

LEARNING DISJUNCTION

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Abstract

To understand language, we rely on mental representations of words and their meanings. What constitutes these representations? How are they learned? To address these questions, I investigate how children learn and interpret the disjunction word *or*. The highly abstract and context-dependent interpretation of *or* challenges word learning theories and provides an exceptional opportunity to better understand how words are associated with their meanings.

Or has several interpretations, including exclusive and inclusive disjunction. Inclusive disjunction, formalized as $A \vee B$ holds when A is true, B is true, or both. For example, a waiter may ask if you would like something to eat or drink, not excluding the possibility that you choose both. Exclusive disjunction, $A \oplus B$, is true when only A is true, or only B is true, but not both. If the waiter later asks whether you would like to see the dessert menu or have the check, his *or* is most likely interpreted as exclusive. He is suggesting that you should choose one or the other. Given these complexities in the interpretation of *or*, how do children learn it?

A previous study has shown that when parents talk to their children, the majority of *or*-examples they use are exclusive. I present an annotation study on parents' speech to children that replicated this finding. Nevertheless, comprehension studies have found that preschool children understand the inclusive interpretation of disjunction around four years of age. In an experimental study with a novel paradigm, I replicated this finding in simple existential sentences. These two findings lead to a puzzle in the literature: How can children learn the inclusive interpretation of *or* if they rarely hear it?

I argue that this puzzle arises in models of word learning that directly map words to their meanings, thereby ignoring accompanying linguistic and conceptual cues. I present an in-depth annotation study demonstrating that exclusive interpretations correlate with contextual cues (such

as intonation and the semantic relation of the alternatives *or* combines with) in children's input. Applying supervised learning techniques to the annotated data, I found that a learner who makes use of these contextual cues can learn the inclusive as well as exclusive interpretation of disjunction from the language heard.

These findings indicate that the representation of a word like *or* cannot be isolated from the linguistic and conceptual environment in which it appears. The linguistic and conceptual aspects of *or*'s environment can act as cues that aid its acquisition and interpretation. Together, these studies show that learning a function word like *or* requires richer lexical representations than are currently assumed by our theories of word learning.

Dedication

To my parents, Abbas Jasbi and Tahereh Haj-Ebrahimi, who taught me the meaning of *life*.

Acknowledgments

This dissertation is about *or*, but first, I will take a moment to focus on *thanks*. I would like to thank the many people who, through the years, have selflessly and generously offered me their knowledge, skills, time, kindness, and support. Words do not do justice to what they have done for me, but in thanking them here, I hope I succeed in expressing my gratitude. I will never forget the influence they have had on my development, and will always strive to pay their kindness and generosity forward.

I would like to first thank the Stanford Linguistics department, who trusted me and supported my learning and growth in the past six years. Undoubtedly, it has been an honor to know every single member of the Stanford linguistics community. I would like to especially thank my principal advisor, Eve Clark. I feel extremely lucky to have had Eve as my advisor and it will always be my honor to have been her last (official) doctoral student. Academic work can sometimes feel too abstract, but Eve's advice always drew me back to the critical points of examining linguistic development. I can still hear Eve say: "But what is the context of use?" The readers of this dissertation will surely notice Eve's immense influence on its content, as well as my research more broadly.

I would like to express my sincere gratitude to Mike Frank for his excellent and kind mentorship. Mike's guidance was crucial in shaping my research on disjunction and logical words. Among many other topics, Mike introduced me to open science and best practices in experimental research. His ideas and teachings in this area have had a deep and lasting impact on my own research and thinking. I strive to challenge and support students just as he has done for me.

Through his incisive comments and criticism, Chris Potts has been extremely influential in shaping the direction and approach of this dissertation, as well as my own thinking on semantics and

pragmatics. I will always be grateful for the example that he set for me in critically assessing theories, especially those of my own. I would like to also thank Ellen Markman, whose helpful comments on earlier drafts of this dissertation helped shape its logical flow. Many thanks to Thomas Icard for sharing his comments and deep insights with me so generously.

My first research project as a graduate student examined differential object marking in Persian. At times, it seemed frustratingly impenetrable. The advances I made in that project and in others would not have been possible without the helpful insights of Paul Kiparsky and Cleo Condoravdi. I am grateful to both for what they taught me. Cleo's contagious passion for crosslinguistic research in semantics and pragmatics pushed me to continue my research on Persian function words. Her careful and rigorous work, as well as extensive knowledge of the field, showed me the kind of semanticist I would like to be. I will always be grateful to her for that.

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My research is deeply indebted to the people at the Bing Nursery School. It is fair to say that the biggest challenge in developmental research is methodological: how can we best capture children's knowledge and mental state? Experimental environment is the key. If children feel nervous or confused about what is going on in the study, we won't be able to capture what we like to know about them. The staff and teachers at the Bing Nursery School create the right environment for research where children feel at home, and researchers feel at ease while running their studies. For this, as well as their generous help and support with my research, I would like to thank Jennifer Winters, Beth Wise, Chia-wa Yeh, and all the kind teachers and staff at the Bing Nursery School.

During my time at Stanford, I have had the pleasure of teaching undergraduate students and serving as the linguistics undergraduate mentor. My teaching and mentorship helped me meet brilliant students and researchers such as Akshay Jaggi and Kutay Serova, who joined me later as research assistants. Akshay played a major role in developing annotation categories for this

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I am eternally grateful for the sacrifices that my parents have made for my education. All I have achieved and all I will achieve, truly belongs to them. I am also lucky to have the support of my two loving sisters, Fahimeh and Elham, who always bring me joy and laughter. My graduate education meant that I had to leave behind my family back home, often not being able to see them for very long periods of time. This was really hard for me, and for them, despite their jokes that life is a lot easier when I'm not around! Finally I would like to thank Mona Matsumoto-Ryan: for being who she is and for who she has helped me to be.

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Chapter 1

Introduction

In the literature on word learning, the story goes that one day, a linguist with great mastery of phonetics and phonology, heard of a people with an unknown language. She immediately packed her bags and traveled to learn about this new language. When she arrived, she saw a man walking down the road. Suddenly a rabbit scurried by. The man saw the rabbit and said “gavagai”. The linguist immediately pulled out her notebook. As an excellent phonetician with trained ears for detecting linguistic sounds, she wrote down the phonetic transcription of what she heard with great confidence. It was only when she tried to write the meaning that doubt and uncertainty seeped in. “Does *gavagai* mean rabbit?”, she whispered quietly. As a good scientist, she could see that her observation was compatible with a large number of hypotheses for the meaning of *gavagai*: “white-thing”, “furry thing”, “animal”, “fast”, “what was that?”, “oh gosh!”, “rabbit-on-the-road”, and even “undetached rabbit parts”! She shook her head and let out a sigh. She had encountered “referential uncertainty” (Quine, 1960, Ch. 2, pp. 27).

Unlike what most of us think, the story did not end there (Quine, 1960, Ch. 2, pp. 52). The linguist continued with her observations and soon she learned the meaning of *gavagai* as well as many other words, mostly nouns, adjectives, and verbs. But soon she encountered a new challenge. One day when she was walking down the same road with the same man, she noticed some movement in the nearby bushes. The man pointed to the bushes and said: “tonomi yok gavagai”. She knew that *gavagai* meant “rabbit”. She also knew that *tonomi* was another animal. But she had never heard the word *yok* before. What did *yok* mean? Maybe the man saw an animal and was not sure

whether it was a *gavagai* **or** a *tonomi*. However, the man did not sound uncertain. What if he was trying to say that the animal was a *gavagai* **and not** a *tonomi*? Maybe he saw two animals and wanted to let her know that there was a *gavagai* **and** a *tonomi* in the bushes. It was also possible that by that time, the man knew she was trying to learn their language and wanted to let her know that *gavagai* and *tonomi* are terms that apply to the same animal; something like: “this is called a *gavagai* **or** a *tonomi*”. The linguist in our story sighed again. Even though she knew the meaning of words for things and actions, she needed to know the meaning of words that put them together to convey larger concepts. Legend has it that she did not go home until she discovered the meaning of all such “function words” in the language.

1.1 Word Learning

Learning the meaning of a word is often construed as mapping a linguistic form such as *gavagai* to a concept/meaning such as “rabbit”. This mapping process is described in three stages: First the learner isolates the word form; then s/he isolates a meaning from a set of possible meanings; and finally s/he maps (or associates) the isolated word to the isolated meaning (Clark, 1993). A fundamental question in the acquisition of meaning concerns the second step of mapping: how do children select the right meaning from a set of candidate meanings? Quine (1960)’s thought experiment with the linguist and the new language showed that this is not a trivial task. In any given context, a word is compatible with many possible meanings. The problem of selecting the right meaning for a given word is called the “mapping problem” or the “*gavagai* problem”.

Solutions to the mapping problem often place constraints on either the hypothesis space or the structure of the lexicon to make word learning tractable (Clark, 1993). For example, the taxonomic constraint (Markman & Hutchinson, 1984) proposes that children generate semantic hypotheses for nouns that denote a set of taxonomically related entities and do not hypothesize meanings that capture sets of entities with thematic relations. For example, given the word *gavagai*, children hypothesize the meaning “rabbit” which denotes the set of rabbits (taxonomically related) but not “rabbit and carrot” (thematically related). Therefore, the taxonomic constraint limits the space of hypotheses that the learner entertains. On the other hand, the mutual exclusivity constraint (Markman & Wachtel, 1988) as well as the pragmatic principle of contrast (Clark, 1987) limit the structure of the lexicon such that two words are not mapped into the same meaning. This

constraint on the lexicon makes the word learning task easier by removing hypotheses that are already associated with learned words.

Another solution to the mapping problem is to propose cues that bias the learner towards one hypothesis rather than another. For example, socio-pragmatic cues such as pointing and joint-attention (D. Baldwin, 1993; Clark, 2009; Tomasello, 2003) direct the learner to bias one hypothesis over others. For example, given a rabbit and a cat, the speaker pointing to the rabbit and saying *gavagai* biases the learner to map the meaning of *gavagai* to “rabbit” rather than “cat”. Learning models can also integrate cues and constraints to develop a learning account that uses multiple cues to home in on the target meaning of a word (Hollich et al., 2000).

While there has been a large body of research on the set of cues and constraints that aid the acquisition of content word, function words have not received comparable attention. This dissertation takes a small step in advancing research on the acquisition of functions words by focusing on the challenging case of the disjunction word *or*. The case of *or* shows that function words, due to their special properties such as abstract and variable interpretations, will play an important role in shaping theories of word learning. In the next section I explain the scope of this dissertation within a program that aims at developing a cue-based acquisition of function words.

1.2 Defining the Scope

The lexicon of a language can be divided into two classes: content words and function words. Content words consist of nouns (e.g. *cat, Bob, freedom*), verbs (e.g. *run, blink, imagine*), adjectives (e.g. *happy, red, fake*), and adverbs (e.g. *fast, quietly, quickly*). Function words include articles (e.g. *a, the*), quantifiers (e.g. *some, most, all*), prepositions (e.g. *in, on, at*), pronouns (e.g. *he, they, her*), auxiliary verbs (e.g. *did, can, am/is/are*), connectives (e.g. *or, if, because*), interrogatives (e.g. *who, what, when*) and more. Function words differ from content words in (at least) five crucial ways. First, function words are phonologically simpler than content words (Shi, 1995). Second, even though content words vastly outnumber function words, function words are a lot more frequent. Third, while content words frequently admit new members, function words rarely do so. This is why content words are considered an open class in the lexicon while function words are called a closed-class. Fourth, the common intuition is that content words carry more meaning and the concepts they denote are more tangible. The meanings of function words, however, are subtle and abstract.

Finally, function words appear in children’s speech later than content words.

Even though content words are more salient and commonly steal the spotlight in public discourse, the unique properties of function words make them a valuable resource to linguists and cognitive scientists. They are the essential nuts and bolts that combine smaller words and concepts to form large sentences and thoughts. They provide crucial information on the structure and inner workings of language. The crosslinguistic and psycholinguistic study of function words provides us with an exceptional window into the structure and building blocks of our minds.

Within function words, logical connectives *and*, *or*, *not*, *if*, have received considerable attention in the linguistic and psychological literature due to the foundational role that the concepts of conjunction, disjunction, negation, and implication play in logic and mathematics. In linguistics and philosophy, a large body of research has investigated the connections between the meanings of these words and their corresponding operators in formal logics. Similarly in psychology, there has been substantial research on children’s development and adults comprehension of logical concepts and logical reasoning. This dissertation focuses on the acquisition of the disjunction word *or* by preschool children. It proposes a learning account for *or* (and its counterpart *and*), that can be expanded in the future to linguistic connectives in general such as *but*, *because*, *yet*, *so*, *after*, *before*, *although*, *however*, etc.

1.3 Why Disjunction?

The disjunction word *or* has been the lab rat of formal semantics and pragmatics. The main reason is that even though it seems to have a simple meaning, it gives rise to a variety of inferences that reveal the interaction of semantics and pragmatics. In fact, Paul Grice’s original investigations that lead to the birth of formal pragmatics was partly motivated by resolving apparent discrepancies between the logical and linguistic accounts for the meaning of disjunction (Grice, 1989). Since then, there has been a flood of research on the meaning of *or* and as a result, much more is known about the meaning and interpretation of *or* than perhaps any other function word. This makes *or* an ideal case for better understanding how the meaning of function words are learned by children. Furthermore, research on disjunction has lead to a developmental puzzle that I explain in the next section.

1.4 The Puzzle of Learning Disjunction

The word *or* has been a case study for linguistic semantics due to its apparent ambiguity between an inclusive and an exclusive interpretation. An inclusive disjunction such as “ $A \vee B$ ” is true when either A , B , or both are true. An exclusive disjunction such as “ $A \oplus B$ ” is true only when A or B is true, but not both. The linguistic connective *or* appears to be ambiguous between an inclusive interpretation like “ $A \vee B$ ” and an exclusive one like “ $A \oplus B$ ”. For example, a waiter may ask if you would like something to eat or drink, not excluding the possibility that you would like both. This is an inclusive disjunction. However, the waiter may later ask if you would like to see the dessert menu or have the check, suggesting that you should choose one or the other, and not both. This is an exclusive disjunction.

Given the complexity involved in interpreting a disjunction, how can children learn it? A previous investigation has suggested that children rarely hear the word *or*; and when they do, they hear the exclusive interpretation. Morris (2008) investigated instances of *and* and *or* in parents' and children's speech using 240 transcripts in the CHILDES database (MacWhinney, 2000). He found that compared to *and*, *or* is rare in child-directed speech. Furthermore, the majority of *or* examples children heard (75-80%) and produced (90%) had exclusive interpretations. Based on these findings, he concluded that children's early meaning for *or* is exclusive disjunction and that they learn the inclusive meaning in later stages of development (possibly at age 6 or 7).

Contrary to Morris (2008)'s conclusion, a series of experimental studies found that children between the ages of 3 and 5 can interpret *or* as inclusive disjunction (Chierchia, Crain, Guasti, Gualmini, & Meroni, 2001; Crain, 2012; Jasbi & Frank, 2017). Given Morris (2008)'s finding that the majority of *or* examples children hear are exclusive, we face a puzzle: how can children learn to interpret *or* as inclusive if they rarely hear inclusive examples of *or*? Crain (2012) considered it unlikely that children learn the meaning of *or* from the examples they hear in adult usage. Instead, he argued that children rely on an innate knowledge that the meaning of a disjunction word must be inclusive. In other words, upon hearing a connective word, children consider inclusive disjunction ($A \vee B$) as a viable candidate for its meaning but not exclusive disjunction ($A \oplus B$). This dissertation provides an alternative answer to the puzzle of learning disjunction. It suggests that children can learn when a disjunction must be interpreted as inclusive if they pay attention to the contextual cues that accompany exclusive uses.

1.5 The Structure of the Dissertation

This dissertation consists of two main parts. Chapters 2-4 constitute the first part and Chapters 5-6 constitute the second part. The first part focuses on the interpretations of disjunction and how children can learn them from the language they hear. It proposes an account that uses multiple cues to learn the interpretation of a disjunction. The main methods used in this part are exploratory corpus studies and computational modeling. The second part discusses the comprehension of disjunction in children and adults, focusing on disjunction in declarative sentences. This part uses confirmatory experimental studies to test children's comprehension and compare them to adults. It shows that children's interpretations of *or* between the ages of 3 and 5 are in line with the predictions of the account presented in the first part. In what follows, I briefly describe the role of each chapter.

Chapter 2 provides an overview of the semantics and pragmatics of *or* in English. The main focus of the chapter is the empirical discoveries about the interpretations of disjunction in different linguistic and nonlinguistic contexts. The chapter shows that on the surface, a disjunction like "A or B" can be interpreted as inclusive (A or B, or both), exclusive (A or B, not both), or conjunctive (both A and B). These interpretations are sometimes accompanied by ignorance implications (the speaker does not know which option is true) or indifference implications (the speaker does not care which option is true). The chapter discusses the factors that affect the interpretation of *or* in a given context. These factors include conversational principles, entailment environment, modality, disjunct semantics, intonation, syntax, metalinguistic speech acts, and some specific constructions such as embedded imperatives and unconditionals. The chapter argues that these factors can act as cues for the acquisition and interpretation of disjunction.

Chapter 3 presents two corpus studies. The first study presents a large-scale analysis of parents and children's productions of *and* and *or*. The results show that children start producing *and* between the first and the second years of their lives and reach their parents' rate of *and* production around their third birthday. For disjunction, children start producing *or* between two and three years of age and by the time they are four, they reach a constant rate of *or* production. This rate is slightly lower than that of their parents. The chapter discusses three factors that may contribute to children's lower rate of production: conceptual complexity, input frequency, and utterance type frequency. It argues that children's lower rate of production is at least partly due to utterance type frequency: parents ask more questions from children than children from parents. Since *or* is more

common in questions, parents have more opportunities to use it than children. Overall, the findings suggest that children develop their understanding of disjunction between their second and fourth birthdays.

The second corpus study selected a subset of *and* and *or* in child-directed speech for five children between the ages of one and three. First, every instance of *or* in a question was annotated for the type of response it received from children. The results showed that around age 2, children start providing appropriate answers to questions with disjunction. Second, the study annotated utterances containing *and* and *or* for their interpretation (exclusive, inclusive, conjunctive), as well as five types of cues: intonation (flat, rising, rise-fall), utterance type (declarative, question, imperative), syntax (clausal vs. subclausal), consistency (inconsistent: “clean or dirty” - consistent: “clean or tidy”), and communicative function. The results confirmed previous findings that exclusive interpretations are more common in children’s input than non-exclusive ones. However, the study also found that intonation and consistency play a large role in determining whether a disjunction is exclusive or not. If intonation was rise-fall, or the disjuncts were inconsistent, the disjunction was most likely exclusive; otherwise, inclusive. These results show that even though exclusive interpretations are more common in children’s input, they correlate with certain contextual cues.

Based on the annotation study of Chapter 3, I introduce a learning account in Chapter 4 which uses contextual cues to learn the interpretations of disjunction. The basic idea behind this account is that *or* receives its interpretation as exclusive or inclusive based on the specific context of use. Given a set of contextual cues, *or* may receive an exclusive interpretation, while given another set of cues, it may be inclusive. Therefore, if the learner keeps track of contextual cues and how they correlate with the interpretation of a function word like *or*, she can learn multiple interpretations of a function word according to the context of use. I call this account cue-based context-dependent learning.

I show that this account resolves the puzzle of learning disjunction. As a reminder, the puzzle asserted that children learn the inclusive interpretation of *or* despite the fact that most examples of *or* they hear are exclusive. I argue that this observation is only puzzling if we assume that function words like *or* should be mapped to their most frequent interpretation overall (e.g. exclusivity). However, the annotation study found that exclusive interpretations are common in certain contexts while inclusive ones are common in others. Therefore, if learners track contextual cues and learn the

interpretation of a function word within a specific context of use, they can learn both the exclusive and inclusive interpretations of disjunction. To test this account more formally, I trained random decision forests (Breiman, 2001; Ho, 1995) on the annotation dataset developed in Chapter 3. While without using contextual cues, a disjunction was classified as exclusive, using contextual cues decision tree classifiers learned to classify instances of disjunction as exclusive and inclusive, depending on the context of use. Crucially, disjunctions in declarative sentences with a flat intonation and consistent alternatives (disjuncts) were found to be more likely to be inclusive. This is the context most frequently tested in comprehension studies on disjunction.

Chapter 5 provides an overview of the developmental research on children's comprehension of disjunction. Early developmental research in the 70s and 80s suggested that children and even high school students struggled with correctly interpreting a disjunction. They reported that they interpreted it as conjunction and exclusive disjunction. Later research suggested that the conjunctive interpretations may be due to non-linguistic strategies that are deployed when the experimental tasks are demanding or confusing to participants. Recent studies in the past two decades within a Gricean framework of semantics and pragmatics have shown that children interpret *or* as inclusive disjunction, especially in declarative sentences. However, most previous studies did not control for one or more of the following factors: complexity of the linguistic stimuli, complexity of the task, ignorance of the speaker, interpretation of the conjunction word (e.g. *and*) in the same task, and finally interpretation of adults in the same task.

Controlling for the factors enumerated in Chapter 5, Chapter 6 presents three studies on adults' and children's comprehension of *or* in simple existential sentences ("there is A or B"). The first study tests adults comprehension of discussion using two and three-alternative forced-choice truth-value judgment tasks (2AFC and 3AFC TVJTs). The 2AFC task showed that adults interpret *and* as conjunction and *or* as inclusive disjunction. The 3AFC task showed that adults do not consider a disjunction completely felicitous when both disjuncts are true. The second study used a similar 3AFC task to test three-to-five year old children's comprehension of *and* and *or*. The study also analyzed and categorized children's open-ended spontaneous feedback in the task. Children's interpretations were similar to adults except in cases where both disjuncts were true. In such cases, children's forced choice responses showed no sign of infelicity while their spontaneous feedback showed such signs: children corrected the utterance with *or* and suggested that *and* should have been used instead. The

third study used a two-alternative forced choice (2AFC) task and categorized children's open-ended feedback. The two-alternative forced choice task showed similar results to adults and the study replicated children's open-ended feedback in study 2: children provided corrections to the utterance when both disjuncts were true and offered the connective *and*. Overall the results suggested that three-to-five year old children's interpretations of disjunction may not differ substantially from those of adults. I review the findings of this dissertation and discuss the conclusions in Chapter 7.

Chapter 2

Interpretations of Disjunction

2.1 Introduction

Despite its modest appearance, the word *or* has been a major trouble maker for formal theories of meaning. Perhaps the main reason is that capturing its meaning has always seemed within the reach of formal accounts at the time, yet more examination has shown that *or* is much more complex than expected. Consequently, few words have managed to prove as influential as *or* in advancing formal semantics and pragmatics. This chapter is dedicated to the semantics and pragmatics of disjunction, and specifically *or* in English. My primary goal is to provide an overview of the empirical discoveries in the interpretation of *or* in adult language before moving to disjunction in child language acquisition.

In discussing linguistic meaning, often different words are used to refer to different types of meaning. Here I clarify my terminology. In what follows, I may use the terms “meaning”, “implicature”, “inference”, “implication”, and “interpretation”. I use the term “meaning” to refer to “literal meaning”: the meaning of words and word combinations in their most “literal”, least context-dependent, and least enriched version. Most of the time my usage of “meaning” refers to “lexical meaning”. I use “implicature” (conversational) when the meaning is considered to be derived from literal meaning via the Gricean cooperative principle and its associated conversational maxims (Grice, 1989). The term “inference” is used more generally to refer to any type of meaning that is derived from literal

meaning using some form of reasoning. I use “implication” to refer to all linguistic meaning regardless of the source and theoretical status. Therefore, literal meanings, implicatures, and inferences are all implications. Finally, I use interpretation in the broadest and most theoretically neutral way to include all types of meaning; linguistic or non-linguistic.

In what follows, I start with the discussion of disjunction in logic and philosophy. Disjunction has enjoyed a great deal of investigation in these fields and it would not be possible to understand current semantics and pragmatics of disjunction without first understanding its logical background. Then I move to the discussion of disjunction in language, and more specifically *or* in English. I show that since the early linguistic investigations, two different approaches to the meaning of disjunction have co-existed: first lexical ambiguity accounts, and second Gricean accounts. I explain that lexical ambiguity accounts consider *or* ambiguous between several meanings or senses while the Gricean accounts propose a single meaning for *or* and derive different interpretations of a disjunction from other linguistic and conversational factors. Then I enumerate some of the factors that affect the interpretation of disjunction. I argue that these factors provide a starting point for a cue-based acquisition of disjunction.

2.2 Disjunction in Logic

The first explicit account of propositional connectives in logic was developed by Stoic philosophers (3BC - 3AD) (Bonevac & Dever, 2012). They divided logical propositions into simple (atomic) and complex (molecular) propositions. Complex propositions were made of simple propositions connected by connective such as conjunction and disjunction. Similar to logical systems today, they defined these connectives in terms of the truth conditions of the propositions they connect. A conjunction was considered true when all propositions were true and false otherwise. Disjunction, however, received two definitions: exclusive disjunction and inclusive disjunction. Exclusive disjunction was true when exactly one proposition was true and the rest were false. Inclusive disjunction was true when at least one proposition was true, the rest could be true or false. Table 2.1 shows the truth conditions for binary conjunction (\wedge), exclusive disjunction (\oplus), and inclusive disjunction (\vee)¹.

¹Binary exclusive disjunction has an “odd property” in that linking a sequence of exclusive disjuncts results in a disjunction that is true if and only if odd number of disjuncts are true. This is not the case for the Stoic version of disjunction which is not a binary operator.

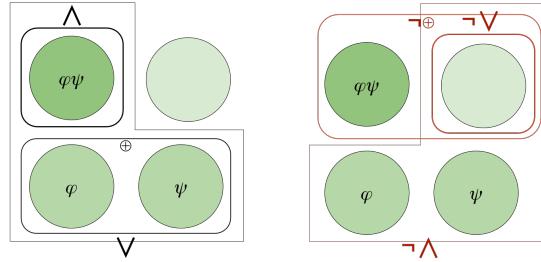


Figure 2.1: The relation between conjunction, inclusive disjunction, exclusive disjunction, and their negations.

Table 2.1: Truth conditions for conjunction and disjunction in classical logic

ϕ	ψ	$(\phi \wedge \psi)$	$(\phi \oplus \psi)$	$(\phi \vee \psi)$
T	T	T	F	T
T	F	F	T	T
F	T	F	T	T
F	F	F	F	F

It is important to note that there are entailment relations between the connectives in Table 2.1. A proposition ϕ entails another proposition ψ if in all situations that ϕ is true ψ is true as well. Conjunction of two propositions entails their inclusive disjunction but not the other way round. When the conjunction is true (row 1), the inclusive disjunction is also true but there are situations where inclusive disjunction is true but the conjunction is false (rows 2 and 3). Similarly, exclusive disjunction entails inclusive disjunction but not the other way round. This is because in every situation that exclusive disjunction is true, inclusive disjunction is also true but there is one situation where inclusive disjunction is true but exclusive disjunction is not. Conjunction and exclusive disjunction stand in contradiction to each other. If the conjunction of two propositions is true then the exclusive disjunction is false and if the exclusive disjunction is true then their conjunction is false. Figure 2.1 shows propositions as sets of situations in which they are true. The entailment relations can be seen as inclusion: a proposition that is contained within another proposition entails it. Exclusive disjunction and conjunction are both contained within inclusive disjunction and they both entail it. Negation in classical logic is a unary operator that flips the

truth value of a proposition. Figure 2.1 also shows the negation of conjunction and two types of disjunction. Negated inclusive disjunction is contained within negated conjunction and negated exclusive disjunction; consequently it entails them. Table 2.2 shows the meaning of negative atomic propositions ($\neg\phi$, $\neg\psi$), negative inclusive disjunctions ($\neg(\phi \vee \psi)$), negative conjunctions ($\neg(\phi \wedge \psi)$), inclusive disjunction of negative propositions ($\neg\phi \vee \neg\psi$), the conjunction of negative propositions ($\neg\phi \wedge \neg\psi$), negative exclusive disjunction, and exclusive disjunction of negative propositions.

Table 2.2: Truth conditions for statements that involve the interaction of conjunction and disjunction with negation in classical logic.

ϕ	ψ	$\neg\phi$	$\neg\psi$	$\neg(\phi \vee \psi)$	$\neg(\phi \wedge \psi)$	$\neg\phi \vee \neg\psi$	$\neg\phi \wedge \neg\psi$	$\neg(\phi \oplus \psi)$	$\neg\phi \oplus \neg\psi$
T	T	F	F	F	F	F	F	T	F
T	F	F	T	F	T	T	F	F	T
F	T	T	F	F	T	T	F	F	T
F	F	T	T	T	T	T	T	T	F

Comparing the columns in Table 2.2 we can observe at least three equivalence relations. The first two are the ones named after the 19th-century British mathematician Augustus De Morgan². The negation of an inclusive disjunction is equivalent to the conjunction of their negatives and the negation of a conjunction is equivalent to the disjunction of their negatives.

De Morgan's Laws:

$$\begin{aligned}\neg(\phi \vee \psi) &\Leftrightarrow \neg\phi \wedge \neg\psi \\ \neg(\phi \wedge \psi) &\Leftrightarrow \neg\phi \vee \neg\psi\end{aligned}$$

The third equivalence relation concerns exclusive disjunction. The exclusive disjunction of two propositions has similar truth conditions to the exclusive disjunction of their negatives. If exactly one disjunct is true and the other false, flipping the truth values using negation results in exactly one disjunct true and another false again. If the disjuncts have similar truth values, their negatives will also have similar truth values.

$$\phi \oplus \psi \Leftrightarrow \neg\phi \oplus \neg\psi$$

Table 2.3 shows some other logical properties of exclusive and inclusive disjunction. Truth

²The so called De Morgan laws were known even to Stoics so the discovery of them certainly predate De Morgan's formulation.

preservation refers to the property that if both disjuncts are true, then their disjunction is also true. Truth preservation holds for inclusive disjunction but not exclusive disjunction. Falsehood preservation is the opposite: the property that if both disjuncts are false then the disjunction is also false. Both inclusive and exclusive disjunction are falsehood preserving. Idempotency for disjunction refers to the property that the disjunction of a proposition with itself is equivalent in truth conditions to the original proposition. Inclusive disjunction is idempotent but not exclusive disjunction. However, both inclusive and exclusive disjunction are commutative and associative; meaning neither the order of the operands nor the order of the operations alter the outcome of the disjunctions. While inclusive disjunction distributes over conjunction, exclusive disjunction does not.

Table 2.3: Some logical properties of inclusive and exclusive disjunction.

