Children's Comprehension of Object-Gapped Relative Clause Sentences: Investigating the Contribution of NP Number Mismatch

By

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CHAPTER I

INTRODUCTION

For children as well as adults, center-embedded object-gapped relative clause (ORC) sentences, as in (1), are generally more difficult to comprehend than right-branching object-gapped relative clause sentences, as in (2) (Kidd & Bavin, 2002). By mismatching features of the head noun phrase (NP) and the relative clause subject NP (e.g., animacy of nouns), comprehension of center-embedded relative clause sentences can be enhanced for children as well as adults (Friedmann et al., 2009; Garraffa & Grillo, 2008). Adani et al. (2014) hypothesized that comprehension can be enhanced when the head NP number information differs from the relative clause subject NP number information. For example, a sentence in which the head NP is plural and the relative clause subject NP is singular, as in (3), should be easier to comprehend than (1), where both NPs are singular.

(1) The boy that the mother praised won the award.[1]

(2) The coach acknowledged the boy that the mother praised.

(3) The boys that the mother praised won the award.

Adani et al. (2014) tested their hypothesis in a task that required 6-year-old children to match spoken stimulus sentences to one of four pictures. The 6-year-olds accurately matched sentences with mismatched NP number information (e.g., - singular, + singular) to the correct picture more than sentences with matched NP number information (odds ratio 1.75; Adani et al., 2014). They concluded that NP number mismatch across the main clause subject NP and relative clause subject NP enhanced children's comprehension. However, in their sentence stimuli such as (4) and (5), mismatching NP number information was expressed also on the VPs. Mismatching NP and VP number information could help children select correct pictures more than sentences such as (5), with mismatching NP number information only. Therefore, it

[1] Throughout this document, relative clauses are underlined in exemplar sentences.

remains unclear whether NP number mismatch or the combination of NP number mismatch and mismatching VP number information enhanced ORC sentence comprehension.

(4) The cats that the mouse is washing have climbed onto the stool (Adani et al., 2014).

(5) The cat that the mouse is washing has climbed onto the stool (Adani et al., 2014).

To address the limitations of Adani et al. (2014), the study reported here isolated the effects of NP number mismatch on children's comprehension of ORC sentences. We tested comprehension of ORC sentences that contrasted NP number mismatch with NP number match wherein the main clause and relative clause VPs had no number information (i.e., modal auxiliary *can*).

NP Features and Relative Clause Sentence Comprehension

A small body of research has considered whether manipulation of NP lexical and grammatical features enhances comprehension of object-gapped relative clause sentences (Arnon, 2010; Friedmann et al., 2009; MacDonald et al., 2020). Researchers have evaluated center-embedded as well as right-branching relative clauses. For example, Adani (2012) reported that German-speaking 4-year-olds comprehended relative clause sentences with inanimate head NPs (e.g., the sweater) better than those with animate head NPs (e.g., the man) when the head NP preceded an animate relative clause subject (e.g., the child). Friedmann et al. (2009) reported that NP lexical restriction, or the presence of a lexical noun rather than word classes such as pronouns, influences relative clause sentence comprehension. NP lexical restriction mismatch resulted in a comprehension advantage over NP lexical restriction match such that (6) was better comprehended than (7).

(6) Show me the one the boy is wetting (Friedmann et al., 2009).

(7) Show me the monkey the boy is hugging (Friedmann et al., 2009).

Adani et al. (2010) reported that Italian-speaking, preschool children comprehended ORC sentences with NP gender mismatch, as in (8), better than ORC sentences with NP gender match, as in (9) (odds ratio .52; Adani et al., 2010). Italian marks gender on NPs, unlike English.

(8) Il gatto che la capra sta lavando e salito sullo sgabello (Adani et al., 2010).
The cat that the goat is washing has climbed onto the chair.

(9) Il gatto che il topo sta lavando e salito sullo sgabello. (Adani et al., 2010).
The cat that the mouse is washing has climbed onto the stool.

Turning back to the issue of NP number, Adani and colleagues concluded that NP number mismatch enhanced ORC sentence comprehension for 5-and 6-year-old English (2014) and Italian speakers (2010). The children performed better on NP number mismatch ORC sentence comprehension than NP number match object relative clause sentence comprehension. Adani et al. (2010) concluded that mismatched NP number features were the critical component in the ORC sentence comprehension advantage.

Explanations of NP Number Mismatch and Sentence Comprehension Advantage

Two theoretical accounts may explain why children's comprehension of ORC sentences improve when NPs mismatch rather than match in number: (a) relativized minimality effects (Rizzi,1990) and (b) cue-based accounts of relative clause comprehension (McElree et al., 2003). First, we briefly summarize each account and then consider the predictions that each generates.

Rizzi (1990) proposed that relative clause sentence comprehension is difficult when the head NP and the gap in the relative clause is interrupted by a NP with features that are similar to the head NP (Figure 1). This comprehension difficulty is an instance of relativized minimality effects, in which X and Y fail to relate if Z, the intervener, shares featural specifications with X and is linearly closer to Y (Garraffa & Grillo, 2008). For example, in Figure 1, the head NP *the cat* and the relative clause subject NP *the mouse* share singular number features. Due to these shared number features, a disruption in thematic role assignment would result in the head NP being inappropriately interpreted as the relative clause subject. Friedmann et al. (2009) speculated that thematic role assignment is challenged because preschool and early school-aged children adhere to a stricter version of relativized minimality effects which makes it difficult

for them to fill the gap with the copy of the head NP. Friedmann et al. stated that this stricter version of relativized minimality has to do with children applying universal grammar principles in a stricter form as the product of their still-developing language systems. It is hypothesized that older children and adults do not adhere to this stricter version of relativized minimality; however, NP feature mismatch continues to impart a small object relative clause sentence comprehension advantage (Friedmann et al., 2009).

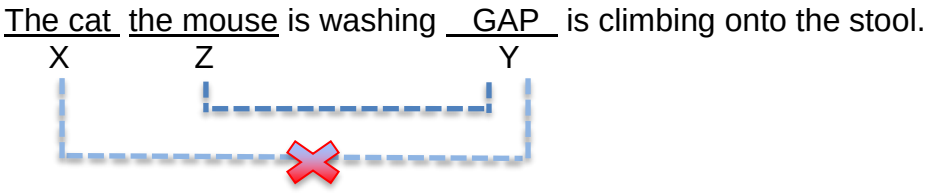

Figure 1. Illustration depicting how relativized minimality can result in incorrect comprehension of an object relative clause sentence (Friedmann et al., 2009; Rizzi, 1990). "X" is the target of the local relation, "Z" is the ''intervener'', and "Y" is the ''origin''. The relation between "X" and "Y" fails if intervening "Z" is similar in featural specification to "X" (Friedmann et al., 2009). This failure allows for inappropriate relation between "Z" and "Y".

McElree et al. (2003) proposed that listeners and readers use cues to make sense of relative clause sentences. Cues provide information that establishes a linguistic dependency, such as a subject-predicate dependency (Martin & McElree, 2018). When multiple NPs satisfy the featural constraints of a VP (e.g., number agreement, gender agreement), subject identification is difficult and children do not establish the distant dependency (Lewis et al., 2006; Wagers et al., 2009). In Figure 2 below, the shared grammatical features of the head NP *the cat* and the relative clause subject *the mouse* satisfy the featural constraints of the main VP *is climbing* (e.g., singular number).

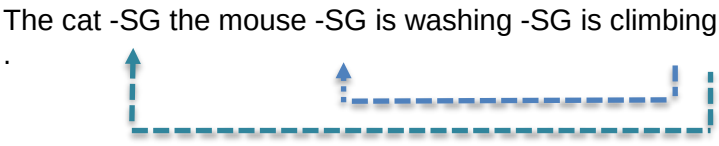

Figure 2. Illustration depicting how subject identification is made difficult within cue-based accounts of relative clause sentence comprehension. In the figure, subject NP identification is made difficult because multiple NPs satisfy the featural constraints of the VPs (e.g., number agreement). -SG indicates singular number.

We consider how NP number mismatch leads to an ORC sentence comprehension advantage within these theoretical accounts. Within the relativized minimality account, the influence of NP number mismatch leads to a comprehension advantage after the second of two NPs is comprehended. In contrast, within cue-based accounts, listeners receive the benefit of number mismatch once dependencies between NPs and VPs are established. When the NPs differ in number, listeners may use VP number information to establish dependencies between NPs and VPs.

Research Questions and Hypotheses

To our knowledge, researchers have not evaluated the impact of NP number features (match vs. mismatch) in the absence of VP number information. Importantly, the methods of Adani et al. can be manipulated to create sentence and picture stimuli that isolate NP number features, allowing for an evaluation of whether NP number mismatch leads to an ORC sentence comprehension advantage. We asked one primary research question. **In a group of typically developing 6-year-olds, is there a within-group difference between comprehension of NP number match ORC sentences and NP number mismatch ORC sentences?** We asked this question using stimuli that did not include VP number information, such as (10) and (11).

