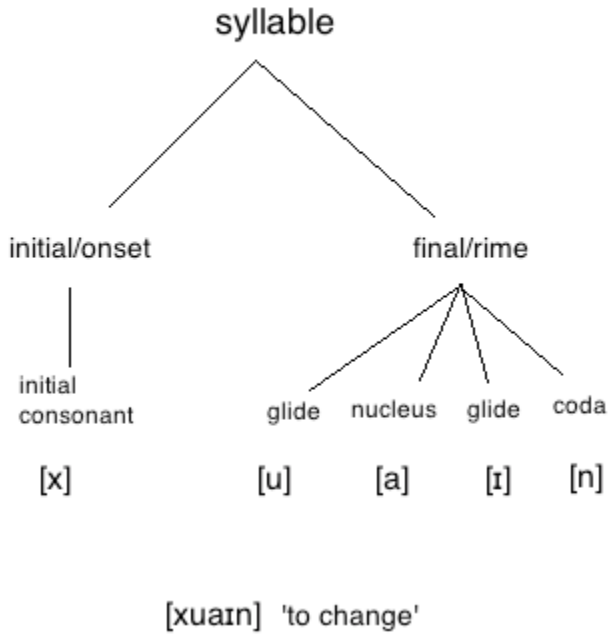

Figure 1. Syllable structure in Mandarin

The novel verbs constructed for the experimental trials had the C[17]V[18](C) structure. Ten of the novel verbs had the CV structure, and the remaining five had the CVC structure. The CV structure is the most common syllable structure in Mandarin. However, it did not yield enough nonwords, so CVC syllables were also used for creating the novel words. To ensure that the novel verbs contained simple syllable structures, the novel verbs for the experimental trials did not have a prenuclear glide. By contrast, the two novel verbs designed for the practice trials both had prenuclear glides. The reason was to maximize the differences in the novel verbs between the practice and the experimental trials. As such, participants' verb learning during the practice trials would not influence the learning during the experimental trials.

All the CV(C) syllables had the fourth tone. The purpose of using the fourth tone consistently across novel verb items was to avoid the effect of tone sandhi. Mandarin Chinese is a tonal language consisting of four tones. Each tone can be described phonetically as: high-level

[17] Consonant
[18] Vowel

(tone 1), high rising (tone 2), dipping/falling-rising (tone 3), and high falling (tone 4) (Li & Thompson, 1981). Tone sandhi refers to the "change of tones when syllables are juxtaposed" (Li & Thompson, 1981), and mostly occurs in the use of third-tone syllables. When a third-tone syllable is followed by another third-tone syllable, the first syllable changes its tone from tone 3 to tone 2. For example, *gan3*[19] 'to drive away' and *gui3* 'demon' both have tone 3. However, when pronouncing these two syllables together, as in *gan3-gui3 'to drive the demon away',* the third-tone for *gan3* changes to the second tone. The fourth tone is not influenced by the tone of a subsequent syllable. Therefore, this study used syllables that contained the fourth tone.

A set of 173 CV(C) syllables that followed the Mandarin phonotactic constraints and had the fourth tone was identified (Mandarin Textbook Editorial Committee of National Taiwan Normal University, 1991). Then, CV(C) syllables that corresponded to real words in the fourth tone were teased out. The Mandarin phonetic chart listed in Mandarin Chinese Phonetics (Mandarin Textbook Editorial Committee of National Taiwan Normal University, 1991) was used for this process. The chart lists all the monosyllables with all four Mandarin tones that correspond to existing Mandarin words.

After that, among the remaining non-word CV(C) syllables, those that did not correspond to any existing words in any tones were excluded. These syllables were sometimes termed the "accidental gap" syllables. That is, these were possible syllables according to Mandarin phonotactic rules. However, they just do not exist in any tone. These syllables were removed because they were never heard in the input. Therefore, these CV(C) syllables might sound too unfamiliar to children, adding another piece of difficulty to the task.

[19] The number after the syllable indicates the original tone for the syllable. Gan3-gui3 is an example borrowed from Li & Thompson (1981).

After removal, 22 fourth-tone CV(C) syllables remained to be the possible syllables for the experimental trials. An example of this type of syllable was ***chao***. When this syllable was pronounced in tone 1 (***chao1***), it corresponded to a word meaning "super, very, extreme". ***Chao2*** corresponded to a word meaning "waves", whereas ***chao3*** had a word meaning "noisy". On the contrary, ***chao4*** did not match any existing words in Mandarin, thus was selected as a candidate for the novel verb pool for the experimental trials.

Among these 22 syllables, syllables that corresponded to slang or common verbs in the Taiwanese dialect (e.g., / ts^h aŋ4/ refers to the Taiwanese verb 'hide') were removed from the list. Seven syllables were removed for this reason. At last, a total of 15 CV(C) syllables remained to be presented as novel verbs during the experimental trials. For these 15 novel verbs, six verbs had one of the late-acquired Mandarin consonants (i.e., ch[20], sh, r, z, c). According to a study on phonemic discrimination (Cheung & Hsu, 2000), four-year-old Taiwanese children could identify these sounds with a 75% accuracy rate. Two CV(C) syllables that contained a prenuclear glide were selected for the novel verb practice trials. These two novel verbs thus had the syllable structure of onset + glide + vowel + (coda). The two novel verbs for the practice trials were pie4 and *zhun4*. Therefore, a total of 17 novel verbs were created for the novel verb practice trials and the experiment trials. See appendix D for a list of all novel verbs in Mandarin.

Sentence stimuli for real-word practice trials. A total of eight questions were created for the real-word practice trials. The purpose of the practice trials was to familiarize child participants with selecting the correct video from a side-by-side video pair by touching the computer screen. The eight questions had the wording "*which video is X*[21]?" Half of the eight questions contained a causative verb, and the other half contained a non-causative verb.

[20] Transcripts in Pinyin
[21] The symbol X here represents the target verb.

Sentence stimuli for novel verb practice trials. The design of the novel verb practice trials had two goals: (1) to familiarize children with the "teach-then-test" procedure of the verb learning experiment; and (2) to familiarize children with hearing verbs that they had never heard before.

As previously described, two novel verbs were constructed for this practice session. For each novel verb, participants first heard a sentence that taught the novel verb, followed by a question to elicit participants' interpretation of the verb meaning. The current study aimed to examine the influence of different syntactic frames on verb learning. In order to prevent biasing participants toward a specific sentence structure, one novel verb was taught in the NVN structure and the other one in the NV structure. The presentation order of the NVN sentence and the NV sentence was randomized across participants. The subjects in the teaching sentences were also counterbalanced so that both characters in the video were mentioned as the subject in one sentence. Table 5 provides a list of sentence stimuli that participants received for this session (English translation).

Table 5.
Sentence Stimuli for the Novel Verb Practice Trials

	Novel verb 1	Novel verb 2
Teaching sentence	Kiki is pie4-ing Mei Mei.	Meimei is zhun4-ing.
Testing sentence	Which video is pie4-ing?	Which video is zhun4-ing?

Sentences and conditions for novel verb experimental trials. A total of three novel verb conditions and one real verb condition were created. The 15 novel verbs were evenly distributed to the (1) object-omission condition, (2) the NVN-control condition, and (3) the NV-control condition.

Three types of "two-sentence pairs" (sentence 1 plus sentence 2) were created for each novel verb (See Table 6). A total of 45 novel verb sentence pairs (3 conditions x 15 novel verbs) were constructed. Participants learned each novel verb in one of the three conditions, resulting in learning a total of five novel verbs for each condition. Which novel verb was taught in which condition depended upon which experimental version the participants received. A detailed description of experimental versions is provided in the experimental version section later in this chapter.

After listening to each two-sentence pair, children heard a testing question to elicit their interpretation of the novel verb. The testing sentence was created in the form of a question: "Which video is X?" A total of 20 question sentences were created.

In the **object-omission condition**, the novel verb was first taught in the NVN structure, followed by the second sentence of a NV structure. In the **NVN-control condition**, both sentences presented the novel verb in the NVN structure. For the **NV-control condition**, the novel verb appeared in the NV structure in both sentences. Compared with the previous studies (Cheung, 1998; Lee & Naigles 2008), the NVN- and the NV-control conditions were identical to those used in the previous literature, except that target verbs were taught only once in the previous literature, but verbs were taught twice in the current study.

Table 6.
Sentence Design for Each Novel Verb

	NV condition	**NVN Condition**	**Omission Condition**
Sentence 1	*xiao3-mao1 zai4 PO* **'Cat is PO-ing'** **(NV)**	*xiao3-mao1 zai4 PO xiao3-gou3* **'Cat is PO-ing Dog'** **(NVN)**	*xiao3-mao1 zai4 PO xiao3-gou3* **'Cat is PO-ing Dog'** **(NVN)**
Sentence 2	*tu4-zi ye3 zai4 PO* **'Rabbit is also PO-ing'** **(NV)**	*tu4-zi ye3 zai4 PO xiao3-gou3* **'Rabbit is also PO-ing Dog'** **(NVN)**	*tu4-zi ye3 zai4 PO* **'Rabbit is also PO-ing'** **(NV)**
Testing sentence	*Na3 yi2 ge ying3-pian4 shi4 PO?* **'Which action is PO(-ing)?'**		

Under the NV condition, sentence 1 and 2 had different verb subjects. For example, in Table 6, the subject/agent was Cat in sentence 1, but Rabbit in sentence 2. Under the NVN condition, similarly, the subjects of the verb were different in sentence 1 and 2, but the object of the sentence remained the same (e.g., Dog in Table 6). In the omission condition, the redundant object was omitted in sentence 2, for it carried old information.

In addition to the three novel verb conditions, a "real-verb" condition was created. Five real verbs were selected and presented in the "real-verb" condition. The purpose of creating this "real-verb" condition was to balance participants' choices of the causative and the non-causative videos. That is, when participants learned a total of ten verbs in the NVN-control and the object-omission conditions, they were expected to interpret these verbs as causative and select the causative videos. However, only five verbs in the NV-control condition were expected to be interpreted as non-causative. Therefore, in order to balance the verb interpretation between

causative and non-causative, five real verbs describing "non-causative" actions were selected for the "real-verb" condition. Five two-sentence pairs were created for the real-verb condition. These sentence pairs had the same sentence structure as that in the NV-control condition. An example of a real-verb sentence pair was "Cat is walking (sentence 1). Rabbit is also walking (sentence 2)." These non-causative real verbs (walk, sleep, jump, run, and cry)were common verbs that were familiar to four-year-old children.

Notice that for all the sentence stimuli, for novel verbs and real verbs, the first sentence used the present progressive aspect *zai4*. The reason was that these sentences were played concurrently with the videos, so the present progressive aspect was the most natural way to describe the on-going actions in the videos. The second sentence also used the present progressive aspect, with an addition of the connective word *ye3* (meaning *also* in English), to emphasize that the target verb in the first and the second sentences were the same verb.