Properties	Inclusive Disjunction \vee	Exclusive Disjunction \oplus
Truth Preservation	$a = T, b = T \Rightarrow a \vee b = T$	X
Falsehood Preservation	$a = F, b = F \Rightarrow a \vee b = F$	$a = F, b = F \Rightarrow a \oplus b = F$
Idempotency	$a \vee a \Leftrightarrow a$	X
Commutativity	$a \vee b \Leftrightarrow b \vee a$	$a \oplus b \Leftrightarrow b \oplus a$
Associativity	$(a \vee b) \vee c \Leftrightarrow a \vee (b \vee c)$	$(a \oplus b) \oplus c \Leftrightarrow a \oplus (b \oplus c)$
Distributivity	$a \vee (b \wedge c) \Leftrightarrow (a \vee b) \wedge (a \vee c)$	X
Monotonicity	$(a \rightarrow b) \Rightarrow (a \vee c) \rightarrow (b \vee c)$	X

Logical systems often pick one or the other definition of disjunction and give it more primacy. For example, Stoics considered exclusive disjunction as primary. Inclusive disjunction was considered “pseudo-disjunction” or merely the negation of a conjunction. It seems that the main reason for considering exclusive disjunction as primary was that unlike inclusive disjunction, it cannot be concisely redefined using conjunction and negation. Therefore, Stoics thought that exclusive disjunction must have an independent and primary status as an operator while inclusive disjunction is just a derivative. Unlike their Stoic colleagues, medieval philosophers defined disjunction as inclusive. Leibniz dispensed with both definitions of disjunction but later Bolzano (1781-1840) used both. George Boole (1815 - 1864) gives more primacy to exclusive disjunction since it corresponds

$A + B$	\top	\perp	NAND	IF	FI	IOR	IFF	XOR	A	nA	B	nB	NOR	ANB	NAB	AND
$A^T B^T$																
$A^T B^F$																
$A^F B^T$																
$A^F B^F$																

Figure 2.2: The truth table for the 16 binary logical connectives. The rows represent the set of situations where zero, one, or both propositions are true. The columns represent the 16 possible connectives and their truth conditions. Green cells represent true situations.

to addition modulo 2. Later Charles Sanders Peirce (1839-1914) changed Boole’s system to use inclusive disjunction instead. Inclusive disjunction has enjoyed a primary role in modern logical systems since then.

The question of whether inclusive disjunction is “primary” in a logical system or exclusive disjunction depends on the goal of the system. The properties of exclusive disjunction make it ideal as an operator for some purposes but not others. When it comes to natural language semantics and modeling the meaning of the word *or*, we can similarly ask whether exclusive disjunction is primary (better represents *or*’s meaning) or inclusive disjunction. In the following sections we will discuss linguistic work that has addressed this issue but before I move to the discussion of disjunction in natural language, I would like to comment on two properties of exclusive disjunction that mismatch the properties of *or* in English.

First the lack of idempotency suggests that the exclusive disjunction of a proposition with itself ($\phi \oplus \phi$) is necessarily false. Applied to the word *or* in natural languages, the prediction is that a sentence such as “Bob is happy or Bob is happy” should be judged as false regardless of whether Bob is happy or not. This intuition seems to be absent in judgments of such sentences with *or*. In fact, there is an intuition that such disjunctions are redundant and have the same truth value as the atomic proposition itself. For example, “the sky is blue or the sky is blue” is redundant and equivalent to “the sky is blue”. This intuition is predicted if *or*’s meaning is represented by inclusive disjunction but not exclusive disjunction.

Second, exclusive disjunction of two propositions has the same truth values as the exclusive disjunction of their negatives ($\phi \oplus \psi \Leftrightarrow \neg\phi \oplus \neg\psi$). Considering the natural language *or*, this

property suggests that the sentence “the door is open or the window is open” should have the same truth conditions as “the door is not open or the window is not open”. However, the first seems false intuitively when both are closed while the second is false when both are open. Therefore, two essential properties of exclusive disjunction seem to mismatch the meaning of *or* in English. Inclusive disjunction on the other hand does not face these problems. However, many examples of English *or* such as “He is a basketball player or a soccer player” seem to exclude the possibility of both disjuncts being true. Therefore, exclusive disjunction seems too strong for the meaning of *or* and inclusive disjunction often falls short of the interpretation *or* receives. This tension has lead researchers in semantics and pragmatics to consider inclusive disjunction as the primary meaning of *or* in English, and resort to other mechanisms that pragmatically strengthen the inclusive meaning of *or* to an exclusive interpretation. In the next few sections, I briefly review the history and the current issues in the semantics and pragmatics of disjunction.

2.3 Disjunction in Language

In natural languages, disjunction and conjunction are types of coordination. Haspelmath (2007) defines coordination (or coordinate constructions) as: “syntactic constructions in which two or more units of the same type are combined into a larger unit and still have the same semantic relations with other surrounding elements.” The example below shows several coordinate constructions in English.

- (1)
 - a. The dog barked *and* the cat ran behind the sofa.
 - b. I will get some coffee *or* tea.
 - c. He went to bed *because* he was sleepy.
 - d. She was sick *but* she finished the homework.

The word/affix that marks coordination is called a coordinator. The coordinators are shown in italics in the example above. The units that are marked by the coordinator are called coordinands. “The dog barked” is a coordinand in the first example. In English, a conjunction is a coordination marked by the coordinator *and*, and a disjunction is marked by *or*. The coordinands in conjunctions and disjunctions are called conjuncts and disjuncts respectively.

While there has been no report of a language that does not have ways to express conjunction and disjunction, several languages lack overt coordinators that mark conjunction or disjunction. In fact, Haspelmath (2007) reports that the mere juxtaposition of the conjuncts is a widespread strategy to convey conjunction crosslinguistically. For disjunction, often the juxtaposition is also accompanied by a marker of uncertainty or modality. For example, in Maricopa a sentence such as “John and Bill will come” is expressed as “John, Bill, will-come.” while the disjunction “John or Bill will come” is expressed as “John, Bill may-come.” (Gil 1991) Similarly in Dyirbal a disjunction such as “A or B” is expressed as “maybe A, maybe B” (Dixon 1972: 363). A similar effect of modals on the interpretation of coordination can also be found in English. Consider the English examples below.

(2) Here is what you will see on the table: a book, a pen, a calculator.

(3) Here is what you may see on the table: a book, a pen, a calculator.

A list of items with no overt coordinator such as “a book, a pen, a calculator” can be interpreted as a conjunction or a disjunction. In the first sentence, the list is interpreted as a conjunction: you will see a book, a pen, and a paper. In the second example, the list is interpreted similar to a disjunction: you may see a book, a pen, or a calculator. The sentences are identical except for the modal verbs. The sentence with a disjunctive interpretation uses the possibility modal *may*. Ariel (2014) reports a similar naturally occurring example with the modal *perhaps*, repeated below. Such examples point to a systematic connection between the notions of disjunction and modality.

(4) Practices of abortion, perhaps, pre-partum, perhaps postpartum (LSAC).

(5) Practices of abortion, pre-partum, or postpartum.

Languages that mark coordination overtly do it in several ways. The most common pattern, at least in European languages, is to place the coordinator in between the coordinands like “A and B” and “A or B” in English. However, other patterns such as “A B-and” where the coordinator appears after the coordination is also attested (see Haspelmath (2007) for more details). Another notable and common cross-linguistic pattern is the doubling of the coordinator on each coordinand. For example in Persian (Farsi), a disjunction can be expressed using the disjunction word *ya* like “A ya B” or it can be doubled on each disjunct like “ya A ya B”. Similar patterns have been attested in Polish (“albo A albo B”), Dutch (“of A of B”), Basque (“ala A ala B”), Somali (“ama A ama B”), and French (“ou A ou B”) among many others. In English the *either A or B* construction comes close

to this pattern. In the next section, I focus on the interpretations of disjunction in English but the discussion is not limited to English and similar results have also been attested in other languages.

2.4 Disjunction in English

The use of the word *or* in English is informally observed to correlate with one or more of the following implications (Aloni, 2016):

1. Inclusivity (IOR): at least one of the disjuncts is true;
2. Exclusivity (XOR): exactly one disjunct is true;
3. Conjunctivity (AND): both disjuncts are true;
4. Ignorance: the speaker does not know which disjunct is true;
5. Indifference: which disjunct is true does not matter for the purpose of the conversation.

These five implications do not have equal status with respect to each other. The first three (inclusivity, exclusivity, and conjunctivity) are binary truth-conditional meanings discussed in section 2.2. The fourth, ignorance, is related to the knowledge state of the speaker, and the fifth, indifference, is related to the role of disjunction within the conversation.

These five implications are also not necessarily caused by the word *or* itself. They may directly stem from the meaning of *or*, or they may be the result of *or* interacting with several other factors that shape the overall communicative message of the utterance. The goal of semantic and pragmatic research on *or* is to separate the implication(s) contributed by *or* from those caused by other words or factors in the communication of meaning. Disentangling the contribution of *or* from the contribution of other communicative elements has proven difficult, yet extremely fruitful in advancing semantic and pragmatic theories. In what follows I try to provide a short overview of the difficulties that *or* poses to theories of meaning.

Table 2.4: Implications of *or* for three example sentences.

Example	IOR	XOR	AND	Ignorance	Indifference
Study today or tomorrow, to pass the exam!	✓	X	X	✓	✓
Bob studied yesterday or the day before.	X	✓	X	✓	X
Students, like Bob or Becky, will pass.	X	X	✓	X	X

Table 2.4 shows three example sentences with the disjunction word *or* and marks the presence or absence of each *or*-implication. A sentence such as “Study today or tomorrow, to pass the exam.” implies that the addressee is asked to study today, tomorrow, or possibly both days. The overall message is that the addressee should study at least one of those two days to pass the exam. It does not rule out the possibility of the addressee studying both today and tomorrow, so there is no exclusivity implication. Furthermore, it is not asking the addressee to both “study today” **and** “study tomorrow”, so a conjunctive implication is absent. It is also possible to infer that the speaker does not know or it does not matter to them whether the addressee studies today or tomorrow. The command is complied with as long as the addressee studies one of those two days.

Compare this to a sentence like “Bob studied yesterday or the day before.” The overall message is that Bob studied one day and that day may have been yesterday or the day before. It suggests that Bob did not study both yesterday and the day before, so there is an exclusivity implication and no conjunctivity implication. It is also implied that the speaker does not know which day exactly Bob studied so we have an ignorance implication, but it is not implied that the speaker is indifferent towards which day Bob actually studied. Now compare the previous sentences to a sentence such as “students like Bob or Becky will pass the exam.” This sentence does not imply inclusivity or exclusivity. It does not communicate anything like “Either students like Bob will pass, or students like Becky will pass, or both.” It does not exclude the possibility of students like both Bob and Becky passing at all. In fact to the contrary, the main message is that “both students like Becky **and** students like Bob will pass”. In this example, *or* has a conjunctive implication. Even replacing *or* with *and* does not substantially alter the meaning of the sentence: “students like Bob and Becky will pass the exam”. No ignorance or indifference implication accompanies this conjunctive implication.

Just looking at Table 2.4 one might conclude that there is no systematicity behind the use of *or* and the implications that accompany it. This was indeed the prevailing view among many logicians and philosophers that considered language messy, fraught with ambiguities, and illogical. For example, while discussing disjunction in his influential introductory book on logic, Alfred Tarski warns readers about the many interpretations of *or* in natural language and explains that there are “quite noticeable differences between the usage of it in everyday language and in logic” (Tarski, 1941). He first points out that “the word *or* in everyday language has at least two different meanings”. A

child may ask us to be taken to a hike in the morning and a theater in the afternoon, but we may respond: “No, we are going on a hike or we are going to the theater”. He explains that the interpretation of *or* in this example is exclusive because “we intend to comply with only one of the two requests” and not both. However, a disjunction may also have an inclusive interpretation like the following example: “Customers who are teachers or college students are entitled to a special reduction”. Tarski explains that *or* in this example is inclusive “since it is not intended to refuse reduction to a teacher who is at the same time a college student.” He advises readers to avoid this exclusive vs. inclusive ambiguity by reserving the word *or* for the “logical” (inclusive) sense and use the construction “either … or …” for the exclusive one.

However, he immediately notes that there are other interpretations of *or* that go beyond the exclusive/inclusive distinction. I include his discussion here directly since in addition to addressing the ignorance implication of *or*, it foreshadows future developments in semantics and pragmatics initiated years later by Paul Grice.

In common language, two sentences are joined by the word *or* only when they are in some way connected in form and content. (The same applies, though perhaps to a lesser degree, to the usage of the word *and*) … anybody unfamiliar with the language of contemporary logic would presumably be little inclined to consider such a phrase as “ $2+2=5$ or New York is a large city” as a meaningful expression, and even less so to accept it as a true sentence. Moreover, the usage of the word *or* in everyday English is influenced by certain factors of a psychological character. Usually we affirm a disjunction of two sentences only if we believe that one of them is true but wonder which one. If, for example, we look upon a lawn in normal light, it will not enter our mind to say that the lawn is green or blue, since we are able to affirm something simpler, and at the same time, stronger, namely that the lawn is green. Sometimes even, we take the utterance of a disjunction as an admission by the speaker that he does not know which of the members of the disjunction is true. And if we later arrive at the conviction that he knew at the time that one – and specifically, which – of the members was false, we are inclined to look upon the whole disjunction as a false sentence, even should the other member be undoubtedly true. Let us imagine, for instance, that a friend of ours, upon being asked when he is leaving town, answers that he is going to do so today, tomorrow, or the day

after. Should we then later ascertain that, at that time, he had already decided to leave the same day, we shall probably get the impression that we were deliberately misled and that he told us a lie. The creators of contemporary logic, when introducing the word *or* into their considerations, desired, perhaps unconsciously, to simplify its meaning and to render the latter clearer and independent of psychological factors. (Tarski, 1941)

Tarski ended his discussion by saying that these linguistic and psychological factors should not enter logical considerations. The view that language is not amenable to the tools of logic remained prevalent but faced substantial challenges from philosophers that argued for more attention to ordinary language use. Finally, the work of two philosophers, Richard Montague, a student of Tarski, and Paul Grice, tilted arguments towards the “ordinary language” philosophers. Montague’s focus was on quantification in logic and natural language while Grice focused on the logical connectives such as *or* and *if*. Grice (1989) argued that the perceived differences between the meaning of natural language words such as *or* and the operators in formal logic such as inclusive disjunction “arise from inadequate attention to the nature and importance of the conditions governing conversation.” He set out to show that when we take conversational factors into account, the meaning of linguistic connectives are similar to the common definitions of their counterparts in formal logic.

An important contribution of Grice was his typology of meaning that lead to the establishment of semantics and pragmatics. He differentiated between “what is said” and “what is implied”. “What is said” refers to the literal meanings of words; the conventional association between words and meanings that is independent of any particular context. “What is said” is the most primary type of meaning and not derived from any other process. The field of semantics is concerned with this type of meaning and all else that relies on context of use is relegated to pragmatics. On the other hand, “what is implied” (conversationally) or as he called them “conversational implicatures” refer to meanings that are created by using words and sentences in specific contexts³. Conversational implicatures are the result of refining the literal meanings of words (what was said) to suit the assumptions and purposes of the conversational context. As such, implicatures are derivative and not primary.

Grice was also influential because he pioneered the methodology of studying linguistic meaning. He viewed the interpretation of an utterance as the composite of many interacting factors. In order to

³I set aside conventional implicatures here since they do not come up in the semantics and pragmatics of disjunction.

understand the literal meaning of a word, a semanticist needs to examine it in different contexts and understand its interaction with other factors that shape the general interpretation of the utterance. Utterances containing a word like *or* may be interpreted differently in different contexts, giving the impression that the word is polysemous. However, it is possible that the word has one underlying meaning (i.e. its semantics) and that in interaction with other elements of the sentence and the conversation, it gives rise to a variety of interpretations. In such cases, the underlying meaning can be recovered by detecting the factors that influence interpretation and reversing their effects. In Grice's view, true polysemy is stable polysemy across a wide range of contexts.

In addition to context-sensitivity, Grice suggested cancellability and computability as other properties of pragmatic enrichment. Cancellability refers to the following observation: a speaker explicitly denying a pragmatic enrichment of what they said does not result in the speaker contradicting themselves. For example, if I say that "the chocolate box is in the fridge or the cupboard", you may infer that I do not know where it is (ignorance implication). But, I can continue by saying "I know where it is but I'm not going to tell you" without contradicting what I said before. According to Grice, this suggests that the ignorance implication is not part of the literal meaning of what I said. The idea is that my continuation cancelled the pragmatic inference that I do not know where the chocolate box is. With literal meaning on the other hand, a speaker explicitly denying what they literally said results in a contradiction. For example, if I say "the chocolate box is in the fridge or the cupboard", I cannot add "it is in neither place" without sounding contradictory. Grice also emphasized on calculability of non-literal (non-conventional) meaning (i.e. conversational implicatures). He believed that if researchers propose a certain interpretation to be non-literal (more accurately non-conventional), they should be able to explain the mechanism that gave rise to that interpretation. Finally, it is important to note that Grice did not mean to introduce an exhaustive and definite set of diagnostics to distinguish literal and implicated meaning. He emphasized that in many cases, our intuitions will be the guide on what is said literally and what is merely implicated by what is said.

2.5 Factors Involved in the Interpretation of Disjunction

This section presents a brief list of factors that influence the interpretation of disjunction in English. This list is not meant to be exhaustive; it only provides a window into the factors that an account

of disjunction acquisition needs to consider. The factors discussed in this section include: conversational principles, entailment environment, modality, semantics of the disjuncts, metalinguistic communication (definitions and repairs), syntactic categories of the disjuncts, question intonation, embedded imperatives, and alternative unconditional constructions. I start this section with Grice's discussion of conversational principles that contribute to the overall interpretation of an utterance.

2.5.1 Conversational Principles

Grice's focus was on how conversational factors enrich utterance interpretation. He saw conversation as a cooperative social activity in which participants follow a certain set of rules or "maxims". Below I list the overarching "cooperative principle" as well as its maxims. Grice contended that these maxims further enrich the primary meaning of words and sentences in a given context. He used the term *conversational implicature* to refer to implications that are derived from the cooperative principle and the conversational maxims.

- **Cooperative Principle:** Make your conversational contribution such as is required, at the stage at which it occurs, by the accepted purpose or direction of the talk exchange in which you are engaged.
 - **Maxim of Quality:** Try to make your contribution one that is true. Do not say what you believe to be false. Do not say that for which you lack adequate evidence.
 - **Maxim of Quantity:** Make your contribution as informative as required. Do not make your contribution more informative than is required.
 - **Maxim of Relation:** Be relevant.
 - **Maxim of Manner:** Be perspicuous. Avoid obscurity of expression. Avoid ambiguity. Be brief. Be orderly.

Grice's account provided some informal explanations for the divergences between the interpretation of *or* and inclusive disjunction in logic. For example, Tarski pointed out that sentences that are connected with *or* should be related with respect to their content. He reported that English speakers find a sentence like "2+2=5 or New York is a large city" very odd and hard to judge as true, even though one of the disjuncts is certainly true. Grice's "maxim of relation" provides an independently motivated explanation for this observation. In conversations, speakers are expected to provide information relevant to the topic of the conversation. It is extremely hard to think of a context where

“ $2+2=5$ ” and “New York is a large city” are relevant alternatives to the conversational topic. Tarski himself noticed, however, that this phenomenon is not limited to the word *or*. Other connectives face the similar problem: “ $2+2=4$ and New York is a large city” or “if $2+2=4$, then New York is a large city”.

Tarski also pointed out that a disjunction such as “A or B” is often odd when the speaker knows which alternative is true. In other words, a disjunction often implies that the speaker is ignorant with respect to the truth of the disjuncts. The definition of disjunction in classical logic lacks this aspect. Grice’s theory provides a separate mechanism that is responsible for the ignorance implication. The maxim of quality requires the speaker to say what they believe to be true and the maxim of quantity requires them to be as informative as required. In many contexts the speaker is expected to be maximally informative. If the speaker knows A then they should say “A”. In Tarski’s example, if the speaker knows that the grass is green, then the most informative statement would be “the grass is green.” Saying that “the grass is green or blue” goes against the maxim of quantity. The speaker is providing less information even though it is clear they know more.

However, as Grice points out, in some contexts there is a reason for being underinformative and in such cases there is no ignorance implication for the speaker. For example, he mentions that in a treasure hunt with his children, he may say: “The prize is in the garden or the attic. I know that because I know where I put it, but I’m not going to tell you.” In this context the speaker knows which alternative is true. However, the context does not require him to be maximally informative. In fact, given the rules of a treasure hunt, he is required to not divulge the whereabouts of the prize. Therefore, the speaker’s underinformative utterance is warranted. This way Grice shows that the (speaker) ignorance implication is not part of what *or* means but rather the result of *or* interacting with conversational maxims. It is important to point out that a disjunction such as “A or B” is unacceptable when both the speaker and the addressee know which disjunct is true. In Grice’s example, while Grice knows which disjunct is true (there is no speaker ignorance), the addressee does not (there is addressee ignorance). However, in Tarski’s example, both the speaker and the addressee know whether the grass is green or blue. Therefore, the assertion of a disjunction seems to require a common ground that is not settled with respect to A and B when “A or B” is uttered. Experimental studies that test disjunction comprehension need to control for this requirement by making either the speaker or addressee ignorant of which disjunct actually holds.

Tarski discussed the exclusive and inclusive interpretations of *or* as well. He explained that even though in logic a disjunction is commonly defined as inclusive, a sentence like “we are going on a hike or we are going to the theater” has an exclusive interpretation. Grice’s account provides an explanation for this supposed “ambiguity” as well. In some contexts, the speaker knows whether both alternatives are true or not (Competence Assumption). If the speaker knows both alternatives to be true and the context requires maximal informativeness, then they should use the connective *and*. If they know that only one alternative is true, then they cannot use *and* because using it would violate quality (the speaker has said something false.) In such contexts using *or* instead of *and* implies that only one alternative is true and not both. The exclusive example provided by Tarski is similar to such contexts. The father knows (and in fact decides) whether both alternatives will be true or only one. If he intended for both to be true he could use the word *and*: “we are going on a hike and we are going to the theater”. Since he did not, we can infer that he does not intend to do both. In fact in Tarski’s original context, the father says the sentence with *or* in contrast to the child’s utterance with *and*.

The Gricean account has been developed and made more explicit by several authors. Here I present the current standard neo-Gricean account which is mostly due to U. Sauerland (2004). Assuming the speaker has uttered a disjunctive assertion such as “P or Q”, the reasoning proceeds as follows:

- **Utterance:** the speaker said “P or Q”.
- **Alternatives:** the speaker could have said: P, Q, or “P and Q”. Why didn’t s/he?
 1. **Ignorance:** The speaker is uncertain about the truth of P (i.e. $\neg B_S(P)$)
 2. **Ignorance:** The speaker is uncertain about the truth of Q (i.e. $\neg B_S(Q)$)
 3. **Ignorance:** The speaker is uncertain about the truth of P and Q (i.e. $\neg B_S(P \wedge Q)$)
- **Competence:** The speaker knows whether both propositions hold or not (i.e. $B_S(P \wedge Q) \vee B_S \neg(P \wedge Q)$)
 4. **Exclusivity:** Given ignorance inference 3 and speaker competence, the speaker believes that only one of the disjuncts is true (i.e. $B_S \neg(P \wedge Q)$).

Inferences 1-3 are ignorance implications. It is important to notice that the exclusivity inference in step 4 develops from the ignorance inference in step 3 and the competence assumption. For the exclusivity implicature to arise, the context of the utterance must be one where the speaker should

know whether both disjuncts hold or not, but s/he is not sure about which one holds. As Geurts (2006) argues, it is not clear how common such contexts are and what proportion of exclusivity implications are in fact implicatures derived via this type of pragmatic reasoning. Nevertheless, it is not impossible to think of such contexts. For example, if I say that “Bob went to the shop and bought a cardigan or a shirt”, it is reasonable for the addressee to assume that I know whether one item was bought or two. At issue is not whether exclusivity implicatures exist at all but rather how common they are. There seems to be a tacit assumption in the literature on semantics and pragmatics that the majority of exclusivity implications are derived via the Gricean reasoning sketched above.

While ignorance, indifference, and exclusivity implications of *or* can be explained (at least partly) via the Gricean mechanism above, the conjunctive interpretation remains unexplained. Geurts (2010) revises the Gricean account to cover the conjunctive inferences of free-choice expressions like “you can have coffee or tea”. Potts & Levy (2015) extend the Gricean account to cover definitional uses like “he is a wine lover or an oenophile”. I will discuss free-choice inferences and definitional uses below. As far as I know, there are no Gricean accounts for conjunctive interpretations in examples such as “Students, like Bob or Becky, will pass.” There are also no Gricean accounts for examples of self-repair with disjunction such as “Bob changed the font, or I mean, the size of the text.” These cases will be discussed below as well.

Before moving on, I would like to add that in Gricean pragmatics, the notion of “alternatives” or “what the speaker could have said” plays a crucial role. In the case of the ignorance implicature, the explanation relies on the assumption that instead of “A or B” the speaker could have said something simpler but more informative, namely “A”. The Gricean explanation relies on the addressee reasoning about why the speaker did not just say “A”. In case of the exclusivity implication, the Gricean approach relies on the assumption that instead of “A or B” the speaker could have used a different connective, namely *and* to say “A and B”. The addressee reasoning about why the speaker did not do so derives the exclusivity implicature. Alternatives also play an important role in developmental accounts of pragmatics. Barner, Brooks, & Bale (2011) argue that children are not adult-like in their access to the linguistic alternatives and as a result, they show non-adult-like interpretations.

An active area of research in Gricean pragmatics is the question of what constitutes an alternative and how implicatures are computed given a set of alternatives to the asserted utterance. The alternatives to a lexical item were traditionally considered as a scale ordered by entailment. Horn

(1972) proposed that words such as *or* and *and* as well as *some* and *all* form scales of alternatives represented as $\langle or, and \rangle$ and $\langle some, many, most, all \rangle$. This is why the exclusivity implicature of *or* is also called a “scalar implicature”. The basic idea is that asserting an utterance with the weaker lexical item on the scale (e.g. *or*) results on the inference that the corresponding utterance with the stronger item (e.g. *and*) would have been false (violated the maxim of quality). However, using the scale $\langle or, and \rangle$ will only derive the exclusivity implicature and does not provide an account of ignorance implications. In the standard account provided above, the ignorance implications rely on including each disjunct in the alternative set as well. Due to this problem (among others), the notion of “scale” has been replaced by “the set of alternatives”. Nevertheless the term “scalar implicature” is still used to refer to the implicatures of *some*, and *or*. A large body of literature suggests that children do not compute scalar implicatures at the rate that adults do (See Katsos, 2014 for a review). I discuss this issue more in the next two chapters.

2.5.2 Entailment Environment

The concept of entailment plays an important role in logic and semantics. The concept is often introduced as a relation among propositions. P entails Q if and only if P ’s truth makes Q necessarily true. Based on this, two other notions are defined: upward entailing and downward entailing environments.

- A linguistic environment ϕ is upward entailing if and only if for any two expressions a and b , if a entails b , then $\phi[a]$ entails $\phi[b]$.
- A linguistic environment ψ is downward entailing if and only if for any two expressions a and b , if a entails b , then $\psi[b]$ entails $\psi[a]$.

Let’s consider a as “student”, b as “human”, ϕ as “Bob is a []”, and ψ as “Bob isn’t a []”. Since “student” entails “human”, and “Bob is a student” entails “Bob is a human”, we can conclude that “Bob is a []” is an upward entailing environment. On the other hand, “student” entails “human” but “Bob isn’t a human” entails “Bob isn’t a student”. Therefore, we can conclude that “Bob isn’t a []” is a downward entailing environment. In short, upward entailing environments preserve entailment direction while downward entailing environments reverse it.

As explained earlier, exclusive disjunction entails inclusive disjunction. In an upward entailing environment, this entailment relation is preserved: “Bob is a student or a teacher (but not both)”

entails “Bob is a student or a teacher (or both).” However, in a downward entailing environment this relation is reversed: “Bob isn’t a student or a teacher (neither)” entails “Bob isn’t a student or a teacher (but may be both or neither)” A common observation is that the exclusive interpretation of *or* is more common in upward entailing environments while the inclusive interpretation is more common in downward entailing environments. For example a disjunction like “Bob is a student or a teacher” is more likely to be interpreted as “exclusive” while its negative counterpart “Bob is not a student or a teacher” is more often interpreted as “neither”, which is expected if *or* is inclusive. This is predicted by Grice’s maxim of quantity. In an upward entailing environment, exclusive disjunction is stronger and conveys more information. In a downward entailing environment, this pattern is reversed; inclusive disjunction results in a stronger and more informative statement. If a listener expects the speaker to make their contribution as informative as possible, then we can expect a bias towards exclusive disjunction in upward entailing environments and inclusive disjunction in downward entailing ones.

As explained in the section on logic and disjunction, the interaction of negation with disjunction, and conjunction is captured by the so-called De Morgan laws. It is sometimes argued that the interaction of negative particles with disjunction and conjunction words follow these rules in natural languages as well. For disjunction the argument is that “not A or B” is interpreted as the conjunction of negatives “not A and not B”. While this may be true in many cases, there are notable and systematic exceptions. This point is perhaps best illustrated by the negative phrase “not one or the other” in the following naturally occurring examples (6-10). In (6) below, “not one or the other” is used to mean “both”. In example (7) it is used to mean “neither”. In the (8) and (9) examples, the authors explicitly explain that by “not one or the other” they mean “neither or both”. Finally (10) shows that these observations are not isolated to the expression “one or the other”.

(6) Speed or Quality? It’s Not One or the Other. It’s Both! (Online Blogpost title by Chris Manuel)

(7) ... there is no in-between: you’re either masculine or feminine because you’re either male or female, and if you’re not one or the other of these two genders, then there must be something wrong with you. In numerous other cultures, however, there are gender systems that are not binary.

(8) In the above example [containing this expression: \$time =~ /(+):(+)(:+)?/], the third set

of parentheses is used to associate both the colon and the digits with “?” - either both should be specified, or neither, but not one or the other. (Response to a programming exercise on an online forum)

- (9) Everything is either physical or spiritual ... This is of course the root of the problem ... If things are either A or B, it actually makes sense to assume that once they're not one, then they are the other. But what if they're not A or B? what if, for instance, they're neither? Or ... both? (Medium Article by Doc Ayomide: I'm Christian and I don't believe mental illness is spiritual)
- (10) The church of the Lord is not here or there, but everywhere. (online newsletter at newchurch.org)

The examples above suggest that in natural language, the negation of a disjunction is not necessarily the conjunction of negations. These examples are not presented here to suggest that the NOR and AND interpretations of not (A or B) are equally likely. The examples show the importance of linguistic and non-linguistic factors in shifting our biases one way or another. Entailment environment is simply one of these factors.

Nevertheless, research in semantics has shown that the entailment environment is an important factor in the interpretation and distribution of lexical items (see Giannakidou (2011) for a discussion). Based on this, Crain (2012) has suggested that the entailment environment and its interactions with logical words such as *or* must be an innate property of the human mind. I will cover this nativist model of logical word acquisition in Chapter 5. In the next section I discuss the role of modality in the interpretation of disjunction.

2.5.3 Modals

The interaction of *or* with modals, especially possibility modals such as *may* and *can* presented the biggest challenge for the proposal that *or* has the semantics of inclusive disjunction. The issue was first discussed by Kamp (1973) in the context of giving permissions. Consider a sentence like: “You may pay using cash or credit card.” It has two main interpretations. One is the standard inclusive interpretation which is more accessible if it is followed by an expression of uncertainty: “you may use cash or you may use credit card, or possibly both but I'm not sure”. This interpretation is predicted by the standard inclusive account. However, there is a second and often more prominent

interpretation for this sentence which suggests customers are free to choose: they are allowed to use cash *and* they are allowed to use credit card. This so called “free choice” interpretation is not expected if *or* means inclusive disjunction and *may* acts like a standard possibility modal. “It is possible that A or it is possible that B” is weaker and less informative than “it is possible that A and it is possible that B”. However, it seems that in natural language when *or* appears with possibility modals it can have both interpretations. There have been many proposals to tackle this problem. Here I discuss two main proposals and expand on one that has made its way into acquisition research. In one approach, semanticists abandoned the truth-conditional inclusive semantics of *or* and proposed that *or* encodes the conjunction of two possibilities (Geurts, 2005; Zimmermann, 2000). In a second approach, they kept the standard semantics of *or* and treated the free choice inference as an implicature (Fox, 2007; Geurts, 2010).