(10) The pig <u>that the tiger can push</u> can sit on the bed.

(11) The pig <u>that the tigers can push</u> can sit on the bed.

We hypothesized that there would be a significant within-group difference such that NP number mismatch ORC sentences would be comprehended more accurately than NP number match ORC sentences. Our hypothesis was based on prior work that has shown that children comprehend NP feature mismatch sentences without VP feature information better than NP feature match sentences without VP feature information (e.g., lexical restriction; Friedmann et al., 2009; Adani et al., 2010).

Two potential follow-up research questions were identified, with the question asked contingent on the primary research question outcome. If the hypothesis for a benefit of NP

number mismatch alone is supported, then we ask whether VP number information enhances the impact of NP number mismatch. **In a group of typically developing 6-year-olds, is there a within-group difference between comprehension of NP number mismatch sentences with VP number information and NP number mismatch sentences without VP number information?** We ask this question using stimuli such as (12) and (13).

(12) The pig that the tigers are pushing is sitting on the bed.

(13) The pig that the tigers can push can sit on the bed.

Due to the dearth of research on the impact of VP number information on relative clause sentence comprehension, we did not have a hypothesis for this research question.

If the hypothesis for an effect of NP number mismatch alone is not supported, then we ask whether VP number information alongside NP number information is necessary for a comprehension advantage. **In a group of typically developing 6-year-olds, is there a within-group difference between comprehension of NP number mismatch sentences with VP number information and NP number match sentences with VP number information?** We ask this question using stimuli such as (14) and (15).

(14) The pig that the tigers are pushing is sitting on the bed.

(15) The pig that the tiger is pushing is sitting on the bed.

We hypothesized that we would replicate the significant within-group difference of Adani et al. (2010; 2014).

CHAPTER II

METHOD

Methods were approved by the Vanderbilt University Institutional Review Board.

Participants

Sixteen English-speaking 6-year-old children with typical language participated. Six-year-olds were chosen because this age group did not score at floor or ceiling in previous NP number mismatch child studies (Adani et al., 2014; Contemori & Marinis, 2014). The number of participants was set based on a power analysis of Adani et al. (2017). Eighteen children were consented; eligibility assessments identified 16 eligible children and two ineligible children based on norm-referenced eligibility measure scores. Children were recruited within two age bands. Three boys and five girls were between 6;0 – 6;5 and four boys and four girls were between 6;6 – 6;11. Age freely varied within each age band. The mean age of participants was 6;5 (SD = 0;3). Parents reported maternal education and race/ethnicity information (Table 1).

Table 1

Participant Demographic Information

Characteristic	Number of participants
Maternal education	
High school or GED	3
Bachelor's degree	5
Post-baccalaureate	8
Race	
Asian American	3
Black or African American	0
White	13
Ethnicity	
Hispanic or Latino/a	2
Non-Hispanic	14

Note. GED = General Educational Development

Eligibility criteria (Table 2) included: (a) monolingual English speaker, (b) standard score of $\geq$ 85 on the Test of Auditory Comprehension of Language-Fourth Edition (TACL-4; Carrow-Woolfolk, 2014), (c) standard score of $\geq$ 85 on the Structured Photographic Expressive Language Test-Third Edition (SPELT-3; Dawson et al., 2003), (d) 70% accuracy on a right-

branching, object-gapped relative clause sentence comprehension task, and (e) name numbers 1 - 4. We excluded children who (a) currently or previously received speech-language therapy and (b) could not use a digital tablet with assistance from a parent (per parent report).

We recruited children from the metro Nashville TN area using a web-based participant matching system (Research Match) and the Vanderbilt Kennedy Center Study Finder website. We also contacted previous Child Language and Literacy Lab research participants whose parents indicated interest in study participation. We encouraged participating families to share the Child Language and Literacy Lab contact information with friends interested in participating.

Table 2

Participant Scores on Eligibility Measures

Eligibility Measure	Mean (SD)
TACL-4 Standard Score	99.63 (9.89)
SPELT-3 Standard Score	103.63 (7.18)
Right-Branching Task Percent Correct	86.90 (11.40)

Note. SD = standard deviation; TACL-4 = Test of Auditory Comprehension of Language-Fourth Edition (Carrow-Woolfolk, 2014); SPELT-3 = Structured Photographic Expressive Language Test-Third Edition (Dawson et al., 2003); Right-Branching Task Percent Correct refers to percent correct on an eligibility object relative clause sentence comprehension task.

Eligibility Norm-Referenced Measures

The TACL-4 and SPELT-3 were administered to confirm typical language status. The TACL-4 is a measure of receptive semantics, morphology, and syntax normed on children from 3;0 to 12;11. Children select a picture from a field of three that matches a phrase or sentence read aloud by the examiner. The SPELT-3 is a measure of expressive morphology and syntax normed on children from 4;0 to 9;11. Children respond to prompts to explain or describe pictures of children engaged in familiar daily activities.

Number Naming Task

The number naming task was administered to ensure that participants could name numbers 1 - 4. The numbers 1 - 4 appeared in a 2 x 2 array that was presented via a PowerPoint® slideshow. Numbers were positioned in the array such that the number “1” was

positioned in the upper-left quadrant, the number “2” was positioned in the upper-right quadrant, the number “3” was positioned in the lower-left quadrant, and the number “4” was positioned in the lower-right quadrant. The author activated an animation that made a red circle appear around the number “1”. The author asked the participant “What number has a circle around it?” After the child’s response, the circle dissolved and the process was repeated for numbers 2 - 4. All participants correctly identified all numbers.

Eligibility Object Relative Clause Comprehension Task

The eligibility right-branching object relative clause comprehension task provided evidence that children’s potential failure on the experimental task was not attributable to a general failure to comprehend object-gapped relative clause sentences. The task required children to match a spoken sentence to a picture from a four-picture array. The task was presented via a PowerPoint® slideshow; each task item involved presentation of a four-picture array with an embedded audio recording of the sentence. Sentences were recorded by a male speaker on a Sony PCM-D10 recorder, in an anechoic chamber to ensure recording clarity.

Sentence Stimuli. Sentence stimuli (Table 3) matched the length of experimental sentence stimuli, 12 words. The 10 right-branching object relative clause sentence stimuli included the relative marker *that* and a predicate prepositional phrase, for example *Show me the big horse that the puppy washes in the bath*. The VPs consisted of verbs marked with third person singular -s (e.g., washes) which expresses tense and number without providing exposure to the form used in the experimental task (auxiliary + present progressive VPs).

Each sentence contained one animal noun (e.g., *the horse*) as the head NP in the direct object position of the main clause and one animal noun (e.g., *the puppy*) as the subject of the relative clause. In addition, one inanimate noun (e.g*., the bath*) was in a predicate prepositional phrase. The animal nouns in this task were not used in the experimental stimuli. Each animal noun was used two times, once as a head NP and once as a relative clause subject NP. Lexical verbs were selected with three considerations in mind: (a) include verbs from previous number

mismatch studies, (b) include verbs that can be clearly depicted, (c) include verbs that are familiar to 6-year-olds. Words in the sentence stimuli were drawn from Wordbank to include words used by at least 80% of 30-month-olds (http://wordbank.stanford.edu; Frank et al., 2019).

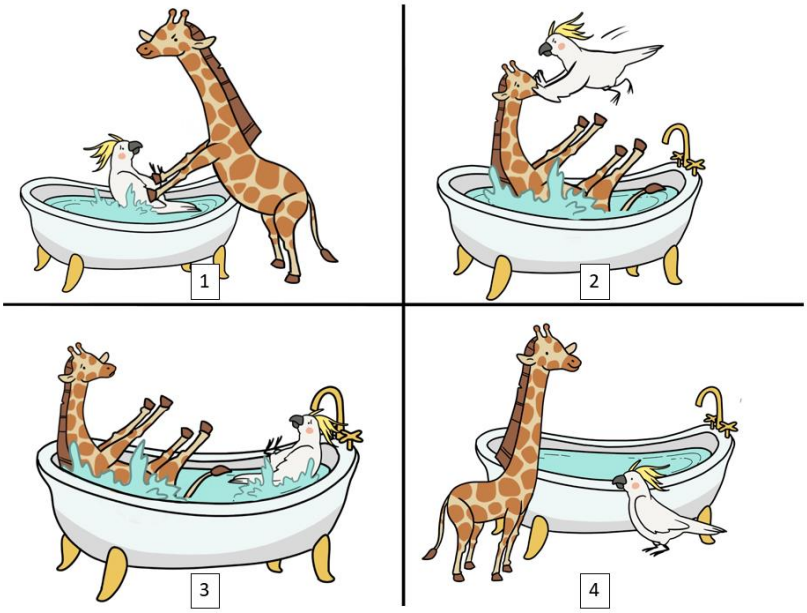

Figure 3. Example illustration for eligibility sentence *Show me the funny bird that the giraffe pushes in the bath*. Picture 1 is the correct selection. Picture 2 depicts a relative clause comprehension error (*Show me the funny bird that pushes the giraffe in the bath*). Picture 3 depicts a relative clause and main clause comprehension error (*Show me funny bird that pushes and the giraffe that pushes in the bath*). Picture 4 depicts an additional incorrect scenario (*Show me the funny bird and the giraffe by the bath*).