Experimental versions. Three groups of novel verbs, each containing five novel verbs, were each taught in one of the three conditions. In order to control for a possible item effect, a total of three experimental versions were created. Experiment versions assigned the three groups of novel verbs to the three conditions in rotation. For instance, the first experimental version taught the first novel verb group in the NVN-control condition, whilst the second experimental version taught the same group of novel verbs in the object-omission condition. Appendix E provides a list of the three novel verb groups and the real verb group. Children were randomly assigned to an experimental version in a counterbalanced manner (i.e., 14 children per version).

Among the groups of novel verbs, the actions for each novel verb presented in the videos were carefully controlled in terms of saliency and novelty. See the section about video stimuli for more information. In addition, the number of late-acquired Mandarin consonants (i.e., jh, ch, sh,

r, z, c, s[22]) used for the novel verbs were also controlled across the three novel verb groups so that every group had two novel verbs containing a late-acquired consonant.

Sentence recording. All sentence stimuli were recorded in an anechoic chamber at the University of Kansas. The context of a "rescue Ding-Ding" game was recorded by two native Mandarin speakers. Trial sentences were recorded by a female speaker. Each sentence had a natural pace and intonation. Sentences were segmented using the Praat software (Boersma & Weenink, 2014). The sound levels of the trial sentences were controlled and adjusted by using Audacity software (Mazzoni & Dannenberg, 2000). Each trial sentence did not differ more than 3dB.

Two native adult speakers of Mandarin who were blind to the design of the study listened to all the target verb stimuli. They were asked to transcribe each verb they heard in zhuyin fuhao. Zhuyin fuhao is the official phonetic coding system of Mandarin in Taiwan. Both speakers' transcriptions were consistent and matched the original sound of each novel verb, suggesting that these verbs were acoustically and phonetically clear to native adult speakers. Participants also wrote down the real verbs and the characters in the sentences they heard in Chinese characters. They wrote down all the words correctly, indicating that each sentence they heard was clearly understood.

Videos for real-word practice trials. A total of eight video pairs were created for the real-word practice trials. Each video pair displayed two videos side by side. One video displayed a causative action (e.g., opening a door) and another one displayed a non-causative action (e.g., reading a book). In each video, there was only one person acting out these actions.

[22] These consonants are spelled out using the pinyin system of Mandarin Chinese. These late-acquired consonants were identified by two studies: Cheung & Hsu (2000), and Wang, Fei, Huang, & Chen (1984).

Videos for novel verb practice trials. Two videos pairs were created for the novel verb practice trials. The design of the video pairs was the same as for the videos for the experimental trials.

Videos for the experimental trials – novel action norming. Each sentence was presented together with an accompanying side-by-side video pair displaying a causative and a non-causative action separately. These actions were designed as novel actions to match the novel verbs. To control the saliency and novelty between the causative and the non-causative actions within each pair, a norming procedure was conducted for the novel actions before filming the videos. A total of 26 causative actions and 26 non-causative actions were designed. Each action was recorded in an individual video. In each video displaying a causative action, a person performed a causative action to another person. On the other hand, in the videos of each non-causative action, only one person appeared in the video and performed a non-causative action to self. A total of 52 videos (26 causative plus 26 non-causative actions) were presented individually to 10 native Mandarin-speaking adults to determine the visual saliency of the action pairs. They were all college students from the University of Kansas. The average age was 31 years.

To assess visual saliency of each action pair, videos displaying the causative and the non-causative actions were presented to participants performing the norming task. Each video was presented individually on PowerPoint. A scoring sheet was given to participants. The scoring sheet asked, "From one (not salient at all) to seven (very salient), how salient do you think the action is in the video?" Participants rated the saliency of each action by using this seven point grading scale. The groups of causative action videos and the non-causative action videos were presented in a counterbalanced order across participants.

In order to control for the "novelty" of each novel action, the same 10 adult participants were asked to write down a sentence describing each action. "Novelty" of each action refers to the ease of linking a novel action to an existing verb. The more novel an action is, the less likely it can be tied to an existing verb. An action that is interpreted as a typical exemplar of an existing verb (e.g., an action of pushing someone's back is a typical action that can easily be identified by the verb "pushing") may influence children's interpretation of the novel verb. Thus, it is desirable to select actions that are not highly typical exemplars of an existing verb (e.g., a non-typical action is like moving the arm in an up-and-down wavelike motion to push someone's back).

The novelty score of a verb was calculated by summing up the number of participants that wrote down elaborate descriptions for that particular verb. Examples of elaborated details included the manner of the motion (e.g., " tapping shoulder with a claw-like hand"), or an additional verb description (e.g., instead of simply writing down "waving an arm", the participant wrote three verbs in the sentence "bending the arm and making it touch the head, then waving the arm"). Descriptions using a metaphor, such as "acted like a monkey", or with a symbolic meaning, such as describing a head-tapping action as "measuring one's height", were categorized as "other." These descriptions were excluded from the calculation of the novelty score. If a participant described an action of hitting one's own stomach with a fist as "punch" (a single word) this would receive a score of 0. In contrast, if a participant described the same action as "make a fist and hit one's own stomach in a slowly and repetitive motion", this would receive a novelty score of 1. The novelty scores of all 10 participants were summed, leading to a novelty score range of 0 (no detailed descriptions for any participants) to 10 (a detailed description from all participants). Thus, higher scores indicated greater novelty.

Detailed information on the saliency and novelty scores for each action is provided in Appendix F. Causative actions were paired with non-causative actions based on their similarities in the saliency and novelty scores. A total of 15 action pairs were created. These 15 action pairs were paired with the 15 novel verbs used in the experimental trials. Within each of the resulting pairs, the saliency scores did not differ by more than 1.5 points and the novelty scores did not differ by more than 1 point. This matching was intended to ensure that paired causative and non-causative actions were similar in saliency and novelty.

Recall that the 15 novel verbs were divided into three groups to create three different experimental versions. Table 7 shows the mean novelty scores and the mean saliency scores among these three groups.

Table 7.
Mean Scores for Novelty and Saliency

Verb groups	Mean Novelty score (SD)	Mean Saliency score (SD)
1	5.75 (.42)	5.60 (2.55)
2	5.80 (.45)	5.60 (2.63)
3	5.69 (.46)	5.60 (2.84)

Videos for experimental trials – training and testing videos. A set of training videos and another set of testing videos were created for the 22 target verbs. Among these verbs, 15 novel verbs and five real verbs were used for the experimental trials, and two novel verbs were for the novel verb practice trials. Two characters performed these actions in front of a white wall as the background of the videos. All videos had a resolution of 1280 x 720.

For the verb teaching videos, a side-by-side video pair was constructed and presented simultaneously with each teaching sentence. Each target verb in the experimental trials was taught twice; thus, participants heard two teaching sentences and watched two videos for each verb. A total of 40 videos (2 x 20 verb items, including the 15 novel verbs and 5 real verbs) were created for the experimental trials. The novel verbs for the novel verb practice trials were only taught in one video pair, resulting in two video pairs in total.

The causative and non-causative distinction was made obvious so children could understand the task easily. Two characters were used throughout the experimental videos, so that the number of characters would not give extra cues to influence children's choice of verbs. Each character wore a different animal costume. As an example of the causative action, the character Cat raised Dog's hand to make it wave (see Figure 2 & 3). In contrast, as an example of the non-causative action, Cat moved her two fingers to mimic the walking action. For each verb in the experimental trials, the character for the AGENT (the doer of the action) changed from pair to pair whereas the character for the PATIENT (the undergoer of the action) between the two video pairs remained the same (see Figure 2 & 3).

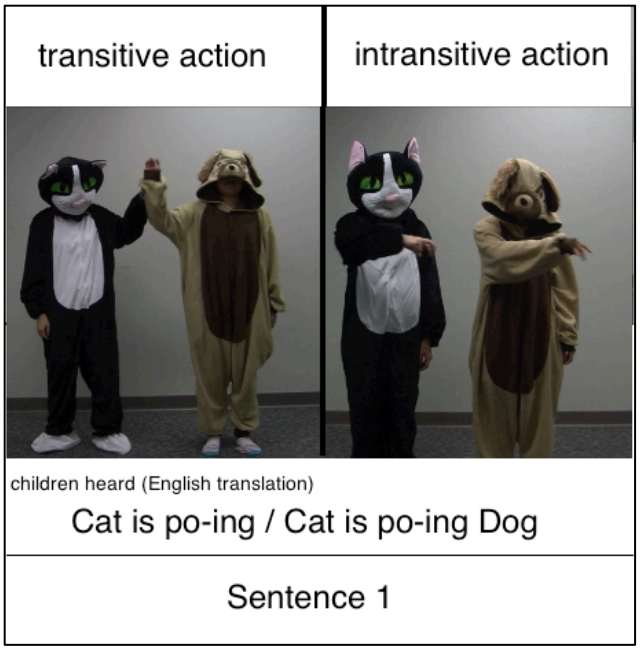

Figure 2. Example of the teaching video in sentence 1

Figure 3. Example of the teaching video in sentence 2

Similar to the teaching videos, testing videos also presented a causative action video and a non-causative video in a side-by-side fashion for each novel verb (see Figure 4 for a testing video pair). The characters in the testing videos did not overlap with the characters appearing in the training videos. The teaching videos had animal characters, whereas the characters in the testing videos were human characters introduced to children at the beginning of the experiment. The purpose of changing to human characters was to eliminate the possibility that children's memory of or preference for a certain character pair in the training videos would interfere with their responses on the testing videos. For example, if a child sees the Cat and Dog characters in the testing video and in one training video in which the verb is presented in a NVN structure, then s/he will be more likely to choose the causative action during testing. Using human characters, participants' responses reflected their initial interpretations of the verbs acquired at the teaching phase, plus the generalization of the initial interpretations to stimuli with human characters at the testing phase.

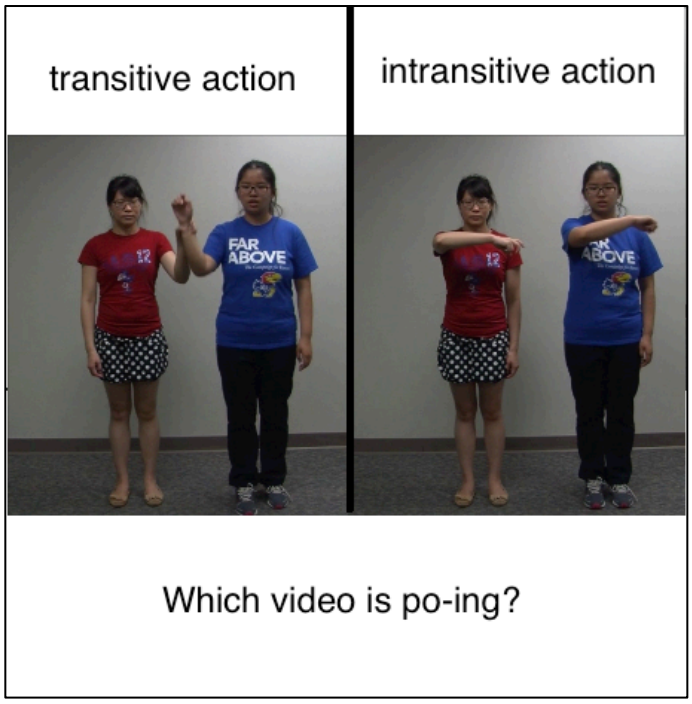

Figure 4. Example of the testing video

Procedure. A consent form and a language background questionnaire were distributed to parents in a recruitment packet. After child assent was obtained, children were tested individually in a quiet room in their preschool.