First, Zimmermann (2000) made a departure from the truth-functional account of *or* and proposed that *or*’s meaning is inherently modal. “A or B” expresses the conjunction of two possibilities and can be paraphrased as “It is possible that A and it is possible that B,” represented in modal logic as $\diamond A \wedge \diamond B$. For example, “Bob paid using cash or credit card” is equivalent to “It is possible that Bob paid using cash and it is possible that Bob paid using credit card.” The modal account of *or* predicts a different logical structure for the free choice sentences. A sentence like “Bob is allowed to pay using cash or credit card” will have two layers of possibility modals: $\diamond\diamond A \wedge \diamond\diamond B$, roughly paraphrased as “it is possible that Bob is allowed to pay using cash, and it is possible that Bob is allowed to pay using credit card.” This is the interpretation without a free-choice implication. The free-choice interpretation is only derived when the speaker is assumed to be an “authority” on the subject. According to the “authority principle”, if an authority considers it possible that Bob is allowed to pay in cash, then Bob is allowed to pay in cash ($\diamond\diamond A \rightarrow \diamond A$). Assuming speaker authority, a statement like “it is possible that Bob is allowed to pay using cash and it is possible that Bob is allowed to pay using credit card” reduces to “Bob is allowed to pay using cash and Bob is allowed to pay using credit card” ($\diamond\diamond A \wedge \diamond\diamond B \rightarrow \diamond A \wedge \diamond B$). Therefore, the modal account of disjunction provides a straightforward answer to the puzzle of free-choice interpretations, yet it dispenses with the truth-functional account of disjunction.

The pragmatic approach strives to keep the truth-functional meaning of *or* and analyze the free-choice interpretation as an implicature. It takes two observations as its starting point. First,

that the free-choice inference is cancellable. As explained before, “you are allowed to drink tea or coffee” can be followed with “but I’m not sure which”, therefore not implying that the addressee has free choice between tea and coffee. Second, when we add negation to free-choice sentences, the interpretation is not the negative of the conjunctive free-choice interpretation, but rather the negative of the standard account in which disjunction is inclusive. For example, the main interpretation of a sentence like “you are not allowed to drink tea or coffee” is one where neither option is allowed. This interpretation is expected if negation is operating on the possibility modal and an inclusive disjunction ($\neg\Diamond(A \vee B)$). Proponents of the pragmatic approach argue that this behavior is not limited to negation and applies to downward entailing environments more generally. Consider a sentence like: if I’m allowed to drink tea or coffee, I’ll be happy. We can infer that the speaker will be happy even if they are only allowed to drink tea. However, under a conjunctive interpretation of *or* with *allowed to*, one should expect that the speaker will only be happy if both are allowed. This is not the interpretation we intuit. The pragmatic approach keeps the semantics of *or* as inclusive disjunction and contends that similar mechanisms should explain exclusivity as well as the conjunctive (free-choice) implication (Chierchia, 2013; Fox, 2007; Geurts, 2010). In what follows, I sketch Fox (2007)’s analysis of free-choice inferences of *or*. This analysis was later adopted by Singh, Wexler, Astle-Rahim, Kamawar, & Fox (2016), who reported that children sometimes interpret disjunction like conjunction in simple declaratives. I talk more about this phenomenon in 5.4.2.

Applying the ordinary pragmatic mechanism explained earlier to sentences with modals such as *may* and *allowed to* results in the wrong prediction. The problem lies in the alternatives considered for pragmatic computation. Consider the sentence “you are allowed to drink coffee or tea”. The standard alternatives to this sentence are: you are allowed to drink coffee, you are allowed to drink tea, and you are allowed to drink coffee and tea. If we mechanistically apply the Gricean recipe, we derive nothing more than the standard interpretation: “you are allowed to drink coffee or tea; but the speaker is not certain that you are allowed to drink coffee, and the speaker is not certain that you are allowed to drink tea, and the speaker is not certain that you are allowed to drink both coffee and tea”. This is not the free-choice inference we have been looking for.

Fox (2007) resolves this issue by changing the alternatives. As explained before, the standard set of alternatives to a disjunction like “A or B” is A, B, and “A and B”. For the sentence “you are allowed to drink coffee or tea”, the standard alternatives are “you are allowed to drink coffee” ($\Diamond A$),

“you are allowed to drink tea” ($\diamond B$), and “you are allowed to drink coffee and tea” ($\diamond A \wedge \diamond B$). Fox (2007) proposes that the alternatives are instead the following set: “you are only allowed to drink coffee” ($\diamond A \wedge \neg \diamond B$), “you are only allowed to drink tea” ($\diamond B \wedge \neg \diamond A$), and “you are allowed to drink coffee and tea” ($\diamond A \wedge \diamond B$). What justifies the change of alternatives from “allowed to X” to “only allowed to X”? In Fox (2007)’s system this follows from the syntactic structure of these sentences. They contain a silent operator that has similar semantic effects as the word *only*. The process of applying this operator to a linguistic expression is called “exhaustification”, and the operator is commonly abbreviated as EXH. In short, $\text{EXH}(\phi)$ asserts that ϕ is true and every alternative not entailed by ϕ is false. In Fox (2007)’s account, EXH applies to each disjunct, as well as the disjunction as a whole. The final product is the following implication: “you are allowed to drink coffee or tea; not **only** coffee, not **only** tea, and not both coffee and tea.”

Geurts (2010) uses essentially the same solution as that of Fox (2007), but casts it in a pragmatic framework rather than a syntactic one. He suggests that pragmatic reasoning is intention-based and even though linguistic alternatives are important, it is the set of possible communicative intentions that play the key role in pragmatic computation. When a sentence such as “you are allowed to drink coffee or tea” is uttered, the listener considers four possible communicative intentions: (1) coffee and tea are both allowed, (2) coffee is allowed but tea isn’t, (3) tea is allowed but coffee isn’t, and (4) neither is allowed. He explains that intention (4) is ruled out because it is in contradiction with the basic meaning of the utterance. Options (2) and (3) are ruled out because if the speaker meant to convey them, they could have said something simpler, namely “you are allowed to drink tea” or “you are allowed to drink coffee”. The only intention left that satisfies Gricean maxims is intention (1) which is the desired free-choice inference.

While the literature on the interaction of disjunction with modals has mostly focused on possibility modals such as *may* and the context of giving permissions, similar conjunctive inferences are present with preference/desire modals such as *want*, *like*, and *love*. If we say “Bob likes/loves going on hikes or climbing rocks or staying outdoors”, it is clear that Bob likes all the activities listed. Therefore, it is possible to infer that “Bob likes/loves rock climbing.” Similarly, we can infer from “Bob would like some coffee or tea” that “Bob **would like** some coffee” and “Bob **would like** some tea” (The inference is easier to access when *would like* is stressed). Similar inferences seem to be valid for “Bob wants some coffee or tea.” However, it seems that the conjunctive inferences in such cases

are not as strong as the case of permissions like “Bob is allowed to drink coffee or tea.” Perhaps the strongest case of conjunctive inferences comes in the context of providing examples with the word “like”. In a sentence such as “Students like Bob or Becky never fail”, the disjunction word is almost equivalent to a conjunction: “Students like Bob and Becky never fail.” These observations suggest that *or* is interpreted as conjunctive in a wider range of environments than commonly discussed in the literature.

2.5.4 Disjunct Semantics

Geurts (2006) points out that even though pragmatic reasoning may be behind some exclusive interpretation of *or*, in many examples deriving the exclusivity interpretation via implicatures may be unnecessary because exclusivity is introduced by the semantics of the disjuncts themselves. Consider an example such as: “Bob is in the kitchen or the bathroom.” In the ordinary world that we live in, both disjuncts in this sentence cannot be true. Bob cannot be in the kitchen and the bathroom at the same time. Given that the inconsistency of the disjuncts is common knowledge to discourse participants, no inclusive interpretation is possible. The only available interpretation of such disjunctions is exclusive but this has little to do with the meaning of *or*. It stems from the semantic relation between the disjuncts. In fact, the exclusive interpretation would be present even when *or* is absent. Suppose someone asks where Bob is and the speaker responds with “Not sure ... in the kitchen ... in the bathroom.” The interpretation of this response is similar to exclusive disjunction.

More generally, our world knowledge provides us with likely relations between different propositions. For example, “Bob fell down” and “Bob hurt himself” are likely to co-occur and are interpreted as causally linked even though they do not have to be. The rich conceptual structure among different propositions can help the interpretation of linguistic connectives. Consider the following naturally occurring example from Ariel (2014): “You come ... you don’ come ... it doesn’t matter to me”. In this example, the speaker uses no connectives between the main three sentences of the utterance, yet the interpretation of the relations among them is clear. The utterance can be paraphrased as “Whether you come or you don’t come, it does not matter to me.” The rich conceptual structure among coordinands often make it transparent what type of coordinator is required and this can subsequently help children’s acquisition of connectives. With respect to disjunction, the disjuncts are

often inconsistent in their meanings; only one can be true and not both. It is noteworthy that stoics described disjunction as “an operator for incompatibles”, which points to the influence of disjunct semantics on the definition of disjunction in stoic logic.

2.5.5 Metalinguistic Communication

In two instances, disjunction is used to communicate about language itself. The first is when a speaker wants to communicate that two expressions have the same meaning (at least for the purposes of the conversation), and the second when a speaker wants to provide a repair; a signal that a linguistic error was made. I discuss these two cases below.

Definitions

Definitional or metalinguistic disjunction is the type of disjunction that I just used at the beginning of this sentence! The primary function of such a disjunction is to communicate that two expressions are equivalent in meaning or function, at least for the current purposes of the conversation. For example, a sentence such as “Bob is a wine lover or an oenophile” communicates that “oenophile” is another term for “wine lover” (Potts & Levy, 2015). Similar to what we saw with modals, definitional uses give rise to conjunctive interpretations of disjunction. If “Bob is a wine lover or an oenophile”, then “Bob is a wine lover” and “Bob is an oenophile”. Potts & Levy (2015) propose that the following sociopragmatic conditions should hold for the definitional interpretations of *or*: First, discourse participants have mutual interest in communicating about the language itself, in addition to interest in communicating about the world. Second, the participants can assume that the speaker has expertise in the relevant domain. Third, that the cost of using a disjunction must justify its verbosity given that a disjunction of A or B is always longer than B itself to communicate the same meaning.

Potts & Levy (2015) provide a Gricean account for definitional disjunctions in which “A or B” has the semantics of inclusive disjunction. The key innovation of the account is that conversational participants use language to convey information about the world as well as about language itself. Potts & Levy (2015) argue that a disjunction can be used to communicate information about a speaker’s preferred lexicon, as well as the state of the world. Therefore, when the right sociopragmatic conditions for the definitional use hold, a disjunction such as “A or B” communicates two

pieces of meaning: 1. “A” is true and 2. “A and B have the same meaning”. The equivalence of A and B in meaning derives the conjunctive interpretation in this account. Given that the speaker has communicated that A and B have the same meaning, they are either both true or both false. Since the speaker also asserted that A is true, then B must be true as well. Therefore, in Potts & Levy (2015)’s account the conjunctive interpretation of definitional uses is primarily the result of disjunct semantics and not *or* itself. In turn, disjunct semantics in definitional uses are the result of sociopragmatic conditions governing the context of the utterance.

It is important to point out that child directed speech often satisfies all three sociopragmatic conditions of definitional interpretations proposed by Potts & Levy (2015). First, parents and children have mutual interest in communicating about the language itself given that children are active language learners. Second, in almost all areas, parents are experts with respect to the lexicon compared to children. Finally, it is reasonable to assume that the pedagogical goal of teaching a child the lexicon of a language justifies the verbosity of using a disjunction. Therefore, we may expect that definitional uses will show up commonly in child-directed speech and in fact, this is what we found in our corpus study presented in Chapter 3.

Repairs

A fairly unexplored area is the role of disjunction in conversational repairs. Often during casual speech, conversational participants notice a mistake either in their own speech or someone else’s. The utterance that signals this mistake and provides correction is called a “repair”. Repairs are often classified into “self-repair” and “other-repair”. Self-repairs are repairs that are provided by the speaker themselves while other-repairs are provided by discourse participants other than the speaker. For example while discussing news on the flat earth society, a speaker may say “I can’t believe there are people who still believe the earth is round” providing an immediate self repair “... I mean flat.” Alternatively, someone else in the conversation may provide the repair with “... you mean flat.” Repairs have the following three components: reparandum (the part of the original utterance that needs repair like “round”), editing term (a discourse marker like “I mean” that signals a repair), and alteration (the corrected section like “flat”) (Heeman & Allen, 1999). Common editing terms include *oh*, *um*, *uh*, *I mean/I meant*, *well*, *sorry*, *no*, *or*, and *let’s see*. Not all repairs are accompanied by editing terms, especially those that repeat a large part of the reparandum in the alteration and make

a minor modification such as “The boy was ha . . . The man was happy.”

The disjunction word *or* can be used as an editing term alone or along with other editing terms such as “I mean”. The sentences below show a few examples of *or* as an editing term.

- (10) “Engine two from Elmi(. . .) or engine three from Elmira.” (example 14 of Heeman & Allen, 1999)
- (11) “Why can’t I change font or I mean size of the typed letters?” (online example)
- (12) “I promised to see Nadelka again,” said he, “or, I mean she promised to see me.” (Stash of the Marsh Country by Harold Waldo)
- (13) “John picked us up in his car, or rather his dad’s car which he’d borrowed.” (online example)
- (14) “I met him very late on Friday night, or rather, early on Saturday morning.” (online example)

It is reasonable to use a coordinator for repairs given that the reparandum-term-alteration structure is similar to the structure of coordination. However, the communicated meaning in a repair is not what *or* often communicates. A repair commonly signals that the reparandum was not true or accurate and that the alteration is true and what the speaker is trying to communicate. A disjunction, on the other hand, commonly allows either disjunct to be true and does not rule out any disjunct. How come *or* is used as the connective for repairs?

It is important to note that while *or* does not carry the repair interpretation itself, its meaning – either as inclusive disjunction or exclusive – is not incompatible with a repair. The repair interpretation (the first disjunct is false, the second is true) is stronger and more specific but still compatible with the meaning of *or*. This is not the case for *and* since conjunction communicates that both conjuncts are true and this is not ideal for repairs. For example, in the repair sentences provided above, using *and* instead of *or* is infelicitous for communicating a repair. Since *or* is compatible with a repair reading but not strong enough, it is quite possible that similar to previous cases, the weak semantics of *or* (inclusive disjunction) is strengthened by external factors.

For example, it is possible that *or* simply contributes the meaning that at least one of the disjuncts are true. Then factors that commonly signal repairs such as pauses, intonation, significant overlap between reparandum and alteration, or co-occurring edit terms such as “I mean” can strengthen the inclusive meaning of *or* to communicate that “in fact it is the second disjunct that is true”. This account is supported by the fact that *or* is often optional in repairs. In the examples recounted before, if *or* is dropped, other elements such as the pause, the intonation, the phrase “I mean”,

or the word “rather” can still signal the repair in the utterance. Therefore, it is possible that *or* contributes inclusivity but these repair factors strengthen the coordination to mean that the first disjunct is false while the second is true.

2.5.6 Syntactic Units

To my knowledge, there has been no systematic investigation of the effect of syntactic category on disjunction interpretation. However, there is some informal evidence suggesting that it may play a role in generating exclusivity inferences. Compare the following example sentence:

- (16) He likes coffee or tea.
- (17) He likes coffee or he likes tea.

A common intuition is that the second disjunction with sentential disjuncts is more likely to be exclusive than the first disjunction with nominal disjuncts. The clausal vs. sub-clausal distinction also plays a role crosslinguistically. Haspelmath (2007) reports that Yapese (an Austronesian language of Micronesia) uses different words for sentential and nominal conjunction. He reports different conjunction words for nominal and event conjunction as a widespread typological phenomenon, especially in African languages. He also reports that in Koromfe (a Gur language of Burkina Faso) a disjunction is only allowed for events so a sentence like “do you want coffee or tea?” must be rephrased as “do you want coffee or do you want tea?” These observations suggest that the syntax of a disjunction may play a role in shaping its interpretation. However, experimental investigations are required before we can confirm the effect of the disjuncts’ syntactic categories on the interpretation of the disjunction.

2.5.7 Question Intonation

Table 2.5: The interpretation of disjunction in polar and alternative questions.

Question	Intonation	Example	Answer	Interpretation
Polar	Rising	Would you like any tea(↑) or coffee↑?	yes/no	∨
Alternative	Rise-Fall	Would you like tea↑, or coffee↓?	tea/coffee	⊕

There are two types of questions with the disjunction word *or*: polar questions and alternative questions. These two types of questions differ in the type of intonation and the responses they receive. Table 2.5 provides a summary of the properties of polar and alternative questions. Disjunctions in polar questions are accompanied by an overall rising intonation, or by rising intonation on each disjunct. Disjunctions in alternative questions receive rising intonation on the non-final disjuncts and falling intonation on the last. Polar questions typically receive a yes/no answer followed by one of the alternatives if the alternative matters for the purpose of the conversation. For example, if a waiter approaches and asks “would you like any tea or coffee?” the appropriate answer is typically “yes, tea/coffee please” or simply “no thank you”. On the other hand, in the context of asking someone out on a date, a simple “yes/no” response to the same question may suffice given that the choice of alternative does not matter for the purpose of the conversation. When the choice of alternative is extremely relevant, the yes/no part of the response may be left unsaid and simply implied by the mention of the alternative. For example, in response to the waiter’s question “would you like any coffee or tea?”, the addressee can say “coffee, please”. When it comes to alternative questions, a yes/no response is infelicitous. The purpose of an alternative question is to find out which alternative is true and a yes/no response does not do that. The one exception is when the alternatives themselves are positive and negative. For example, the alternative question “would you like coffee or not?” can be felicitously responded with “yes/no” but in such cases the alternatives themselves are “yes” and “no”.

Polar questions receive an inclusive interpretation (at least one disjunct is true) while alternative questions receive an exclusive interpretation (exactly one disjunct is true). Intonation plays a crucial role in the interpretation of polar and alternative questions with disjunction. Pruitt & Roelofsen (2013) recorded 24 disjunctive questions with both final rise intonation and final fall intonation. They asked 37 undergraduate participants to choose between two paraphrases: an inclusive paraphrase and an exclusive paraphrase. For example, a question like “did Sally bring wine or bake a dessert?” had the inclusive paraphrase “did Sally do any of these things: bring wine or bake a dessert?” and the exclusive paraphrase “which of these things did Sally do: bring wine or bake dessert?” They showed that the majority of responses (80%) considered a question with falling final intonation as exclusive and a question with rising final intonation as inclusive.

2.5.8 Embedded Imperatives

We can use *and* and *or* to connect imperative and declarative sentences. The two sentences below connect the same imperative and declarative sentences but use different connectives; the first uses *and* and the second *or*. An important observation with respect to the meaning of such utterances is that they can be paraphrased as conditionals. The first sentence with *and* can be paraphrased as “if you go home, you’ll miss the fun.” The second sentence with *or* can be paraphrased as “if you do not go home, you’ll miss the fun.” More accurately, the original sentences and their conditional paraphrases are biconditionals or perfected conditionals (Geis & Zwicky, 1971). The sentence with *and* implies that if the addressee does not go home they will not miss the fun. The sentence with *or* implies that if the addressee goes home they will not miss the fun.

- (18) Go home *and* you’ll miss the fun. (If you go home, you’ll miss the fun.)
- (19) Go home *or* you’ll miss the fun. (If you do not go home, you’ll miss the fun.)

If we consider the relevant propositions as “addressee going home” and “addressee missing the fun”, the first sentence has a conjunction interpretation with respect to these propositions while the second carries an exclusive interpretation. The imperative-or-declarative structure suggests that the proposition inside the imperative and the one inside the declarative will not be true at the same time: “If you go home, you won’t miss the fun and if you don’t go home you will miss the fun.”

2.5.9 Alternative Unconditionals

Consider the following example of the alternative unconditional construction: “Whether you stay here or go home, you will have fun”. The alternative unconditional construction has the following general schema: “Whether X or Y, Z.” Sometimes the alternatives are negatives of each other: “Whether you stay here or not, you will have fun.” When the alternatives are negatives of each other (“Whether X or not X, Z.”), the shorter form “Whether or not X, Z” can also be used: “Whether or not you stay here, you will have fun.” Rawlins (2013) classifies alternative unconditionals as a subtype of unconditionals along with constituent unconditionals (e.g. “Whatever happens, we win.”) and headed unconditionals (e.g. “No matter what happens, we win.”). He points out that unconditionals share “a certain kind of not mattering” or an indifference implication. If we schematize an unconditional construction as “unconditional-adjunct + main-proposition”, the main message of the construction is that the alternatives listed in the unconditional adjunct do not make a difference

with respect to the truth of the main proposition. In other words, the truth of the main proposition does not depend on the truth of the alternatives in the unconditional adjunct.

An alternative unconditional is considered to be equivalent to the conjunction of two conditional statements with the alternatives as their antecedents. This means that a construction such as “Whether X or Y, Z” is equivalent to “If X, Z, and if Y, Z.” For example, “Whether it rains or snows, I won’t go outside.” can be paraphrased as “If it rains, I won’t go outside, and if it snows I won’t go outside.” Notice that the unembedded connective used in the paraphrase is *and* rather than *or*. The paraphrase with *or* would be too weak: “if it rains, I won’t go outside, or if it snows I won’t go outside”. The unconditional does not communicate that at least one of the conditional statements are true; it communicates that both are true. Therefore, the interpretation of *or* embedded under an unconditional adjunct surfaces as conjunction rather than disjunction.

Rawlins (2013)’s analysis of alternative unconditional has four important components. First that the whole construction is a conditional ($X \rightarrow Y$) such that the adjunct (X) restricts the modal base of the main clause (Y). In other words, a sentence like “if you stay, you will have fun” asserts that “you will have fun” is true in the worlds where “you stay” is true. Second, the antecedent of this conditional is a disjunction (If A or B then Y.) Third a disjunction such as “A or B” denotes the set of propositions in the disjunction ($\{A, B\}$). Fourth, the set of propositions provides sequential restrictions on the modal base in the main clause. For example, a sentence like “whether you stay or go, you will have fun” asserts that “you will have fun” is true first in worlds that “you stay” and then in worlds where “you go”. The conjunctive interpretation of disjunction in alternative conditionals follows from this sequential domain restriction.

2.6 Discussion

This chapter provided a brief introduction to disjunction in logic as well as previous approaches to the semantics of *or* in English. In logic, disjunction has always faced two alternate definitions: exclusive and inclusive. While different eras have assigned primacy to one or the other definition, logical systems in the past century or so have adopted the inclusive definition more often. In natural language, disjunction words like *or* are associated with (at least) five implications: inclusivity, exclusivity, conjunctivity, ignorance, and indifference. Table (2.6) shows 10 example sentences in different linguistic environments and marks the presence and absence of each implication. I discussed

a range of factors that may affect the interpretation of *or* including conversational (Gricean) principles, entailment environment, semantic relation of the disjuncts, syntactic category of the disjuncts, question intonation, and a range of linguistic constructions such as the ones with possibility modals, embedded imperatives, repairs, definitions, and unconditionals.

Table 2.6: Implications of *or* for several example sentences.

Example	IOR	XOR	AND	Ignorance	Indifference
Have some food or drinks!	✓	X	X	X	✓
Bob studied yesterday or the day before.	X	✓	X	✓	X
Students like Bob or Becky will pass.	X	X	✓	X	✓
I didn't see Bob or Becky study at all.	X	X	✓	X	X
Did Bob study yesterday, or Becky?	X	✓	X	✓	X
Did either Bob or Becky study yesterday?	✓	X	X	✓	X
Study hard or you will fail!	X	✓	X	X	X
Bob could study or play soccer.	X	X	✓	X	X
Bob studies language acquisition or language development.	X	X	✓	X	X
Becky studies phonetics or semantics; not sure which.	X	✓	X	✓	X

This chapter also discussed two approaches to lexical meaning: lexical ambiguity approaches and Gricean approaches. The crucial difference between them is their adherence to a principle of parsimony for meanings, namely Grice's "Modified Occam's Razor". Grice's razor proposes that lexical meaning should not be multiplied beyond necessity. Lexical ambiguity approaches are more relaxed about Grice's razor and may consider different interpretations of a word as different meanings of the word. Gricean approaches strive to only assign an interpretation as lexical meaning when it cannot be explained by other independently motivated interpretive factors. For example, a lexical ambiguity account considers *or* ambiguous between the five implications mentioned earlier and possibly more. Context of the utterance helps speakers disambiguate the intended meaning of *or*. The Gricean approach proposes a single (more general) meaning for *or* and derives its various

interpretations by strengthening (making more specific) that single meaning.

How does research in semantics and pragmatics of disjunction inform accounts of disjunction acquisition? The literature on semantics and pragmatics of *or* provides a list of factors that affect the interpretation of a disjunction word like *or*. This list can be considered as a set of candidate cues that children may use to learn the interpretation and ultimately the meaning of a disjunction word. It is important to note that both lexical ambiguity and Gricean accounts rely on such cues to derive the intended interpretation. Ambiguity accounts use them to disambiguate among a set of learned lexical meanings while Gricean accounts need them as part of the reasoning process that derives the intended interpretation from a unified lexical meaning for *or*. While previous research in semantics and pragmatics has successfully listed some of the main factors in interpreting *or*, it has not yet addressed how these factors can potentially be weighted for their role in generating the observed interpretations. For example, it is not clear whether conversational factors or the semantics of the disjuncts play a more important role in the interpretation of a disjunction. Chapter 3 investigates the role of a subset of these factors in child-directed speech and Chapter 4 provides computational models that show how these factors can be weighted to better understand their role in deriving different interpretations of disjunction in child-directed speech.

Chapter 3

Parents' and Children's Production of Disjunction

3.1 Introduction

The previous chapter introduced different uses and interpretations of disjunction in English. This chapter investigates the uses and interpretations of disjunction in child-directed speech. It presents two studies on parents' and children's production of *or* as well as *and* (to provide a similar connective for comparison). The first study investigated the frequency of *and* and *or* in parents' and children's speech to answer two questions: 1. At what age do children start to produce *and* and *or*? 2. How does children's rate of production for *and* and *or* compare to their parents'? The second study explored the types of disjunction children heard as well as the frequency of different interpretations of *and* and *or* in child-directed speech. It sought to answer the following questions: 1. What are the most frequent interpretations of *and* and *or* in child-directed speech? 2. What are some reliable cues that can help children interpret a conjunction/disjunction?

3.2 Study 1: *and* and *or* in parents' and children's speech

This study investigates the production of *and* and *or* by children and their parents in an online collection of corpora. The goal is to understand the overall frequencies of these items and investigate

the developmental trends in children's productions. After describing the study methods in section 3.2.1, I investigate some important properties of the corpora such as their word density for parents and children at different ages as well as the frequency of different utterance types in the speech of parents and children. I explain that function words are sensitive to the distribution of utterance types or more broadly speech acts or constructions with particular communicative functions. Therefore, it is important for developmental studies on the production of function words to investigate their frequencies within different utterance types, speech acts, or constructions with specific communicative functions. In section 3.2.3, I first look at the overall and monthly relative frequencies of *and* and *or* in the speech of parents and children. Then, I use utterance type as a proxy for speech acts and investigate the relative frequencies of these connectives within declaratives and questions. I summarize the main results and conclusions of the study in section 3.2.4.

3.2.1 Methods

For samples of parents' and children's speech, this study used the online database childe-db and its associated R programming package `childesr` (Sanchez et al., 2018). Childe-db is an online interface to the child language components of TalkBank, namely CHILDES (MacWhinney, 2000) and PhonBank. Two collections of corpora were selected: English-North America and English-UK. All word tokens were tagged for the following information: 1. The speaker role (mother, father, child), 2. the age of the child when the word was produced, 3. the type of the utterance the word appeared in (declarative, question, imperative, other), and 4. whether the word was *and*, *or*, or neither.

Exclusion Criteria

First, observations (tokens) that were coded as unintelligible were excluded ($N = 290,119$). Second, observations that had missing information on children's age were excluded ($N = 1,042,478$). Third, observations outside the age range of 1 to 6 years were excluded ($N = 686,870$). This exclusion was mainly because there was not much data outside this age range. Figure 3.3 shows the distribution of transcripts based on the age of the child at recording time. The mean age is shown with a red vertical line (Mean Age = 3.73, SD = 2.21). The collection contained the speech of 504 children and their parents after the exclusions.

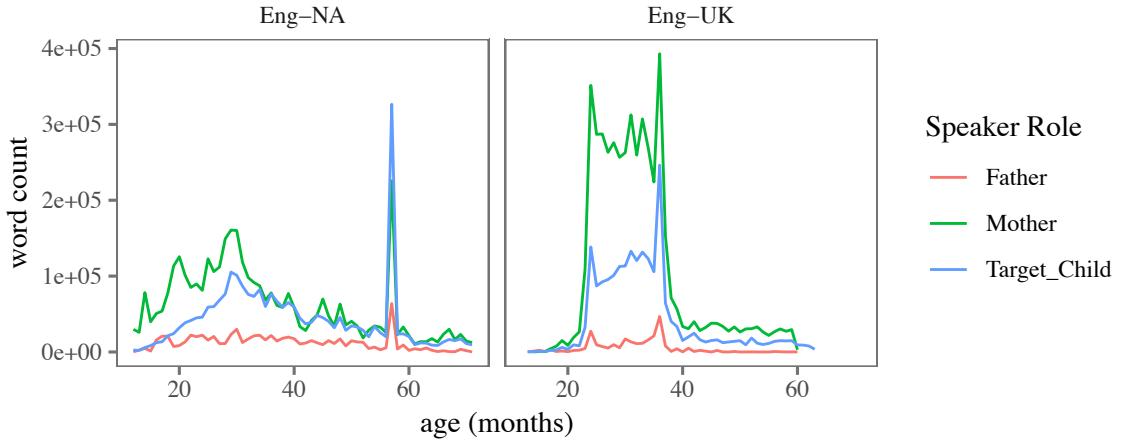


Figure 3.1: Frequency for all the words in the North America and UK corpora of CHILDES.

Procedure

Each token was marked for the utterance type that the token appeared in. This study grouped utterance types into four main categories: “declarative”, “question”, “imperative”, and “other”. Utterance type categorization followed the convention used in the TalkBank manual. The utterance types are similar to sentence types (declarative, interrogative, imperative) with one exception: the category “question” consists of interrogatives as well as rising declaratives (i.e. declaratives with rising question intonation). In the transcripts, declaratives are marked with a period, questions with a question mark, and imperatives with an exclamation mark. It is important to note that the manual also provides terminators for special-type utterances. Among the special type utterances, this study included the following in the category “questions”: trailing off of a question, question with exclamation, interruption of a question, and self-interrupted question. The category imperatives also included “emphatic imperatives”. The rest of the special type utterances such as “interruptions” and “trailing off” were included in the category “other”.

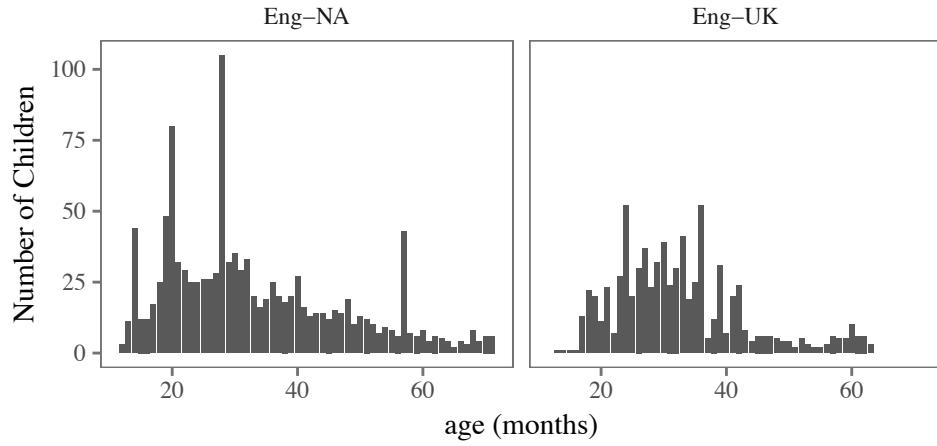


Figure 3.2: The number of children represented at different ages in the North America and UK corpora in CHILDES.