Picture Stimuli. One picture in the four-picture array (see Figure 3) depicted the correct interpretation of the relative clause sentence and three pictures were distractors. Each distractor pictures depicted one of three possible comprehension errors: (1) an object NP comprehension error in which the main clause object NP is interpreted as the relative clause subject NP, (2) a relative clause subject NP comprehension error in which the relative clause subject NP is interpreted as the main clause object NP, and (3) an object NP and a relative clause subject NP comprehension error in which the main clause object NP is interpreted as the relative clause subject NP and the relative clause subject NP is interpreted as the main clause object NP.

Picture arrays were created by a university student artist who worked with the author to

ensure that each picture accurately depicted the intended meaning. The artist received detailed instructions to ensure that each animal type looked as similar as possible from picture to picture (e.g., animal size, color). If an animal type or a depicted action was not consistent across pictures, the artist was given additional instructions so that pictures could be revised. We asked a university graduate student to complete the eligibility object relative clause comprehension task to ensure that the correct picture was the clear and appropriate selection for each sentence. The graduate student received a score of 100%. We also confirmed evidence that 6-year-olds would interpret picture stimuli correctly. Two non-participant 6-year-olds completed the task and received scores above 70%.

Experimental Task

The experimental task required children to match a sentence to a picture from a four-picture array. The task was presented via a PowerPoint® slideshow; each task item involved presentation of a four-picture array with an embedded audio recording of the stimulus sentence. Sentences (Table 4) were recorded by a male speaker on a Sony PCM-D10 recorder, in an anechoic chamber to ensure recording clarity.

Table 3

Constituent Frequency in Eligibility Object Relative Clause Comprehension Task

	RC Constituent	Sentence Constituent		
Sentence and Order of Presentation	Head NP	Relative NP	RC VP	PP NP
1. Show me the big horse that the puppy washes in the bath.	horse (97)*	puppy (93)	wash (89)	bath (97)
2. Show me the tall giraffe that the kitty kisses in the park.	giraffe (84)	kitty (81)	kiss (94)	park (90)
3. Show me the cute puppy that the alligator cleans in the kitchen.	puppy (93)	alligator (80)	clean (90)	kitchen (91)
4. Show me the scared duck that the squirrel hits in the park.	duck (97)	bird (97)	hit (84)	park (90)
5. Show me the small kitty that the bird cleans in the bat	kitty (94)	squirrel (80)	clean (90)	bath (97)
6. Show me the angry alligator that the bird kicks in the kitchen.	alligator (80)	bird (97)	kick (88)	kitchen (91)
7. Show me the funny bird that the giraffe pushes bath.	bird (97)	giraffe (84)	push (84)	bath (97)
8. Show me the little duck that the horse kisses in the park.	duck (93)	horse (97)	kiss (94)	park (90)
9. Show me the silly zebra that the duck hits in the kitchen.	zebra (81)	duck (97)	hit (84)	kitchen (91)
10. Show me the loud squirrel that the zebra pushes in the park.	squirrel (80)	zebra (81)	push (84)	park (90)

Note. Head NP = main clause object noun phrase; Relative NP = relative clause subject noun phrase; RC VP = relative clause verb phrase; PP NP = noun phrase in the predicate prepositional phrase.

Table 4

Number Features of Experimental Sentence Stimuli across Four Conditions

	NP Number	
VP Number	Match	Mismatch
None	The pig that the tiger can push can sit on the bed. **Condition: NP only match**	The pig that the tigers can push can sit on the bed. **Condition: NP only mismatch**
Information	The pig that tiger lion is pushing is sitting on the bed. **Condition: NP + VP match**	The pig that the tigers are pushing is sitting on the bed. **Condition: NP + VP mismatch**

Note. NP = noun phrase; VP = verb phrase.

Sentence Stimuli. We constructed ORC sentence of two types to answer our primary research question: (a) NP only match and (b) NP only mismatch. See the top row of Table 4 (see also Table 5 for all sentences). For NP only mismatch sentences, the subject NP in the main clause and in the relative clause did not match in number. Half of the sentences included a singular subject NP in the main clause and a plural subject NP in the relative clause; the other half had the reverse pattern. For NP only match sentences, the subject NP in the main clause and in the relative clause matched in number. Half of the sentences included a singular subject NP in the main clause as well as relative clause; half of the sentences included a plural subject NP in the main clause as well as the relative clause. These sentences included no number information in the main clause or relative clause VP; the VPs in each clause included the modal auxiliary *can* plus a main verb. Sentences included the relative marker *that* and a predicate prepositional phrase. The relative marker *that* was used to maintain continuity with Adani et al. (2014).[2]

We constructed two types of sentences to answer our two potential follow-up research questions: (a) NP + VP mismatch and (b) NP + VP match. See bottom row of Table 4 (see also Table 5 for all sentences). For NP + VP mismatch sentences, the subject NP and VP in the main clause differ in number from the subject NP and VP in the relative clause. Half of the sentences included a singular subject NP in the main clause and a plural subject NP in the relative clause; the other half had the reverse pattern. For NP + VP match sentences, the subject NP and VP in the main clause matched in number with the subject NP and VP in the relative clause. Half of the sentences included singular subject NPs + VPs in the main clause as well as relative clause; half of the sentences included plural subject NPs + VPs in the main clause as well as the relative clause. Sentences were constructed with auxiliary + present progressive VPs. Each sentence contained one animal noun (e.g., *the tiger*) as the subject NP

[2] Following Friedmann et al. (2009), Adani et al. (2014) interpret the relative marker *that* as a lexical element “of the same structural type” as the relative clause subject NP.

of the main clause and one animal noun (e.g., *the elephants*) as the subject of the relative clause. One inanimate noun (e.g*., the bed*) was within a predicate prepositional phrase. Each animal noun was used two times in each condition, once as a head NP and once as a relative clause subject NP. We selected lexical verbs with the same considerations used when developing the eligibility object relative clause comprehension task. Main clauses included intransitive verbs and relative clauses included transitive verbs. Each verb was used four times within each condition. We did not confirm that all children comprehended each included NP and VP prior to the experimental task (cf. Adani et al., 2010). Rather, to create the likelihood that sentence vocabulary was known to the children, sentence stimuli words were drawn from Wordbank to include only words used by at least 80% of 30-month-olds (Frank et al., 2019).

Table 5

Experimental Sentence Stimuli by Condition

NP Only Match	**NP Only Mismatch**
The frogs that the bunnies can kick can sit on the bed.	The frog that the dogs can bite can climb on the table.
The elephants that the monkeys can hug can stand on the tree.	The pig that the tigers can push can jump on the chair.
The dogs that the cows can hit can jump on the couch.	The monkey that the turtles can kiss can stand on the rock.
The teddybear that the chicken can kiss can jump on the bed.	The lion that the chickens can kick can climb on the table.
The pigs that the turtles can push can sit on the table.	The teddybear that the lions can hug can jump on the bed.
The monkeys that the tigers can kick can climb on the tree.	The elephant that the monkeys can hit can sit on the tree.
The lion that the cat can hug can jump on the table.	The turtle that the bears can clean can sit on the couch.
The chicken that the teddybear can bite can climb on the couch.	The bears that the cat can push can stand on the chair.
The cat that the bear can clean can stand on the rock.	The bunnies that the elephants can clean can climb on the couch.
The turtle that the elephant can kick can climb on the tree.	The pigs that the tiger can hug can jump on the rock.
The tiger that the pig can hug can jump on the table.	The cows that the bunny can hit can stand on the tree.
The bunnies that the dogs can kiss can climb on the rock.	The chickens that the teddybear can kiss can sit on the rock.
The bear that the lion can hit can stand on the table.	The cats that the frog can push can stand on the bed.
The cows that the frogs can clean can sit on the chair.	The dogs that the cow can kick can climb on the table.
NP + VP Match	**NP + VP Mismatch**
The bunnies that the elephants are kicking are sitting on the bed.	The bear that the lions are biting is climbing on the bed.
The bears that the chickens are hugging are standing on the tree.	The bunny that the dogs are cleaning is jumping on the chair.
The pig that the turtle is cleaning is sitting on the chair.	The cat that the teddybears are hitting is sitting on the couch.
The monkey that the tiger is biting is climbing on the couch.	The chicken that the cats are kicking is standing on the rock.
The lion that the teddybear is cleaning is standing on the rock.	The cow that the bunnies are hugging is standing on the table.
The frogs that the bunnies are biting are sitting on the chair.	The dog that the frogs are kissing is sitting on the tree.
The elephant that the dog is pushing is jumping on the rock.	The tiger that the elephants are pushing is jumping on the bed.
The dogs that the cows are kissing are climbing on the rock.	The frogs that the cow is pushing are climbing on the chair.
The cows that the frogs are hitting are standing on the table.	The lions that the chicken is kissing are jumping on the couch.
The chicken that the bear is kissing is jumping on the bed.	The monkeys that the pig is kicking are sitting on the rock.
The cat that the lion is pushing is sitting on the table.	The pigs that the monkey is hugging are standing on the table.
The turtles that the pigs are pushing are sitting on the chair.	The teddybears that the bear is hitting are standing on the tree.
The tigers that the monkeys are biting are jumping on the rock.	The elephants that the turtle is cleaning are sitting on the rock.
The teddybear that the cat is hitting is jumping on the couch.	The turtles that the tiger is biting are jumping on the table.