Children received the experiment session prior to the language assessment. During the experiment, children were seated in front of a touchscreen laptop. At the beginning of the experiment, the researcher said the following instructions to the child: *"Now I will let you play a game. You will see two videos on the computer and hear a sentence each time. You will choose the video that matches the sentence you heard. Choose the video by touching the screen with your finger. Now, we will first see some animal pictures and then we will watch videos. Are you ready?"* After the instructions, the verb-learning game was run on the Paradigm experiment software (Tagliaferri, 2005).

At the beginning of the game, children saw pictures of animal characters, which later appeared again in the experimental trials. Children said the name of each animal out loud. The

names were provided to children if they did not say the names. After children identified each animal, children watched a story in which a witch captured a boy (Tintin). The witch told the participants, "*Ha ha ha, it's not simple to get Tintin out. You have to pass some tests. If you pass them all, I will let Tintin out. I will give you a key after you pass each test*." Children saw three locks on the gate of the jail.

Real word practice trials. After the rules of the game were explained, children practiced selecting videos by touching the screen. Specifically, the witch gave the following instructions: "*You will hear a person tell you something. She will say something, and then you will see two videos. Please tell me which video matches what you heard. If it is the video on the left, touch the video, like this (pause)."*Modeling was provided during the pauses. Children then heard a question, "*Which video is* ***X***[23]*?"* Simultaneously, two videos appeared on the screen side by side. Each video displayed an action. Only one of the two actions matched the verb used in the question (see Figure 5). After hearing the question, children selected the action corresponding to the verb they heard by touching the video. Videos remained on the screen until children touched one of the videos. Feedback about the correctness of their response was provided for each selection. There were eight questions in total. The location (i.e., on the left or right of the screen) of the correct action was counter-balanced across trials. A criterion for discontinuation was set so that children who failed to select the correct action for at least six familiar verbs would not continue further. All the participants passed this criterion and identified the verbs correctly with 100% accuracy.

[23] *X* represents a verb phrase containing the target verb.

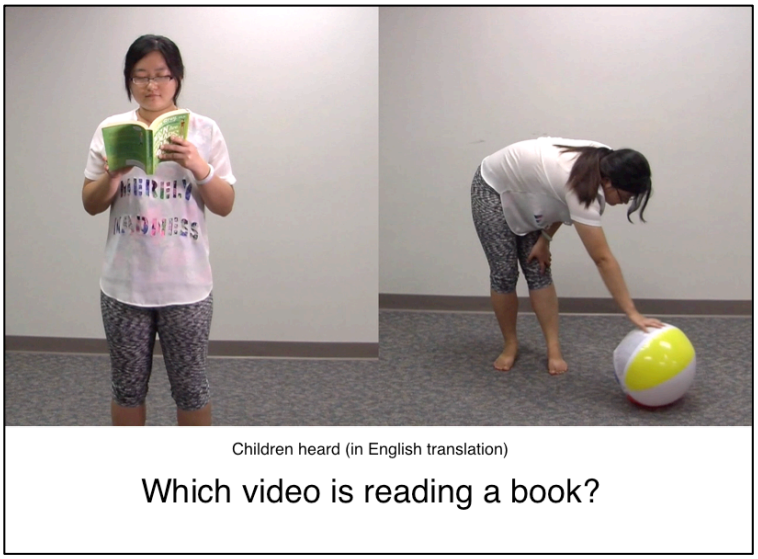

Figure 5. The video pair in the practice trial for the target verb phrase "read a book"

Novel verb practice trials. After responding to the eight questions for the real verbs, children heard the instruction from the witch: *"You will see two videos."* Following this instruction, children saw a pair of videos, in which one video displayed the causative action and the other video the non-causative action. Simultaneously, children heard a description of the two actions in the video. For example, children heard, "*See? One video is raising a leg, the other action is pressing down someone's shoulder*." The purpose of identifying the actions for children was to enhance children's awareness that there were two actions in each video pair. After that, children heard the instruction "*Now, someone is going to speak. After she speaks, you will choose which video matches what she said*." Then the verb-teaching phase started. Children watched the video pair again and this time heard a novel verb in either the NVN structure (e.g., *Meimei is FO-ing Chichi*), or the NV structure (e.g., *Meimei is FO-ing*). Right after hearing the sentence that introduced the novel verb, children heard the question "*Which video was X?*" At the same time, they saw two videos side by side displaying the same two actions, which were performed

by human characters instead of animal characters. Children touched the video to respond. There were two novel verbs in this practice section. The novel verb practice trials did not provide feedback regarding the correctness of each response.

Novel verb experimental trials. After two practice trials, children heard the instruction: "*Just like what you did, someone will teach you a word. Sometimes she will say strange words. She will teach each word twice. You will see two videos, and you have to tell me which video matches the word she said."* After that, children received 15 experimental trials with novel verbs and five trials with real intransitive (non-causative) verbs. Each trial taught the target verb in a two-sentence pair, and in one of the three conditions: the object-omission condition, the NV-control and the NVN-control conditions. The target verbs were presented in three blocks (see Table 8). Block 1 and block 2 presented two verb stimuli[24] in each condition. Block 3 presented one novel verb in each condition. The teaching-then-testing procedure was the same as described in the novel verb practice trials.

Table 8.
Number of Novel Verbs Presented by Conditions and Blocks

	Number of verb items in each condition			
	Real intransitive verbs	NV-control	NVN-control	Object-omission
Block 1	2	2	2	2
Block 2	2	2	2	2
Block 3	1	1	1	1

[24] The verb stimuli included the two real intransitive verbs in the real-verb condition.

Study 2: English Study

Adult participants. A total of 12 adult participants, 3 males and 9 females, were recruited. The mean age was 20.7 years. Participants were all undergraduate students at the University of Kansas, recruited through class announcement or personal contact. Participants filled out a questionnaire similar to the questionnaire used for the Mandarin study. Appendix G lists a full version of the questionnaire. To be recruited for this study, participants had to meet the following criteria: (1) spoke English as their native language and (2) did not speak other languages at the native-like proficiency, and (3) were exposed to English for at least 10 hours daily.

According to the results obtained from the questionnaire, six of the participants spoke another language other than English. However, none of them spoke these languages at the native-like level. The averaged self-rating of the proficiency for these languages was 3.6 (SD = 1.2), based on a Likert scale ranged from 1 (very poor) to 7 (native-like). As for their proficiency in English, all participants rated their English proficiency at the native level (i.e., 7 points on the rating scale) in the area of listening. Two participants rated their speaking and writing skill with the score of 6. One participant rated his speaking skill with the score of 6. These participants might have interpreted the rating of 7 as perfect (i.e., errorless), instead of native-like. Listening skill was the required skill for completing the experiment. The fact that all participants rated their listening skills with a 7 confirmed the validity of using these college students as participants. As participants attended the data collection session, the experimenter asked for their majors, as well as whether they had taken any advanced level linguistic courses. Only one of the participants majored in linguistics. However, none of the participants had taken advanced levels of linguistic courses, such as a course about syntax. The background knowledge of advanced linguistics was

controlled in this way so that it was less likely that the participants knew about the theory of syntactic bootstrapping and applied that to their performance in the experiment.

Child participants. Forty-two children's data were included in the analyses. Among the 42 children, 19 males and 23 females, aged from 4:1 to 5:4, formed the participant group. The average age was 54.9 months (SD = 3.9). Children were recruited from public and private preschools or childcare centers from suburban Kansas. Preschools affiliated with universities or colleges were excluded from recruitment in order to keep the SES and parental education of the participant group at the average level of the Kansas population.

Parents filled out a questionnaire that was the same as the one used for the Mandarin study. The recruiting criteria also paralleled those for the Mandarin study. Based on the information provided on the questionnaire, children (1) spoke English at the native proficiency level, (2) were exposed to English from birth, and (3) spoke English as the only native language. Children were excluded if they (1) spoke any other language at the native-like proficiency level, (2) received other language input from birth, (3) had a history of language impairments or current language impairments, and (4) had any developmental or psychological impairments. According to the information obtained form the questionnaire, four of the child participants spoke at least one non-English language. The questionnaire asked parents to rate children's language proficiency using a descriptive scale. Parents chose one of the following descriptions that best fit their child's proficiency: "native/excellent level", "can converse in that language", "can only say a few sentences or a few words", "understands but cannot speak the language", or "only understands a few words or does not understand at all." For the non-English languages that children spoke, two parents described the proficiency as "only understands a few words or does

not understand at all ". One parent described the proficiency as "can only say a few sentences or a few words." One parent selected two descriptions, thus it was not counted as a valid response.

The Receptive Language Subtest of the Test of Early Language Development (TELD-3; Hresko, Reid, & Hammill, 1999) was used to assess children's language comprehension. TELD-3 was designed to assess children from 2;0 to 7;11. Internal consistency reliability (Cronbach's coefficient alpha) for this subtest was .90 for children four-to-five years old. Test-retest reliability was .87 for this age of children. Inter-scorer reliability was .99. Criterion validity showed a high correlation (from .39 to .84) between the TELD and other widely recognized language assessments. This subtest had 37 questions. Each question was worth 1 point.

Among the children recruited, one child scored below the 16th percentile. His data was excluded from data analysis. The rest of the 42 participants scored at a mean raw score of 27.5 (SD = 2.9). This corresponded to a percentile score of 76.1 (SD = 19.3). Similar to the Mandarin-speaking participants, there was a large variability in children's scores. The raw score range was from 22 to 34. The range for percentile scores was from the 27 to the 97th percentile (See Table 9).

Table 9.
Descriptive Statistics for Participants in Two Language Groups

	Age	SD	Mean percentile of language assessment	SD	Range of percentile
Mandarin-speaking children	54.5	3.4	54.8	20.6	25 - 97
English-speaking children	54.9	3.9	76.1	19.3	27 - 97

Real verbs for "real-word" practice. The real verbs for the real-word practice session were the English equivalents of the real verbs chosen for the Mandarin study. This decision was made so that children in both studies watched the same group of videos during this session, so that the differences of stimuli presented to these two participant groups were reduced to a minimum. See Appendix C for a full list.

Novel verbs for practice trials and experimental trials. A set of novel verbs was created for the English study. The reason for not using the same set of novel verbs for the Mandarin and the English studies was that the majority of the novel verbs created for the Mandarin study had the CV structure (10 out of 15 verbs), and that this was not the most frequent word structure in English. Additionally, a CV structure in English also offered few nonword options. That is, many syllables with the CV structure correspond to real words in English, such as "see" and "tea". Furthermore, there were some consonants and vowels in the nonwords used for the Mandarin study that did not exist in English.