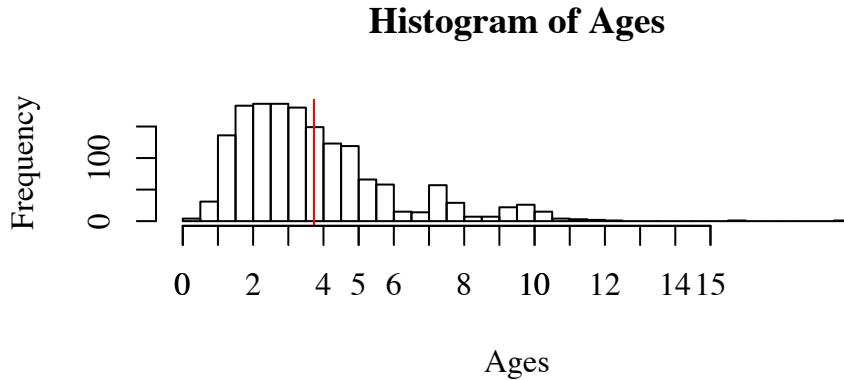


Figure 3.3: Distribution of children's ages at recording times. Mean age is shown using a red vertical line.

3.2.2 Properties of the CHILDES Corpora

In this section, I report some results on the distribution of words and utterances among the speakers in our collection of corpora. The collection contained 14,159,609 words. Table (3.1) shows the total number of *and*'s, *or*'s, and words in the speech of children, fathers, and mothers. The collection contains 8.8 times more words for mothers compared to fathers and 1.8 more words for mothers compared to children. Therefore, the collection is more representative of the mother-child interactions than father-child interactions. Compared to *or*, the word *and* is 10.8 times more likely in the speech of mothers, 9.2 times more likely in the speech of fathers, and 30.3 times more likely in the

Table 3.1: Number of *and*'s, *or*'s, and the total number of words in the speech of children and their parents in English-North America and English-UK collections after exclusions.

Speaker Role	and	or	total
Father	15,488	1,683	967,075
Mother	153,781	14,288	8,511,478
Target_Child	78,443	2,590	4,681,056

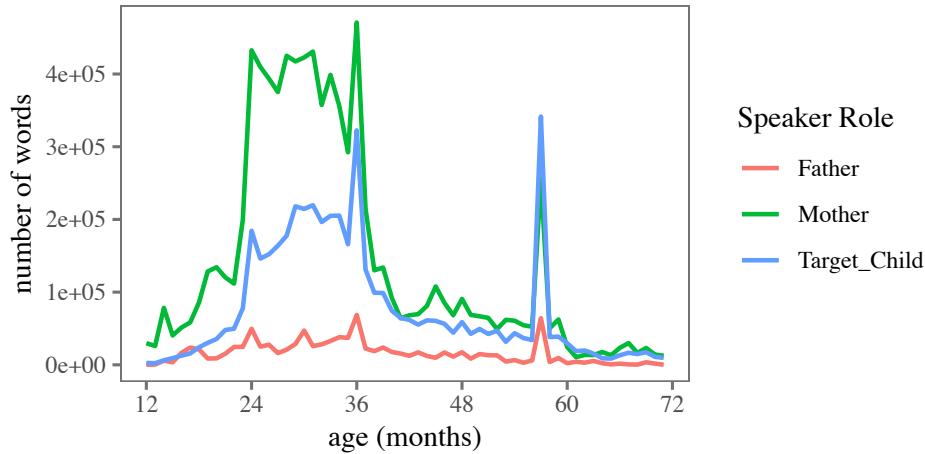


Figure 3.4: The number of words in the corpora for parents and children in each month of children's development.

speech of children. Overall, *and* is 13.35 times more likely than *or* in this collection which is close to the rate reported by Morris (2008). He extracted 5,994 instances of *and* and 465 instances of *or* and found that overall, *and* was 12.89 times more frequent than *or* in parent-child interactions. Figure 3.4 shows the number of words spoken by parents and children at each month of the child's development. The words in the collection are not distributed uniformly and there is a high concentration of data between the ages of 20 and 40 months (around 2 to 3 years of age). There is also a high concentration around 60 months (5 years of age). The speech of fathers shows a relatively low word-count across all ages. Therefore, in our analyses we should be more cautious in drawing conclusions about the speech of fathers generally, and the speech of mothers and children after age 5. The distribution of function words is sensitive to the type of utterance or more broadly the type of speech act produced by speakers. For example, it is not surprising to hear a parent say “go to your room” but a child saying the same to a parent is unexpected. If a function word commonly occurs in such speech acts, it is unlikely to be produced by children, even though they may understand it very

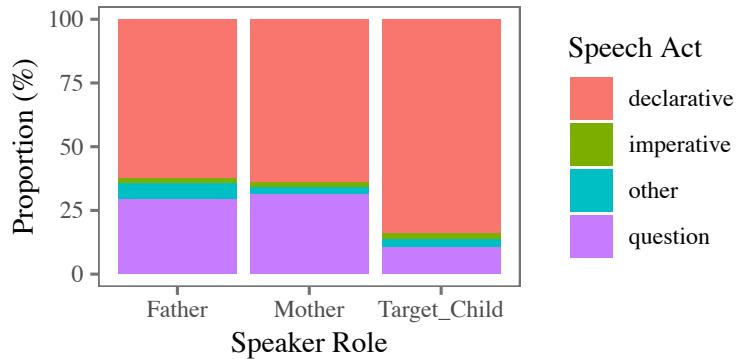


Figure 3.5: The proportion of declaratives and questions in children's and parents' utterances.

well. Therefore, it is important to check the distribution of speech acts in corpora when studying different function words. Since it is hard to classify and quantify speech acts automatically, here I use utterance type as a proxy for speech acts. I investigate the distribution of declaratives, questions, and imperatives in this collection of corpora on parent-child interactions. Figure 3.5 shows the distribution of different utterance types in the speech of parents and children. Overall, most utterances are either declaratives or questions, and there are more declaratives than questions in this collection. While mothers and fathers show similar proportions of declaratives and questions in their speech, children produce a lower proportion of questions and higher proportion of declaratives than their parents. Figure 3.6 shows the developmental trend of declaratives and questions between the ages of one and six. Children start with only producing declaratives and add non-declarative utterances to their repertoire gradually until they get closer to the parents' rate around the age six. They also start with very few questions and increase the number of questions they ask gradually. It is important to note that the rates of declaratives and questions in children's speech do not reach the adult rate. These two figures show that parent-child interactions are asymmetric. Parents ask more questions and children produce more declaratives. This asymmetry also interacts with age: the speech of younger children has a higher proportion of declaratives than older children.

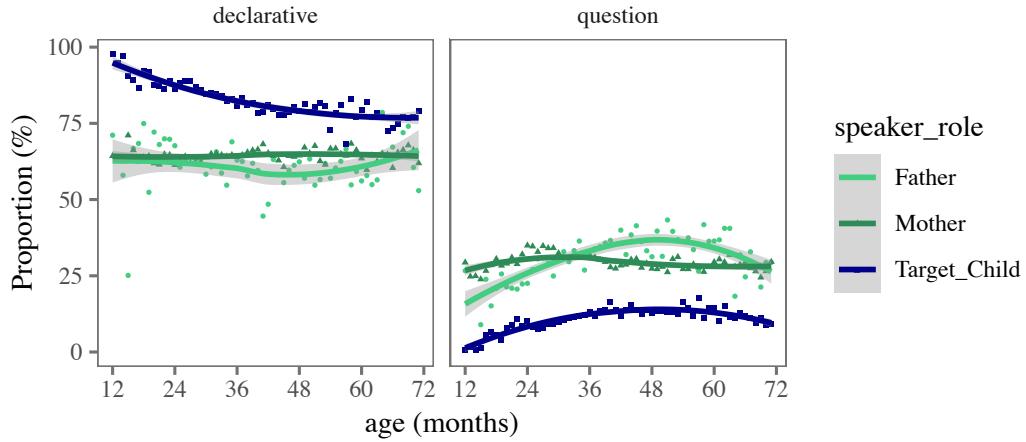


Figure 3.6: Proportion of declaratives to questions in parent-child interactions by age.

The frequency of function words such as *and* and *or* may be affected by such conversational asymmetries if they are more likely to appear in some utterance types than others. Figure 3.7 shows the proportion of *and*'s and *or*'s that appear in different utterance types in parents' and children's speech. In parents' speech, *and* appears more often in declaratives (around 60% in declaratives and 20% in questions). On the other hand, *or* appears more often in questions than declaratives, although this difference is small in mothers. In children's speech, both *and* and *or* appear most often in declaratives. However, children have a higher proportion of *or* in questions than *and* in questions.

The differences in the distribution of utterance types can affect our interpretation of the corpus data on function words such as *and* and *or* in three ways. First, since the collection contains more declaratives than questions, it may reflect the frequency and diversity of function words like *and* that appear in declaratives better. Second, since children produce more declaratives and fewer questions than parents, we may underestimate children's knowledge of function words like *or* that are frequent in questions. Third, given that the percentage of questions in the speech of children increases as they get older, function words like *or* that are more likely to appear in questions may appear infrequent in the early stages and more frequent in the later stages of children's development. In other words, function words like *or* that are common in questions may show a seeming delay in production which is possibly due to the development of questions in children's speech. Therefore, in studying children's productions of function words, it is important to look at their relative frequencies

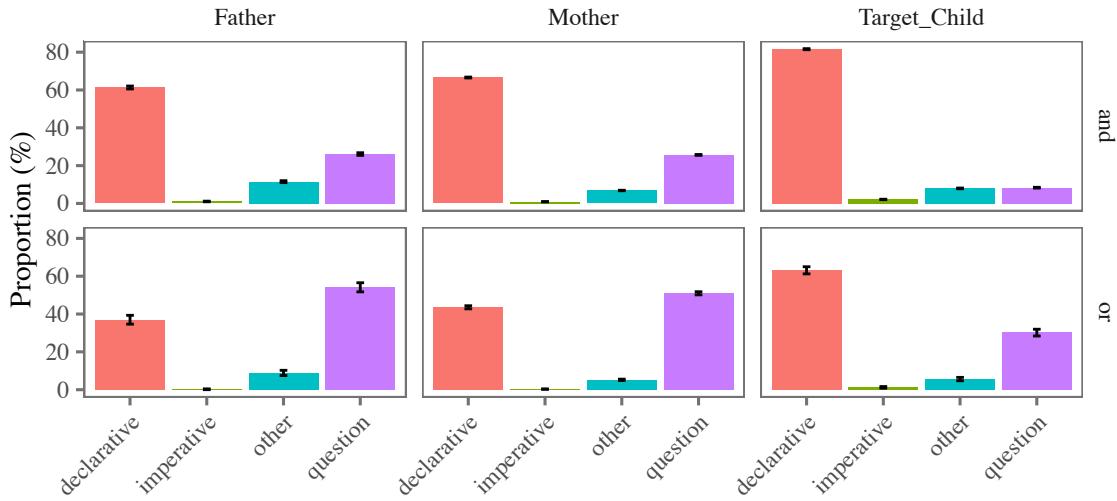


Figure 3.7: The proportion of *and* and *or* in different utterance types in the speech of parents and children.

in different utterance types as well as the overall trends. This is the approach I pursue in the next section.

3.2.3 Results

First, I consider the overall distribution of *and* and *or* in the corpora and then look closer at their distributions in different utterance types. Figure 3.8 shows the frequency of *and* and *or* relative to the total number of words produced by each speaker (i.e. fathers, mothers, and children). The y-axes show relative frequency per thousand words. It is also important to note that the y-axes show different ranges of values for *and* vs. *or*. This is due to the large difference between the relative frequencies of these connectives. Overall, *and* occurs around 15 times per thousand words but *or* only occurs 3 times per 2000 words in the speech of parents and around 1 time every 2000 words in the speech of children. Comparing the relative frequency of the connectives in parents' and children's speech, we can see that overall, children and parents produce similar rates of *and* in their interactions. However, children produce fewer *or*'s than their parents. Next we look at the relative frequencies of *and* and *or* in parents and children's speech during the course of children's development. Figure 3.9 shows the relative frequencies of *and* and *or* in parents' and children's speech between 12 and 72 months (1-6 years). Production of *and* in parents' speech seems to be relatively stable and somewhere between 10 to 20 *and*'s per thousand words over the course of

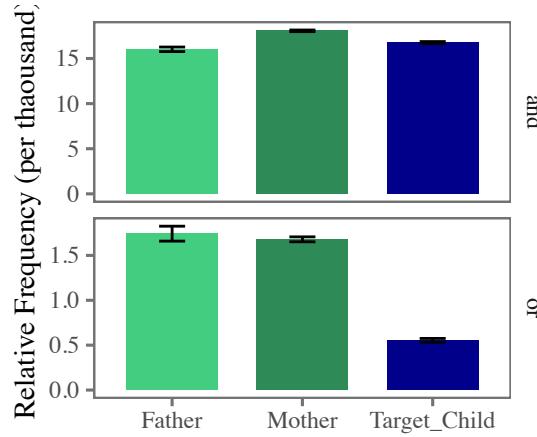


Figure 3.8: The relative frequency of *and/or* in the speech of fathers, mothers, and children. 95% binomial proportion confidence intervals calculated using Agresti-Coull's approximate method.

children's development. For children, they start producing *and* between 12 and 24 months, and show a sharp increase in their production until they reach the parent level between 30 to 36 months of age. Children stay close to the parents' production level between 36 and 72 months, possibly surpassing them a bit at 60 months – although as stated in the previous section, we should be cautious about patterns after 60 months due to the small amount of data in this period. For *or*, parents produce between 1 to 2 *or*'s every thousand words and mothers show a slight increase in their productions between 12 to 36 months. Children start producing *or* between 18 to 30 months of age. They show a steady increase in their productions of *or* until they get close to 1 *or* per thousand words at 48 months (4 years) and stay at that level until 72 months (6 years).

Children's productions of *and* and *or* show two main differences. First, the onset of *or* production is later than that of *and*. Children start producing *and* around 1 to 1.5 years old while *or* productions start around 6 months later. Second, children's *and* production shows a steep rise and reaches the parent level of production at three-years old. For *or*, however, the rise in children's production level does not reach the parent level even though it seems to reach a constant level between the ages of 4 and 6 years.

Not reaching the parent level of *or* production does not necessarily mean that children's understanding of *or* has not fully developed yet. It can also be due to the nature of parent-child interactions. For example, since parents ask more questions than children and *or* appears frequently in questions, parents may have a higher frequency of *or*. There are two ways of controlling for

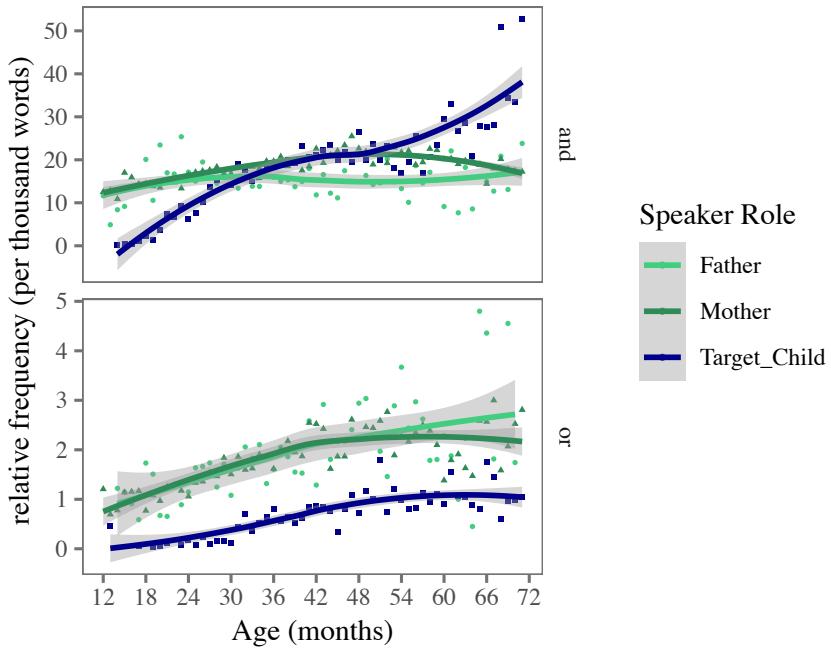


Figure 3.9: The monthly relative frequency of *and/or* in parents and children's speech between 12 and 72 months (1-6 years).

this possibility. One is to research children's speech to peers. Unfortunately such a large database of children's speech to peers is not currently available for analysis. Alternatively, we can look at the relative frequencies and developmental trends within utterance types such as declaratives and questions to see if we spot different developmental trends. This is what I pursue next.

Figure 3.10 shows the relative frequency of *and* and *or* in declaratives, questions, and imperatives. *And* has the highest relative frequency in declaratives while *or* has the highest relative frequency in questions. Figure 3.11 shows the developmental trends of the relative frequencies of *and* and *or* in questions and declaratives. Comparing *and* in declaratives and questions, we see that the onset of *and* productions are slightly delayed for questions but in both declaratives and questions, *and* productions reach the parent level around 36 months (3 years). For *or*, we see a similar delay in questions compared to declaratives. Children start producing *or* in declaratives at around 18 months but they start producing *or* in questions at 24 months. Production of *or* increases in both declaratives and questions until it seems to reach a constant rate in declaratives between 48 and 72 months. The relative frequency of *or* in questions continues to rise until 60 months. Comparing figures 3.9 and 3.11, we see that children are closer to the adult rate of production in declaratives

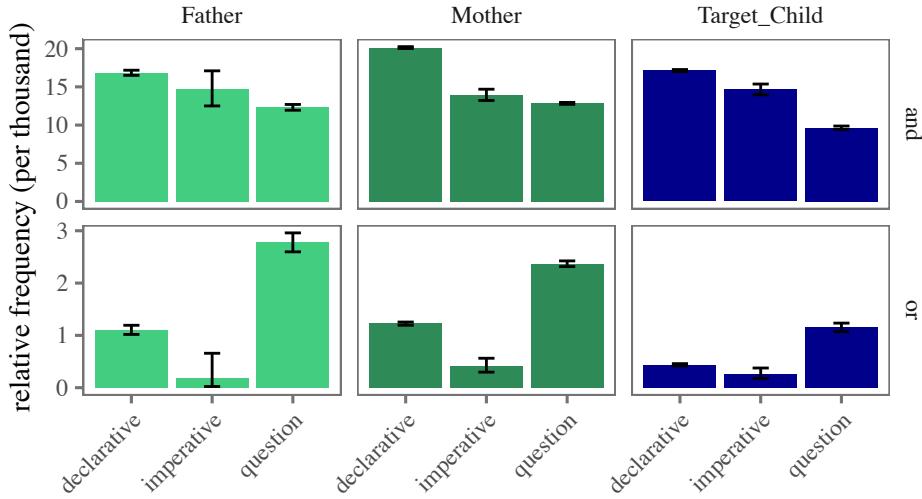


Figure 3.10: Relative frequency of *and/or* in declaratives, imperatives, and interrogatives for parents and children

than questions. The large difference between parents and children's production of *or* in figure 3.9 may partly be due to the development of *or* in questions. Overall the results show that children have a substantial increase in their productions of *and* and *or* between 1.5 to 4 years of age. Therefore, it is reasonable to expect that early mappings for the meaning and usage of these words develop in this age range.

3.2.4 Discussion

The goal of this study was to explore the frequency of *and* and *or* in parents and children's speech. The study found three differences. First, it found a difference between the overall frequency of *and* and *or* in both parents and children. *And* was about 10 times more frequent than *or* in the speech of parents and 30 times more likely in the speech of children. Second, the study found a difference between parents' and children's productions of *or*. Relative to the total number of words spoken by parents and children between the ages of 1 and 6 years, both children and parents produce on average 15 *and*'s every 1000 words. Therefore, children match parents' rate of *and* production overall. This is not the case for *or* as parents produce 3 *or*'s every 2000 words and children only 1 every 2000 words. Third, the study found a developmental difference between *and* and *or* as well. The study found that the onset of production is earlier for *and* than *or*. In the monthly relative frequencies of *and* and *or* in the speech of parents and children, the study also found that children reach the

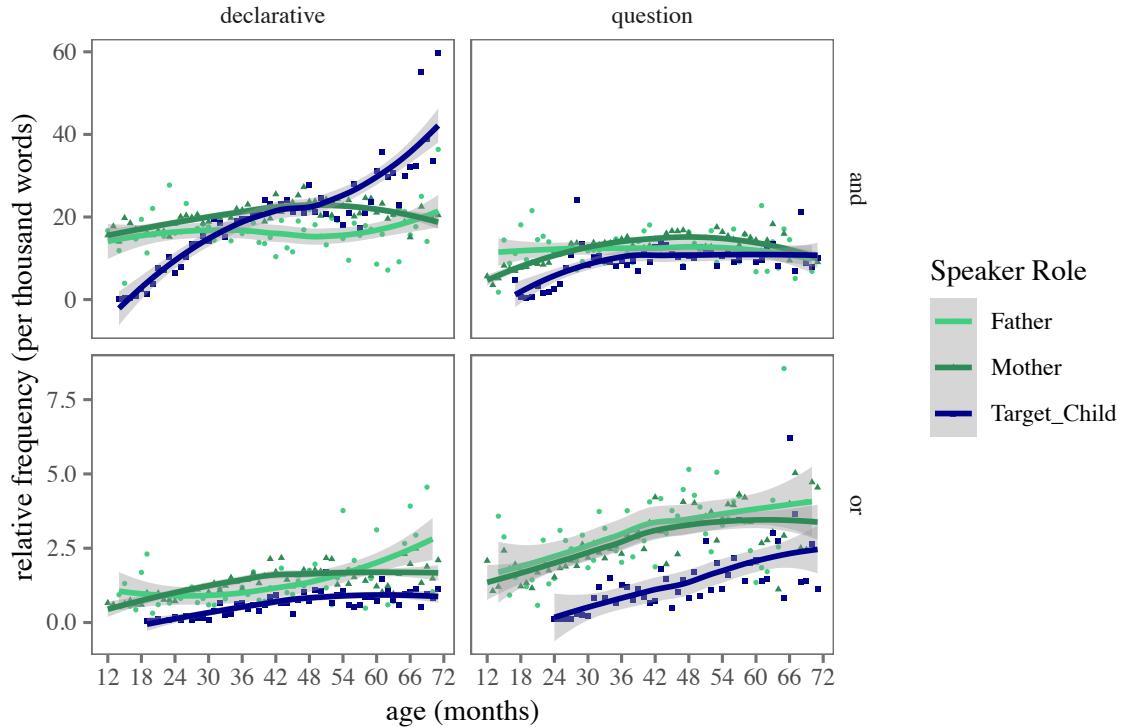


Figure 3.11: Relative frequency of *and/or* in declaratives and questions for parents and children between the child-age of 12 and 72 months (1-6 years).

parents' level of production for *and* at age 3 while *or* does not reach the parents' level even at age 6.

What causes these production differences? The first difference – that *and* is far more frequent than *or* – is not surprising or limited to child-directed speech. *And* is useful in a large set of contexts from conjoining elements of a sentence to connecting discourse elements or even holding the floor and delaying a conversational turn. In comparison, *or* seems to have a more limited usage. The second and the third differences – namely that children produce fewer *or*'s than parents, and that they produce *and* and reach their parents rate earlier than *or* – could be due to three factors. First, production of *and* develops and reaches the parents' rate earlier possibly because it is much more frequent than *or* in children's input. Previous research suggests that within the same syntactic category, words with higher frequency in child-directed speech are acquired earlier (J. C. Goodman, Dale, & Li, 2008). The conjunction word *and* is at least 10 times more likely than *or* so earlier acquisition of *and* is consistent with the effect of frequency on age of acquisition. Second,

research on concept attainment has suggested that the concept of conjunction is easier to conjure and possibly acquire than the concept of disjunction. In experiments that participants are asked to detect a pattern in the classification of cards, participants can detect a conjunctive classification pattern faster than a disjunctive one (Neisser & Weene, 1962). Therefore, it is possible that children learn the meaning of *and* faster and start to produce it earlier but they need more time to figure out the meaning and usage of *or*.

A third possibility is that the developmental difference between *and* and *or* is mainly due to the asymmetric nature of parent-child interactions and the utterance types that each role in this interaction requires. For example, this study found that parents ask more questions of children than children do of parents. It also found that *or* is much more frequent in questions than *and* is. Therefore, parent-child interaction provides more opportunities for parents to use *or* than children. In the next study we will discuss several constructions and communicative functions that are also more appropriate for the role of parents. For example, *or* is often used to ask what someone else wants like “do you want apple juice or orange juice?” or for asking someone to clarify what they said such as “did you mean ball or bowl?”. Both of these constructions are more likely to be produced by a parent than a child. *Or* is also used to introduce examples or provide definitions such as “an animal, like a rabbit, or a lion, or a sheep”. It is very unlikely that children would use such constructions to define terms for parents! Furthermore, such constructions also reveal their own developmental trends. For example, the study found that children start by almost entirely producing declaratives and increase their questions until at age 4 to 6, about 10% of their utterances are questions. Therefore, children’s ability to produce *or* in a question is subject to the development of questions themselves. More generally, the developmental difference between *and* and *or* may also be due to a difference in the development of other factors that production of *and* and *or* rely on, such as the development of constructions with specific communicative functions like unconditionals (Whether X or Y, discussed in Chapter 2). In future research, it will be important to establish the extent to which each of these potential causes – frequency, conceptual complexity, and the development of other factors such as utterance type or constructions with specific communicative functions – contribute to the developmental differences in the production of conjunction and disjunction.

3.3 Study 2: Interpretations of *and* and *or* in child-directed speech

Previous study reported on the frequencies of *and* and *or* in parents and children's speech production. To help us better understand children's linguistic input, this study offers a close examination of the interpretations that *and* and *or* have in child-directed speech. It helps us better understand the available input to children's learning mechanisms. A similar study was conducted by Morris (2008), who reported the most common interpretation of *and* is conjunction and *or* exclusive disjunction. In this exploratory study, annotators judged the interpretation of *and* and *or* and coded them for several linguistic and conceptual cues. The study had two main goals. First, to replicate the finding of Morris (2008) and second, to identify any cues in children's input that might help them learn the interpretations, and ultimately the meaning, of *and* and *or*.

3.3.1 Methods

This study used the Providence corpus (Demuth, Culbertson, & Alter, 2006) available via the PhonBank section of the TalkBank.org archive. The corpus was chosen because of its relatively dense data on child-directed speech as well as the availability of audio and video recordings that would allow annotators access to the context of the utterance. The corpus was collected between 2002 and 2005 in Providence, Rhode Island. Table 3.2 reports the name, age range, and the number of recording sessions for the participants in the study. All children were monolingual English speakers and were followed from around age 1 to 4 years. Based on Study 1, this is the age range when children develop their early understanding or mappings for the meanings of *and* and *or*. The corpus contains roughly biweekly hour-long recordings of spontaneous parent-child interactions, with most recordings being of mother-child interactions. The corpus consists of a total of 364 hours of speech.

Table 3.2: Information on the participants in the Providence Corpus. Ethan was diagnosed with Asperger's syndrome and therefore was excluded from this study.

Name	Age Range	Sessions
Alex	1;04.28-3;05.16	51
Ethan	0;11.04-2;11.01	50
Lily	1;01.02-4;00.02	80
Naima	0;11.27-3;10.10	88
Violet	1;02.00-3;11.24	51
William	1;04.12-3;04.18	44

Exclusion Criteria

I excluded data from Ethan since he was diagnosed with Asperger's Syndrome at age 5. I also excluded all examples found in conversations over the phone, adult-adult conversations, and utterances heard from TV or radio. Such cases did not count as child-directed speech. I excluded proper names and fixed forms such as "Bread and Circus" (name of a local place) or "trick-or-treat" from the set of examples to be annotated. The rationale here was that such forms could be learned and understood with no actual understanding of the connective meaning. I counted multiple instances of *or* and *and* within the same disjunction/conjunction as one instance. The reason is that, in a coordinated structure, the additional occurrences of a connective typically did not alter the annotation categories, most importantly the interpretation of the coordination. For example, there is almost no difference between "cat, dog, and elephant" versus "cat and dog and elephant" in interpretation. In short, I focused on the coordinated construction as units rather than on every separate instance of *and* and *or*. Instances of more than two connectives in a coordination were rare in the sample.

Procedure

All utterances containing *and* and *or* were extracted using the CLAN software and automatically tagged for the following: (1) the name of the child; (2) the transcript address; (3) the speaker of the utterance (father, mother, or child); (4) the child's birth date, and (5) the recording date. Since the focus of the study was mainly on disjunction, we annotated instances of *or* in all the child-directed

speech from the earliest examples to the latest ones found. Given that the corpus contained more than 10 times the number of *and*'s than *or*'s, I randomly sampled 1000 examples of *and* to match 1000 examples of *or*. Here I report the results on 465 examples of *and* and 608 examples of *or*.

3.3.2 Annotation Categories

Every extracted instance of *and* and *or* was manually annotated for 7 categories: 1. Connective Interpretation 2. Intonation Type 3. Utterance Type 4. Syntactic Level 5. Conceptual Consistency 6. Communicative Function and 7. Answer Type. In what follows, I explain how each annotation category was defined in detail and provide some prototypical examples of the category.

Connective Interpretation

This category is the dependent variable of the study. Annotators listened to coordinations such as “A or B” and “A and B”, and decided the intended interpretation of the connective with respect to the truth of A and B. We used the sixteen binary connectives shown in Figure 3.12 as the space of possible connective interpretations. Annotators were asked to consider the two propositions raised by the coordinated construction, ignoring the connective and functional elements such as negation and modals. Consider the following sentences containing *or*: “Bob plays soccer or tennis” and “Bob doesn’t play soccer or tennis”. Both discuss the same two propositions: A. Bob playing soccer, and B. Bob playing tennis. However, the functional elements combining these two propositions result in different interpretations with respect to the truth of A and B. In “Bob plays soccer or tennis” which contains a disjunction, the interpretation is that Bob plays one or possibly both sports (inclusive disjunction IOR). In “Bob doesn’t play soccer or tennis” which contains a negation and a disjunction, the interpretation is that Bob plays neither sport (NOR). For connective interpretations, the annotators first reconstructed the coordinated propositions without the connectives or negation and then decided which propositions were implied to be true/false.

This approach is partly informed by children’s development of function and content words. Since children acquire content words earlier than functions words, we assumed that when learning logical connectives, they better understand the content of the propositions being coordinated rather than the functional elements involved in building the coordinated construction. For example, considering the sentences “Bob doesn’t play soccer or tennis” without its function words as “Bob, play, soccer,

$A + B$	\top	\perp	NAND	IF	FI	IOR	IFF	XOR	A	nA	B	nB	NOR	ANB	NAB	AND
$A^T B^T$	Green			Green	Green	Green	Green		Green		Green					Green
$A^T B^F$	Green		Green	White	Green	White	Green	Green			White	Green			Green	
$A^F B^T$			Green	White	Green	White	Green	White		Green	Green	Green		Green		
$A^F B^F$			Green	Green	White	Green	Green	White		Green	Green	Green				

Figure 3.12: The truth table for the 16 binary logical connectives. The rows represent the set of situations where zero, one, or both propositions are true. The columns represent the 16 possible connectives and their truth conditions. Green cells represent true situations.

tennis”, one can still deduce that there are two relevant propositions: Bob playing soccer, and Bob playing tennis. However, the real challenge is to figure out what is being communicated with respect to the truth of these two propositions. If the learner can figure this out, then the meaning of the functional elements can be reverse engineered. For example, if the learner recognizes that “Bob plays soccer or tennis” communicates that one or both propositions are true (IOR), the learner can associate this interpretation to the unknown element *or*. Similarly, if the learner recognizes the interpretation of “Bob doesn’t play soccer or tennis” as neither proposition is true (NOR), they can associate this interpretation to the combination of disjunction and the overt sentential negation. Table 3.3 reports the connective interpretations found in our annotations as well as some examples for each interpretation.