Note: NP = noun phrase, VP = verb phrase.

Picture Stimuli. Comprehension of experimental sentence stimuli was evaluated in a picture-matching task that paralleled the eligibility object relative clause comprehension task.

One picture in the four-picture array (Figure 4) depicted the correct interpretation of the relative clause sentence and three pictures were distractors, based on Adani et al. (2014). The three distractor pictures depict one of three comprehension error types (Appendix A). First, a main clause error (MCE) type refers to when a relative clause subject NP is interpreted as the main clause subject NP. Second, a relative clause error (RCE) type refers to when a main clause subject NP is interpreted as the relative clause subject NP. Third, a double clause error (DCE) type refers to when a main clause subject NP is interpreted as the relative clause subject NP and the relative clause subject NP is interpreted as the main clause subject NP. Picture positions were determined by a random number generator; first, the correct picture position was assigned, followed by the RCE picture and then the MCE picture.

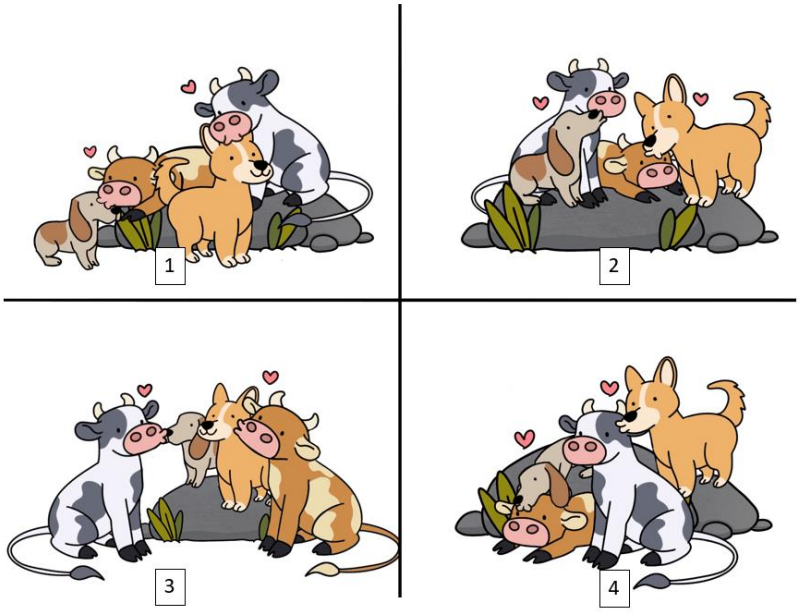

Figure 4. Example illustration for experimental sentence *The dogs that the cows are kissing are climbing on the rock.* Picture 3 is the correct selection. Picture 1 depicts a main clause error (*The cows that are kissing the dogs are climbing on the rock*). Picture 2 depicts a relative clause and main clause comprehension error (*The dogs are kissing the cows that are climbing the rock*). Picture 4 depicts a relative clause error (*The dogs that are kissing the cows are climbing the rock*).

Pictures were produced by seven university student artists who worked with the author to ensure that each picture accurately depicted the correct meaning or the planned incorrect meaning of the sentence. The picture development process and feasibility process were

identical to the eligibility object relative clause comprehension task picture stimuli.

Remote Research Materials

Research tasks were presented via a 10-inch Apple® iPad tablet with 4G cellular data service. Responses were audio recorded using a Palovue iMic Portable Microphone attached to the iPad. The iPad was placed on a Lamicall tablet holder to ensure that children could easily view picture stimuli.

Research Task Procedures

The author delivered the research materials to each family prior to the first research session. Each child completed two remote research sessions from their homes. Parents received written instructions with the iPad to access the video conferencing application (Zoom®) and to start the iPad audio recording application before the child began the session. The author provided spoken instructions to the child at the start of research sessions. All research activities were completed by the author.

In the first session, the child completed, in this order, the TACL-4, the SPELT-3, and the eligibility object relative clause comprehension task. All norm-referenced measures were administered following the manualized instructions with one exception. Each plate of the TACL-4 easel and SPELT-3 picture booklet was scanned and imported into a PowerPoint® slideshow to permit remote administration. In the second session, the child completed the experimental task.

The eligibility object relative clause comprehension task PowerPoint® show began with the author reading the instructions. The author said “We are going to look at some pictures and listen to some sentences. I want you to tell me which picture goes with the sentence. Listen carefully because I can only play each sentence once. Ready?” A four-picture array was presented and, following a 2-second delay, a 2-sentence recording was played (e.g., “Say the number of the picture that goes with what I say. Show me the big horse that the puppy washes in the bath.”) The author manually advanced slides at a pace appropriate for each child until all

items were administered.

The experimental task PowerPoint® show began with two simple sentence training items, followed by 56 experimental items. The two training items were intended to: (a) orient the child to the task by practicing listening to sentences and making picture selections and (b) ensure that the child listened to the entire sentence before making a picture selection. The author read instructions identical to the eligibility task. A four-picture array was presented and, following a 2-second delay, a 2-sentence recording was played (e.g., “Say the number of the picture that goes with what I say. Here is the happy puppy on the chair”). If the child provided an answer before the end of the recording, the author told the child: “Listen to everything before you answer.” The training item was readministered. If the child made an incorrect picture selection, then s/he was told the correct answer and the item was readministered. The training task ended when the child (a) responded after the presentation of the sentences and (b) selected the correct picture after hearing the sentence for both training items.

The 56 sentences were presented to each participant in one of four random sequences. Each experimental sentence was presented in a fashion identical to the training items. Following presentation of the sentence, the child said the number of the picture that corresponded with the sentence. If the child did not respond after hearing the sentence, then the author told the child to “just give your best guess.” If the child responded before the end of the recording, s/he was reminded: “Listen to the whole sentence. Don’t answer until the end of the sentence.” The sentence was replayed if the child answered before the end of the recording. If a child responded before the end of the recording on more than three experimental sentences, the author planned to discontinue the task with the child. However, no child met the discontinuation criteria.

Scoring. The child’s response was recorded on the task protocol (i.e., 1, 2, 3, or 4). The author scored online each response as correct (“1”) or incorrect (“0”). After administration, the

total correct responses within each condition were tallied (max. = 14). We also tallied by condition the number of incorrect responses that aligned with each distractor type.

Reliability. To establish scoring reliability for the eligibility object relative clause comprehension task, a research assistant (an undergraduate student trained in assessment) randomly selected three children in each age band and scored each child's performance from audio recordings. The research assistant's scores were compared to the author's online scoring and mean sentence-by-sentence agreement was 100%. Thus, we concluded that reliability standards were met, and the author's online scoring on the task was used.

To establish scoring reliability for the experimental task, the research assistant randomly selected three children in each age band, listened to the audio recording of the child's performance, and scored each experimental task responses as correct or incorrect. The research assistant's scores were compared to the author's online scoring and mean sentence-by-sentence agreement was 99% (R = 98 to 100%). Again, we concluded that reliability standards were met, and analysis proceeded using the author's online scoring.

Dependent Variables and Analysis Plan

Tallied correct responses yielded four raw score variables for each child: NP Only Match, NP Only Mismatch, NP + VP Match, and NP + VP Mismatch. The purpose of our primary research question was to evaluate the impact of NP number mismatch in isolation; NP Only Match and NP Only Mismatch were compared. A Wilcoxon signed-rank test was used to compare the number of correct responses in NP Only Match to the number of correct responses in NP Only Mismatch. The signed-rank test was selected due to the non-normal distribution of the data. We set statistical significance at .05. If a statistically significant difference was detected, effect size was calculated using the matched-pairs rank biserial correlation coefficient, r_C (Kerby, 2014; King et al., 2018). As suggested by King et al. (2018), we interpreted the r_C values of .5 or greater as representing a large effect size, r_C values less than .5 and larger than

.3 as representing a medium effect size, and r_C values less than .3 or smaller as representing a small effect size.