For all these reasons, a new set of novel verbs was created for the English study. These nonwords had the CVC syllable structure, for that is the most frequent syllable structure in English. CVC syllables were carefully chosen, controlling for the following three variables: (1) phonological probability, (2) neighborhood density, and (3) consonant age of acquisition.

Phonotactic probability refers to the frequency of occurrence of a sound sequence in a language. There are two measures of probability: the *positional segment sum* and the *biphone sum*. The positional segment sum was calculated by summing the positional segment frequencies of the target CVC. The *biphone* sum was calculated in a similar method, but instead of one single sound, the calculation was based on adjacent pairs of phonemes in a target CVC. Neighborhood

density refers to the counting of the all the words available in English that differ from the target CVC in a phoneme in any word position, by substitution, addition or deletion. Consonant age of acquisition means the developmental stage in which a consonant is acquired.

The phonotactic probability and neighborhood density were shown in numerous studies to influence spoken-word recognition, word production, and word acquisition (Munson, Swenson, & Manthei, 2005; Storkel, 2004; Storkel, Bontempo, Aschenbrenner, Maekawa, & Lee, 2013; Storkel & Lee, 2011; Vitevitch & Luce, 1999). Also, it has been argued that phonological acquisition is closely related with word acquisition (Stoel-Gammon, 2011). Therefore, it was necessary to control for these three lexical variables for each novel verb to ensure that each novel verb in the study would be equally easy/difficult to learn, on the lexical level.

Nonwords for novel verbs in this study were selected from a nonword pool created by Storkel (2013), controlling for the above three variables. See Storkel (2013) for details regarding how these lexical variables were calculated and obtained. This nonword pool contained all possible consonant-vowel-consonant (CVC) syllables that were legal (i.e., with possible phoneme sequences) in English. From this nonword pool, nonwords were chosen if the phonotactic probability and neighborhood density were at the medium level. The medium level was defined as having Z scores ranging from -0.5 to +0.5. In addition, all the chosen nonwords contained either two early-8 consonants or one early-8 consonant combined with one middle-8 consonant.

A list of 243 nonwords met the above criteria. From this list of nonwords, nonwords containing a diphthong, including /aʊ/, /aɪ/, and /ɔɪ/ were removed from the list. Also, nonwords that had a vowel followed by a /r/ sound, as in /ɔr/ or /ɪr/, were removed. These nonwords were

removed because diphthong vowels and the consonant /r/ were more difficult to discriminate and were learned by children at a later age (Gibbon, Shockey, & Reid, 1992).

After removing the difficult syllables, a total 185 nonwords remained. From these 185 nonwords, a final list of 15 nonwords was created to use as the novel verbs in this study. The 15 nonwords were chosen carefully so that each consonant and vowel did not repeat more than three times across all the nonwords. Only the consonant /f/ and the vowel /o/were used three times; the other consonants and vowels were used less than three times to make each novel verb as phonetically different as possible.

These 15 novel verbs were chosen for the experimental trials and were divided into three groups, to be assigned to the three experimental conditions (i.e., the NVN-control, the Object-omission, and the NV-control conditions). Details about the lexical variables for each nonword and the averaged scores among the three novel verb groups are provided in Appendix H.

Another two nonwords were selected from the nonword pool, to be used for the novel verb practice trials. One of the nonwords contained a diphthong (/taɪtʃ/), and the other nonword contained a vowel followed by "r" (/lərʒ/). The purpose for using the diphthong and the vowel+r combination was to maximize the differences between these two practice trial nonwords and the 15 experimental trial nonwords.

Design of conditions. The design of conditions in the English study was the same as that of the Mandarin study. In both studies, four conditions were created. Three novel verb conditions included the **NVN-control** condition, the **object-omission** condition, and the **NV-control** condition. In addition to the novel verb conditions, a **real-verb** condition was created. The real-verb condition presented the five real and non-causative verbs that were the same as the ones for the Mandarin study.

Sentences for real-verb practice trials. The sentences for the real-verb practice trials were the same as the ones created for the Mandarin study. Real verbs were presented in a question "*which video is X*?"

Sentences for novel verb practice trials. The sentences created for the novel verb practice trials for the English study paralleled the ones created for the Mandarin study, except that a different set of novel verbs were created for the English study. The "-*ing*" present progressive morpheme was used in the English study, corresponding to the Mandarin lexical morpheme "*za*i". Table 10 provides a list of the sentence stimuli for this session.

Table 10.
Sentence Stimuli for Novel Verb Practice Trials

	Novel verb 1	Novel verb 2
Teaching sentence	Lulu is taɪʧ-ing Kiki.	Kiki is lərʒ-ing.
Testing sentence	Which video is taɪʧ-ing?	Which video is lərʒ-ing?

Sentence for novel verb experimental trials. The sentence stimuli for the novel verb experimental trials were similar to the ones created for the Mandarin study. The English present progressive morpheme "-*ing*" was used. In addition, sentence 2 contained the word "*also*", corresponding to the word "*ye*" in Mandarin. Table 11 provides an example of the sentence stimuli for a target novel verb under all three conditions. Note that each child only heard the sentence stimuli of a target novel verb in one of the conditions.

Table 11.
Sentences for All Conditions

	NV-control condition	NVN-control condition	Object-omission condition
Sentence 1 (training)	'Cat is *vad*-ing' (NV)	'Cat is *vad*-ing Dog' (NVN)	'Cat is *vad*-ing Dog' (NVN)
Sentence 2 (training)	'Rabbit is also *vad*-ing' (NV)	'Rabbit is also *vad*-ing Dog' (NVN)	'Rabbit is also *vad*-ing' (NV)
Testing sentence	'Which video is *vad*-ing?'		

Like Mandarin sentence stimuli, all sentence stimuli were recorded in the anechoic chamber at University of Kansas. The context of a "rescue Ding-Ding" game was recorded by two native English female adult speakers (the witch and the narrator) and one native English-speaking male child (Ding-Ding).

As in the Mandarin study, sentences were segmented using the Praat software (Boersma & Weenink, 2014). The sound levels of the trial sentences were controlled and adjusted by the Audacity software (Mazzoni & Dannenberg, 2000).

Two native English-speaking adults, blind to the design of the study, transcribed each novel verb in alphabet spelling. Their transcriptions were re-transcribed by the experimenter using the IPA format. The IPA transcriptions of the two speakers' spellings all matched with each other and with the original sound of each novel verb. The two adults were also asked to

write down the five real non-causative verbs and all the characters that appeared in all sentences. All their answers were correct.

Video stimuli. Participants in the English study watched the same videos as did the participants in the Mandarin study.

Procedure. Participants in the English study underwent the same experimental procedure used for the Mandarin study. A native English-speaking undergraduate student collected the verb learning experiment data and the language assessment data for the English study. All participants received the experiment and then the language assessment in one testing session.

Chapter 3: Results

Analysis

The same analysis was conducted on all four samples (i.e. Mandarin-speaking children, English-speaking children, Mandarin-speaking adults, and English-speaking adults). Selections of either the causative or non-causative video for the novel verb in each trial were analyzed as the dependent variable. The selection of the causative video was coded as 1. The selection of the non-causative video was coded as 0.

Five real verbs were added to the 15 novel verbs in the trials. As children were expected to choose causative videos in both the NVN-control condition and the object-omission condition, but only choose non-causative videos in the NV-control condition, intransitive/non-causative real verbs, such as walking and jumping, were added to the experimental trials to even out the expected selection of causative vs. non-causative videos. In addition, the descriptive data provided a methodological check to ensure that participants would select the non-causative video for already-known intransitive verbs. If children chose the causative videos for these intransitive verbs, it could be an indicator that children were not paying attention to the task or did not select videos according to their knowledge of the lexical meaning of the target verbs. Video selections for the "real verb" condition were not analyzed by statistical methods, but the results are summarized in Table 12. Adults in both language groups were able to respond without any errors. In contrast, children made some mistakes, but the error rate was low.

Table 12.
Percentages of Causative Selections for the Intransitive Real Verb Condition

	Mandarin study child data	English study child data	Mandarin study adult data	English study adult data
Mean percentage of causative video selection for real verbs (SD)	3.3 (1.4%)	11.9% (3.5%)	0% (0%)	0% (0%)

Selections of the causative videos in the NVN-control, the NV-control, and the object-omission conditions were analyzed using the Generalized Linear Mixed Model (GLMM) procedure. GLMM is commonly used to analyze hierarchical data (dependent or repeated measurements) for categorical outcomes (Agresti & Kateri, 2011; Bolker et al., 2009; Raudenbush & Bryk, 2002). In this research, participants selected videos for novel verbs presented in all conditions. Therefore, video selections in each condition were dependent on each other. For this reason, the variable of condition was set as the fixed effect.

One of the advantages of using the GLMM procedure is that it allows for the inclusion of random effects, or random variance that could influence the results of the model (Raudenbush & Bryk, 2002). By including random effects, the variances associated with the confounding variables are taken into consideration in the statistical analysis.

Two random effects were added to the model, allowing for different intercepts for each random effect. The two random effects were (1) participants, and (2) verbs. “Participants” refers to each individual’s distinct reactions to the effect of condition (the fixed effect) on their selection of causative videos. The other random effect was “verbs.” Treating the variable of verbs as a random effect follows the assumption that each participant responded to each verb

uniquely. The variances resulting from the differences between verbs were added to the GLMM equation by treating "verb items" as a random effect. With this model setting, GLMM analyzed the effect of conditions on the selection of the causative videos, after considering the effect of individual differences and item differences.

For the child data analysis, the deviance test was performed to determine whether different individual intercepts for the variable of participants had an effect on the results of the model. The AICs were compared between the model including and excluding "participants" as a random effect (See Table 13). Within each analysis, chi-square tests revealed a significant difference in AIC, suggesting the variable of participants had a significant effect on each model and thus needed to be retained in each model. The effect of verb items also was significant. In contrast, the random effects for adult data in both language groups were not significant (all $p > .05$). For the ease of comparing child and adult results, adult data analysis also included both the participants and verb items as random effects.

Table 13.
Chi-Square Test for the Two Random Effects

	Chi Square for AIC increase	
	Participant variable[a]	Verbs variable[b]
Mandarin-speaking children	29.8 ($p < .001$)	7.9 ($p < .01$)
English-speaking children	20.8 ($p < .001$)	8.1 ($p < .01$)
Mandarin-speaking adults	1.8 ($p > .05$)	2.0 ($p > .05$)
English-speaking adults	1.1 ($p > .05$)	1.9 ($p > .05$)

[a] AIC was compared between models with and without the participant variable, as the only difference between the models.

[b] AIC was compared between models with and without the verb variable, as the only difference between the models.

To compare the probabilities of causative video selection among the conditions, the GLMM procedure generated pair-wise comparisons. Pairwise comparisons were conducted between (1) NV-control and NVN-control conditions, (2) NV-control and object-omission condition, and (3) NVN-control and object-omission condition.