Table 3.3: Annotation classes for connective interpretation

Class	Meaning	Examples
AND	Both propositions are true	“I’m just gonna empty this and then I’ll be out of the kitchen.” – “I’ll mix them together or I could mix it with carrot, too.”
IOR	One or both propositions are true	“You should use a spoon or a fork.” – “Ask a grownup for some juice or water or soy milk.”
XOR	Only one proposition is true	“Is that a hyena? or a leopard?” – “We’re gonna do things one way or the other.”

Class	Meaning	Examples
NOR	Neither proposition is true	<i>"I wouldn't say boo to one goose or three." – "She found she lacked talent for hiding in trees, for chirping like crickets, or humming like bees."</i>
IFF	Either both propositions are true or both are false	<i>"Put them [crayons] up here and you can get down. – Come over here and I'll show you."</i>
NAB	The first proposition is false, the second is true.	<i>"There's an Oatio here, or actually, there's a wheat here."</i>

Intonation Type

Annotators listened to the utterances and decided whether the intonation contour on the coordination was flat, rise, or rise-fall. Table 3.4 shows the definitions and examples for these intonation types. In order to judge the intonation of the sentence accurately, annotators were asked to construct all three intonation contours for the sentence and see which one is closer to the actual intonation of the utterance. For example, to judge the sentence “do you want orange juice↑ or apple juice↓?”, they reconstructed the sentence with the prototypical flat, rising, and rise-fall intonations and checked to see which intonation is closer to the actual one. It is important to note that while these three intonation contours provide a good general classification, there is a substantial degree of variation as well as a good number of subtypes within each intonation type.

Table 3.4: Definitions of the intonation types and their examples.

Intonation	Definitions	Examples
Flat	Intonation does not show any substantial rise at the end of the sentence.	<i>"I don't hear any meows or bow-wow-wows."</i>
Rise	There is a substantial intonation rise on each disjunct or generally on both.	<i>"Do you want some seaweed? or some wheat germ?"</i>

Intonation	Definitions	Examples
Rise-Fall	There is a substantial rise on the non-final disjunct(s), and a fall on the final disjunct.	<i>"Is that big Q or little q?" – "(are) You patting them, petting them, or slapping them?"</i>

Utterance Type

Annotators decided whether an utterance is a declarative, an interrogative, or an imperative. Table 3.5 provide the definitions and examples for each utterance type. Occasionally, we found examples with different utterance types for each coordinand. For example, the mother would say “put your backpack on and I’ll be right back”, where the first cooridnand is an imperative and the second a declarative. Such examples were coded for both utterance types with a dash in-between: imperative-declarative.

Table 3.5: Definitions of the utterance types and their examples.

Utterance Types	Definitions	Examples
Declarative	A statement with a subject-verb-object word order and a flat intonation.	<i>"It looks a little bit like a drum stick or a mallet."</i>
Interrogative	A question with either subject-auxiliary inversion or a rising terminal intonation.	<i>"Is that a dog or a cat?"</i>
Imperative	A directive with an uninflected verb and no subject	<i>"Have a little more French toast or have some of your juice."</i>

Syntactic Level

For this annotation category, annotators decided whether the coordination is at the clausal level or at the sub-clausal level. Clausal level was defined as sentences, clauses, verb phrases, and verbs. Coordination of other categories was coded as sub-clausal. This annotation category was introduced to check the hypothesis that the syntactic category of the coordinands may influence the interpretation of a coordination. The intuition was that a sentence such as “He drank tea or coffee” is less likely to be interpreted as exclusive than “He drank tea or he drank coffee.” The clausal vs. sub-clausal

distinction was inspired by the fact that in many languages, coordinators that connect sentences and verb phrases are different lexical items than those that connect nominal, adjectival, or prepositional phrases (see Haspelmath, 2007).

Table 3.6: Definitions of the syntactic levels and their examples.

Syntactic Level	Definitions	Examples
Clausal	The coordinands are sentences, clauses, verb phrases, or verbs.	<i>“Does he lose his tail sometimes and Pooh helps him and puts it back on?”</i>
Sub-clausal	The coordinands are nouns, adjectives, noun phrases, determiner phrases, or prepositional phrases.	<i>“Hollies can be bushes or trees.”</i>

Conceptual Consistency

Propositions that are connected by words such as *and* and *or* often stand in complex conceptual relations with each other. For conceptual consistency, annotators decided whether the propositions that make up the coordination can be true at the same time or not. If the two propositions could be true at the same time they were marked as consistent. If the two propositions could not be true at the same time and resulted in a contradiction, they were marked as inconsistent. Our annotators used the following diagnostic to decide the consistency of the disjuncts: Two disjuncts were marked as inconsistent if replacing the word *or* with *and* produced a contradiction. For example, changing “the ball is in my room *or* your room” to “the ball is in my room *and* your room” produces a contradiction because a ball cannot be in two rooms at the same time.

Table 3.7: Definitions of consistency types and their examples.

Consistency	Definitions	Examples
Consistent	The coordinands can be true at the same time.	<i>“We could spell some things with a pen or draw some pictures.”</i>

Consistency	Definitions	Examples
Inconsistent	The coordinands cannot be true at the same time.	<i>"Do you want to stay or go?"</i>

First, it is important to note here that this criterion is quite strict. In many cases, the possibility of both propositions being true is ruled out based on prior knowledge and expectations of the situation. For example, when asking people whether they would like tea or coffee, it is often assumed and expected that people choose one or the other. However, wanting to drink both tea and coffee is not conceptually inconsistent. It is just very unlikely. Our annotations of consistency are very conservative in that they still consider such unlikely cases as consistent. Relaxing this criterion to capture the unlikely cases may increase exclusivity inferences that are caused by alternatives that are considered unlikely to co-occur.

Second, there are other more complex relations between coordinated propositions that we have not coded for. For example, coordinated propositions sometimes stand in a causal relation (e.g. the cup fell and broke) or sometimes in a temporal relation (e.g. she brushed her teeth and went to bed), among many more. It is quite feasible to assume that the rich conceptual structure of these propositions help children learn the meaning and use of connectives such as *and*, *or*, *if*, *therefore*, etc. It is possible to develop a more detailed investigation on the relation between propositions and how that affects the acquisition of connective meaning generally. However, in this study we mainly focus on conceptual consistency of the coordinated propositions and how that affects the acquisition of *and* and *or*.

It is also important to note that if the coordinands are inconsistent, this does not necessarily mean that the connective interpretation must be exclusive. For example, in a sentence like "you could stay here or go out", the alternatives "staying here" and "going out" are inconsistent. Yet, the overall interpretation of the connective could be conjunctive: you could stay here AND you could go out. The statement communicates that both possibilities hold. This pattern of interaction between possibility modals like *can* and disjunction words like *or* are often discussed under the label "free-choice inferences" in the semantics and pragmatics literature (Kamp, 1973; Von Wright, 1968). Another example is unconditionals such as "Ready or not, here I come!". The coordinands are

contradictions: one is the negation of the other. However, the overall interpretation of the sentences is that in both cases, the speaker is going to come.

Communicative Functions

This study constructed a set of categories that captured particular usages or communicative functions of the words *or* and *and*. These communicative functions were created using the first 100 examples and then they were used for the classification of the rest of the examples. Table 3.8 shows the definitions and examples of the 10 communicative functions used in this study. The table contains some functions that are general and some that are specific to coordination. For example, directives are a general class while conditionals are more specific to coordinated constructions. It is also important to note that the list is not unstructured. Some communicative functions are subtypes of others. For example, “identifications” and “unconditionals” are subtypes of “descriptions” while “conditionals” are a subtype of directives. Furthermore, “repairs” seem parallel to other categories in that any speech act can be repaired. We do not fully explore the details of these functions in this study but such details matter for a general theory of acquisition that makes use of the speaker’s communicative intentions as early coarse-grained communicative cues for the acquisition of fine-grained meaning such as function words.

Table 3.8: Definitions of the communicative functions and their examples.

Function	Definitions	Examples
Descriptions	Describing what the world is like or asking about it. The primary goal is to inform the addressee about how things are.	“ <i>It’s not in the ditch or the drain pipe.</i> ”
Identifications	Identifying the category membership or an attribute of an object. Speaker has uncertainty. A subtype of “Description”.	“ <i>Is that a ball or a balloon honey?</i> ”
Definitions and Examples	Providing labels for a category or examples for it. Speaker is certain. Subtype of Description.	“ <i>This is a cup or a mug.</i> ” – “ <i>berries like blueberry or raspberry</i> ”

Function	Definitions	Examples
Preferences	Asking what the addressee wants or would like or stating what the speaker wants or would like	<i>"Do you wanna play pizza or read the book?"</i>
Options	Either asking or listing what one can or is allowed to do. Giving permission, asking for permission, or describing the possibilities. Often the modal "can" is either present or can be inserted.	<i>"You could have wheat or rice."</i>
Directives	Directing the addressee to act or not act in a particular way. Common patterns include "let's do ...", "Why don't you do ...", or prohibitions such as "Don't ...". The difference with "options" is that the speaker expects the directive to be carried out by the addressee. There is no such expectation for "options".	<i>"let's go back and play with your ball or we'll read your book."</i>
Clarifications	Something is said or done as a communicative act but the speaker has uncertainty with respect to the form or the content.	<i>"You mean boba or bubble?"</i>
Repairs	Speaker correcting herself on something she said (self repair) or correcting the addressee (other repair). The second disjunct is what holds and is intended by the speaker. The speaker does not have uncertainty with respect to what actually holds.	<i>"There's an Oatio here, or actually, there's a wheat here."</i>

Function	Definitions	Examples
Conditionals	Explaining in the second coordinand, what would follow if the first coordinand is (or is not) followed. Subtype of Directive.	<i>"Put that out of your mouth, or I'm gonna put it away."</i> – <i>"Come over here and I'll show you."</i>
Unconditionals	Denying the dependence of something on a set of conditions. Typical format: "Whether X or Y, Z". Subtype of Descriptions.	<i>"Ready or not, here I come!"</i> (playing hide and seek)

Answer Type

Whenever a parent's utterance was a polar question, the annotators coded the utterance for the type of response it received from the children. Table 3.9 shows the answer types in this study and their definitions and examples. Utterances that were not polar questions were simply coded as NA for this category. If children responded to polar questions with "yes" or "no", the category was YN and if they repeated with one of the coordinands the category was AB. If children said yes/no and followed it with one of the coordinands, the answer type was determined as YN (yes/no). For example, if a child was asked "Do you want orange juice or apple juice?" and the child responded with "yes, apple juice", our annotators coded the response as YN. The reason is that in almost all cases, if a simple yes/no response is felicitous, then it can also be optionally followed with mentioning a disjunct. However, if yes/no is not a felicitous response, then mentioning one of the alternatives is the only appropriate answer. For example, if someone asks "Do you want to stay here or go out?" a response such as "yes, go out" is infelicitous and a better response is to simply say "go out". Therefore, we count responses with both yes/no and mentioning an alternative as a yes/no response.

Table 3.9: Definitions of answer types and their examples.

Type	Definitions	Examples
No Answer	The child provides no answer to the question.	Mother: “ <i>Would you like to eat some applesauce or some carrots?</i> ” Child: “ <i>Guess what Max!</i> ”
YN	The child responds with <i>yes</i> or <i>no</i> .	Father: “ <i>Can I finish eating one or two more bites of my cereal?</i> ” Child: “ <i>No.</i> ”
AB	The child responds with one of the disjuncts (alternatives).	Mother: “ <i>Is she a baby elephant or is she a toddler elephant?</i> ” Child: “ <i>It’s a baby. She has a tail.</i> ”

3.3.3 Inter-annotator Reliability

To train annotators and confirm their reliability for disjunction examples, two annotators coded the same 240 instances of disjunction. The inter-annotator reliability was calculated over 8 iterations of 30 examples each. After each iteration, annotators met to discuss disagreements and resolve them. They also decided whether the category definitions or annotation criteria needed to be made more precise. Training was completed after three consecutive iterations showed substantial agreement between the annotators for all categories (Cohen’s $\kappa > 0.7$). Figure 3.13 shows the percentage agreement and the kappa values for each annotation category over the 8 iterations.

Agreement in the following three categories showed substantial improvement after better and more precise definitions and annotation criteria were developed: connective interpretation, intonation, and communicative function. First, connective interpretation showed major improvements after annotators developed more precise criteria for selecting the propositions under discussion and separately wrote down the two propositions connected by the connective word. For example, if the original utterance was “do you want milk or juice?”, the annotators wrote “you want milk, you

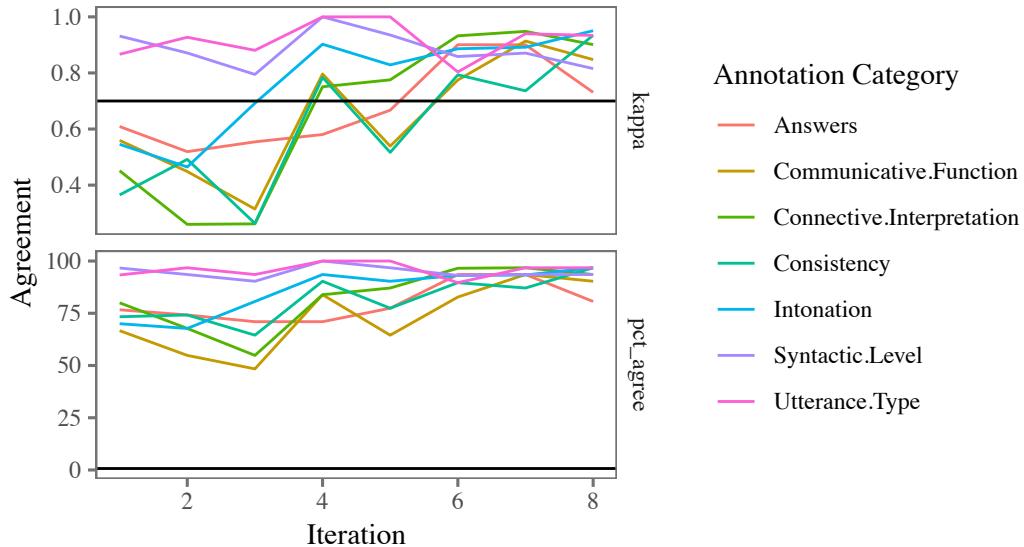


Figure 3.13: Inter-annotator agreement for disjunction examples.

want juice” as the two propositions under discussion. This exercise clarified the exact propositions under discussion and sharpened annotator intuitions with respect to the connective interpretation that is communicated by the utterance. Second, annotators improved agreement on intonation by reconstructing an utterance’s intonation for all three intonation categories. For example, the annotator would examine the same sentence “do you want coffee or tea?” with a rise-fall, a rise, and a flat intonation. Then the annotator would listen to the actual utterance and see which one most resembled the actual utterance. This method helped annotators judge the intonation of an utterance more accurately. Finally, agreement on communicative functions improved as the definitions were made more precise. For example, the definition of “directives” in Table 3.8 explicitly mentions the difference between “directives” and “options”. Clarifying the definitions of communicative functions helped improve annotator agreement.

Inter-annotator reliability for conjunction was calculated in the same way. Two different annotators coded 300 utterances of *and*. Inter-annotator reliability was calculated over 10 iterations of 30 examples. Figure 3.14 shows the percentage agreement between the annotators as well as the kappa values for each iteration. Despite high percentage agreement between annotators, the kappa values did not pass the set threshold of 0.7 in three consecutive iterations. This paradoxical result is mainly due to a property of kappa. An imbalance in the prevalence of annotation categories can drastically lower its value. When one category is extremely common with high agreement while other

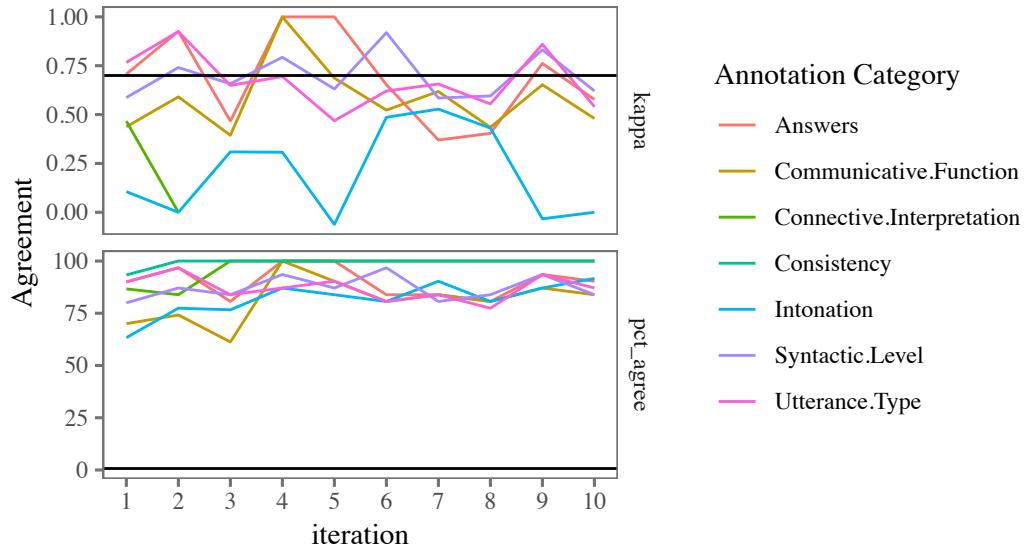


Figure 3.14: Inter-annotator agreement for conjunction examples.

categories are rare, kappa will be low (Cicchetti & Feinstein, 1990; Feinstein & Cicchetti, 1990). In almost all annotated categories for conjunction, there was one class that was extremely prevalent. In such cases, it is more informative to look at the class specific agreement for the prevalent category than the overall agreement measured by Kappa (Cicchetti & Feinstein, 1990; Feinstein & Cicchetti, 1990). Table 3.10 lists the dominant classes as well as their prevalence, the values of class specific agreement index, and category agreement index (Kappa). Class specific agreement index is defined as $2n_{ii}/n_i + n_{.i}$, where i represents the class's row/column number in the category's confusion matrix, n the number of annotations in a cell, and the dot ranges over all the row/column numbers (Fleiss, Levin, & Paik, 2013, p. 600; Ubersax, 2009). The class specific agreement indices are high for all the most prevalent classes showing that the annotators had very high agreement on these class, even though the general agreement index (Kappa) was often low. The most extreme case is the category “consistency” where almost all instances were annotated as “consistent” with perfect class specific agreement but low overall Kappa. In the case of utterance type and syntactic level where the distribution of instances across classes was more even, the general index of agreement Kappa is also high. In general, examples of conjunction showed little variability across annotation categories and mostly fell into one class within each category. Annotators had high agreement for these dominant classes.

Table 3.10: Most prevalent annotation class in each annotation category with the values of class agreement indeces and category agreement indeces (Kappa).

Annotation Category	Class	Prevalence	Class Agreement Index	Kappa
intonation	flat	0.86	0.89	0.24
interpretation	AND	0.96	0.98	0.39
answer	NA	0.84	0.94	0.67
utterance_type	declarative	0.76	0.94	0.70
communicative_function	description	0.77	0.90	0.59
syntactic_level	clausal	0.67	0.91	0.70
consistency	consistent	0.99	1.00	0.50

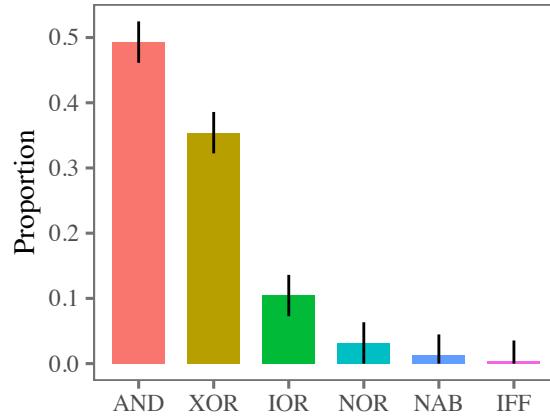


Figure 3.15: The proportion of different interpretations of the connectives *and/or* in child-directed speech

3.3.4 Results

First, I show the results for the study's dependent measure¹. Figure 3.15 shows the distribution of the connective interpretations in the study. The most common interpretation was the conjunctive interpretation (AND, 49%) followed by the exclusive interpretation (XOR, 35%). Figure 3.16 shows the distribution of connective interpretations by the connective words *and* and *or*. For *and*, the most frequent interpretation (in fact almost the only interpretation), is conjunction AND. For *or*, the most frequent interpretation is exclusive disjunction XOR. These results replicate the findings of Morris (2008). Based on these results, Morris argued that given the high frequency of conjunction and exclusive disjunction in the input, children should map the meanings of *and* and *or* as conjunction and exclusive disjunction, at least initially, between the ages of 2 and 5 years. According

¹All the confidence intervals shown in the plots for this section are simultaneous multinomial confidence intervals computed using the Sison & Glaz (1995) method.

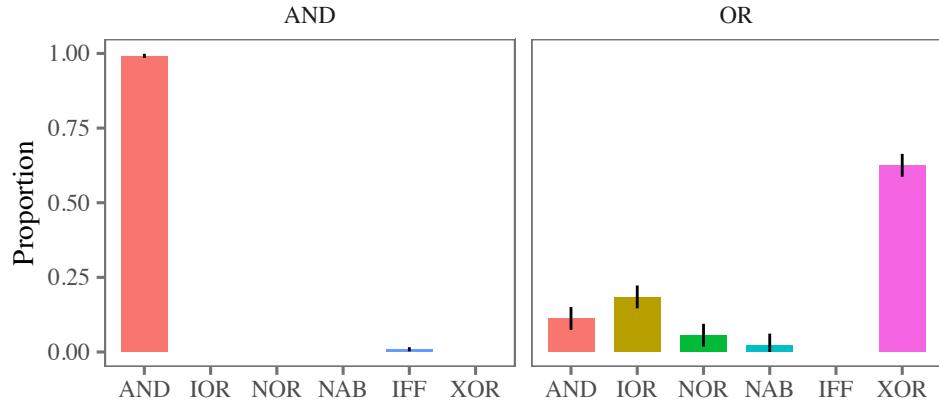
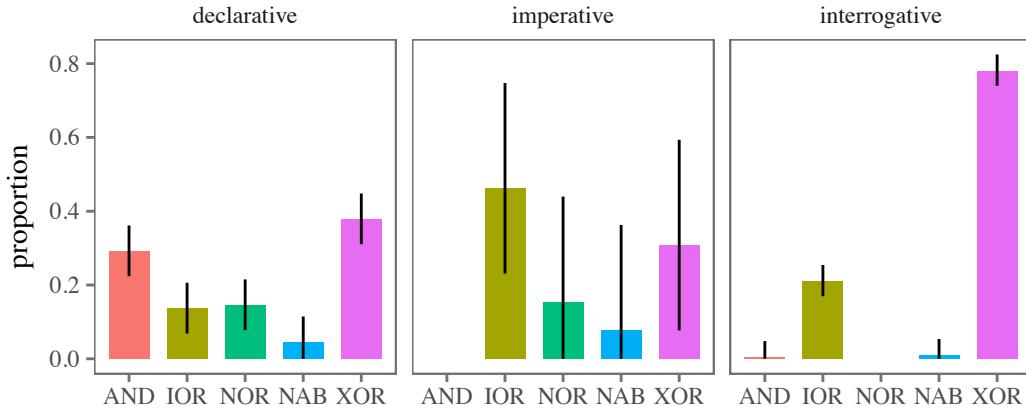
Figure 3.16: Interpretations of *and/or* in child-directed speech

Figure 3.17: Connective interpretations in different sentence types.

to Morris (2008), children learn the inclusive interpretation of disjunction later as they encounter more inclusive (logical) uses of *or*. However, comprehension tasks show that children between 3 and 5 tend to interpret *or* as inclusive disjunction rather than exclusive disjunction in a variety of declarative sentences (Chierchia et al., 2001; Gualmini, Crain, & Meroni, 2000a; Gualmini, Meroni, & Crain, 2000b, among others; Notley, Zhou, Jensen, & Crain, 2012). How can children learn the inclusive semantics of *or* if they rarely hear it? This is the puzzle of learning disjunction, discussed in the first chapter. The remainder of this section explores the role of cues that could help children successfully interpret a disjunction as inclusive or exclusive.

I will first look at the effect of utterance type on the interpretation of *or*. Figure 3.17 shows the distribution of connective interpretations in declarative, interrogative, and imperative sentences.

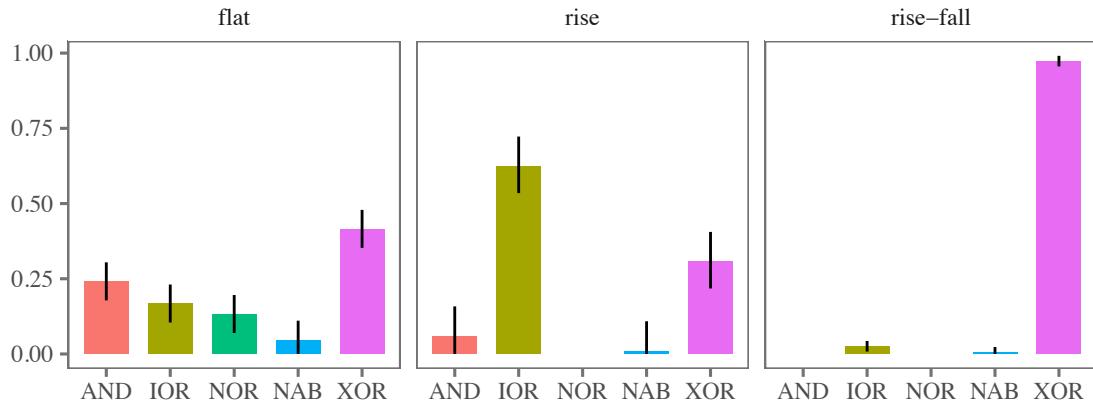


Figure 3.18: The distribution of connective interpretations in flat, rising, and rise-fall intonation.

Interrogatives are more likely to be interpreted as exclusive disjunction (XOR), imperatives are more likely to be interpreted as inclusive (IOR) or exclusive (XOR), and declaratives are most likely exclusive (XOR) or conjunctive (AND). It is important to note here that the inclusive interpretations of imperatives are largely due to invitations to action such as “Have some food or drink!”. Such invitational imperatives seem to convey inclusivity (IOR) systematically. They are often used to give the addressee full permission with respect to both alternatives and it seems quite odd to use them to imply exclusivity (e.g. “Have some food or drink but not both!”), and they do not seem to be conjunctive either (e.g. “Have some food and have some drink”). They rather imply that the addressee is invited to have food, drink, or both.

Figure 3.18 shows the proportions of different connective interpretations in the three intonation contours: flat, rise, and rise-fall. A disjunction with a rise-fall intonation is most likely interpreted as exclusive (XOR). If the intonation is rising, a disjunction is more likely to be interpreted as inclusive (IOR). And a disjunction with a flat intonation may be interpreted as exclusive (XOR), conjunctive (AND), or inclusive (IOR). These results are consistent with Pruitt & Roelofsen (2013)'s experimental findings that a rise-fall intonation contour on a disjunction results in an exclusive interpretation. Since rise-fall and rising intonation contours are almost always on interrogatives, Figures 3.17 and 3.18, suggest that the rise-fall and rising intonation types distinguish exclusive and inclusive interpretations of disjunction in interrogatives. Furthermore, given a flat intonation type, an imperative may be more likely to be inclusive (IOR).

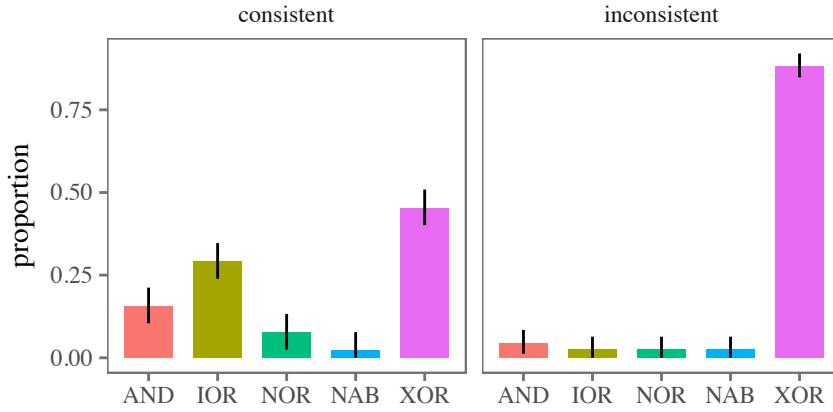


Figure 3.19: Connective interpretations in disjunctions with consistent and inconsistent disjuncts.

Figure 3.19 shows the proportions of connective interpretations in disjunctions with consistent vs. inconsistent disjuncts. When the disjuncts were consistent, the interpretation could be exclusive (XOR), inclusive (IOR), or conjunctive (AND). When the disjuncts were inconsistent, a disjunction almost always received an exclusive interpretation. These results suggest that the exclusive interpretation of a disjunction often stems from the inconsistent or contradictory nature of the disjuncts themselves and not necessarily the connective word *or*. It should be noted here that in all *and*-examples, the disjuncts were consistent. This is not surprising given that inconsistent meanings with *and* result in a contradiction. The only exception to this was one example where the mother was mentioning two words as antonyms: “short and tall”. This example is quite different from the normal utterances given that it is meta-linguistic and list words rather than asserting the content of the words.