Based on the outcome of the primary research question analysis, we planned a follow-up analysis. If there was a significant within-group difference for the primary research question, then NP Only Mismatch and NP + VP Mismatch would be compared. If we could not reject the null hypothesis for the primary research question, then NP + VP Match and NP + VP Mismatch would be compared. We stated a priori that we would not reject the null hypothesis if obtained p-value was larger than .05.[3] A Wilcoxon signed-rank test was used to compare the two dependent variables in our follow-up analysis. We set statistical significance at .05. Effect size was calculated using the matched-pairs rank biserial correlation coefficient, r_C.

[3] Failure to reject the null hypothesis is not intended to show no difference between conditions.

CHAPTER III

RESULTS

Table 6 provides number of correct responses by condition (median and range). Because NP mismatch and NP + VP mismatch data were not normally distributed based on the Shapiro-Wilk test (*p*s < .05), we report the median data for each condition. Table 7 summarizes the mean number of response types by condition. We report response type mean data to assist in comparison to Adani et al. (2010; 2014).

Table 6

ORC Sentence Comprehension by Condition

Condition	*Median*	*Range*
NP only mismatch	7.50	4 - 11
NP only match	7.00	1 - 13
NP + VP mismatch	8.50	5 - 13
NP + VP match	6.50	1 - 11

Note. M = mean; *SD* = standard deviation; NP = noun phrase; VP = verb phrase; NP only mismatch = no VP number information provided and NPs that mismatch in number; NP only match = no VP number information provided and NPs that match in number; NP + VP mismatch = VP number information provided and NPs that mismatch in number; NP + VP match = VP number information provided and NPs that match in number.

Table 7

ORC Mean (Standard Deviation) Number of Responses by Response Type for Each Condition

	Response Types			
Condition	Correct	MCE	RCE	DCE
NP only mismatch	7.25 (2.65)	2.20 (0.84)	3.83 (1.33)	2.17 (0.98)
NP only match	6.75 (3.19)	3.17 (1.14)	4.17 (1.60)	2.33 (0.52)
NP + VP mismatch	9.13 (2.70)	2.00 (2.49)	2.50 (1.05)	1.50 (0.84)
NP + VP match	6.06 (3.13)	3.12 (1.30)	3.52 (1.38)	2.67 (0.82)

Note. NP = noun phrase; VP = verb phrase; MCE = Main Clause Error; RCE = Relative Clause Error; DCE = Double Clause Error.

In a group of typically developing 6-year-olds, is there a within-group difference between comprehension of NP number match ORC sentences and NP number mismatch ORC sentences?

Figure 5 illustrates scores used in the Wilcoxon signed-rank test. To construct the figure, each child's score on NP only match was subtracted from the child's score on NP only

mismatch. When a child's NP only mismatch score exceeded the NP only match score, a positive value was obtained, represented by solid blue bars. When a child's NP only match score exceeded the NP only mismatch score, a negative value was obtained, represented by the striped bars. The frequency distribution of values is represented along the x-axis. There was not a significant within-group difference (Wilcoxon Z = –0.92, p = .36; N = 16). Contrary to our hypothesis, children's performance on the NP only mismatch sentences did not exceed the NP only match sentences.

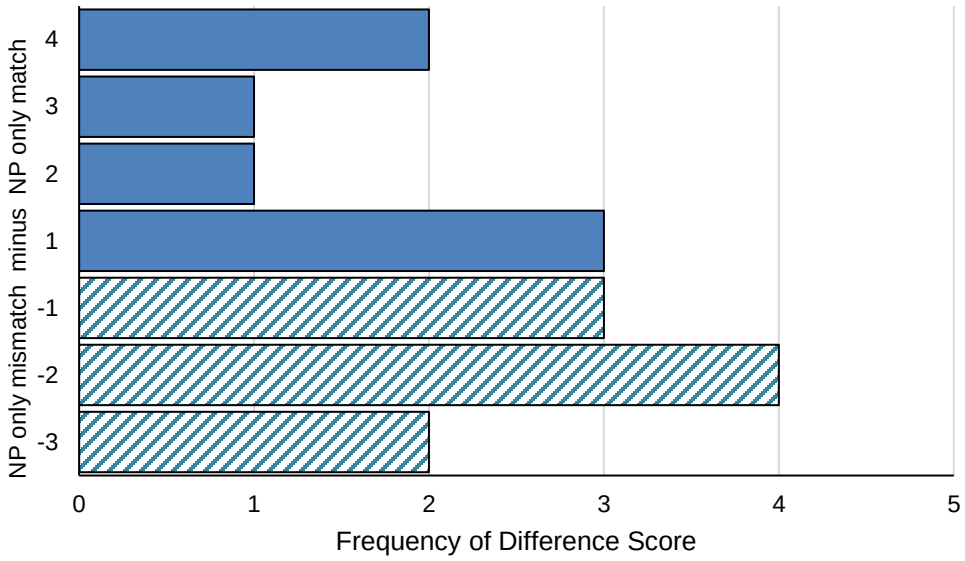

Figure 5. Bar graph of NP only mismatch sentence and NP only match sentence difference scores. The y-axis indicates the NP only match score subtracted from the NP only mismatch score for each child. The x-axis indicates the frequency in which each difference score was obtained (solid blue bars indicate NP only mismatch > NP only match; striped, blue bars indicate NP only mismatch < NP only match). Difference scores of "0" (*n* = 0) are not represented on the bar graph.

In a group of typically developing 6-year-olds, is there a within-group difference between comprehension of NP number mismatch sentences with VP number information and NP number match sentences with VP number information?

Given the lack of statistical significance on the primary research question, NP + VP number conditions were compared. Figure 6 illustrates scores used in the Wilcoxon signed-rank

test. To construct the figure, each child's score on NP + VP match was subtracted from the child's score on NP + VP mismatch. When a child's NP + VP mismatch score exceeded the NP + NP match score, a positive value was obtained, represented by solid blue bars. When a child's NP + VP match score exceeded the NP + VP mismatch score, a negative value was obtained, represented by the striped bars. The frequency distribution of values is represented along the x-axis. There was a significant within-group difference (Wilcoxon Z = 3.19, p = .001; N = 16). The effect size was large (r_C = .69). In line with our hypothesis, and consistent with Adani et al., children's performance on the NP + VP mismatch sentences exceeded the NP + VP match sentences.

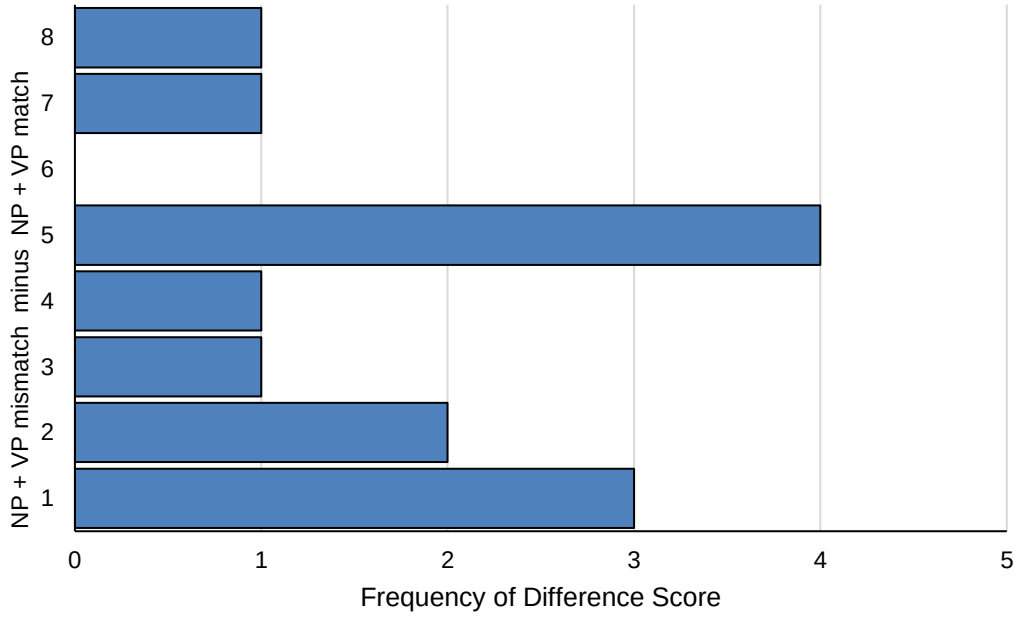

Figure 6. Bar graph of NP + VP mismatch sentence and NP + VP match sentence difference scores. The y-axis indicates the NP + VP match score subtracted from the NP + VP mismatch score for each child. The x-axis indicates the frequency in which each difference score was obtained (solid blue bars indicate NP + VP mismatch sentences > NP + VP match sentences). Difference scores of "0" (*n* = 3) are not represented on the bar graph.

Exploratory Analysis

Interpretation of these results can be aided by two exploratory analyses. First, VPs expressing number information are more common in children's input than VPs that do not

express number information (Räsänen et al., 2014). Second, if a relative clause sentence comprehension advantage only occurs when mismatching VP number information is present, children's comprehension of NP + VP mismatch sentences should be greater than NP only mismatch sentences.