Analysis was performed with R (R Core Team, 2015), using the package of lme4 (Bates et al., 2016) and the link of "logit". Below is a code of the syntax for the GLMM procedure for the model.

Code:

model ← glmer (causative_selection ~ (1|idf) + (1|verb.f) + condition, family=binomial (link="logit"), nAGQ=1, data=data name)

Results of the Child Data – Mandarin Study

Table 14 lists the percentages of selecting the causative video for verbs in each condition, as well as the odds ratios and the estimated probabilities generated by the GLMM procedure. Results are discussed in terms of each pairwise comparison.

Table 14.
Results for the Child Data from the Mandarin Study

	NV-control	NVN-control	Object-omission
Mean percentage	77%	86%	82%
SE	3%	3%	3%
Odds ratio	4.4	8.8	6.3

95% CI of estimated probability			
Upper bound	88%	94%	92%
Lower bound	72%	83%	78%
Percentage range of causative video selection by individuals			
Upper bound	100%	100%	100%
Lower bound	20%	40%	40%

NV-control condition vs. NVN-control condition. The pairwise comparison found a significant difference of causative video selections between the NV-control and the NVN-control conditions ($Z=2.52$, $p< .05$). Specifically, children chose more causative videos in the NVN-control condition (M = 86%) than in the NV-control condition (M = 77%). This result suggests that the NVN sentence structure was useful to Mandarin-speaking children. When they heard a novel verb presented in the NVN structure, they were fairly confident in interpreting the novel verb as causative/transitive. On the other hand, when they heard a novel verb presented in the NV structure, they were less likely to interpret the verb as causative/transitive. In this way, the pattern of results with this discourse paradigm replicates that of prior studies that used a single sentence paradigm.

Object-omission condition vs. NV-control and NVN-control conditions. Pairwise comparison indicated that the difference of causative video selection between the NV-control and object omission conditions was not significant ($Z= 1.34$, $p >.05$). Likewise, the difference between the NVN-control and object omission conditions was not significant ($Z= -1.21$, $p > .05$). In fact, causative selection for the omission condition (M = 82%) was in-between causative selection for the NVN-control condition (M = 86%) and the NV-control condition (M = 77%).

Although a null result does not permit strong conclusions, the trend suggests that Mandarin-speaking children may be able to use pragmatic cues to interpret a verb with an omitted object as causative. One thing to note is the overall high selection of the causative videos. Even in the NV-control condition, Mandarin-speaking children overwhelming chose the causative video for the majority of trials. This suggests that Mandarin-speaking children might have a fairly strong bias in interpreting a novel verb as causative regardless of conditions.

Results of the Child Data –English Study

Table 15 lists the percentages of causative video selections for verbs in each condition, as well as the odds ratios and the estimated probabilities generated by the GLMM procedure.

Table 15.
Results for the Child Data from the English Study

	NV-control	NVN-control	Object-omission
Mean percentage	64%	81%	74%
SE	4%	3%	4%
Odds ratio	2.0	5.2	3.4
95% CI of estimated probability			
Upper bound	76%	90%	84%
Lower bound	56%	76%	68%
Percentage range of causative video selection by individuals			
Upper bound	100%	100%	100%
Lower bound	0%	40%	20%

NV-control condition vs. NVN-control condition. The pairwise comparison found a significant difference in the causative video selection between the NV-control and the NVN-control conditions ($Z = 3.99$, $p < .001$). Again this result matched prediction. Children chose more causative videos in the NVN-control condition (M = 81%) than in the NV-control condition (M = 64%). This suggests that English-speaking children used the NVN structure in verb interpretation. Specifically, as they heard a novel verb in the NVN structure they tended to infer that verb was a causative/transitive verb. By comparison, when they heard a novel verb in an NV structure they were less likely to interpret the verb as causative/transitive.

Object-omission condition vs. NV-control and NVN-control conditions. Pairwise comparison indicated a significant difference between the object-omission and the NV-control conditions ($Z = 2.3$, $p < .05$). The difference between the object-omission condition and the NVN-control condition did not reach significance ($Z= -1.76$, $p > .05$). Causative video selection in the object-omission condition (M = 74%) was significantly higher than the NV-control condition (M = 64%) but not as high as the NVN-control condition (M = 81%).

Comparing Mandarin-Speaking Children and English-Speaking Children

For both the Mandarin- and English-speaking children, the percentages of selecting the causative videos are ordered from low to high in this sequence: NV-control condition << object-omission condition << NVN-control condition. There was a significant difference between the NV-control and the NVN-control conditions in both studies. The comparison between the object-omission and the NV-control conditions was also significant in the English study, but not in the Mandarin study. Furthermore, Mandarin-speaking children overall chose more causative videos in all three conditions compared to English-speaking children.

However, with a closer look, there was significant difference between these two groups' language scores received from language assessment. The Mandarin-speaking children had an average percentile of 54 (SD= 19) while the English-speaking children had an average percentile of 76 (SD=19). A t-test indicated a significant difference in language scores between these two groups, $t(82) = -5.09$, $p < .001$. It is reasonable to infer that the differences in causative video selections between these two groups might result from the discrepancy in their language scores.

To determine whether language score played a role in causative video selections between the two groups of children, the interaction between language and condition was checked. Random effects remained the same: individual and verb items. In addition to the fixed effect of condition, interaction between condition and language scores was added as the second fixed effect. The code for the model is shown below:

model ← glmer (causative_selection ~ (1|id) + (1|verb) + condition +

condition*language_scores, family=binomial (link="logit"), nAGQ=1, data=data name)

The deviance test results indicate no interaction effect between conditions and language scores in both the Mandarin study ($Z = .66$, $p > .05$) and the English study ($Z = .93$, $p > .05$). This suggests that the discrepancy of language scores between the two language groups did not contribute to the group differences in pairwise comparisons.

Several statisticians warn about the risk of distorted coefficients using the GLMM for group comparisons when group heterogeneity is a concern (Allison, 1999; Mood, 2010). Although language scores did not correlate with conditions, the discrepancy of language scores between the two language groups may still distort the coefficients of the GLMM results. Therefore, ANOVA was chosen to compare the performance of the two language groups. In the NVN-control condition, there was no between group differences, $F(1,82) = 1.7$, $p > .05$.

Likewise, no group difference was found for the object-omission condition, $F(1,82) = 3.0$, $p > .05$. However, in the NV-control condition, the percentage of selecting the causative videos was higher for the Mandarin-speaking children (77%) than the English-speaking children (64%), $F(1,82) = 7.0$, $p < .01$). This discrepancy of causative video selections between the two groups reflects the gap in the frequency of object dropping between Mandarin and English, suggesting that Mandarin-speaking children selected more causative videos in the NV-control condition probably because it is more frequent for a causative verb to be presented in the NV structure in Mandarin, compared to English.

However, the causative video selections in the NV-control condition were above the chance level in either study. If the NV structure did not provide information for verb transitivity, children should be expected to select the causative video for each novel verb in this condition at chance. One possible explanation for the high percentage of causative video selection in the NV-control condition was that children received all conditions in the novel verb experiment in this study. Therefore, as they learned a novel verb in one condition, that experience might influence their learning of the next novel verb in another condition. There were two conditions (NVN-control and the object-omission condition) that were expected to result in causative video selections, and only one condition (NV-control condition) that was expected to result in non-causative video selections. If children's novel verb learning in the NV-control condition was influenced by the experience in the NVN-control and the object-omission condition, it was reasonable to result in high causative video selections in the NV-control condition.

To address this possible issue, another GLMM analysis was conducted for the data in the NV-control condition. Children learned five novel verbs in the NV-control condition. The presentation order was coded as 1 to 5, representing the first verb to the final verb (i.e., the 5th

verb) children learned in this condition. The dependent variable was the binomial outcome of causative video selection (yes=1, no=0). The two random effects, individuals and verb items, were also included in the model. The results suggest that for Mandarin-speaking children, there was a significant effect of the presentation order ($Z=2.42$, $p < .05$, odds ratio = 3.00, 95% CL = 1.23-7.32). A marginal effect on the presentation order of verbs was also found for English-speaking children ($Z= 1.90$, $p = .06$, odds ratio = 2.20, 95% CL = .98-4.96). For both groups of children, as they were further engaged in the experiment, they selected more causative videos for the NV-control condition. The percentage of causative video selections for each presentation order is provided in Table 16.

Table 16.
Causative Video Selection by Presentation Order

	Mandarin-speaking children		English-speaking children	
Presentation order	Percentage	SD	Percentage	SD
1	64%	48%	52%	51%
2	74%	45%	52%	51%
3	86%	35%	76%	43%
4	71%	46%	71%	46%
5	90%	30%	69%	47%

Results of the Adult Data – Mandarin Study

Table 17 presents the mean percentage of causative video selection in each condition, as well as the GLMM results. Video selection in the NVN-control condition was identical to that in the object-omission condition. Pairwise comparison indicated a significant difference between the NV-control and both the NVN-control condition and the object-omission condition ($Z= 5.4$, $p < .001$, for both comparisons).

Like children, Mandarin-speaking adults selected the causative video significantly more often in the NVN-control than NV-control conditions. Specifically, Mandarin-speaking adults selected the causative for 97% of verbs in the NVN-control condition but only 27% of verbs in the NV-control condition. Although the pattern was the same for both the adults and the children, adults were less likely than children to select a causative video in the NV-control condition (i.e., 27% for adults, 77% for children). Unlike children, Mandarin adults selected the causative video significantly more often in the omission condition (97%) than the NV-control condition (27%), and there was no significant difference between causative selection in the omission (97%) and NVN-control (97%) condition. This suggests that structural and pragmatic cues were equally strong indicators of causative/transitive verbs for adults, but not for children. Compared to children, adults selected causative videos as frequently in the NVN-control as in the object-omission condition.

Table 17.
Results for the Adult Data from the Mandarin Study

	NV-control	NVN-control	Object-omission
Mean percentage	27%	97%	97%
SE	8%	2%	2%
Odds ratio	0.4	31.0	31.0
95% CI of estimated probability			
Upper bound	40%	99%	99%
Lower bound	16%	88%	88%
Percentage range of causative video selection by individuals			

Upper bound	80%	100%	100%
Lower bound	0%	80%	80%

Results of the Adult Study – English Study

Table 18 presents the results of the GLMM analysis for the English-speaking adults. In accordance with the prediction, the causative video selection was significantly different between the NV-control and the NVN-control conditions ($Z=4.9$, $p< .001$). The comparison between the object-omission and the NV-control conditions was also significant ($Z=4.9$, $p< .001$). The difference between the object-omission condition and the NVN-control condition was not significant ($Z = -.5$, $p > .05$).

English-speaking adults' selection patterns overall paralleled English-speaking children's patterns; however, the adults did select the causative videos in the object-omission condition (97%) as often as in the NVN-control condition (100%) and were less likely to choose a causative video in the NV-control condition (23%). The adults in both language groups exhibited similar patterns of video selection. Both the sentence structural and the pragmatic cues seemed to be consistently used by adults for both language groups.