In Figure 3.20, I break down connective interpretations by both intonation and consistency. The results show that disjunctions are interpreted as exclusive XOR when they carry either inconsistent disjuncts or a rise-fall intonation. If the disjunction has consistent disjuncts and carries a rising intonation, it is most likely interpreted as inclusive IOR. Disjunctions with consistent disjuncts and a flat intonation contour could have conjunctive (AND), inclusive (IOR), or exclusive (XOR) interpretations. Figure 3.21 shows connective interpretations by the syntactic level of the disjunction. As a reminder, we annotated disjunctions with clausal/verbal disjuncts as “clausal”, and those

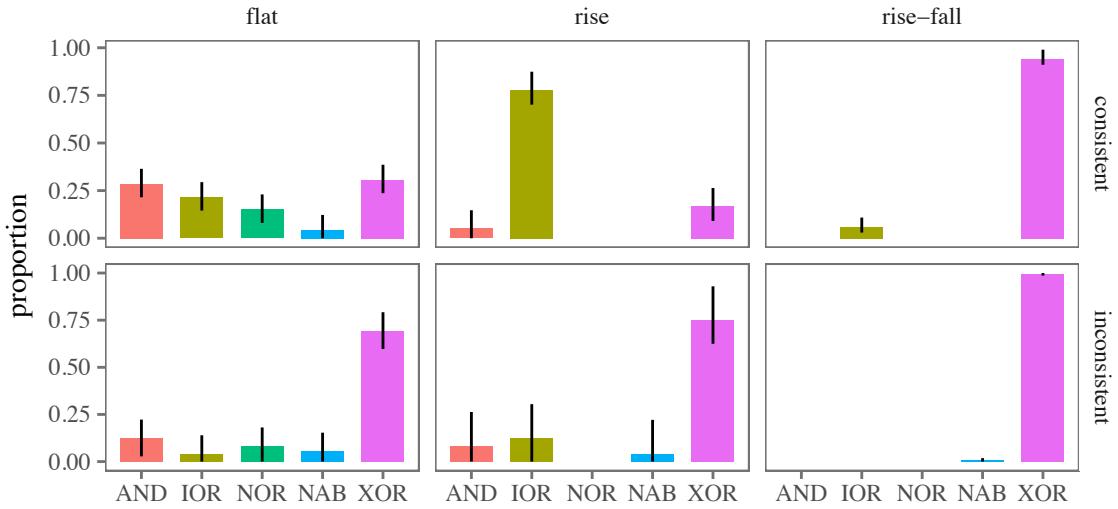


Figure 3.20: Interpretations of and/or in the three intonation contours flat, rising, and rise-fall.

with other syntactic categories as sub-clausal. The goal was to assess the role of syntax in the interpretation of disjunction. The results suggest a small effect of clausal level disjuncts. Disjunctions are more likely to be interpreted as exclusive when their disjuncts are clauses or verbs rather than nominals, adjectives, or prepositions (all sub-clausal units). For the last independent variable in our study, I take a look at how disjunction interpretations are affected by the communicative function of the utterance they appear in. Figure 3.22 shows the proportions of connective interpretations in the 10 different communicative functions of this study. The results show that certain functions increase the likelihood of some connective interpretations. An exclusive (XOR) interpretation of *or*

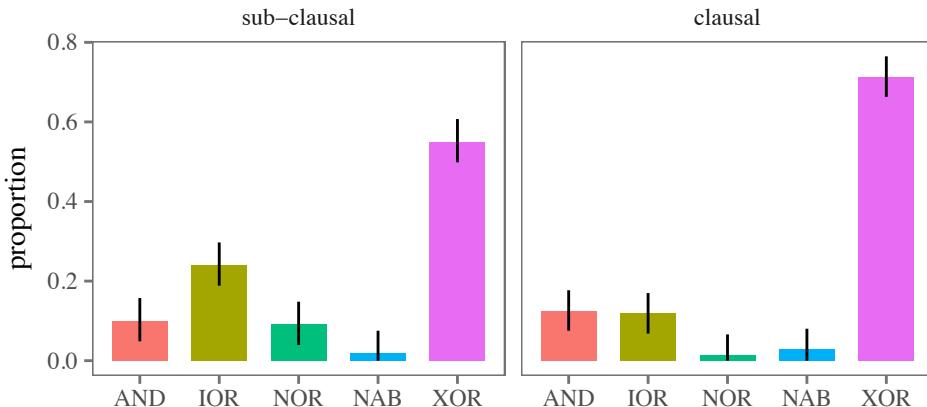


Figure 3.21: Connective interpretations in clausal and sub-clausal disjunctions.

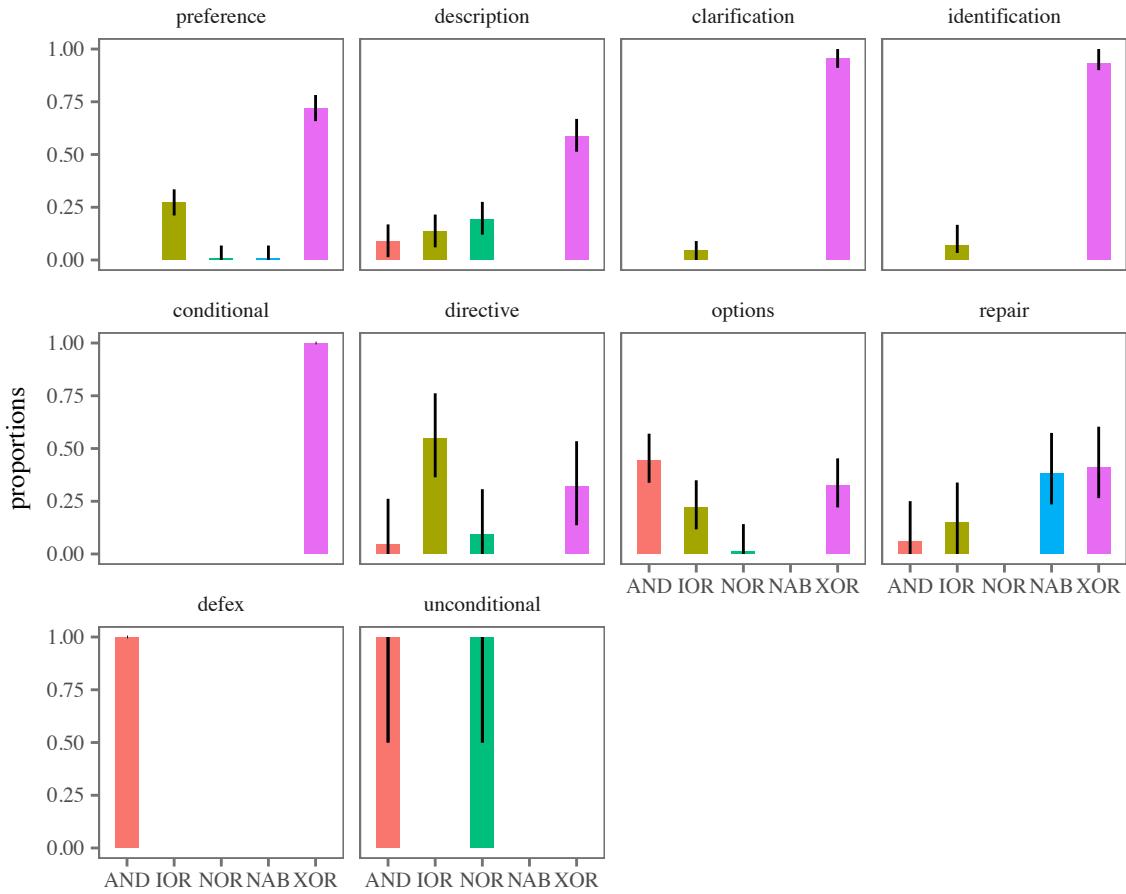


Figure 3.22: Connective interpretations in different communicative functions.

is common in acts of clarification, identification, stating/asking preferences, stating/asking about a description, or making a conditional statements. These results are consistent with expectations on the communicative intentions of that these utterances carry. In clarifications, the speaker needs to know which of two alternatives the other party meant. Similarly in identifications, speaker needs to know which category does a referent belongs to. In preferences, parents seek to know which of two alternatives the child wants. Even though descriptions could be either inclusive or exclusive, in the current sample, most descriptions were questions about the state of affairs and required the child to provide one of the alternatives as the answer. In conditionals such as “come here or you are grounded”, the point of the threat is that only one disjunct can be true: either “you come and you are not grounded” or “you don't come and you are grounded”. This is similar to an exclusive interpretation of *or*.

Repairs often received an exclusive (XOR) or a second-disjunct-true (NAB) interpretation. This is expected given that in repairs the speaker intends to say that the first disjunct is incorrect or inaccurate. Unconditionals and definitions/examples always had a conjunctive (AND) interpretation. Again, this is to be expected. In such cases the speaker intends to communicate that all options apply. If the mother says that “cats are animals like lions or tigers”, she intends to say that both lions and tigers are cats and not one or the other. Interestingly, in some cases (not all), *or* is replaceable by *and*: “cats are animals like lions and tigers”. In unconditionals, the speaker communicates that in both alternatives, a certain proposition holds. For example, if the mother says “ready or not, here I come!”, she communicates that “I come” is true in both cases where “you are ready” and “you are not ready”.

Options were often interpreted either as conjunctive (AND) or inclusive (IOR). The category “options” contained examples of free-choice inferences such as “you could drink orange juice or apple juice”. This study found free-choice examples much more common than the current literature on the acquisition of disjunction suggests. Finally, directives received either an IOR or XOR interpretation. It is important to note here that the most common communicative function in the data were preferences and descriptions. Other communicative functions such as unconditionals or options were fairly rare. Despite their infrequent appearance, these constructions must be learned by children at some point, since almost all adults know how to interpret them. It is clear from the investigation here that any learning account for function word meaning/interpretation also needs to account for how such infrequent constructions are learned.

Finally, I take a look at how children responded to the questions containing *or*. As a reminder, we annotated every polar question such as “do you want cereal or toast?” for the type of answer children provided. An answer such as “yes/no” is annotated as YN and an answer with alternatives such as “cereal/toast” is annotated as “AB”. Figure 3.23 shows the monthly proportions of these answer types between 1 and 3 years of age. Initially, children provided no answer to polar questions, but by the age of 3 years, the majority of such questions received a yes/no (YN) or alternative (AB) answer. These two answer types are not appropriate for all types of polar questions that contain *or*. For example, alternative answers are typically provided to alternative questions with the rise-fall intonation. For example, a question such as “do you want to stay here or go out?” receives an answer such as “stay-here/go-out” and not “yes/no”. However, a polar disjunctive question such as “do you

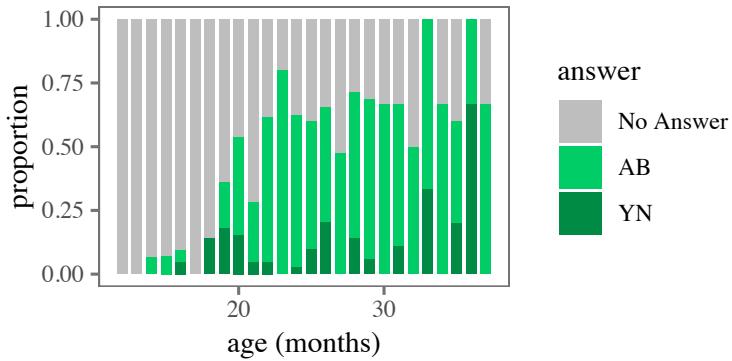


Figure 3.23: The proportions of children's answer types to polar questions containing the connective *or* at different ages (in months).

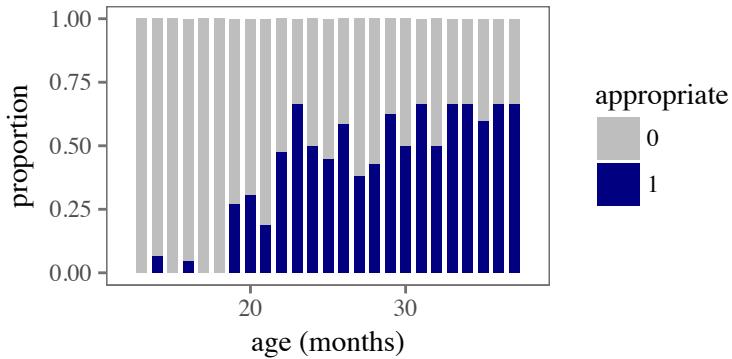


Figure 3.24: Proportion of children's appropriate responses

want any tea or coffee?” typically receives a “yes”/“no” rather than only one of the alternatives like “tea/coffee”, even though both answers are possible.

Based on such typical responses patterns, we can define appropriate answers to questions with disjunction in the following way: an alternative (AB) answer is appropriate for an alternative questions (with “or” and rise-fall intonation) and a “yes/no” answer (YN) is appropriate for a polar question. Of course this classification is too strict and misses some nuanced cases but it provides a rough estimate of appropriate answers offered to parents’ questions. Figure 3.24 shows the monthly proportion of children’s appropriate answers between the ages of 1 and 3. The results show that even with a strict measure, children show an increase in the proportion of their appropriate responses to questions containing *or* between 20 to 30 months of age (roughly 2 and 3 years of age). This increase in appropriate responses is consistent with the results from comprehension studies that suggest children’s understanding of *and* and *or* develops between 2 and 4 years of age.

3.3.5 Discussion

The goal of this study was to discover the potential cues in child-directed speech that could help children learn the interpretations of *and* and *or*. The study presented 1000 examples of *and* and *or* in child-directed speech, annotated for their truth-conditional interpretation, as well as five candidate cues to their interpretation: (1) Utterance Type; (2) Intonation Type; (3) Syntactic Level; (4) Conceptual Consistency; (5) Communicative Function. Like Morris (2008), this study found that the most common interpretations of *and* and *or* are conjunction AND and exclusive disjunction XOR. When the data were broken down by the connectives, *and* was almost always interpreted as a conjunction while *or* received three main interpretations: exclusive disjunction XOR, inclusive disjunction IOR, and conjunction AND.

While the most frequent interpretation of *or* was exclusive XOR overall followed by IOR, the distribution of disjunction interpretations shifted when they were broken down by the cues identified here. A disjunction was most likely exclusive if the alternatives were inconsistent (i.e. contradictory). A disjunction was most likely exclusive if it appeared in a question. Within questions, a disjunction was most likely exclusive if the intonation was rise-fall. If the intonation was rising, the question was interpreted as inclusive. The syntactic category of the disjuncts could also provide information for interpretation. If the disjuncts were clausal then it was more likely for the disjunction to be interpreted as exclusive, even though this effect was small. Finally, specific communicative functions required specific interpretations of the connective. *Or* often received a conjunctive interpretation in the following contexts: defining terms and providing examples, enumerating options, and in unconditional constructions. These results suggest that in order to successfully learn to interpret a disjunction, children need to pay attention to a wide variety of formal and conceptual factors.

In order to have a rough measure of children's comprehension of disjunction, this study also investigated the types of answers they provided to polar questions with disjunction. Between the ages of 20 and 30 months (roughly 1;6 to 2;6 years), children start to answer *or* questions appropriately. They would respond to a yes/no question such as "do you want any apple juice or orange juice?" with a yes/no answer. They would also respond to an alternative question, as in "do you want to play inside or outside?", with one of the alternates, e.g. "inside". This finding is consistent with the first corpus study presented in this chapter, which reported that the age range between 1;6 and 4 is the age range in which children develop their understanding of *and* and *or*.

Due to the exploratory nature of this study, it is important to replicate and extend these results and conclusions in future studies. For example, future studies could use an automated procedure for the annotation of categories such as utterance type, syntactic level, and intonation. An automated procedure would also allow for the annotation of larger samples and so could result in more reliable estimates for the role of various factors in learning the meanings of function words. For categories such as communicative function and connective interpretation, future studies could use a larger number of independent annotators to increase the speed and number of annotations. However, several results reported in this study are independently supported by previous research. Morris (2008) found similar results with respect to the overall interpretation of disjunction in child-directed speech: *and* is most often interpreted as conjunction and *or* as exclusive disjunction. In an experimental study, Pruitt & Roelofsen (2013) have shown that a rise-fall intonation results in an exclusive interpretation. Geurts (2006) has argued that a portion of exclusivity inferences are simply due to the fact that the alternatives are mutually exclusive and inconsistent.

Finally, the list of cues investigated here is in no way exhaustive. There are at least two additional, possibly important factors/cues that I set aside due to the difficulties that their annotation would have introduced. First, an exclusive interpretation is sometimes the result of a presupposition that only one alternative can hold or would matter for the purposes of the conversation. For example, in the context of a class activity where students pair up, a statement such as “Lisa worked with Ann or John” is interpreted as exclusive simply because the context already presupposes that only one disjunct can be true. Second, some exclusivity inferences are due to the speaker’s choice of connective, namely using *or* rather than *and*. Grice (1989) famously argued that in some cases, we interpret a disjunction like *A or B* as *A or B*, but not both because we reason that if the speaker intended to communicate that both alternatives hold, s/he would have said *A and B*. This study did not annotate for such cases. However, the study’s results suggest that such cases of exclusive interpretations are less frequent in child-directed speech than the ones already annotated for. Investigating how often such cases of pragmatic exclusion appear in child-directed speech can help us better understand the role of input in children’s acquisition of scalar implicatures.

3.4 Conclusion

This chapter presented two studies on the frequency and usage of the disjunction word *or* as well as *and* in parents' and children's speech. The first study looked at the frequencies of these two words in a large collection of corpora for children between the ages of 1 and 6 years. It showed that children start producing *and* between 12 to 18 months of age and rapidly increase their production until they reach the adult rate at 30 months. The production of *or* starts a little later, between 18-30 months, and rapidly reaches a steady rate at 48 months. The results suggest that we can expect an early understanding of disjunction between the ages of 18 and 30 months. For both *or* and *and*, the production data suggest that children develop their understanding of them between 2 to 4 years of age.

The second study looked at the interpretations of *and* and *or* in a sample of child-directed speech, as well as the cues that accompany these instances. The study confirmed previous finding that exclusive disjunction is the most common interpretation of *or* in child directed speech. However, it also found that exclusive interpretations are reliably cued by intonation and the logical consistency of the disjuncts. In the absence of these cues, a disjunction is most likely inclusive or conjunctive. In the next chapter, I provide a computational model that uses these cues to learn the interpretation of utterances containing *and* and *or*.

Chapter 4

Cue-based Acquisition of Disjunction

4.1 Introduction

In Chapter 2, I reviewed the complexities involved in interpreting a disjunction word such as *or* in English. I showed that a disjunction can be interpreted as inclusive, exclusive, and even conjunctive. In addition to these truth-conditional interpretations, a disjunction is sometimes associated with speaker ignorance/indifference as well. Given the wide range of interpretations that *or* can have, how can children learn to interpret it correctly? This is what the current chapter will address. In doing so, it also provides a potential solution to the puzzle of learning disjunction mentioned in the Introduction. To recap the puzzle, previous corpus research as well as the study in Chapter 3, have shown that the majority of *or*-examples children hear are exclusive. However, comprehension studies report that between the ages of three and five, children can interpret *or* as inclusive disjunction in declarative sentences (Crain, 2012). The finding of the comprehension studies and the corpus studies taken together present a learning puzzle: how can children learn to interpret *or* as inclusive if they mostly hear exclusive examples? This chapter provides a solution by developing a cue-based account for children’s acquisition of connectives. More generally, the account proposed in this chapter is helpful for learning words with multiple interpretations when one interpretation dominates the learner’s input.

Learning from multiple cues is a common approach in language acquisition (see Monaghan & Christiansen, 2014, for an overview). In the domain of function word semantics, Bloom & Wynn (1997) proposed a cue-based account for the acquisition of number words. In the next section, I briefly review their proposal and report their findings. The annotation study in Chapter 3 used a methodology similar to that of Bloom & Wynn (1997) and reported several cues that may help children’s acquisition of the connectives *and* and *or*. In this section, I use the data in my annotation study to present a cue-based account of connective acquisition. This account provides a straightforward solution to the learning puzzle of disjunction. I provide support for the cue-based account using three modeling experiments. The models incorporate the proposed cues to learn decision trees that predict the interpretation of a disjunction/conjunction.

4.2 The Cue-based Account for Number Words

Research on children’s acquisition of numeral words (e.g. *one*, *two*, *three*, etc.) has suggested that children initially know that number words greater than “one” refer to precise numerosities but they do not know exactly which word refers to which number (Wynn, 1992). Bloom & Wynn (1997) searched for linguistic cues that could help children associate numerals with quantity and numerosity. They considered two classes of cues: syntactic and semantic. Syntactic cues to word meaning were first discussed by R. Brown (1957). He wrote: “If a part of speech has reliable semantic implications, it could call attention to the kind of attribute likely to belong to the meaning of the word . . . the part of speech membership of the new word could operate as a filter selecting for attention probably relevant features of the nonlinguistic world.” He tested preschoolers with nonce constructions “to sib”, “a sib”, and “any sib” showing that children could use the modifying function words to decide whether the nonce word *sib* should refer to an action, an object, or a substance.

Semantic cues, on the other hand, are provided by the meaning of the known words in the sentence. Consider the sentence “there were several gloobs.” The use of *gloob* in the plural noun phrase “several gloobs” makes it possible to infer that “gloob” is not an action or a spatial relationship but rather an entity that can have multiple instances. Using only the syntactic cues, there still remains a wide range of referential uncertainty since a gloob may be anything from an egg to an alien creature. Now consider the sentence “I ate several gloobs for breakfast.” What a gloob may be is now restricted to edible entities, probably those that are suitable for breakfast. The meanings

of the verb *eat* and the adverbial phrase “for breakfast” help further narrow down the possible meanings for *gloob*.

It is not always easy to tell whether a cue is syntactic or semantic. Here I avoid this issue by using the term “compositional cues” to refer to both syntactic and semantic cues that aid the interpretation of an unknown word. Using the term “compositional” also brings into attention the fact that syntactic and semantic cues are interrelated and do not act in an independent or unstructured way. Consider the sentence “After eating breakfast, I saw several gloobs.” Even though the words *eat* and *breakfast* are present in the sentence, they do not restrict the possible meanings for *gloob* as they did before. In other words, it is not the mere presence of these words in the sentence that act as cues but rather the way they combine with the unknown word. The phrase “compositional cues” can help us highlight such important nuances.

Bloom & Wynn (1997) proposed that children learn number word meanings by attending to the compositional cues that accompany number words such as the words’ ordering relative to other words, function words they co-occur with, and the count-mass status of the nouns they modify. They specifically discussed four cues. Two cues could help children notice that number words pattern like quantifiers. First, similar to quantifiers, number words precede adjectives and do not follow them. Second, they participate in the “... of the Xs” construction: “one of the gloobs”, “some of the gloobs”, “most of the gloobs”, etc. The third cue is the co-occurrence of number words with count nouns. This cue can inform learners that their meaning is restricted to the quantification of individuals. Finally, unlike other adjectives, numerals cannot be modified further using an adverb such as *very* or *too* (“very big animals” vs. “*very two animals”). According to Bloom & Wynn (1997), this cue can help a learner understand that number words pick an absolute property of a set rather than a continuous one.

Using the data available in the CHILDES corpora, Bloom & Wynn (1997) investigated the presence of cues to number-word meaning in child-directed speech for three children between the ages of one and three. They found that these children and their parents only use number words with count nouns; they do not use number words with modifiers and only use them before adjectives, not after. Finally, they found that these children and their parents use only number words and quantifiers in the partitive construction and not with adjectives. The results of their corpus study show that the compositional cues they proposed for number-word acquisition are available in children’s linguistic

input. In the next section, I discuss some compositional cues that can help a learner limit the hypothesis space to connective meanings for coordinators such as *and*, *or*, *but*, *so*, etc.

4.3 Cues to coordinator meanings

Three important compositional cues can help learners in restricting their hypotheses to coordinator meanings. First, as pointed out by Haspelmath (2007), coordination has specific compositional properties. Coordinators combine two or more units of the same type and return a larger unit of the same type. The larger unit has the same semantic relation with the surrounding words as the smaller units would have had without coordination. These properties separate coordinators from other function words such as articles, quantifiers, numerals, prepositions, and auxiliaries which are not used to connect sentences or any two similar units for that matter. In fact, the special syntactic properties of coordinators have compelled syntactic theories to consider specific rules for coordination.

The literature on syntactic bootstrapping suggests that children can use syntactic properties of the input to limit their word meaning hypotheses to the relevant domain (R. Brown, 1957; see Fisher, Gertner, Scott, & Yuan, 2010 for a review; Gleitman, 1990). In the current 1073 annotations of conjunction and disjunction, I found that *and* and *or* connected sentences/clauses 56% of the time. This pattern is unexpected for any other class of function words and it is possible that the syntactic distribution of coordinators cue the learners to the space of sentential connective meanings.

Second, in the annotation study I found that *and* never occurs with inconsistent coordinands (e.g. “clean and dirty”) while *or* commonly does (e.g. “clean or dirty”). The inconsistency of the coordinands can cue the learner to not consider conjunction as a meaning for the coordinator given that a conjunctive meaning would too often lead to a contradiction at the utterance level. On the other hand, choosing disjunction as the meaning avoids this problem. Third, the large scale study of Chapter 3 found that *or* is more likely to occur in questions than statements while *and* is more likely in statements. Since questions often contain more uncertainty while statements are more informative, it is possible that these environments bias the learner towards selecting hypotheses that match this general communicative function. Disjunction is less informative than conjunction and it is possible that the frequent appearance of *or* in questions cues learners to both its meaning as a disjunction as well as the ignorance inference commonly associated with it.

$A + B$	\top	\perp	NAND	IF	FI	IOR	IFF	XOR	A	nA	B	nB	NOR	ANB	NAB	AND
$A^T B^T$																
$A^T B^F$																
$A^F B^T$																
$A^F B^F$																

Figure 4.1: The truth table for the 16 binary logical connectives. The rows represent the set of situations where zero, one, or both propositions are true. The columns represent the 16 possible connectives and their truth conditions. Green cells represent true situations.

Finally, it is reasonable to assume that not all binary connective meanings shown in Figure 4.1 are as likely for mapping. For example, coordinators that communicate tautologies or contradictions seem to be not good candidates for informative communication. Similarly, if A coordinated with B simply asserts the truth of A and says nothing about B, it is unclear why it would be needed if the language already has the means of simply asserting A. It is possible that pragmatic principles already bias the hypothesis space to favor candidates that are communicatively more efficient. Even though these findings are suggestive, they need to be backed up by further observational and experimental evidence to show that children do actually use these cues in learning connective meanings. In the next section, I turn to the more specific issue of learning the correct interpretation of *and* and *or* from the input data. As in the case of number words, previous research has provided insight into how children comprehend a disjunction and what they hear from their parents. The main question is how children learn what they comprehend from what they hear. I turn to this issue in the next section.

4.4 Learning to interpret *and* and *or*: A cue-based account

Previous comprehension studies as well as the one reported in Chapter 6 have shown that children as early as age three can interpret a disjunction as inclusive. However, Morris' (2008) study of child-directed speech showed that exclusive interpretations are much more common than other interpretations of disjunction in children's input. In Figure 4.2, I show the results of Chapter 3's annotation study by grouping the disjunction interpretations into exclusive (EX) and inclusive (IN),

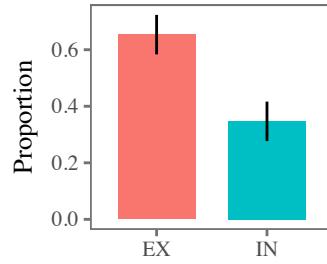


Figure 4.2: Proportion of exclusive and inclusive interpretations of disjunction in child-directed speech. Error bars represent bootstrapped 95% confidence intervals.

i.e. non-exclusive categories. These results replicate Morris' (2008) finding and reinforce a puzzle raised by Crain (2012): How can children learn the inclusive interpretation of disjunction when the majority of the examples they hear are exclusive? To answer this question, I draw on insights from the Gricean approach to semantics and pragmatics discussed in Chapter 2. Research in Gricean semantics and pragmatics has shown that the word *or* is not the only factor relevant to the interpretation of a disjunction. It is not only the presence of the word *or* that leads us to interpret a disjunction as inclusive, exclusive, or conjunctive, but rather the presence of *or* along with several other factors such as intonation (Pruitt & Roelofsen, 2013), the meaning of the disjuncts (Geurts, 2006), and the conversational principles governing communication (Grice, 1989). The interpretation and acquisition of the word *or* cannot, therefore, be separated from all the factors that accompany it and shape its final interpretation.

In the literature on word learning and semantic acquisition, form-meaning mapping is often construed as mapping an isolated form such as *gavagai* to an isolated concept such as “rabit”. While this approach may be feasible for content words, it will not work for function words such as *or*. First, the word *or* cannot be mapped in isolation from its formal context. As Pruitt & Roelofsen (2013) showed, the intonation that accompanies a disjunction affects its interpretation. Therefore, a learner needs to pay attention to the word *or* as well as the intonation contour that accompanies it. Second, the word *or* cannot be mapped to its meaning isolated from the semantics of the disjuncts that accompany it. As Geurts (2006) argued, the exclusive interpretation is often enforced simply because the options are incompatible. For example, “to be or not to be” is exclusive simply because one cannot both be and not be. In addition, conversational factors play an important role in the interpretation of *or* as Grice (1989) argued. In sum, the interpretation and acquisition of function words such as *or* require the learner to consider the linguistic and nonlinguistic context of the word

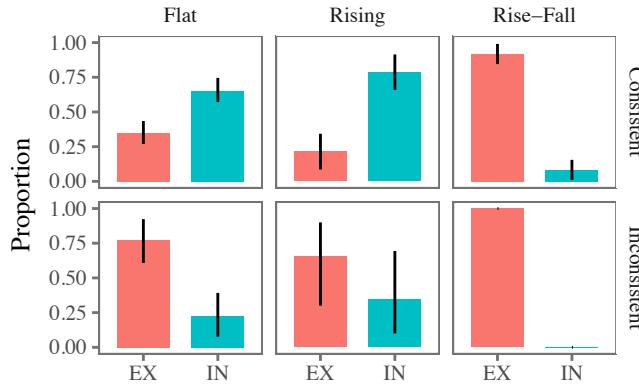


Figure 4.3: Exclusive and inclusive interpretations broken down by intonation (flat, rising, rise-fall) and consistency. Error bars represent bootstrapped 95% confidence intervals.

and map the meanings accordingly.

Previous accounts have adopted a model in which a function word such as *or* is mapped directly to its most likely interpretation:

$$\textit{or} \rightarrow \oplus$$

This model is often used in cross-situational accounts of content words. Here I argue that the direct mapping of *or* to its interpretation without consideration of its linguistic context is the primary cause of the learning puzzle for *or*. Instead, I propose that the word *or* is mapped to an interpretation in a context-dependent manner, along with the interpretive cues that accompany it such as intonation and disjunct semantics:

$$[\text{connective: } \textit{or}, \text{ Intonation: rise-fall, Disjuncts: inconsistent}] \rightarrow \oplus$$

$$[\text{connective: } \textit{or}, \text{ Intonation: rising, Disjuncts: consistent}] \rightarrow \vee$$

Figure 4.3 shows that the rate of exclusive interpretations change systematically when the data are broken down by intonation and consistency. Given a rise-fall intonation contour, a disjunction is almost always interpreted as exclusive. Similarly, if the propositions are inconsistent, the disjunction is most likely interpreted as exclusive. When either of these two features are absent, a disjunction is more likely to receive an inclusive interpretation. In this account, it is not a single word that gets mapped to an interpretation but rather a cluster of features. This method has two advantages. First, it deals with the context dependency of disjunction interpretation. The learner knows that *or* with some intonation has to be interpreted differently from one with another. Second, it allows the learner to pull apart the contribution of *or* from the interpretive cues that often accompany

it. In fact, analysis of all mapping clusters in which *or* participates and generalization over them can help the learner extract the semantics of *or* the way it is intended by Gricean accounts of semantics/pragmatics. For those skeptical of such an underlying semantics for *or*, there is no need for further analysis of the mapping clusters. The meaning of *or* as a single lexical item is distributed among the many mappings in which it participates. In the next section, I implement this idea using decision tree learning.

4.5 Modeling Using Decision Tree Learning

A decision tree is a classification model structured as a hierarchical tree with nodes, branches, and leaves (Breiman, 2017). The tree starts with an initial node, called the root, and branches into more nodes until it reaches the leaves. Each node represents the test on a feature, each branch represents an outcome of the test, and each leaf represents a classification label. Using a decision tree, observations can be classified or labeled based on a set of features. For example, we can make a decision tree to predict whether a food item is a fruit or not based on its color (green or not) and shape (round or not). An example decision tree is the following: at the root, the model can ask whether the item is green or not. If yes, the model creates a leaf and labels the item as “not fruit”. If not, the model creates another node and asks if the item is round. If yes, the item is classified as a “fruit” and if not it is classified as “not fruit”.

Decision trees have several advantages for modeling cue-based accounts of semantic acquisition. First, decision trees use a set of features to predict the classification of observations. This is analogous to using cues to predict the correct interpretation of a word or an utterance. Second, unlike many other machine learning techniques, decision trees result in models that are interpretable. Third, the order of decisions or features used for classification is determined based on information gain. Features that appear higher (earlier) in the tree are more informative and helpful for classification. Therefore, decision trees can help us understand which cues are probably more helpful for the acquisition and interpretation of a word.