Analysis of NP Number Match Conditions. Regardless of NP number match or mismatch, relative clauses with VP number information may be easier to comprehend than relative clauses with modals because children are more familiar with VPs containing number information (Brynes & Duff, 1989). If the presence of VP number information matters in relative clause comprehension, children's comprehension of NP + VP match sentences should be greater than NP only match sentences. We analyzed NP only match and NP + VP match sentences to clarify the role that VP number information play in relative clause comprehension.

Figure 7 illustrates scores used in the Wilcoxon signed-rank test. To construct the figure, each child's score on NP only match was subtracted from the child's score on NP + VP match. When a child's NP + VP match score exceeded the NP only match score, a positive value was obtained, represented by solid blue bars. When a child's NP only match score exceeded the NP + VP match score, a negative value was obtained, represented by the striped bars. The frequency distribution of values is represented along the x-axis. There was not a significant within-group difference (Wilcoxon $Z = -1.03$, $p = .30$; $N = 16$). Children's performance on the NP + VP match sentences did not exceed the NP only match sentences.

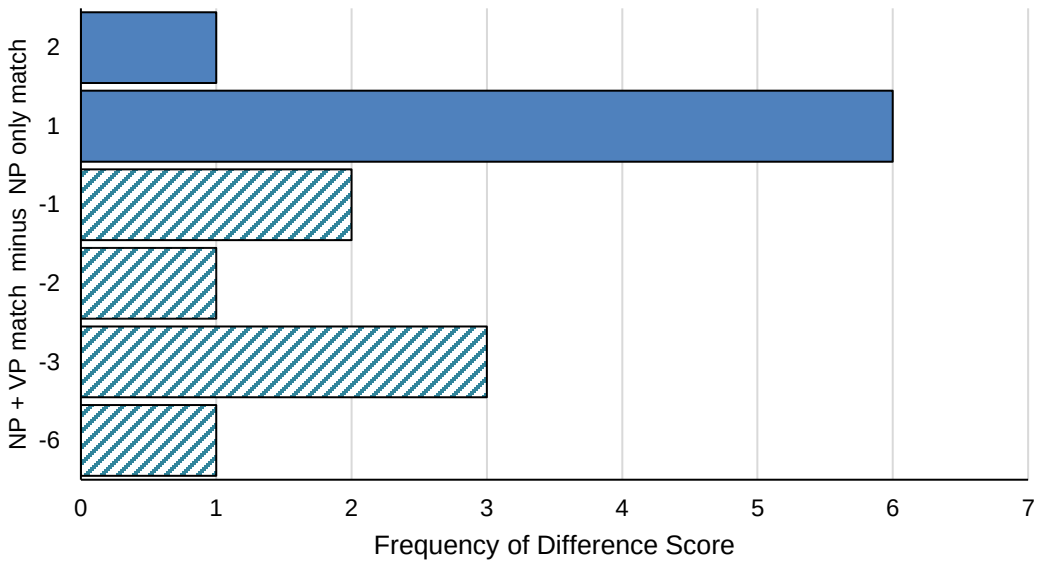

Figure 7. Bar graph of NP + VP match sentence and NP only match sentence difference scores. The y-axis indicates the NP only match score subtracted from the NP + VP match score for each child. The x-axis indicates the frequency in which each difference scores was obtained (solid blue bars indicate NP only match > NP + VP match; striped blue bars indicate NP only match < NP + VP match). Difference scores of "0" (*n* = 2) are not represented on the bar graph.

Analysis of NP Number Mismatch Conditions. If the NP number mismatch comprehension advantage is the result of matching VPs with NPs, then NP + VP mismatch sentence comprehension should exceed NP only mismatch sentence comprehension. We compared NP only mismatch and NP + VP mismatch to rigorously test whether the NP number mismatch comprehension advantage is dependent on the presence of VP number information.

Figure 8 illustrates scores used in the Wilcoxon signed-rank test. To construct the figure, each child's score on NP only mismatch was subtracted from the child's score on NP + VP mismatch. When a child's NP + VP mismatch score exceeded the NP only mismatch score, a positive value was obtained, represented by solid blue bars. When a child's NP only mismatch score exceeded the NP + VP mismatch score, a negative value was obtained, represented by the striped bars. The frequency distribution of values is represented along the x-axis. There was a significant within-group difference (Wilcoxon Z = 3.19, p = .001; N = 16). The effect size was

large (r_C = .67). Children's performance on the NP + VP mismatch sentences exceeded the NP only mismatch sentences.

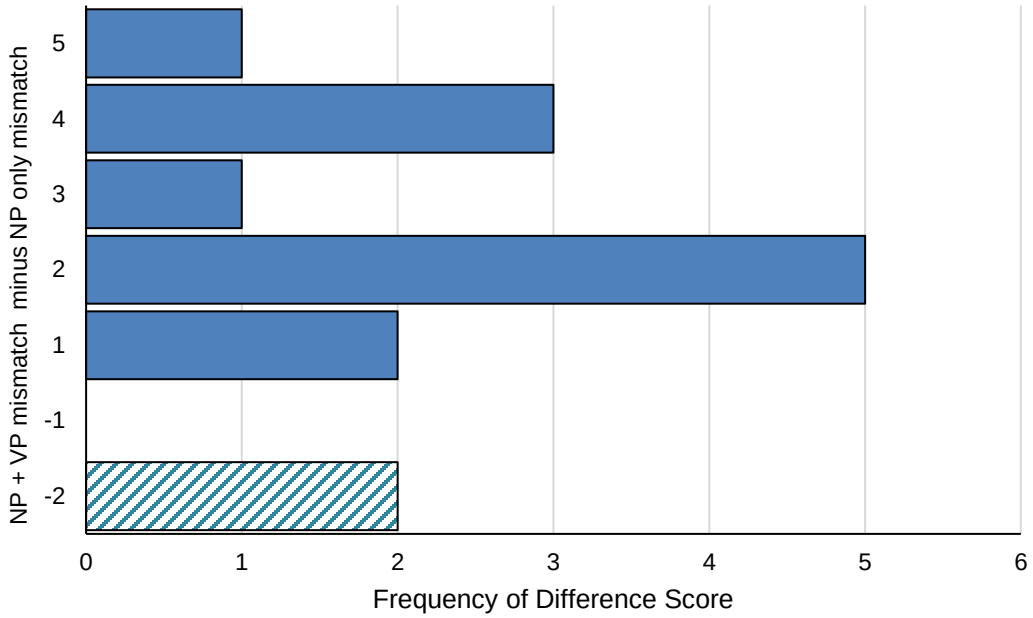

Figure 8. Bar graph of NP + VP mismatch sentence and NP only mismatch sentence difference scores. The y-axis indicates the NP only mismatch score subtracted from the NP + VP mismatch score for each child. The x-axis indicates the frequency of each difference score (solid blue bars indicate NP + VP mismatch > NP only mismatch; striped blue bars indicate NP + VP mismatch < NP only mismatch). Difference scores of "0" (*n* = 2) are not represented on the bar graph.

CHAPTER IV

DISCUSSION

ORC sentences are difficult for listeners to comprehend, especially preschool and school-age children (Kidd & Bavin, 2002). In this study, we explored whether NP number mismatch provided an advantage for 6-year-olds' comprehension of ORC sentences. English-speaking 6-year-olds with typical language completed a comprehension task in which main clause subject NPs and the main clause VPs, and relative clause subject NPs and relative clause VPs, were presented in ORC sentences. Our study is the first to isolate the contribution of NP number mismatch. To answer our primary and follow-up research questions, we constructed ORC sentences with and without NP number mismatch and with and without VP number information.

We hypothesized that NP number mismatch would provide an advantage for 6-year-olds' comprehension of ORC sentences. Our hypothesis was not supported. However, the presence of NP number mismatch and VP number information did provide a comprehension advantage. Children's performance on NP + VP mismatch sentences was greater than children's performance on NP + VP match sentences. Our NP + VP mismatch sentences closely resemble Adani and colleagues' sentence stimuli in that: (a) number information was manipulated to create number match and number mismatch conditions and (b) there was VP number information in sentence stimuli (Adani et al. 2010; 2014). When converted into a percentage, the mean of the NP + VP mismatch sentences comprehended (65.2%) is virtually identical to the mean of English-speaking 6-year-olds (64.6%) and Italian-speaking 5-year-olds (64%) in prior NP number mismatch studies (Adani et al., 2010; 2014). These findings highlight the importance of VP number information in children's comprehension of NP mismatch ORC sentences.

The Relativized Minimality Account

Our findings do not support the notion that NP mismatch provides a comprehension advantage by blocking the relativized minimality effect (Adani et al., 2010). Within the relativized

minimality account, a restrictive relativized minimality effect makes it difficult for preschool and school-aged children to fill the relative clause gap with the copy of the main clause subject NP. When the features of the relative clause subject NP match the features of the main clause subject NP, the relative clause subject NP may fill the gap. The main clause subject NP is interpreted as the relative clause subject NP. However, when the number features on NPs mismatch, the relative clause subject NP is blocked from inappropriately filling the gap. As a result, "featural disjointness" on NPs enhances comprehension (Friedmann et al., 2009). Within this account, VP number information does not contribute to the featural disjointness on ORC sentence NPs.