Table 18.
Results for the Adult Data from the English Study

	NV-control	NVN-control	Object-omission
Mean percentage	23%	100%	97%
SE	8%	0%	3%
Odds ratio	0.2	102.9	52.8

95% CI of estimated probability			
Upper bound	39%	100%	100%
Lower bound	7%	92%	89%
Percentage range of causative video selection by individuals			
Upper bound	80%	100%	100%
Lower bound	0%	100%	60%

Chapter 4: Discussion

This study investigated children's use of multiple cues to learn novel verbs in Mandarin and English. Particularly, the learning process focused on the ability to infer the transitivity of a novel verb. Two possible cues were explored: the sentence structure (syntactic) cues and the pragmatic cue of NEWNESS/OLDNESS. Previous literature shows empirical evidence to

support that children use sentence structure to infer the transitivity of verbs (Arunachalam & Waxman, 2010; Lidz et al., 2003; Naigles, 1990; Noble et al., 2011). However, little is known about how children infer the transitivity of a novel verb when it is presented in variable syntactic structures. One instance of syntactic structure variation is object dropping. When an object in the sentence is dropped, the NV structure is ambiguous and can be used for both the transitive/causative verbs and intransitive/non-causative verbs. Luckily, object dropping is in accordance to pragmatic principles. One principle is the NEWNESS/OLDNESS principle, which states that a referent in the conversation is droppable when it carries old information, such as information mentioned in the prior discourse context. Under this particular circumstance, the referent (i.e., the object) can be dropped and thus be presented in the NV structure. If children can use the pragmatic cue of NEWNESS/OLDNESS to detect the appropriate contexts for object dropping, then the NV structure might no longer be ambiguous.

This study compared Mandarin-speaking children and English-speaking children's inference of verb transitivity under different syntactic environments, with the aim to further determine whether children across languages used syntactic and/or pragmatic cues in their inferences. Mandarin and English were chosen because object dropping occurs more frequently and less restrictively in Mandarin, compared to English. On the other hand, the NEWNESS/OLDNESS principle is language-universal. With a cross-linguistic approach, language-specific and language-general features of novel verb learning may be explored.

The results show a similar behavioral pattern between Mandarin-speaking and English-speaking children. The percentage of their causative video selections was the highest in the NVN-control condition, and then the object-omission condition, and the least in the NV-control condition. The high probability of causative video selection in the NVN-control condition

suggests that children from both language groups used the NVN structure as an indicator for a causative/transitive verb. The high probability of causative video selection was also found in the object-omission condition for both language groups, suggesting they might have used the NEWNESS/OLDNESS principle as a cue to infer that a novel verb was causative. Children from both language groups did not choose more non-causative videos in the NV-control condition, suggesting that the strength of the NV structure cue was not strong enough for children to interprete a novel verb as non-causative. It was also found that Mandarin-speaking children chose more causative videos in the NV-control condition than English-speaking children did, reflecting language differences in the interpretations of the NV structure.

The Use of Syntactic Cues

This study found converging evidence that both the English-speaking and Mandarin-speaking children used the NVN structure as a reliable cue to infer that a novel verb in this structure was a transitive/causative verb. In the NVN-control condition, children from both language groups heard the novel verb first presented in the NVN structure. Using the NVN cue, they most likely noticed the post-verbal noun phrase, and arguably reasoned that the novel verb was very likely a transitive verb. Then, as they heard the novel verb the second time in a slightly different NVN structure, their first inference was confirmed and their confidence was strengthened.

This finding of the study accords with the findings in other syntactic bootstrapping studies using a single-sentence paradigm, from ages as young as 19 months old (Yuan et al., 2012) to as old as four years old in English (Noble et al., 2011) and five years old in Mandarin (Jiang & Haryu, 2014). Similar findings were found from studies using an act-out paradigm, both

in English-speaking (Naigles, Fowler, & Helm, 1992; Naigles & Maltempo, 2011) and in Mandarin-speaking children (Lee & Naigles, 2008). The finding of the study confirmed that children across languages use the syntactic cue of NVN in novel verb learning in a multi-sentence discourse-like paradigm.

The Use of the NEWNESS/OLDNESS Pragmatic Cue

Results from the English study show that children's percentage of choosing the causative videos was high in the object-omission condition, and moreover, significantly higher than that in the NV-control condition. For the Mandarin study, the difference in causative video selections between the object-omission condition and the NV-control condition did not reach significance. However, the lack of significance likely results from the fact that the causative video selections in the NV-control condition was as high as 77% (this issue will be further addressed later in this chapter), making it difficult to reach a significant difference from the object-omission condition. Many studies have shown that Mandarin-speaking children were sensitive to the NEWNESS/OLDNESS principle in choosing the way to express a referent in conversations with mothers (Huang, 2011, 2012). Thus, it was likely that Mandarin-speaking children used the NEWNESS/OLDNESS cue in this study in the context of novel verb learning. Thus, the following paragraphs discuss the interpretations for the English and Mandarin results together.

Considering the high percentage of causative video selections in the object-omission condition, we could possibly draw a conclusion that, as predicted in this study, children exploited the pragmatic cue of NEWNESS/OLDNESS. In the first sentence, children heard a novel verb presented in the NVN structure, with a subject (e.g., Cat) and an object (e.g., Dog). Using the NVN structure, they inferred the novel verb was transitive/causative. Then, as children heard the

same verb again in the NV structure, they most likely realized that the object was missing this time. However, the fact that the object (e.g., Dog) was already mentioned in the first sentence, and that Dog was the undergoer of the action in the videos for both sentences, indicated to the children that the object in the second sentence carried old information. Due to this old information, children inferred that the object was omitted due to low informativeness in the second sentence containing the NV structure. Thus, children likely maintain a causative interpretation of the second sentence.

However, such interpretation is built upon some assumed abilities pre-requisite to using this NEWNESS/OLDNESS cue. First, children needed to link sentence 1 and sentence 2 together and read them as a combined unit. Without this ability, children might assume sentence 1 and sentence 2 were irrelevant statements and that the pragmatic principle of NEWNESS/OLDNESS did not apply. To reduce this possibility, this study used the conjunctive adverb *ye* in the Mandarin study and *also* in the English study. *Ye/also* has the function of marking "coordination" (Paris, 1979, p.64) and emphasizes the similarities between two propositions (Lin, 2000). Therefore, in this current study, as children heard the conjunctive adverb *ye/also*, they were likely to link sentence 1 and sentence 2 together and assumed that they constituted a combined unit (e.g., a context).

Another required ability in using the NEWNESS/OLDNESS cue was that children must discern whether sentence 1 and sentence 2, and the videos for sentence 1 and 2 presented the same or different subject and object in the sentence. If the characters remained the same across the two sentences or two videos, the sameness implied old information. For example, as shown in Table 6, in this study, the object/patient remained the same (i.e., Dog) in the videos for sentence 1 (Cat is PO-ing Dog) and sentence 2 (Rabbit is also PO-ing). If the characters changed

between the two sentences and/or two videos, the contractiveness implied new information. For example, in this study, sentence 1 and 2 and their corresponding videos had different subject/agents. As shown in Table 6, Cat was the subject for sentence 1and Rabbit was the subject for sentence 2. In conclusion, children needed to discern whether the subject or object of the sentence remained the same or changed in order to evaluate the newness/oldness status. Past literature suggests that the four-year-old children in the current study likely would have the ability to recognize the repeated object across the two sentences (Matthews, Lieven, Theakston & Tomasello, 2006; Graf, Theakston, Lieven & Tomasello, 2014).

It is important to point out the possible alternative explanation for the high causative video selection percentage in the object-omission condition. The conjunctive adverb *ye/also* was used in this condition. *Ye/also* is an additive marker that "introduces an existential presupposition, requiring that there is another individual that has the property attributed to the focus of the sentence with too [or also]" (Schwartz, 2007, p378). For example, in the current study, when adults heard *also* in sentence 2 "Cat is also vading ___" in the object-omission condition, it triggered the presupposition that "someone other than Cat" has performed the same action of "vading". If that presupposition was triggered, participants could assert that the same action was performed in the second sentence, without the need to process the rest of the sentence and notice that sentence 2 contained a NV structure. That is, with the use of *also* in sentence 2, participants might not notice that the object in sentence 2 was dropped. In this vein, children's high percentage of causative video selections in this object-omission condition might not reflect the use of the NEWNESS/OLDNESS cue, but rather, it might merely reflect that the correct presupposition was successfully triggered. The use of *ye/also* was obligatory in the contexts created for this study. According to Liu (2009), when the topics differ from sentence to sentence,

the use of "*ye/also*" is obligatory to put a focus on the contrast. In the contexts for the study, the subjects differed from sentence 1 to sentence 2, thus making *ye/also* necessary in the sentences. Due to the design of the contexts, this alternative interpretation of the causative video selections in the object-omission condition cannot be ruled out.

This influence of "*ye/also*" could potentially be avoided in several ways. One option is to use a paradigm that yields temporal sensitive measures, such as an eye-tracking paradigm. Children's fixation between the causative and non-causative video pair could be measured along the unfolding of the target sentences. If children rapidly fixate on the causative video as soon as they hear *ye/also* in the sentence, it could be an indicator that children simply rely on their understanding of *ye/also* to give the correct response. Another option is to replace *also* with *too* in the English study (but see Schwartz, 2007, for differences between *also* and *too*). In this way, English-speaking children would hear sentences like "Cat is PO-ing Dog. Rabbit is PO-ing too." Paired with the eye-tracking paradigm, children's fixation could be gathered before and after hearing the additive marker *too*.

NV-Control Condition

Children's causative video selections in the NV-control condition suggested children from the English and the Mandarin group might interpret the NV structure differently. For the English-speaking children, they started out by interpreting the novel verb in the NV structure in this condition with no preference for the causative or non-causative videos. This at chance level of video selection replicated the previous findings in the previous literature (Arunachalam & Waxman, 2010; Naigles & Kako, 1993; Yuan et al., 2012).

When English-speaking children received the NV structure in sentence 1 in this condition, children might find this NV structure ambiguous, for they had heard this NV structure used for both transitive/causative verbs and intransitive/non-causative verbs. As they encountered the second sentence again in the NV structure, no additional cue was provided. Without any additional cue, children selected videos at chance.

As for Mandarin-speaking children, they started out with a higher percentage of causative video selection in comparison with the English-speaking group. As they heard the first NV structure in sentence 1, they may have relied on their language experience and inferred that since the NV structure is often used for transitive verbs in Mandarin, it was likely that the novel verb was a transitive/causative verb. As they heard the NV structure again in sentence 2, they continued to interpret the verb as transitive/causative because no additional cue was provided.

For both language groups, as children received more trials, some of which presented novel verbs in the NVN and the object-omission conditions, their causative video selections increased, appearing to be higher than prior studies (Yuan et al., 2012, Jiang & Haryu, 2014) by the end of the experiment.