Decision tree learning is the construction of a decision tree from labeled training data. This section applies decision tree learning to the annotated data of Chapter 3 by constructing random forests (Breiman, 2001; Ho, 1995). In random classification forests multiple decision trees are constructed on subsets of the data and the decisions are made by taking the majority vote. Next section

discusses the methods used in constructing the random forests for interpreting connectives *or*/*and*.

4.5.1 Methods

The random forest models were constructed using python’s Sci-kit Learn package (Pedregosa et al., 2011). The annotated data had a feature array and a connective interpretation label for each connective use. Connective interpretations included exclusive (XOR), inclusive (IOR), conjunctive (AND), negative inclusive (NOR), and NPQ which states that only the second proposition is true. The features or cues used included all other annotation categories: intonation, consistency, syntactic level, utterance type, and communicative function. All models were trained with stratified 10-Fold cross-validation to reduce overfitting. Stratified cross-validation maintains the distribution of the initial data in the random sampling to build cross validated models. Maintaining the data distribution ensures a more realistic learning environment for the forests. First a grid search was run on the hyperparameter space to establish the number of trees in each forest and the maximum tree depth allowable. The default number of trees for the forests was set to 20, with a max depth of eight and a minimum impurity decrease (i.e. gini decrease) of 0. Decision trees were fit with high and low minimum gini decrease values. High minimum gini decrease results in a tree that does not use any features for branching. Such a tree represents the baseline or traditional approach to mapping that directly maps a word to its most likely interpretation. Low minimum gini decrease allows for a less conservative tree that uses multiple cues/features to predict the interpretation of a disjunction. Such a tree represents the cue-based context-sensitive account of word learning discussed in the previous section.

4.5.2 Results

I first present the results of the random forests in the binary classification task. The models were trained to classify exclusive and inclusive interpretations of disjunction. Figure 4.4 shows the best performing decision tree with high minimum gini decrease. As expected, a learner that does not use any cues would interpret *or* as exclusive all the time. This is the baseline model. Figure 4.5 shows the best performing decision tree with low minimum gini decrease. The tree has learned to use intonation and consistency to classify disjunctions as exclusive or inclusive. As expected, if the intonation is rise-fall or the disjuncts are inconsistent, the interpretation is exclusive. Otherwise,

the disjunction is classified as inclusive.

```

gini = 0.348
samples = 272
value = [99, 343]
class = XOR

```

Figure 4.4: Baseline tree grown with minimum impurity decrease of 0.2. The tree always classifies examples of disjunction as exclusive.

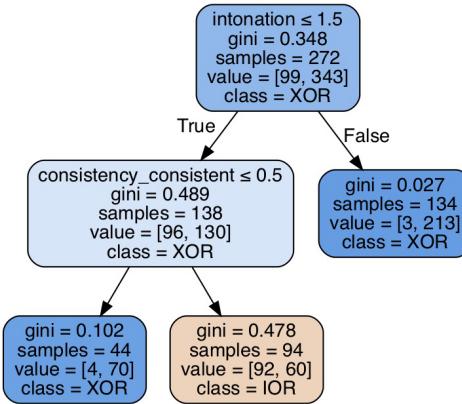


Figure 4.5: Cue-based tree grown with minimum impurity decrease of 0.01. The tree classifies examples of disjunction with rise-fall intonation as exclusive ($\text{intonation} > 1.5$). If the intonation is not rise-fall but the disjuncts are inconsistent ($\text{consistency} < 0.5$), then the disjunction is still classified as exclusive. However, if neither of these two hold, the disjunction is classified as inclusive.

Figure 4.6 shows the average F1 scores of the baseline and cue-based models in classifying exclusive examples. The models perform relatively well and similar to each other, but the cue-based model performs slightly better. The real difference between the baseline model and the cue-based model is in their performance on inclusive examples. Figure 4.7 shows the F1 score of the forests as a function of the training size in classifying inclusive examples. As expected, the baseline model performs very poorly while the cue-based model does a relatively good job and improves with more examples.

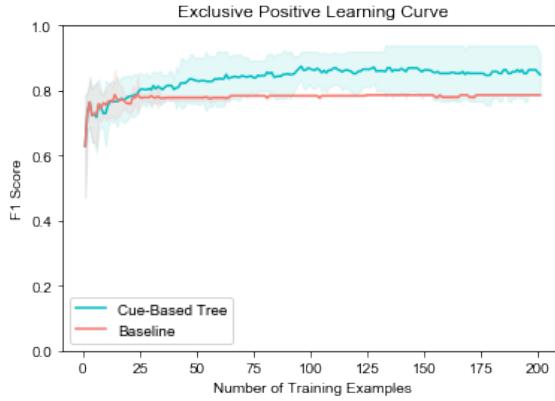


Figure 4.6: The average F1 score for class XOR (exclusive) as a function of the number of training examples in the baseline and cue-based models. The colored shades show the 95% confidence intervals.

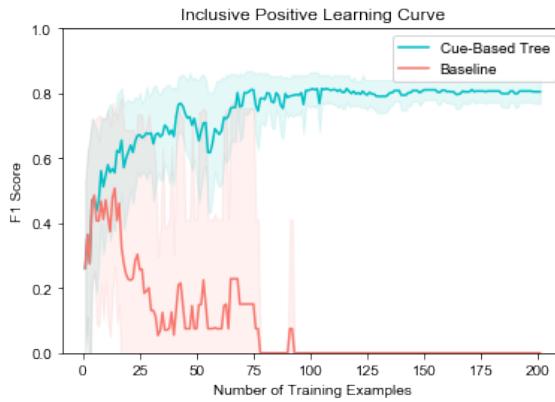


Figure 4.7: The average F1 score for class IOR (inclusive) as a function of the number of training examples in the baseline and cue-based models. The colored shades show the 95% confidence intervals.

Next, I use decision tree learning in a ternary classification task. The model uses features to interpret a coordination with *and* and *or* as inclusive (IOR), exclusive (XOR), or conjunctive (AND). Figure 4.8 shows the baseline decision tree with high minimum gini decrease, which only uses the presence of the words *or/and* to interpret conjunction and disjunction. As expected, the tree interprets a coordination with *and* as a conjunction and one with *or* as exclusive disjunction. Figure 4.9 shows the cue-based decision tree with low minimum gini decrease. In addition to the presence of *and* and *or*, the tree uses intonation, consistency, communicative function, and utterance

type to distinguish exclusive, inclusive, and conjunctive uses of disjunction. In short, a disjunction that is rise-fall, inconsistent, or has a conditional communicative function is classified as exclusive. Otherwise the disjunction is classified as inclusive. The tree also finds conjunctive interpretations of disjunction more likely in declarative sentences than interrogatives.

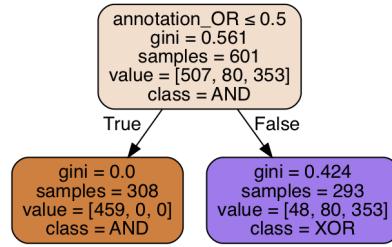


Figure 4.8: The baseline tree grown on conjunctions and disjunctions with minimum impurity decrease of 0.2. The tree uses the words *and/or* and classifies them as conjunction and exclusive disjunction respectively.

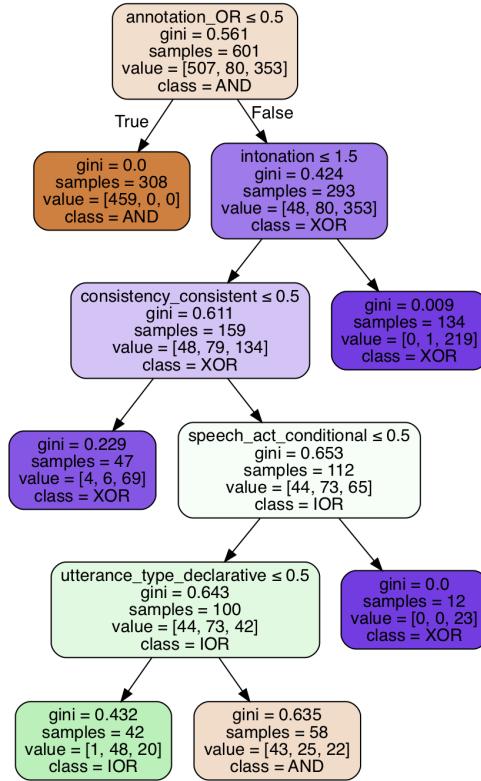


Figure 4.9: The cue-based tree grown on conjunctions and disjunctions with minimum impurity decrease of 0.01. After using the words *and/or*, the tree uses intonation, consistency, and the conditional communicative function to classify a large number of exclusive cases. Then it uses utterance type (interrogative) to label inclusive cases.

Figure 4.10 shows the average F1 score of the conjunctive interpretations (AND) for the baseline and the cue-based models. Since the vast majority of the conjunctive interpretations are predicted by the presence of the word *and*, the baseline and cue-based models show similar performances. Setting aside conjunction examples, Figure 4.11 shows the average F1 score of the AND interpretation of disjunction only. Here we see that the cue-based model performs better than the default model in guessing conjunctive interpretations of disjunction. The informal analysis of the trees suggest that the model does this by using the “speech act” cue. Figure 4.12 shows the average F1-score of the exclusive interpretations (XOR) for the baseline and the cue-based models. The cue-based model does slightly better than the baseline model. As before, the most important improvement

comes in identifying inclusive examples. Figure 4.13 shows the average F1-score of the inclusive interpretations (IOR) for both baseline and cue-based models. The baseline model performs very poorly while the cue-based model is capable of classifying inclusive examples as well.

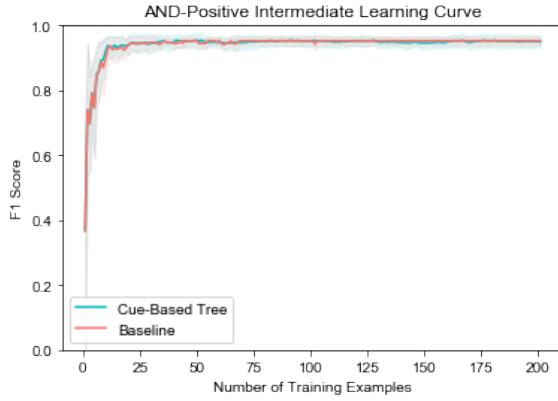


Figure 4.10: The average F1 score for class AND as a function of the number of training examples in the baseline and cue-based models. The colored shades show the 95% confidence intervals.

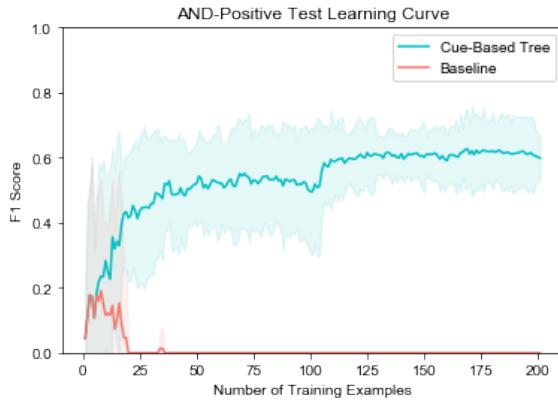


Figure 4.11: The average F1 score for class AND of disjunction examples as a function of the number of training examples in the baseline and cue-based models. The colored shades show the 95% confidence intervals.

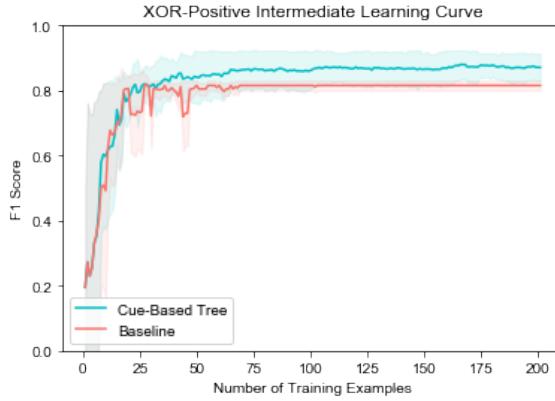


Figure 4.12: The average F1 score for class XOR as a function of the number of training examples in the baseline and cue-based models. The colored shades show the 95% confidence intervals.

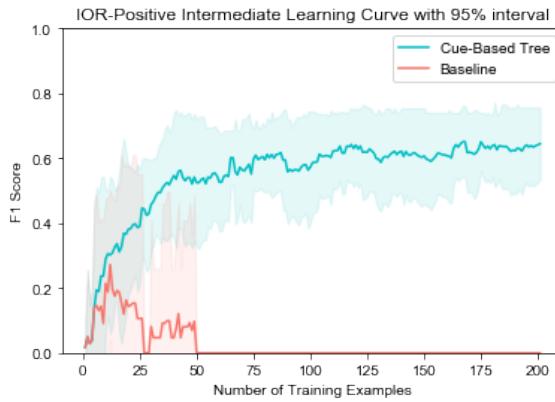


Figure 4.13: The average F1 score for class IOR as a function of the number of training examples in the baseline and cue-based models. The colored shades show the 95% confidence intervals.

Finally, I look at decision trees trained on the annotation data to predict all the interpretation classes for disjunction: AND, XOR, IOR, NOR, and NPQ. Figure 4.14 shows the baseline model that only uses the words *and* and *or* to classify. As expected, *and* receives a conjunctive interpretation (AND) and *or* receives an exclusive interpretation (XOR). Figure 4.15 shows the best example tree of the cue-based model. The leaves of the tree show that it recognizes exclusive, inclusive, conjunctive, and even negative inclusive (NOR) interpretations of disjunction. How does the tree achieve that? Like the baseline model, the tree first asks about the connective used: *and* vs. *or*.

Then like the previous models, it asks about intonation and consistency. If the intonation is rise-fall, or the disjuncts are inconsistent, the interpretation is exclusive. Then it asks whether the sentence is an interrogative or a declarative. If interrogative, it guesses an inclusive interpretation. This basically covers questions with a rising intonation. Then the tree picks declarative examples that have conditional speech act (e.g. “give me the toy or you’re grounded”) and labels them as exclusive. Finally, if negation is present in the sentence, the tree labels the disjunction as NOR.

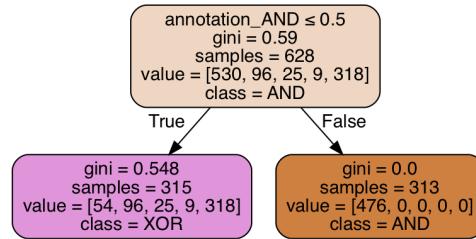


Figure 4.14: The baseline tree grown on conjunctions and disjunctions with minimum impurity decrease of 0.2. The tree uses the words *and/or* and classifies them as conjunction and exclusive disjunction.

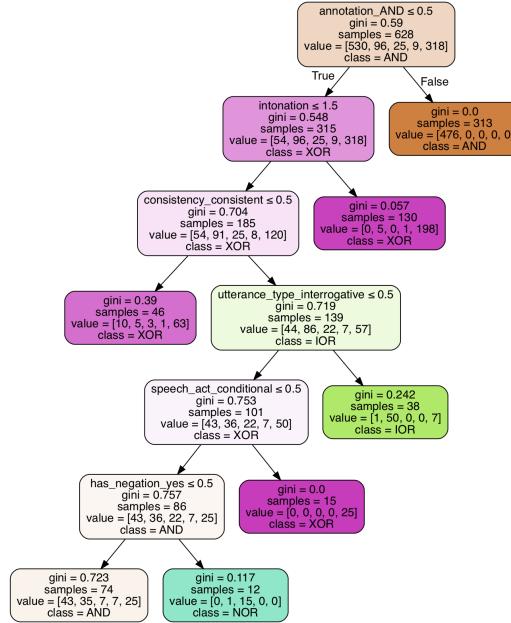


Figure 4.15: The cue-based tree grown on conjunctions and disjunctions with minimum impurity decrease of 0.01. After using the words *and/or*, the tree uses intonation and consistency to classify a large number of exclusive cases. Then it uses utterance type (interrogative) to label many inclusive cases, as well as the communicative function (conditional) to catch more exclusive examples. Finally, it asks whether the sentence has negation or not. If so, it classifies the negative inclusive examples as NOR.

Figures 4.16, 4.17, and 4.18 show the average F1-scores for the conjunctive (AND), exclusive (XOR), and inclusive (IOR) interpretations as a function of training size. The results are similar to what I reported before with the ternary classification. While the cue-based model generally performs better than the baseline model, it shows substantial improvement in classifying inclusive cases.

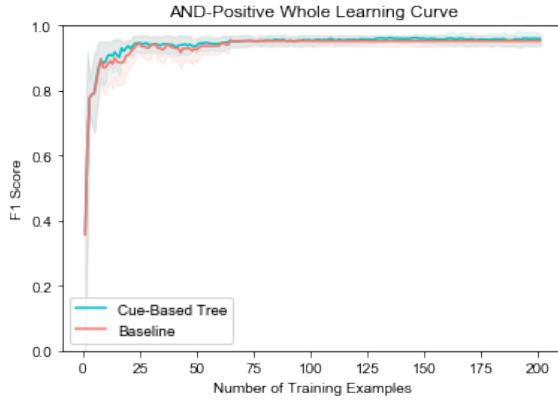


Figure 4.16: The average F1 score for class AND as a function of the number of training examples in the baseline and cue-based models. The colored shades show the 95% confidence intervals.

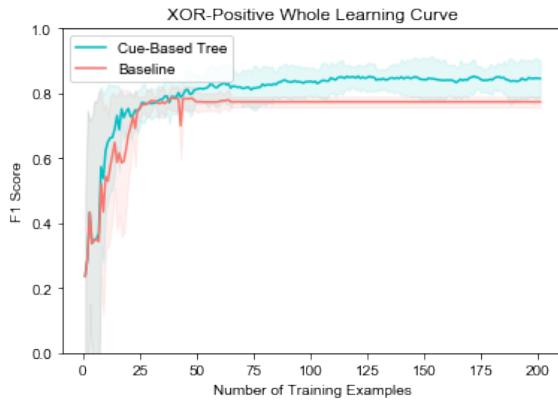


Figure 4.17: The average F1 score for class XOR as a function of the number of training examples in the baseline and cue-based models. The colored shades show the 95% confidence intervals.

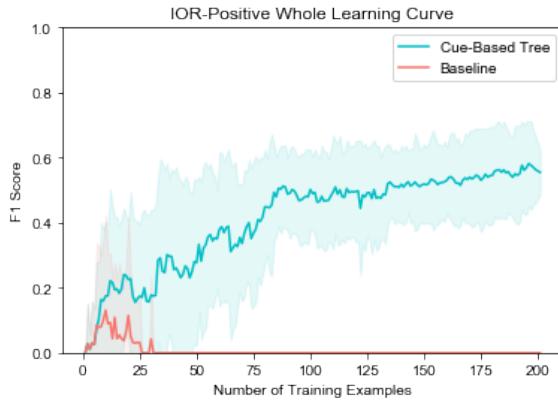


Figure 4.18: The average F1 score for class IOR as a function of the number of training examples in the baseline and cue-based models. The colored shades show the 95% confidence intervals.

Figure 4.19 shows the average F1-score for the negative inclusive interpretation as a function of training size. Compared to the baseline model, the cue-based model shows a substantially better performance in classifying negative sentences. The success of the model in classifying negative inclusive examples (NOR) suggests that the cue-based model offers a promising approach for capturing the scope relation of operators such as negation and disjunction. Here, the model learns that when negation and disjunction are present, the sentence receives a negative inclusive (NOR) interpretation. In other words, the model has learned the narrow-scope interpretation of negation and disjunction from the input data. In a language where negation and disjunction receive an XOR interpretation (not A or not B), the cue-based model can learn the wide-scope interpretation of disjunction.

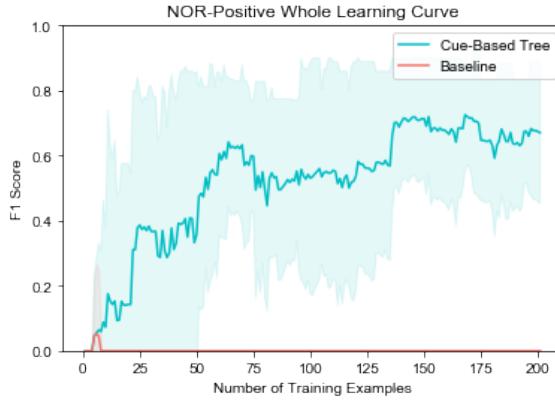


Figure 4.19: The average F1 score for class NOR as a function of the number of training examples in the baseline and cue-based models. The colored shades show the 95% confidence intervals.

Finally, Figure 4.20 shows the average F1 score for the class NPQ. This interpretation suggested that the first disjunct is false but the second true. It was seen in examples of repair most often and the most likely cue to it was also the communicative function or speech act of repair. The results show that even though there were improvements in the cue-based model, they were not stable as shown by the large confidence intervals. It is possible that with larger training samples, the cue-based model can reliably classify the NPQ interpretations as well.

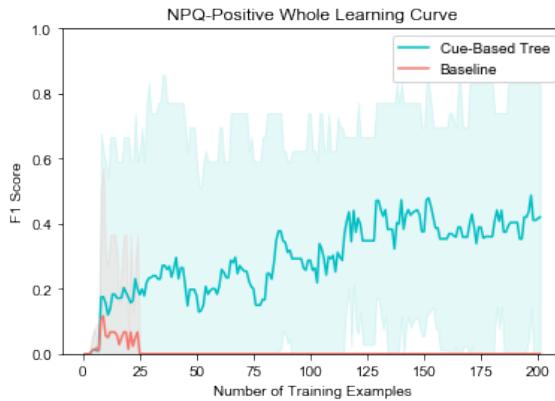


Figure 4.20: The average F1 score for class NPQ as a function of the number of training examples in the baseline and cue-based models. The colored shades show the 95% confidence intervals.

4.6 Discussion

In this chapter, I discussed two accounts for the acquisition of function words. The first account was a baseline (context-independent) account that is used in vanilla cross-situational word learning: words are isolated and directly mapped to their most frequent meanings. The second account is what I called the cue-based context-dependent mapping in which words are mapped to meanings conditional on a set of present cues in the context. I argued that the puzzle of learning disjunction arises because in the baseline account, forms are mapped directly to meanings without considering the context of use. Under this account, the input statistics supports an exclusive interpretation for *or*. However, comprehension studies show that children can interpret *or* as inclusive. I showed that the cue-based account resolves this problem by allowing *or* to be mapped to its interpretation according to the set of contextual cues that disambiguate it. The results of computational experiments with decision tree learning on data from child-directed speech suggested that such an approach can successfully learn to classify a disjunction as inclusive or exclusive. More broadly, cue-based context-dependent mapping is useful for the acquisition of ambiguous words and interpretations that are consistent but relatively infrequent in child-directed speech.

Chapter 5

Children’s Comprehension of Disjunction

5.1 Introduction

The previous chapters focused on disjunction in child-directed speech, but most of the developmental research on disjunction has concentrated on experimental studies that test children’s comprehension. This chapter provides a summary of these studies. They divide roughly into two periods. First, in the late 1950s and early 1960s, many psychologists conducted research on children’s development of logical reasoning following Inhelder & Piaget (1958). Even though this line of research started by investigating the interpretations of linguistic connectives such as *and* and *or*, the main interest was the development of logical concepts and later investigations focused on non-linguistic logical reasoning. Second, in the late 1990s and early 2000s, a separate line of research inspired by advances in formal semantics and pragmatics began, focused more on the development of the words *and* and *or* and aimed at capturing children’s semantic and pragmatic knowledge.

With respect to children’s comprehension of *or*, these two research programs diverge both empirically and theoretically. Empirically, the early research on logical reasoning suggested that children first learn the exclusive interpretation of *or* (\oplus), and only later develop an understanding of inclusive (often called logical) disjunction. Furthermore, the research suggested that sometimes children (and even teenagers) interpret *or* like a conjunction. In contrast, later research on semantic acquisition

suggested that children learn the inclusive interpretation before the exclusive one. The existence of conjunctive interpretations was denied for a long time but it has resurfaced recently (Singh et al., 2016). Theoretically, the research on logical reasoning considered logical thinking as an abstract kind of thinking that is present only in later stages of development. The research in semantic acquisition considers logical concepts present early in development and some researchers even consider them innate.

These two research programs also diverge in their assumptions with respect to the learning process. As in many other areas of developmental research, the present accounts of children's acquisition of disjunction fall either closer to the nature side or the nurture side of the nativist-empiricist debate. In fact, in the past decade the interpretation of *or* has become a stronghold for nativist theories of language acquisition (Crain & Khlebtzoz, 2008). The empiricists have not been as unified and vocal but it is possible to see them represented by the early work on logical reasoning as well as a usage-based approach of the kind Morris (2008) advocated.

The nativist and usage-based positions differ on almost every major acquisition issue: the nature of the input data (poverty vs. richness), the cognitive mechanisms applied to the data (domain specific vs. domain general), and the nature of linguistic knowledge (abstract generative model vs. constructions and generalizations). In the nativist account, linguistic knowledge is the result of the triggering effect of poor and noisy input data on innate linguistic (hence domain specific) principles and parameters. The common metaphor is that of maturation, from an initial state of the language faculty to a final stage. In the usage-based approach, linguistic knowledge is the result of applying general purpose cognitive mechanisms and principles to the input linguistic data. The input data is rich and plays a major role in children's acquisition of language. Frequency in the input is an important component of the usage based theory's predictions about acquisition patterns. More frequent constructions are predicted to be acquired earlier and faster.

The debate on children's acquisition of logical connectives mirrors this overarching nature-nurture debate. The nativist literature emphasizes the poverty of the stimulus and posits innate logical principles and parameters. The usage-based approach emphasizes the richness of the input and the predictive power of child-direct speech on children's linguistic productions. In the next three subsections, I go over the existing literature on children's acquisition of logical connectives. I start

with the research program on children's development of logical reasoning. Then I discuss the usage-based approach to the acquisition of logical connectives which can be considered the true heir of the research on logical reasoning. In the third subsection, I discuss the literature on semantic and pragmatic acquisition, specifically in the logical nativist tradition that stands in contrast to the first two views.

5.2 The Development of Logical Reasoning

5.2.1 Theoretical Landscape

Investigations into children and adults' comprehension of logical words such as *or* started in the 1960s with the work of Nitta & Nagano (1966) on Japanese and Neimark & Slotnick (1970) on English, and continued until mid 1980s. These studies focused mainly on children's conceptual development and more specifically, on children's development of logical reasoning. The theoretical paradigm behind them was Piaget's theory of cognitive development. There were four main stages of development: the sensorimotor stage (ages 0-2;0), the pre-operational stage (ages 2-7 years), the concrete operational stage (ages 7-11 years), and the formal operational stage (11 years and above). The operational stages (concrete and formal) were considered the period where children develop logical thinking (Inhelder & Piaget, 1958). The idea was that children start applying logical thinking or abstract mental operations (rule-based thinking) around the age of 7. At first, they can only apply logical thinking to concrete objects (concrete operational stage) but later when they are about 11, they learn to reason logically in an abstract and hypothetical fashion. As a result, most research on children's understanding of logical connectives in this period focused on children and adolescents between the ages of 6 and 18.

Early studies such as Neimark & Slotnick (1970) reported findings that appeared to support the Piagetian theory. For example, they found that the meaning of *or* is not understood until late in the period of formal operations (Neimark, 1970). Later research such as Johansson & Sjolin (1975) and Braine & Rumain (1981), though, showed that the development of children's connective comprehension does not fully match the stages in Piagetian theory. However, the idea that a full mastery of the "logical" (inclusive) meaning of *or* is acquired later survived and was inherited by the usage-based approach. The main idea was that children's initial conceptualization and interpretation

of disjunction is simply a “choice” between two options (exclusive) and only later do they learn the logical and inclusive meaning of *or*. These approaches predicted that the exclusive interpretation emerges before the inclusive interpretation in child language.

5.2.2 Empirical Landscape

Studies of the development and comprehension of logical connectives began with Nitta & Nagano (1966). They tested 679 Japanese children in grades K, 2, 4, 6, and 8. Children were tested on negation, conjunction, and disjunction. Each question provided six alternatives, for example a fish, a bird, and a flower, each with a white and a black version. Participants were asked to circle all the items described by statements such as: “flower”, “not bird”, “bird and flower”, “bird or flower”, “black and bird”, “black or flower”, etc. The researchers reported that all children understood the negation of a statement well. Conjunction was understood by older children better than by younger ones. With disjunction, however, even older children struggled to interpret the statements correctly. Neimark & Slotnick (1970) replicated these findings in English. They tested 455 children in grades 3-8 and 58 college students. They concluded that the majority of the participants understood negation and conjunction, but only college students correctly answered statements with containing disjunction.

Table 5.1 reports the percentages of correct responses in Neimark & Slotnick (1970). They reported that participants made two types of errors. First across all ages, some participants interpreted disjunction as conjunction. For example they circled black birds when the instruction said “black or bird”. Second, some selected only one of the two categories. For example, they selected only birds in “black or bird”. They also tested participants on disjunctions like “A, B, or both”. In Table 5.1, the incorrect responses for a statement like “A or B” could be due to exclusive or conjunctive interpretations, but the incorrect responses for a statement such as “A or B, or both” were probably due to conjunctive interpretations. Based on these results Neimark (1970) concluded that a correct understanding of disjunction only develops in the high school years and depends on the attainment of formal operations as defined in Piagetian theory.

Table 5.1: Percentage of correct responses to statements with conjunction and disjunction on the picture selection task in Nitta & Nagano (1966) and Neimark & Slotnick (1970) as reported in Neimark & Slotnick (1970). Abbreviations: J=Japanese, G= Grandview Elementary High School, H=Highland Park Middle School, C=Conackamack Junior High School, Col = Douglass College.

Construction	KJ	2J	3G	4G	4J	5G	6G	6H	6J	7C	7H	8C	8H	8J	9C	Col
A and B	92	84	35	50	92	50	41	54	98	60	67	61	68	100	65	93
A or B	2	9	15	8	22	19	23	31	59	45	38	39	28	49	55	97
A, B, or Both	15	20	12	29	49	31	14	50	82	60	62	48	52	88	60	97

Paris (1973) used a similar in-classroom setup to test children's comprehension of connectives in Grades 2, 5, 8, 11, and college. Two hundred participants (40 per grade) were asked to judge the truth of sentences with the connectives *and*, *or*, and *either-or*. The experimenter showed participants slides of pictures, for example a bird in a nest, with descriptions such as "the bird is in the nest or the shoe is on the foot." The participants were asked to judge the statement as true or false. Paris found that statements with *and* were almost always judged correctly, as expected. This was not the case with disjunction.

Table 5.2 summarizes the percentage of errors for disjunctive statements. The results show two trends. First, older participants produce more errors when both disjuncts were true (A=T, B=T). This suggests that older participants were more likely to interpret a disjunction as exclusive. Second, the majority of younger children, and even around a fifth of college students considered a disjunction false when only one of the disjuncts was true (A=T,B=F or A=F,B=T). The combination of these two trends suggested that initially, children do not differentiate *or* from *and*, interpreting both as conjunction. Finally, Paris also found that there were fewer errors with *either-or* statements compared to *or* statements. He suggested that the word *either* could provide further cue on how disjunction should be interpreted.

Paris (1973) attributed the conjunctive interpretations of *or* to children applying non-linguistic strategies when an utterance is hard to interpret (See Clark, 1973 for a discussion of nonlinguistic strategies in child language acquisition). He suggested that children in his task were "comparing visual and auditory information with little regard for the implied logical relationship in the verbal description." In other words, children responded with "true" if the individual disjuncts matched

the pictures and false otherwise. Such a non-linguistic strategy would yield correct answers for conjunction but incorrect (conjunctive) answers for disjunction. This explains why conjunctive readings reduce with age and why using the word *either* helps reduce conjunctive interpretations further.