Two key findings do not support the relativized minimality account. First, if the relativized minimality account is correct, there should be a within-group difference between comprehension of NP only mismatch sentences and NP only match sentences. We did not find a within-group difference. Second, within the relativized minimality account, VP number information should not contribute to a NP mismatch comprehension advantage. However, there was a within-group difference between comprehension of NP + VP mismatch sentences and NP only mismatch sentences.

Although two key findings undermine the predictions generated by the relativized minimality account, participant error patterns offer some support for the relativized minimality account. For ORC sentences, instances of relativized minimality effects should result in the RCE type; the relative clause subject NP should fill the gap and the main clause subject NP should be interpreted as the relative clause subject (Adani et al., 2010). Although our study lacked the required power to conduct Adani et al.'s (2010) error analyses, we tallied participant error types when scoring responses. The RCE type was numerically larger than the MCE and DCE types, which is in line with prior ORC sentence comprehension studies (Adani et al., 2010; 2014). However, when RCE response type was compared to MCE and DCE, the effect size was small-to-medium (r_C = .20 and r_C = .23, respectively). We do not consider this strong evidence

in support of the relativized minimality account. Indeed, other theoretical accounts of relative clause sentence comprehension generate the prediction that children may interpret the first NP in a sentence as the relative clause subject (Slobin & Bever, 1982).

Cue-Based Accounts of Relative Clause Comprehension

Within cue-based accounts of relative clause sentence comprehension, VP number information is one of many available cues (e.g., word order, animacy) that helps listeners build a sentence representation, or a meaning of *who* does *what* in a sentence (MacWhinney, 2001). Our findings provide support for VP number information as a converging cue for ORC sentence comprehension.

Six-year-olds' comprehension of NP + VP mismatch provide some support for cue-based accounts of ORC sentence comprehension. Within cue-based accounts, VP number information is a cue that integrates NPs with VPs when a listener comprehends an ORC sentence (McElree et al., 2003). As a result, number information expressed on the VP should assist in the identification of its related NP and provide a ORC sentence comprehension advantage.

Cue-based accounts generate the prediction that there is a within-group difference between comprehension of NP + VP mismatch ORC sentences and NP + VP match ORC sentences. Because there was a within-group difference between NP + VP mismatch sentences and NP + VP match sentences, we argue that VP number information is used as a cue when a listener comprehends an ORC sentence.

Within most cue-based accounts of ORC comprehension, VP number information is considered less important for comprehension of English sentences than other cue types (MacWhinney et al., 1984; Lewis et al., 2006). Our findings suggest that, despite questions of its relative importance, VP number information plays a role in the NP mismatch ORC sentence comprehension advantage.

Verb number information as a converging cue. Within MacWhinney's (2001) competition model, the strongest cues are those that are the most available and reliable

(MacWhinney, 2001; MacWhinney, 2008). In English, word order is a strong and reliable cue; native English speakers overwhelmingly identify the first NP in the preverbal position as the clausal agent (MacWhinney et al., 1984). Because word order is such a strong cue in English, verb number information has been considered a "weak" cue and largely ignored by English listeners (MacWhinney, 2001). However, there are instances in which the first NP in the preverbal position is not the clausal agent, as in ORCs. In such cases, it is possible that agent identification is supported by converging cues, or cues that "point in the same … direction for meaning interpretation in a sentence" (Li & MacWhinney, 2013).

Our findings support the notion that English speakers use VP number information as a converging cue when identifying the agents of ORC sentences (Li & MacWhinney, 2013).[4] Our findings are in line with prior work that found that VP number information played a larger role in agent identification in noun-noun-verb (NNV) word sequences – the word sequence found in ORC sentences – than NVN word sequences (MacWhinney et al., 1984; Devescovi et al., 1999; Schelstraete & Degand, 1998). A related body of research has found that English-speaking preschool children used the converging cues of NP animacy and word order to identify the agent in NNV word sequences (MacWhinney et al., 1985; Noble et al., 2016). In summary, our study adds to the small body of evidence that weak cues, like VP number information and NP animacy, play a role in the comprehension of NNV word sequences.

Although our findings support the plausibility that VP number information aids in ORC sentence comprehension, it is possible that our findings may not generalize to all ORC sentences. We briefly describe why our findings should be interpreted with caution and why future ORC sentence research is needed.

Exploring other explanations for our findings. Our sentence comprehension tasks required participants to match VPs with NPs by using VP and NP number features. However,

[4] In this context, the converging cues would be verb number morphology and word order (listeners using the second-noun strategy; MacWhinney et al, 1984).

sentence comprehension is a complex task that involves other important factors, such as the familiarity of a NP or the semantic plausibility of a NP as an agent (Kim & Osterhout, 2005; Van Dyke & McElree, 2006). We controlled for factors such as word familiarity by selecting only NPs and VPs that are very familiar to 6-year-old children (Frank et al., 2019). However, by controlling for these other factors, we may have removed many of the cues that listeners use when comprehending ORC sentences. Although we have argued for verb number information as a converging cue, it is possible that VP number information only emerges as a useful cue when other important factors are excluded from the comprehension task (Ambridge & Lieven, 2011).

We also consider whether our findings generalize beyond ORC sentences. ORC sentences are infrequent in preschool and school-age children's input and are rarely produced in conversation (Diessel, 2004; Roland et al., 2007). In contrast, right-branching object-gapped relative clause sentences (e.g., "The mom sees the boy that the dog kisses") frequently occur in children's input and are easier to comprehend than ORC sentences for children and adults (Diessel, 2004; Kidd & Bavin, 2002). Due to the unfamiliarity and difficulty of ORC sentences, our participants may have adopted an agent identification strategy that they would not employ with more familiar and frequently occurring relative clause sentence types (Martin & McElree, 2018). Because only ORC sentences were evaluated, it is unknown whether our findings extend to other relative clause sentence types.

Study Limitations

In this study we asked whether NP number mismatch in isolation provided an ORC sentence comprehension advantage. We designed this study based on previous experimental studies of NP number mismatch in ORC sentences. For example, we matched several aspects of our sentence stimuli and picture stimuli with the Adani et al. (2014) sentence stimuli and picture stimuli. However, our study differed from Adani et al. in some notable ways. First, COVID-19 restrictions may have introduced a confound by requiring remote administration of all experimental tasks. Selecting correct picture numbers within a videoconferencing session may

be more demanding for 6-year-olds than selecting correct pictures in-person. Although 6-year-old participant performance matched that of the Adani et al. (2014) 6-year-olds, it is possible that the challenges of videoconferencing adversely affected our participants' performance. For example, because children only listened to ORC with number match and mismatch, it is possible that our participants would have obtained scores that exceeded Adani et al. (2010; 2014). Our findings would be strengthened by a replication study with in-person administration.

Second, we recruited participants from a single age group rather than multiple age groups. We streamlined our study to investigate whether NP number mismatch in isolation produced an ORC sentence comprehension advantage in a participant age group likely to show a comprehension advantage. However, it remains unclear whether NP number mismatch provides an ORC sentence comprehension advantage for a brief period in development or for a prolonged period beyond childhood (Adani et al., 2010; 2014). Our findings would be strengthened by future cross-sectional studies including multiple age groups.

Third, the sample size of our study may have restricted useful secondary analyses. Previous studies of the ORC sentence comprehension have analyzed error patterns for evidence of relativized minimality effects using mixed effects models (Adani et al., 2014). Although such an analysis was outside of the scope of our study, we reported error patterns that align with Adani et al. (2014). The type of mixed effects model used by Adani et al. (2014) would require a larger sample size than what was included in our study (Brysbaert & Stevens, 2018). We acknowledge that studies of NP number mismatch and ORC sentence comprehension should consider error pattern analyses.

Finally, our findings have been discussed in the context of two families of theoretical models: the relativized minimality account and cue-based accounts of sentence comprehension. Due to our focus on the NP number mismatch and VP number information, we only considered theoretical models that explicitly address the roles of NP and VP number features. However, we have not considered many lexical, structural, and semantic factors that are included in other

theoretical accounts of sentence comprehension (Padó et al., 2009). For example, within surprisal-based accounts, listeners and readers generate online predictions about upcoming words and phrases (Levy, 2008). Sentences are most difficult to understand when low-probability words and phrases disrupt a listener's or reader's online predictions. Our study is ill-suited for evaluation of accounts like Levy's (2008) surprisal-based account for two reasons. First, we included high-frequency NPs and VPs in our experimental sentences and ensured that all NPs could complete all actions indicated in VPs (e.g., all NPs were animate; Frank et al., 2019). Second, all sentences were ORC sentences, a syntactic structure that is infrequently heard in adult and child conversations. Because we did not manipulate the familiarity of experimental sentences' NPs or relative clause sentence types, our findings do not provide meaningful information about surprisal-based accounts.