Two possible explanations could account for why children's video selections shifted over time. First, children's interpretation of the NV structure in the NV-control condition was influenced by their interpretation of the NV structure in the object-omission condition. In the object-omission condition, children selected the causative video most of the time, even when they heard the NV structure in the second sentence. This occurred because children understood that the NV structure in the object omission condition contained an omitted object. If a child received the object-omission condition followed by a NV-control condition, it was possible that the child would make the assumption that the NV structure in the NV-control condition also

contained an omitted object in both sentences, even though the pragmatic cue did not allow it. In sum, given that child participants learned novel verbs in all three conditions, it was possible that their pattern of interpretation of the NV structure in the object-omission condition influenced their interpretation of the NV-control condition.

An alternative but related explanation was that in this study, both the NVN-control condition and the object-omission condition were expected to boost the causative interpretation for the novel verbs, yielding 10 expected causative video selections. On the other hand, only the NV-control condition was expected to produce non-causative or at chance interpretation for the novel verbs, yielding 5 or less expected non-causative video selections. The unbalanced numbers of expected causative versus non-causative interpretations might induce a causative bias. Even though real intransitive verbs were added to the verb list to even out the number of expected causative versus non-causative answers, children from both language groups in this study might only track their video selections for the novel verb, and the causative bias still remained. Future follow-up studies can subdivide children into two groups for each language. One group of children would learn novel verbs under the NV-control and the NVN-control condition, the other half would receive the NV-control and the object-omission condition. As such, it can further determine which explanation is more plausible.

It is worthy to note that the NV sentences used in this study differed from those in other studies. Most studies used a NV sentence with conjoined subjects (e.g., Cat and Dog are FO-ing), whereas this study only used one subject (e.g., Cat is FO-ing). The reason for the one-subject design was to control the number of subjects, so that children would not form the assumption that a one-subject sentence mapped to the causative video, and a two-subject sentence was for the non-causative video (in which two characters performed the same action). In the previous

literature, a possible explanation was raised to account for the fact that children selected videos at chance in the NV condition. The explanation was that children did not fully comprehend the NV structure, thus associating the first noun to the agent role, and, mistakenly, the second noun to the patient role. As a consequence, they mistakenly interpreted the novel verb as causative (Noble et al., 2011). This study found evidence to show that this explanation could not fully account for children's selections in the NV condition. The NV structure in this study did not have a second subject for the child to map to the patient role. Therefore, children's preference for the causative video in this study was indeed due to the uninformativeness of the NV structure (Arunachalam, Syrett, & Chen, 2016), but not due to their inability to map the nouns to the correct semantic roles.

Language-Specific and Language-General Factors of Novel Verb Learning

Comparing the causative video selections between the two groups of children, the group difference was only significant in the NV-control condition. No group difference was found in the NVN-control condition or the object-omission condition. Mandarin-speaking children were significantly more likely to choose causative videos in the NV-control condition, compared to English-speaking children. The discrepancy in causative video selections may reflect the language-specific features in object dropping between these two languages. In Mandarin, object dropping occurs more extensively and freely than in English. As a topic-prominent language, an object that is a topic in a discourse context is commonly dropped in Mandarin. On the other hand, English as a predicate-comment language does not allow object dropping except in certain pragmatic contexts (Goldberg, 2001). Object dropping is less frequent in English than it is in Mandarin (Lee & Naigles, 2005; Naigles & Hoff-Ginsberg, 1993). In sum, the discrepancy

observed between Mandarin-speaking and English-speaking children suggests that Mandarin-speaking children have a greater bias toward interpreting a novel verb in the NV structure as causative because they likely hear causative verbs more frequently in NV structures than English-speaking children due to the more frequent omission of objects in Mandarin.

In terms of language-general factors, this study found that the pragmatic cue of NEWNESS/OLDNESS was used by English-speaking children and most likely also by the Mandarin-speaking children. The tendency to express a new referent lexically, but to present old referents with pronouns or null objects (i.e., dropped objects) has previously been observed in languages that allow object dropping (Mandarin, Huang 2011; Inuktitut, Allen, 2000; Allen & Schröder, 2003; Korean, Clancy, 1997; Japanese, Guerriero et al., 2006), and languages that do not typically allow object dropping (Italian, Serratrice et al., 2004; English, Pérez-Leroux, Pirvulescu, & Roberge, 2008). The findings of this study suggest that in accordance with the previous literature, the pragmatic cue of NEWNESS/OLDNESS was most likely used across languages.

This study also found that the NVN structure is a cue that is used cross-linguistically and consistently when children encounter a novel verb.

Recommendations for Future Research

This research has added new insights into novel verb learning in children and could be extended in several ways. For example, it could be extended to children with language impairment. Verb learning is difficult for all children, but even more challenging for this population. It is possible that verb learning problems in this population stem from their difficulties in using the syntactic and pragmatic cues utilized by typically developing children

(See Leonard and Deevy, 2004, for a review; also see Appendix I for the discussion on a pilot study).

In addition, more cross-linguistic studies are warranted to examine other language-general factors that may affect children's use of syntactic and pragmatic cues in novel verb learning. For example, Pérez-Leroux, Pirvulescu, Roberge and Castilla (2013) investigated the language-general pragmatic principle of "contrastiveness" (Allen, 2000). However, that study used a verb production task. Whether the contrastiveness cue can be used in novel verb learning is worth exploring.

More studies on the language-specific factors are also needed. For example, Mandarin and English differ in whether an argument of a verb can be dropped. Whereas Mandarin can drop objects that are the "topic" of the sentence (e.g., through topic chaining, see Huang 1984), English does not allow topical arguments to be dropped (Goldberg, 2001). Future studies could investigate this difference directly.

Conclusion

This study examined whether English-speaking and Mandarin-speaking children used syntactic and pragmatic cues in novel verb learning. Language-universal and language-specific patterns were found. Both the Mandarin group and English groups used the NVN structure and interpreted a novel verb in such syntactic structure as a transitive/causative verb. Both language groups selected the causative video with high probability in the object-omission condition, suggesting that the NEWNESS/OLDNESS pragmatic cue was potentially used cross-linguistically. However, this interpretation should be considered with caution due to the influence of the use of the conjunctive adverb *ye/also* in this study. Language-specific influence was found in children's causative video selections for the NV structure in the NV-control

condition. Mandarin-speaking children selected more causative videos than English-speaking children did. Such discrepancy may result from the fact that the NV structure in Mandarin is more likely to be used for a transitive verb than it is in English.

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Appendix A: Adult Language background questionnaire (English translation)

1. Name : _____

2. Age : _____

3. Sex: □MALE □ FEMALE

4. Is Chinese Mandarin your only native language? □YES □NO

5. Nationality of your child: □Taiwan □other, specify _____

6. Ethnicity of your child: □Han people □Aboriginal people □Other, specify _____

7. What degree are you currently working on? □B.A./B.S. □Master's degree □Doctoral degree

8. Please rate your language proficiency of Chinese Mandarin with the scale of 1 to 7 below:

very poor	poor	fair	functional	good	very good	native-like
1	2	3	4	5	6	7

Language	Listening	Speaking	Reading	Writing
Mandarin Chinese				

9. Do you speak other dialect of Chinese (e.g., Taiwanese, Hakkanese)? If so, please rate your proficiency in each dialect you speak, using the 1(very poor)-to-7 (native- like) rating scale you used for question 5.

very poor	poor	fair	functional	good	very good	native-like
1	2	3	4	5	6	7

Dialects of Chinese	Listening proficiency	Speaking proficiency

10. Do you speak other languages (e.g., English)? If so, please specify the age when you started to learn the language and rate the proficiency using the 1(very poor)-to-7 (native- like) rating scale.

very poor	poor	fair	functional	good	very good	native-like
1	2	3	4	5	6	7

Language	At what age did you start to learn this language?	Listening	Speaking	Reading	Writing

11. Please list the total time (in hours) you are currently exposed to ***Mandarin Chinese*** everyday in the following contexts

Context	At school	At home	Other, please specify :_____
Time (hours per day)			

12. Please list the total time (in hours) you are currently exposed to ***English*** everyday in the following contexts

Context	At school	At home	Other, specify below :_____
Time (hours per day)			

Appendix B: Child Participant Background Questionnaire

1. Child Name _____

2. Child Gender: □ Male □ Female

3. Birth Date: _____ YEAR _____ MONTH _____ DAY

4. Which school does your child go to? School name _____

5. Nationality of your child: □Taiwan □other, specify _____

6. Ethnicity of your child: □Han people □Aboriginal people □other, specify _____

7. Who are the main caregivers of your child?
   □ Parents □ Grandparents □ Other, please specify _____

8. Caregivers' backgrounds:
Caregiver 1:

Relationship to child _____, nationality _____, Occupation _____

Highest educational level	Elementary	Junior High	Senior High	Junior College	Vocational school	Undergraduate	Master's	Doctoral	Other, _____
Please check									

Caregiver 2:

Relationship to child _____, nationality _____, Occupation _____

Highest educational	Elementary	Junior High	Senior High	Junior College	Vocational school	Undergraduate	Mater's	Doctoral	Other, _____

level									
Please check									

9. Check *ALL* the languages your child is exposed to each day. How many hours of exposure daily?

Language	Places of exposure	Averaged hours of exposure /day
□ Mandarin	□ Home □ School □ Other	For _____ hours everyday
□ Taiwanese	□ Home □ School □ Other	For _____ hours everyday
□ Hakka	□ Home □ School □ Other	For _____ hours everyday
□ English	□ Home □ School □ Other	For _____ hours everyday
□ Other, specify: _____	□□ Home □ School □ Other	For _____ hours everyday
NOTE:		

10. Check *ALL* the languages your child knows. Indicate the age when your child was first exposed to these languages.

Language	**Age of acquisition (when was your child first exposed to the language?)**

□ Mandarin	At birth? □YES □NO, age of initial exposure _____ years old
□ Taiwanese	At birth? □YES □NO, age of initial exposure _____ years old
□ Hakka	At birth? □YES □NO, age of initial exposure _____ years old
□ English	At birth? □YES □NO, age of initial exposure _____ years old
□ Other, specify: _____	At birth? □YES □NO, age of initial exposure _____ years old

11. For each language checked in question 10, rate your child's current proficiency of the language(s)

Languages	Proficiency (please select one)
□ Mandarin	□native-like/excellent □can converse in that language, but not native-like □can only say a few sentences or few words □understand but cannot say the language □only understand a few words or do not understand at all
□ Taiwanese	□native-like/excellent □can converse in that language, but not native-like □can only say a few sentences or few words □understand but cannot say the language □only understand a few words or do not understand at all
□ Hakka	□native-like/excellent

	□can converse in that language, but not native-like □can only say a few sentences or few words □understand but cannot say the language □only understand a few words or do not understand at all
□ English	□native-like/excellent □can converse in that language, but not native-like □can only say a few sentences or few words □understand but cannot say the language □only understand a few words or do not understand at all
□ Other, please specify :_____	□native-like/excellent □can converse in that language, but not native-like □can only say a few sentences or few words □understand but cannot say the language □only understand a few words or do not understand at all

12. Does you child **currently** have language delay or disorder ?

□ **NO**

□ **YES, specify the kind:** _____

13. Does you child have **history** of language delay or disorder ?

□ **NO**

□ **YES, from age _____ to age _____,**

was there a diagnosis by a doctor? □YES □NO

14. Is your child currently or has received language therapy?

□ **NO**

□ **YES, from age _____ to age _____**

15. Are you currently worried about your child's language development?

□ **NO**

□ **YES, in what ways? Please specify in the box below**

16. Does you child have developmental delay in other aspects (e.g., physical, cognition)**?**

□ **NO**

□ **YES,** please fill in the type of delay below:

_____

17. Does you child have any psychopathological or neuropathological disorders (e.g., autism, attention deficits)**?**

□ **NO**

□ **YES,** please fill in the type of disorder(s) below:

18. Please write down any other information about your child you'd like to share with us.

Appendix C: List of all the 8 real verbs for practice trials

Causative verb phrase	1. Which video is **opening a door**? 2. Which video is **closing a door**? 3. Which video is **rolling a ball**? 4. Which video is **drinking water**?
Non-causative verb phrase	1. Which video is **grabbing a toy**? 2. Which video is **shaking a cup**? 3. Which video is **eating an apple**? 4. Which video is **reading a book**?

Appendix D: List of all the novel verbs created for this study

Novel verbs for practice items	Phonetic spelling - pinyin
1	pie4
2	zhun4
Novel verbs for experimental trials	**Phonetic spelling - pinyin**
1	dei4
2	gei4
3	de4
4	teng4
5	keng4
6	za4
7	ca4
8	mang4
9	ha4
10	po4
11	hang4
12	shei4
13	zei4
14	chao4
15	ran4

Appendix E: Novel verbs, action pairs, and characters for the 3 stimuli lists

Stimuli list	Novel verb	Action pair #	Video for sentence 1		Video for sentence 2	
			AGENT	PATIENT	AGENT	PATIENT
List A	ha4	1[25]	monster	duck	bird	duck
	zei4	5	bird	doctor	monster	doctor
	keng4	12	monkey	panda	pig	panda
	za4	13	bear	tiger	monkey	tiger
	dei4	8	pig	kangaroo	bear	kangaroo
List B	shei4	4	monster	duck	bird	duck
	po4	2	bird	doctor	monster	doctor
	teng4	11	monkey	panda	pig	panda
	de4	10	bear	tiger	monkey	tiger
	ran4	7	pig	kangaroo	bear	kangaroo
List C	hang4	3	monster	duck	bird	duck
	chao4	6	bird	doctor	monster	doctor
	ca4	14	monkey	panda	pig	panda
	mang4	15	bear	tiger	monkey	tiger
	gei4	9	pig	kangaroo	bear	kangaroo

Design of the three experimental versions

	Object-omission condition	NVN-control condition	NV-control condition
Experimental Version 1	List A	List B	List C
Experimental Version 2	List B	List C	List A
Experimental Version 3	List C	List A	List B

[25] For the description of each action pair, see appendix F.

Appendix F: List of the causative and non-causative action pairs for the novel verb learning task

Action pair	**Causative action**			**Non-causative action**		
	Action description	Saliency	Novelty	Action description	Saliency	Novelty
1	A[26] sits with one leg on the other leg's knee, using the leg to kick B's knee to make B's knee move	5.5	9	A rotates her bent elbow 90% degrees downward	5.9	8
2	A sits and uses one hand to rock B's knee	6.0	6	A uses a stuck-out thumb to slide between chest and abdomen	5.2	7
3	A pushes B's back with an arm moving in a wavelike motion	5.7	9	A touches her nose with a stuck-out thumb while the rest of the fingers stretch out upwards	5.2	9
4	A uses her little finger to push B's right shoulder to make B move a step backward	5.8	10	With a rock & roll gesture, A uses the back of the hand to touch her forehead.	5.7	9
5	A uses her hand to grab B's wrist to make B wave	5.8	8	A moves her index and middle fingers, as mimicking a walking action, and moves horizontally	5.7	8
6	A uses her elbow to push B, making B skip to the right	5.9	9	A waves her arm in a motion like the infinity symbol	6.5	8
7	A uses her elbow to move upwards along the side of B's body, making B stand on	5.4	6	A puts one hand behind her head, moving the bent elbow horizontally	5.5	6

[26] A and B are characters performing the actions

	tiptoes					
8	A rotates B's shoulder to make it move in a circular motion	5.7	6	A puts her arm with palm facing downward in front of her abdomen, and raises the arm to touch the chin with the back of hand	5.4	5
9	A pulls B's clothes upward to make B stand up	5.7	4	A curves her arm and moves it upward across the front of the body in a scooping motion	6.0	5
10	A uses one hand to go behind B's back to grab B's shoulder, and pull B toward her	6.1	2	A rotates her arm in a circular motion	6.8	3
11	A puts her palm on B's back and moves in a circular motion, making B move in a circular motion accordingly	5.6	3	A knocks on her own shoulder with a hand that has fingers bent like claws	5.9	4
12	A bends her arm backward to push B with the tips of her fingers, making B step backward (both face forward)	5.9	3	A uses her palm to tap on her head	6.3	4
13	A uses her hand to raise B's chin up	5.2	3	A pushes her arm forward with the palm facing the front	6.5	2
14	A and B sit together, A uses one leg to hook B's leg from behind, making it move forward	6.0	3	A uses her index finger to snap her knee	4.9	4
15	A pushes B with a finger,	5.9	3	A opens and closes her palm	5.3	2

	making B's body rock sideways					

Appendix G: Language background questionnaire -English Adult Study

1. Name : _____
2. Age : _____
3. Sex: ❐MALE ❐ FEMALE
4. Is English your native language? ❐YES ❐NO
5. Nationality: ❐U.S. ❐Other, specify _____
6. Race/Ethnicity:
   ❐White ❐Hispanic/Latino ❐Black ❐Asian
   ❐Native Hawaiian/Other Pacific Islander ❐American Indian/Alaska ❐Two or more races
7. What degree are you currently working on?
   ❐B.A./B.S. (undergraduate) ❐Master's degree ❐Doctoral degree
8. Please rate your language proficiency of ***English*** with the scale of 1 to 7 below:

very poor	poor	fair	functional	good	very good	native-like
1	2	3	4	5	6	7

Language	Proficiency			
English	Listening	Speaking	Reading	Writing
	(please fill in a number from 1 to 7) _____	(please fill in a number from 1 to 7) _____	(please fill in a number from 1 to 7) _____	(please fill in a number from 1 to 7) _____

9. Do you speak other languages (e.g., Spanish)? If so, please specify the age when you started to learn the language and rate the proficiency using the rating scale below.

very poor	poor	fair	functional	good	very good	native-like
1	2	3	4	5	6	7

Name of the language	At what age did you start learn this language?	Proficiency			
		Listening	Speaking	Reading	Writing
	_____years old	(fill in a number from 1 to 7)			
	_____years old				

	_____years old				

10. Please list the total time (in hours) you are currently exposed to ***English*** everyday in the following contexts

Context	At school	At home	Other, specify below :_____
Hours per day			

Appendix H: Descriptive statistics for novel verbs by groups

Novel verb group	Nonword[a]	Consonant age of acquisition C1	Consonant age of acquisition C2	Positional segment	Biphone	Neighborhood density	Mean positional segment	Mean biphone	Mean neighborhood density
1	**/hob/**	early-8	early-8	0.31[b]	0.50[b]	-0.44[b]	0.21[b]	-0.01[b]	0.03[b]
	/vɑd/	mid-8	early-8	0.09	-0.23	-0.20			
	/mif/	early-8	mid-8	-0.17	-0.05	0.49			
	/nɛm/	early-8	early-8	0.46	0.14	0.03			
	/wut/	early-8	mid-8	0.38	-0.41	0.26			
2	**/fep/**	mid-8	early-8	0.22	-0.05	-0.20	0.19	-0.01	0.07
	/gom/	mid-8	early-8	0.37	0.26	0.26			
	/næf/	early-8	mid-8	0.09	-0.05	0.03			
	/yik/	early-8	mid-8	-0.16	-0.38	0.03			
	/boʒ/	early-8	mid-8	0.46	0.14	0.26			
3	**/bef/**	early-8	mid-8	0.47	0.05	0.26	0.05	0.11	0.03
	/gʌp/	mid-8	early-8	0.17	0.32	0.03			
	/wɑb/	early-8	early-8	0.09	0.23	0.26			
	/huv/	early-8	mid-8	-0.30	-0.20	-0.20			
	/yæg/	early-8	mid-8	-0.21	0.17	-0.20			

[a] Transcripts were presented in SIL IPA.

[b] Values were presented in Z scores.

Appendix I: Pilot study in special population

A pilot study was conducted aiming to test the practicality of the same methodology in children with language impairment. One child of language impairment participated in the novel verb learning experiment, which was the same one tested on typically-developing children in this study.

This participant was a six-year-old English-monolingual male child. His receptive language was at the 3rd percentile and his expressive language was at the 4th percentile assessed by TELD-3. He presented with receptive and expressive language impairment, plus a diagnosis of autism spectrum disorder.

This child demonstrated adequate ability to follow along the experiment directions. For the real verb practice trials, in which he practiced making video selections, this child correctly selected the corresponding videos for all eight real verbs. He also correctly selected the corresponding videos for all real intransitive verbs in the experimental trials, suggesting these verbs were easy enough for him to understand. No disruptive behaviors were observed that interfere with the flow of the data collection process.

For his causative video selections in the three conditions, the percentage of causative video selections was 100% in the NVN-control condition, 60% in the NV-control condition, and interestingly, only 40% in the object-omission condition.

The discrepancy of causative video selections between the two control conditions suggests that he was sensitive to the difference in syntactic structures, and was likely to use the NVN structure as a cue for a causative inference. Like his younger typically-developing peers in

this study, the NV structure cue was not strong enough for him to interpret the novel verb as non-causative.

Compared with his younger typically developing peers, he selected fewer causative videos in the object-omission condition. This result may suggest that he did not use the pragmatic cue of NEWNESS/OLDNESS in this condition, so that the NV structure in sentence 2 biased him toward a non-causative reading of the novel verb. However, it was also possible that as he heard sentence 1 and 2, he did not treat them as a context. That is, he might have treated sentence 1 and sentence 2 as unrelated sentences. If that was the case, as he heard sentence 1 he formed an interpretation of the novel verb; as he heard the following NV structure (sentence 2), he formed another interpretation. It was possible that his response in the object-omission condition only reflected his interpretation gathered from sentence 2.

To conclude, though behaviorally this child with language impairment seemed to have the capability to follow along with the experiment, a more sensitive measure is needed to examine whether participants like him view the setup of the multiple-sentence context as context, or as two unrelated sentences.