Conclusions

This study adds to the basic language science knowledge base by demonstrating that NP number mismatch alone does not result in an ORC sentence comprehension advantage. There was a NP number mismatch ORC sentence comprehension advantage only when VP number information also was present. Available descriptions of relativized minimality effects cannot explain our results (Friedmann et al., 2009). This is the first study of NP number mismatch and ORC sentence comprehension to offer support for cue-based accounts of relative clause sentence comprehension.

Future Directions

Children's performance on a picture pointing comprehension task may not illustrate all that they know about an area of morphology or syntax. Picture selection tasks may be difficult for young children for many reasons, including difficulties in relating instructions to picture stimuli (Smolík & Bláhová, 2017). Eye-tracking methodologies avoid the challenges of picture selection tasks and can provide valuable insight about the role that verb number information plays in relative clause sentence comprehension. For example, Beyer and Hudson Kam (2009)

found that 6-and 7-year-old children search out NP-VP agreement upon hearing a verb morpheme that expresses number (e.g., *She leaves the playground*). An eye-tracking study could provide fine-grained information about when verb number information results in gaze shift to a pictured NP with agreeing number features (Acuña-Fariña et al., 2014).

Our results predict that children's gaze should alight on the main clause agent upon hearing the verb number information on the main clause VP. However, other cue-based accounts of sentence comprehension generate different predictions (Tanner et al., 2014). After the relative clause agent has been matched with the relative clause VP, the listener may anticipate that the upcoming VP will pair with the unmatched NP (main clause agent; McElree et al., 2003). In this case, children's anticipatory eye movements toward the correct selection should precede hearing the verb number information on the main clause VP. With the inclusion of an eye-tracking measure, NP number mismatch studies could evaluate the hypotheses of a larger number of cue-based sentence comprehension accounts.

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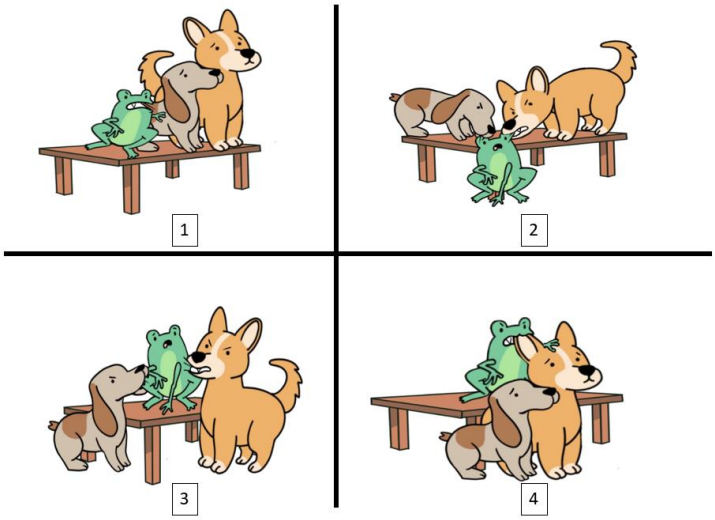
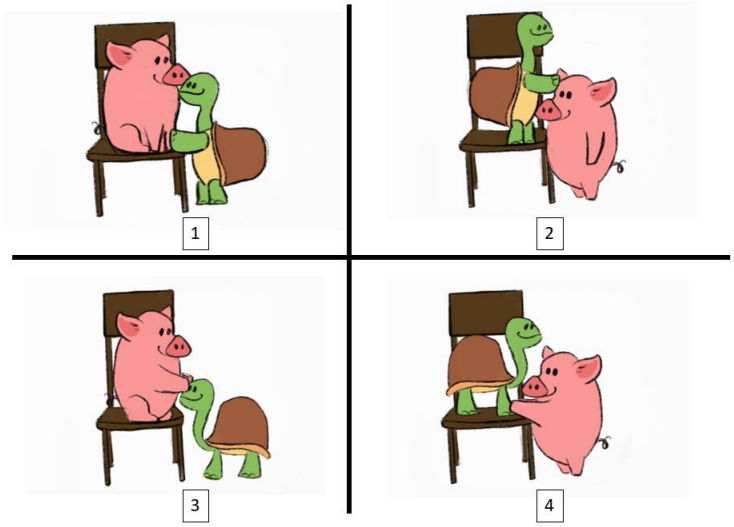
Appendix A: Experimental Sentence and Picture Stimuli for Conditions 1-4

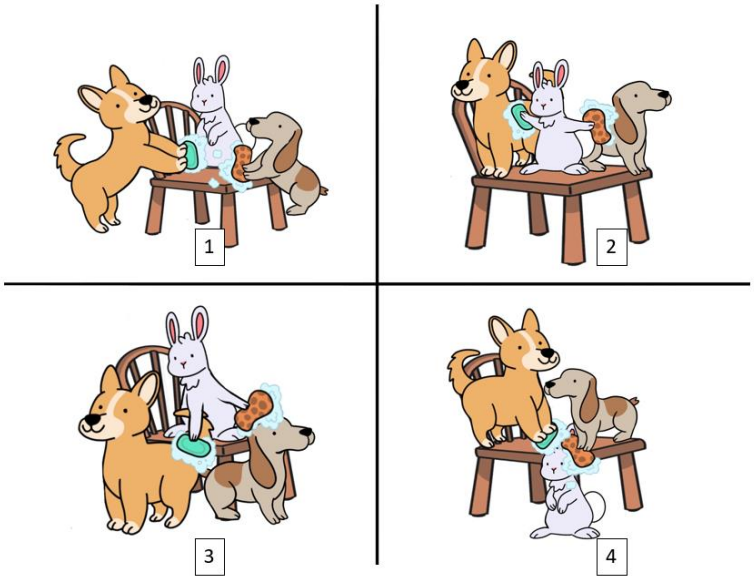
Picture array (A) is a NP only mismatch item, (B) is a NP only match item, (C) is a NP + VP mismatch item, and (D) is a NP + VP match item.



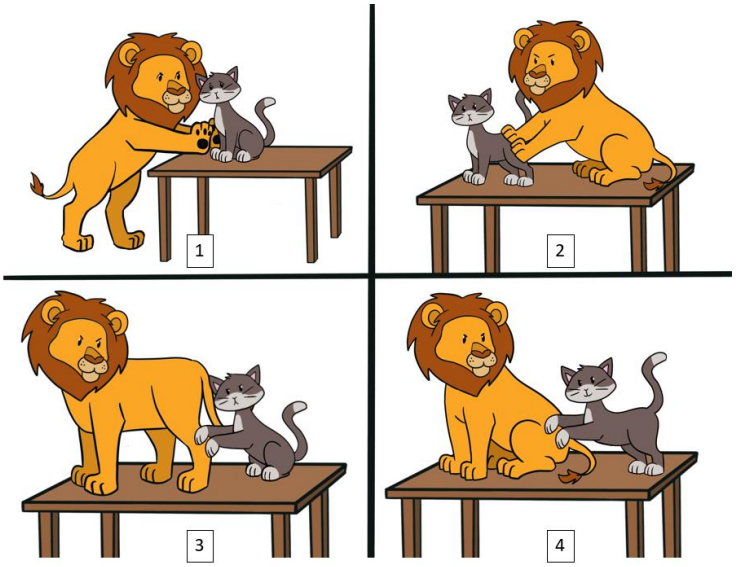
(A) The frog that the dogs can bite can climb on the table.



(B) The turtle that the pig can push can stand on the chair.



(C) The bunny that the dogs are cleaning is sitting on the chair.



(D) The cat that the lion is pushing is sitting on the table.

Appendix B. Table Outlining Differences Between Adani et al. (2010; 2014) and Present Study

Study Component	Study Type	
	Present Study	Adani et al. (2010; 2014)
Participants	Only English-speaking 6-year-olds with typical language were recruited.	Italian-speaking 5-, 7-, and 9-year-olds (2010) and English-speaking TD 6-, 7-, and 8-year-olds were recruited.
Sentence Stimuli	Experimental sentence stimuli with VPs that either (a) consisted of the modal *can* and a verb that did not express number information (e.g., "can push"), (b) consisted of an auxiliary + present progressive.	Contained experimental sentence stimuli with VPs that consisted of an auxiliary + past participle.
Sentence Stimuli	All NPs and VPs in the sentence stimuli were drawn from Wordbank to include words used by at least 80% of 30-month-olds.	Confirmed that all children comprehended each NP and VP that appeared in the experimental task.
Task Administration	Children directed their responses to the researcher.	Children completed a toy animal familiarization activity and directed their responses to toy.
Training Items	Administered two training items.	Administered four training items.
Experimental Task	For experimental items, children were told to name the picture number that matched the sentence that they heard.	Children pressed a keyboard key to select an answer.
Experimental Task	Children only heard main clause in the context of the experimental sentence.	A spoken preamble to the experimental sentence stimuli contained the main clause.