Table 5.2: Percentage of errors to statements with disjunction in Paris (1973).

Construction	Truth Values	2	5	8	11	C
A or B	A=T, B=T	2.5	22.5	15	25	25
A or B	A=T, B=F	67.5	70	50	30	27
A or B	A=F, B=T	72.5	62.5	47.5	27.5	20
A or B	A=F, B=F	2.5	2.5	2.5	0	0
Either A or B	A=T, B=T	7.5	25	25	27.5	32.5
Either A or B	A=T, B=F	50	57.5	35	10	12.5
Either A or B	A=F, B=T	62.5	45	37.5	10	10
Either A or B	A=F, B=F	5	17.5	10	0	0

Suppes & Feldman (1969) was the first study to investigate children's understanding of connectives in an experimental setting rather than an in-class test. The study had 64 children between the ages of 4.5 and 6.5 years and used 18 wooden blocks with different shapes (star, circle, square) and colors (red, green, black). The experimenter asked children to give her the blocks using 12 different imperative sentences. The sentences with *and* and *or* in Study 1 and 2 are listed in Tables 5.3 and 5.4. The responses were coded based on the objects handed to the experimenter. Consider a command such as “give me the things that are green or square!” An “intersection” response was coded when the child gave the experimenter all green squares. With a “union” response, the child gave the experimenter all green objects and all square objects. Finally, an “only one” response was coded when children gave the experimenter all objects that had only one of the properties, for example all green objects. “Other” includes all other types of responses. The results showed two patterns of interpretation for *or*. First, interpreting it as *and* which often resulted in an “intersection” response. Second, interpreting *or* as exclusive disjunction resulted in an “only one” response. Suppes & Feldman (1969) were probably the first to show that preschool children can interpret *or* as exclusive in

imperative sentences.

Table 5.3: Percentages of responses to the statements with *and* and *or* in Study 1 of Suppes & Feldman (1969).

Command	Intersection	Union	Only One	Other
Give me the red things and the square things!	11	33	33	23
Give me all the things that are black and square!	42	13	33	12
Give me the green things, or, the round things!	9	6	68	17
Give me the things that are green or square!	47	3	31	19

Table 5.4: Percentages of responses to the statements with *and* and *or* in Study 2 of Suppes & Feldman (1969).

Command	Intersection	Union	Only One	Other
Give me the things that are red and square!	42	10	12	36
Give me the round and black things!	34	10	22	32
Give me the black things and the square things!	21	14	33	32
Give me the things that are round or green!	30	7	24	39
Give me the red or star things!	34	6	36	24
Give me the stars or the green things!	21	6	34	39

Johansson & Sjolin (1975) provided further evidence that young children often interpret a disjunction as exclusive in imperative sentences. They investigated 60 2-to-7-year-old Swedish-speaking children on their interpretation of the words *and* and *or*. They used a felt board and 8 pictures of toys, clothes, food, furniture, and tools. In one of their tasks, they provided children with 4 pictures and asked them to put some pictures on the felt board. The commands included the words *and* and *or*, for example, “put up the doll and the dog” or “put up the car or the bicycle”. The study found that more than 80% of the children who were four-years-old and older interpreted *and* correctly and placed both pictures on the board, while most younger children simply put all the four available pictures on the board. With *or*, most four-year-olds and older children put only one of the pictures mentioned on the board which suggests an exclusive interpretation. As with *and*, most

younger participants put all the available pictures on the board. In another task, the connectives were placed in a declarative sentence such as “Richard wants to drink lemonade or milk” and the experimenter asked the children to use the pictures to show what Richard drank. The study found similar results. Johansson (1977) used an in-class test similar to Neimark & Slotnick (1970) but adopted the commands used in Suppes & Feldman (1969). He showed that children over 6 years old as well as college students often interpret *or* as exclusive in commands like “circle all figures that are blue, or, all that are square.”

Finally, Braine & Rumain (1981) tested children and adults on both commands and statements with *or*. They had 22 children in each four age groups of 5-6, 7-8, 9-10, and college students. In one task, they used the same paradigm as Suppes & Feldman (1969) and asked the children to give them wooden blocks. They used commands such as “give me all the green things or give me all the round things”. Table 5.5 summarizes the findings. They found that the majority of participants in all age groups interpreted *or* as an exclusive disjunction in this task.

In a second task, Braine & Rumain (1981) asked participants to judge the truth value of a puppet’s statement about four boxes. Each box had several animals in it and the content was visible to children but not the puppet. The puppet would look into each box and say statements such as “either there’s a duck or a horse in the box.” The boxes represented the four possible truth values with respect to each proposition: TT, TF, FT, and FF. The experimenter asked children if the puppet’s statement was right. Table 5.6 summarizes the findings of this task and categorizes the responses for each box as a string of yes’s and no’s. The younger participants showed more conjunctive and inclusive interpretations while older participants, especially college students, showed inclusive and exclusive interpretations.

Given that the same participants took both tasks, Braine & Rumain (1981) show that the task design can affect our conclusions on how participant’s interpret a disjunction. In the first task where experimenters used commands to ask for objects, participants appeared to interpret *or* as exclusive disjunction. However, the same participants showed inclusive and conjunctive interpretations in a task where they were asked to judge the statement of a puppet as “right” or “wrong”. Since the tasks differed in their linguistic stimuli as well as the non-linguistic aspects of the task, it is not clear how much of the difference between the tasks is due to the difference in the speech acts used, namely commands vs. statements.

Table 5.5: Percentages of exclusive responses to the commands in Study 1 of Braine & Rumain (1981)

Command	5-6	7-8	9-10	Adults
Give me all the green things or give me all the red things!	86	91	86	91
Give me all those things that are either blue or round!	95	86	82	73

Table 5.6: Percentages of response categories to the statements in Study 3 of Braine & Rumain (1981). Y= Yes, N= No, P= Partly right. Category “other” includes YYNN, and NNNN.

Command	5-6	7-8	9-10	Adults
YYYN (Inclusive)	18	41	50	32
NYYN (Exclusive)	0	14	9	41
YNNN (Conjunctive)	32	14	14	9
YPPN	41	19	14	9
Other	10	14	14	9

Table 5.7 summarizes the 7 studies discussed in this section. The major take-away from these studies was that the interpretation of disjunction depends on the age of the participants and the task used. Younger participants interpreted *or* as exclusive disjunction or conjunction. Conjunctive interpretations were explained as the application of a non-linguistic strategy when the meaning of *or* was not known or the task was too demanding/confusing. Older participants and adults interpreted *or* often as exclusive disjunction, and sometimes as inclusive disjunction. The consensus was that the inclusive (often called “logical”) interpretation of a disjunction develops in high school years.

Studies in this period also found that a correct interpretation of *and* develops earlier than *or*. They connected this finding to the literature on disjunctive and conjunctive rule learning. Some studies had discovered that conjunctive rules are easier to detect and learn than disjunctive ones (Neisser & Weene, 1962). However, most authors also acknowledged the role of language and suspected that *or* gives rise to a wider range of interpretations, and this could delay its acquisition. French & Nelson (1985) suggested that *or* is less frequent in children’s input and discussed frequency

as another factor that could cause a delay in children's acquisition of linguistic disjunction.

Table 5.7: Summary of some studies on children's interpretation of the disjunction word in the literature on children's cognitive development. K is short for kindergarten, G for grade, and C for college.

Study	Age	n	Language	Environment	Interpretation
Nitta & Nagano (1966)	K, G2,4,6,8	679	Japanese	Imperatives, Universal (Nuclear Scope)	\oplus, \wedge
Neimark & Slotnick (1970)	3-9G, C		English	Imperatives, <i>all</i> (Nuclear Scope)	\oplus, \wedge
Suppes & Feldman (1969)	4;5-6;7	64	English	Imperatives, <i>all</i> (Nuclear Scope)	\oplus, \wedge
Paris (1973)	G2,5,8,11, C	200	English	Present Declarative	\oplus, \wedge
Johansson & Sjolin (1975)	2;0-7;6	60	Swedish	Present Declarative	\oplus
				Imperative	\oplus
Johansson (1977)	6-10, 12, 22	70	Swedish	Imperative	\oplus
				Imperative, <i>all</i> restrictor	\oplus
Braine & Rumain (1981)	5-10, C	88	English	Imperative, <i>all</i> (Restriction)	\oplus
				Present Declarative	$\wedge, \vee, (\oplus$ for C)

5.3 The Usage Based Approach

Usage-based researchers have not been active in children's acquisition of logical words. There is only one paper by Morris (2008) that investigates children's acquisition of *and* and *or* by conducting a corpus study. Here I summarize the assumptions, claims, and hypotheses of his paper and more generally the usage based approach to the acquisition of meaning.

5.3.1 Theoretical Landscape

The usage-based theory contends that “meaning is use” and “structure emerges from use” (Tomasello, 2009). Therefore communication is viewed as *raison d'être* of language and it is used as an explanatory factor either in the study of adult language or children's acquisition of it. Most importantly, linguistic structure is viewed as a phenomenon emergent from communicative principles and conventions, along with domain general cognitive mechanisms recruited to achieve communicative goals. In stark contrast to the nativist theories, the usage-based theory of language acquisition emphasizes children's reliance on the linguistic input. They consider the language children hear around them, especially child-directed speech, as the main source of their linguistic knowledge. Under the usage-based approach, children's input language is viewed as a rich source of linguistic information for domain general cognitive mechanisms to analyze and learn their structure. Therefore, children's early language will closely matches what they hear around them.

The usage-based approach contends that children's acquisition of language is initially item-based. Children acquire words and word uses (meanings) item by item and in an isolated fashion. Later they form generalizations over these isolated items and extract abstract information and use a word to convey a broader range of meanings (Akhtar, 1999; Lieven, Pine, & Baldwin, 1997). In usage based theory, meaning is represented as a usage protocol. In usage-based acquisition of meaning children form representations for use based on input from their natural language environments, which might be best described as a conceptual prototype associated with a usage script (E. Levy & Nelson, 1994; Tomasello, 2003).

One hypothesis regarding the development of meaning in this framework is the confirmed core-meaning hypothesis:

“The initial meaning of a connective should be limited to a single, essential meaning (MacWhinney, 2002). Through increased attention to the productions of others and more heterogeneous functional contexts, children acquire additional meanings (i.e., logical uses) and rules for appropriate use (i.e., pragmatics), and generalize items to more abstract grammatical structures. This confirmed core should (a) have a prototypical meaning, (b) have the least interference with other meanings, and (c) require the least amount of additional cognitive resources (MacWhinney, 1989). A prototypical meaning likely covers the core function ascribed to a word. The likely prototypical meaning for

and is conjunction (denoting the inclusion of two or more objects or phrases in a set) while choice (exclusive-or) is a likely candidate for *or*. These functions may help form the basis of word meanings and aid in their acquisition" (Morris, 2008).

The assumption here is that lexical items have multiple meanings or uses, and logical connectives are not exempt. Both *and* and *or* are considered polysemous. They express a variety of uses (interpretations). *And* has a conjunctive use (e.g. that's a mommy and two dogs.), an explanatory use (e.g. you hit him and that is not OK), a temporal use (e.g. He broke the window and then stole the television.), and an extension use (e.g. And who should this be?). *Or* has an exclusive (choice) use (e.g. You can go the table or to the free play area), an inclusive use (e.g. you can have apples or bananas), and a conditional use (e.g. Stop hitting him or you will have to have a time out!)

The developmental predictions of the usage-based approach is that *and* starts from the core meaning of conjunction and is later associated with other uses such as the temporal and causal interpretations. *Or* starts with the core "exclusive" (choice) use but expands into its other uses such as "inclusive" and "conditional". Children start with the exclusive meaning since it is more frequent in the input data and furthermore, interferes less with the meaning of conjunction. This usage-based account of Morris predicts that children will learn the exclusive interpretation of disjunction before its inclusive interpretation.

5.3.2 Empirical Landscape

In order to support the hypotheses mentioned in the previous section, Morris (2008) investigated the use of *and* and *or* in child-directed speech and children's production between the ages of 2;0 and 5;0, using 240 transcriptions of audiotaped exchanges obtained in the CHILDES database. Each connective was analyzed with respect to its frequency, syntactic frame, meaning, and formal/informal use. With respect to frequency, the study found that overall, *and* is approximately 12.8 times more likely to be produced than *or*. There were a total of 6,459 connective uses: *and* was produced 5,994 times and *or* 465 times.

As for the syntactic frames, instances of the connective use were coded as appearing in *statements* or *questions*. Morris reported that *and* appeared predominantly in statements (more than 90% of the time) while *or* was most common in questions (more than 85% of the time). For the meanings and uses of *and* and *or*, the study reported that for both adults and children, the dominant meanings of

and and *or* were “conjunction” and “exclusive disjunction”, respectively. This was taken to support the confirmed core-meaning hypothesis. There was also a significant increase in the mean number of different uses for *and* and *or*. *And* started with only the core conjunctive meaning at 2;0-2;6 and around the age of 3;0 to 4;0, children expanded it to two different uses on average. At 4;6-5, children were producing three different uses of *and*. The production of *or* started at around 3;0-3;6 with the “exclusive” meaning and expanded to 1.5 uses on average by 4;6-5;0.

However, this account faces an important issue. The conjunctive *and* and temporal/explanation *and*'s do not have the same syntactic status. The former often conjoins noun phrases while the latter two only conjoin clauses. We can have conjoined nouns phrases in utterances with 3 or 4 words while conjoined clauses require utterances longer than 4 words. How can a two-year-old with an average MLU of 1.5-2.5 words produce the temporal or explanation *and* which require conjoined clauses? It is possible that the increase in the number of words can be explained by syntactic rather than semantic development. The absence of non-conjunctive uses of *and* in the corpus data may only be a phenomenon in production and not comprehension. Even if children understand the meaning of temporal *and*, if they cannot yet produce conjoined clauses, temporal *and* will not be observable in corpus data. This question cannot be resolved from corpus evidence alone.

Utterances were also coded as informal or formal. Formal uses of connectives were defined as utterances about truth values or states of affairs. For example, a question like “does the dog have a tennis ball and a hockey puck?” to which the child answered with “No” was coded as formal. This is because the inquiry is about the state of the world. However, “I'd like peanut butter and jelly” was considered informal, presumably because it pertains to wants and desires. The study found that there are rare cases of formal use in parents' and children's speech. This is interpreted as evidence for the developmental claim that the connectives' formal or logical (or truth-conditional) interpretation is acquired later in development and is not part of the core meaning.

5.4 The Gricean Approach and Logical Nativism

The nativist inquiry started by pointing out that the literature on logical reasoning did not control for the linguistic context of *or*. Inspired by Gricean pragmatics, Stephen Crain and colleagues argued that *or* is often accompanied by an exclusivity implicature. They suggested that to understand children's semantic knowledge of *or*, we need to use it in contexts where the exclusivity implicature

does not arise. Since early studies on logical reasoning did not control for exclusivity implicatures, they paint an inaccurate picture in which children understand the meaning of *or* as exclusive disjunction. Therefore, most Gricean and nativist research on disjunction focus on linguistic contexts that are considered to be “implicature/exclusivity-canceling”. The argument is that in such contexts, we get a chance to assess the semantics of *or*, rather than its pragmatics. Furthermore, imperative utterances were abandoned because a disjunctive imperative is appropriately complied with, when only one of the disjuncts is carried out. However, participants may be carrying out only one of the tasks because it involves less work. Therefore, imperatives cannot differentiate between an inclusive and an exclusive interpretation of disjunction. The next two subsections provide theoretical and empirical summaries of the Gricean and logical nativist account. I should add here that while the nativist account assumes Gricean pragmatics, not all Gricean approaches to semantic development are nativist. I discuss those studies at the end of the subsection on the empirical landscape.

5.4.1 The Theoretical Landscape

Logical nativism supposes that humans are biologically endowed with the tools for logical reasoning. The meanings of logical expressions in natural languages are captured by the semantics of logical operators in classical logic. The semantics of these logical operators along with some logical principles and parameters are hypothesized to be innate. The logical nativist position is extensively argued for in Crain (2008), Crain (2012), Crain & Khlebtzlos (2008), and Crain & Khlebtzlos (2010). Here I briefly summarize the main claims, assumptions, and hypotheses. I start with the nativist assumption about language processing in general.

According to the Modularity Matching Model, the human language faculty is modular and operations within the language faculty are hierarchically organized (syntax → semantics → pragmatics). Operations of higher level components apply to the output of lower level ones. The syntax module may propose several analyses of a string of which only some satisfy the input requirements of the semantics module and create a well-formed logical form. The semantics module may propose more than one logical form for a sentence while only one is deemed felicitous by the pragmatics module. (Crain & Thornton, 1998; Crain & Wexler, 1999) The famous aphorism of the modularity matching hypothesis is that “syntax proposes and semantics disposes”; then, semantics in turn proposes and pragmatics disposes.

Let's consider the nativist claim about the meaning of logical words such as *and* and *or* across languages. The claim is that the native speaker knowledge of the meanings of logical expressions in natural languages is captured by the semantics of logical operators in classical logic. For example, the meaning of *or* and similar logical words across languages correspond to \vee (inclusive) and not \oplus (exclusive). Let's call this the "logical meaning". This claim is one that logical nativists share, more or less, with many formal semanticists. Discrepancies between the meanings of logical words in natural languages and the logical operators are often attributed to either pragmatic enrichment or crosslinguistic differences in scope assignment. However, a formal semanticist may argue for the logical meaning claim while remaining agnostic with respect to how logical representations relate to psychological representations. This is not the case for logical nativists. Implicit in the arguments of logical nativism is the assumption that the formal (logical) descriptions used in modeling linguistic meaning also have psychological reality. In fact, the logical nativist position is even stronger. The main claim is that "the human genome contains a set of innate logical structures" (Crain, 2012, p. 76). This set of logical structures includes at least the semantics of logical operators in classical logic, downward entailment, and two scope parameters. I investigate these in more detail here.

First it is hypothesized that the meanings of logical operators such as \neg , \wedge , \vee , \exists , \forall are part of the biological endowment of human beings. Let's call this hypothesis the "Innateness of Logical Meaning". This hypothesis strictly limits the hypothesis space for the meanings of logical words to just those provided by classical logic. The meaning of *or* is a good example here. While the meaning of \vee is innate, the meaning of \oplus is not. The innateness of logical meaning predicts that children do not assign the (lexical) meaning of \oplus to *or* and similar disjunctive expressions in other languages because the meaning of \oplus is simply not provided to them by the Universal Grammar. This is also offered as an explanation for the claim that languages do not lexicalize the meaning of \oplus . In other words, if \oplus is never available to humans for form-meaning mapping, it will never appear in world languages as the meaning of a lexical item. The exclusive interpretations of disjunction are explained as pragmatic enrichment.

At this point, a fair objection to the nativist position is the limitation of classical logic in capturing the meaning of logical expressions such as *most*, *many*, and *few*. There are no operators in classical logic that correspond to the meaning of these expressions and under the current formulation of the nativist position, it is not clear how children learn them. However, logical nativism can avoid this

criticism by assuming that the human logical faculty is not completely modeled by classical logic and several operators provided by UG fall outside its scope. In other words, nativists can argue that classical logic is a good approximation to the human logical faculty in many cases such as those capturing the core meaning of *every*, *some*, *and*, and *or*.

Secondly, Crain (2012) suggests that the property of downward entailment is also innate. More specifically, he argues that the child is innately instructed that downward entailing environments license Negative Polarity Items (NPIs) and generate a conjunctive reading of *or*. Below, Δ stands for a downward entailing operator such as negation, the restrictor of *every*, the meaning of *before*, or the antecedent of a conditional (Crain, 2008, 2012).

Innateness of Downward Entailment: Downward entailment and the behavior of logical operators in such environments are innate. Example; The conjunctive entailment of disjunction: $\Delta(A \vee B) \Rightarrow \Delta(A) \wedge \Delta(B)$.

It is not clear why the property of downward entailment needs to be innate. One way to explain this is to claim that downward entailment is a grammatical feature that is not learnable and needs to be part of Universal Grammar. However, on purely semantic grounds, children's awareness of subset-superset relations along with the innateness of logical meaning may predict the downward-entailing behavior of operators or negative polarity items.

Logical nativism also claims that languages vary with respect to their scope taking properties when disjunction and conjunction appear with negation. Languages like English require disjunction and conjunction to scope under negation, while those like Mandarin require disjunction and conjunction to scope above negation. Two scope parameters are proposed to explain this scope variation. One guides the scope of negation and conjunction and the other commands the scope relation of negation and disjunction: 1. $[\neg > \vee]$ vs. $[\vee > \neg]$ 2. $[\wedge > \neg]$ vs. $[\neg > \wedge]$.

I have written the default value of each parameter on the left. The default value for disjunction is $[\neg > \vee]$ and for conjunction $[\wedge > \neg]$. Children speaking any language in the world are expected to start with these default values and if the input data are consistent with the non-default value, then there will be a switch in the parameter setting. As a result, the pattern of children's early scope errors in different languages is attributable to the default settings of scope parameters that happen not to match the target language, but are perfectly acceptable in many other languages of the world. According to the nativist theory, these patterns of errors conform to the continuity

hypothesis, namely that children's non-adult like linguistic behavior will consist of constructions attested in other human languages (Crain, 1991). Finally, the hypothesis that logical meaning is innate along with the claim that young children fail at adult-like computation of scalar implicatures leads to the formulation of the logical stage hypothesis. According to this hypothesis, children's acquisition of meaning for certain logical operators, occurs in two stages. First, the logical stage in which they assign the basic logical meaning to the logical words and do not yet compute scalar implicatures associated with them. Second, the pragmatic (adult-like) stage in which the basic semantics of these words is enriched with pragmatic implicatures. The logical stage hypothesis along with the innateness of logical meaning result in the prediction that children's initial interpretation of *or* should be inclusive, and that only later, when they reach the pragmatic stage, are they capable of deriving the exclusive reading (Inclusive-First hypothesis). This prediction is the opposite of the exclusive-first prediction made by the usage-based account of language acquisition.

5.4.2 The Empirical Landscape

Almost all nativist studies use the Truth Value Judgment Task (TVJT) of Crain & Thornton (1998). TVJT involves a storyteller, a story, and a puppet. One experimenter is in charge of narrating the story and the other is in charge of the puppet. The story creates the context for the evaluation of a target sentence and then the puppet utters the target sentence either as a description of what happened in the story (Description Mode), or as a prediction about what will happen next (Prediction Mode). In Prediction Mode, the story continues so that the child can see whether the puppet's prediction was realized or not. Then the puppet repeats the prediction, and either the puppet itself or the storyteller asks the child whether the puppet was right. Children can provide their judgments either by saying either "Yes" or "No" (or other equivalent utterances). Sometimes children are asked to reward the puppet if the puppet is right. When children say that the puppet is wrong, they are asked to explain why.

An advantage of TVJT is that it allows for an explicit truth value judgement from children rather than relying on implicit measures or behaviors. However, as Crain & Thornton (1998) acknowledge, children tend to accept utterances when they are confused or uncertain as well. As a result, their rejections and explanations about their rejections are much more informative than their acceptances of the target sentence. Since inclusive interpretations involve more positive responses than exclusive

or conjunctive responses, it is possible that TVJT has a slight tendency to overestimate inclusive interpretations as well. This methodological issue about TVJT may have been neglected in many later investigations of disjunction words where children's acceptance of *or* when both disjuncts were true was viewed as evidence for the inclusive meaning for *or*. However, it may be the case that children accept such cases because they are uncertain about the judgment.

There have been numerous Gricean/nativist studies of disjunction and a detailed discussion of each study is beyond the scope of this chapter. Therefore, in what follows, I first discuss some of the main findings, take up important topics in this literature, and finally provide a brief summary of the studies I have surveyed in Table 5.8 (see Crain (2012) for a comprehensive discussion of the nativist theory and its empirical findings).

The Gricean and nativist investigations into children's interpretation of *or* started with Chierchia, Crain, Guasti, & Thornton (1998). They argued that in order to truly understand children's semantic knowledge of *or*, we need to test it in contexts where it is not accompanied by exclusivity implicatures. This reasoning was adopted by the majority of nativist/Gricean studies since then and as a result, in most studies the disjunction word is embedded under some implicature-cancelling operator such as negation or the restriction of a universal quantifier. However, such environments sometimes make the interpretation of the connective *or* similar to that of *and*. For example, Notley and colleagues (2012) test the interpretation of *or* in the scope of *before*. However, a sentence such as "The dog reached the finish line before the turtle or the bunny" receives the same interpretation as its counterpart with *and*. The same is true for the restriction of a universal quantifier such as *every*: "Every boy or/and girl finished the task." Negation has a similar problem given that it can often be interpreted as "neither": "He did not eat the carrot and/or the pepper." (emphasizing *and* often avoids the "neither" reading in negative sentences.) As a result, such linguistic environments may mistakenly group responses from children that distinguish *and* and *or* from those that do not. Many studies also did not use a statement with *and* as a control.

Su (2014) investigated the interpretation of disjunction in conditional sentences in Mandarin speaking participants. One advantage of this study is that it had both adult controls as well as a control task with conjunction. Here I discuss two studies from Su (2014). The first tested children's and adults' interpretation of the Mandarin disjunction word *huozhe* in conditional constructions with *ruguo*. Thirty-two children (2;6-5 years, M=3;9) and 28 adults were tested on sentences such

as “if Mickey Mouse conjures up a rabbit or a bear, then he can get a reward” as well as “if the elephant jumped over the big stone, then he got a pear or a strawberry.” There were 8 trials for each sentence. In half of them both disjuncts were true (e.g. Mickey mouse conjured up a rabbit as well as a bear), and in the other half only one was true. When *huozhe* was in the antecedent of the conditional (e.g. if Mickey Mouse conjures up a rabbit or a bear, . . .), children accepted the sentence (i.e. rewarded the puppet) when either one or both disjuncts were true. Adults showed a similar acceptance pattern. When *huozhe* was in the consequent of the conditional (e.g. . . . then he got a pear or a strawberry), children accepted the sentences either when either one or both disjunct were true. Adults, on the other hand, accepted the sentences when only one of the disjuncts was true. The results suggested that children interpret *huozhe* as inclusive disjunction in the antecedent as well as the consequent of conditionals. Adults, on the other hand, interpreted *huozhe* as inclusive in the antecedent and as exclusive in the consequent of the conditional.

In a second task, Su (2014) compared the interpretation of conjunction and disjunction in Mandarin conditionals like “If a caterpillar picks a green leaf or/and a red flower, then we will get a painting” as well as “If the swordfish walks out of the maze, then he will get a butterfly or a crown.” 29 Mandarin-speaking children (3;11-6;6, M=4;11) and 15 adults were tested. The results showed that children differentiated between *and* and *or* both in the antecedent and the consequent of the conditional construction. Based on these findings, Su (2014) argued that children differentiate between the meanings of conjunction and disjunction, and that the earliest meaning they assign to disjunction words is inclusive. She contended that “children’s adherence to inclusive-*or* in both the two conditional clauses runs counter to the assumption on the usage-based account, according to which children’s initial knowledge of disjunction is restricted to the nonlogical meaning of exclusive-*or*.”

It is important to point out that some recent studies adopt Gricean assumptions, yet do not necessarily assume nativism. In the remainder of this section I take up some of these studies. Hochstein, Bale, Fox, & Barner (2014) tested 22 English-speaking four-year-olds (4;0-4;11, M=4;4) and 21 five-year-olds (5;0-5;11, M=5;4). They tested each group on two inferences/tasks: ignorance implicatures and exclusivity implicatures. In each task, participants watched a scene, the experimenter presented a description, and then asked participants to determine which of two characters uttered the sentence. In the ignorance implicature task, there were two characters, one blindfolded

and one not. There were two objects on the table and in the critical trials an animal took one or both objects. The experimenter quoted one of the characters, for example: “someone said the bear took a cup or a plate.” Then the experimenter asked: “Who do you think said that?” The study found that five-year olds successfully identified the disjunctive statement with the blindfolded character, probably reasoning that the character who could see the scene could have uttered a more informative sentence. This was not the case for four-year-olds.

In the second task, both characters saw the scene, but one was introduced as a smart puppet and one as a silly puppet. Experimenters placed two animals on the scene, each with some fruits. In a control condition each animal had three apples and the experimenter reported that: “someone said each animal has two apples.” The study showed that children picked the silly puppet as the speaker. In the exclusivity condition, where each animal had an apple and a strawberry, the experimenter reported that: “someone said each animal has an apple or a strawberry”. In this condition, children (both four- and five-year-olds) were more likely to pick the smart puppet as the speaker. Hochstein et al. (2014) concluded that children did not find it infelicitous when a disjunction had both disjuncts true, which suggests an inclusive interpretation. Unfortunately the study did not use adult controls so we do not know whether adults would have had a significantly lower rate of exclusive interpretations.

More recently, some studies have revived the earlier findings that preschool children can interpret disjunction as conjunction. Singh et al. (2016) tested 56 English-speaking children ($M=4;11$, $3;9$ - $6;4$) and 26 adults in a TVJT task. The experiment involved four pictures: a boy holding a banana, a boy holding an apple and a banana, three boys holding either an apple or a banana, and three boys holding both apples and bananas. In each trial, participants saw one of the pictures and a puppet described the pictures with four possible utterances: “The/every boy is holding an apple or/and a banana.” Participants were asked: “Was [the puppet] right or wrong about this picture?” They found that children were more likely to say the puppet was right when both disjuncts were true than when only one was. They concluded that “many preschool children - the majority in [the study’s] sample - understand disjunctive sentences . . . as if they were conjunctions.”

Since previous nativist studies suggested that children understood the meaning of *or* as inclusive disjunction, Singh et al. (2016) proposed to explain both sets of findings using Fox’s (2007) proposal for deriving free choice inferences. The explanation goes like this. Children understand the meaning of *or* as inclusive disjunction. However, some children perform the typical inference on a free-choice

sentence (e.g. The boy may have an apple or a banana) on non-free-choice sentences too (e.g. the boy is holding an apple or a banana). After hearing the non-free-choice sentence, they generate two alternatives: the boy is only holding an apple, the boy is only holding a banana. Then they negate these two alternatives: the boy is not only holding an apple, the boy is not only holding a banana. The combination of these two negated alternatives and the inclusive interpretation of “the boy is holding an apple or a banana” becomes something like this: “the boy is holding an apple, a banana, or both. He is not only holding an apple, and he is not only holding a banana.” This compound statement is equivalent to “the boy is holding an apple AND a banana.”

It is important to note that Singh et al. (2016) tested the participants’ understanding of *or* in another way too. They asked them “Was [the puppet] right or wrong about this picture?” It seems that the participants correctly interpreted this disjunction as exclusive and did not think the experimenter wanted their assessment on something that can be both “right and wrong”. In other words, the conjunctive interpretation was not present for the question used by the experimenter, otherwise there could have been a lot of confusion with respect to the goal of the task. The fact that children showed different interpretations of *or* in the question sentence and in the puppet statements suggests that they are sensitive to the context of use.

Tieu et al. (2016) also found evidence for conjunctive interpretations of disjunction in preschool children. They tested 28 French-speaking children (3;7-6;6, M=4;5) and 18 Japanese-speaking children (4;7-6;6, M=5;5) as well as 20 French-speaking and 21 Japanese-speaking adults. They used the “prediction mode” of the Truth Value Judgment Task, in which the puppet provides a prediction or guess, an event occurs, and participants are asked if the prediction was right. For example, there was a chicken on the screen, next to a toy bus and a toy plane. The puppet appeared on the screen and predicted that “the chicken pushed the bus or the plane.” Then the chicken pushed either one or both of the objects. Participants stamped on a happy face or a sad face to show whether the puppet’s guess was right or wrong. Like Singh et al. (2016), they reported that unlike adults, children were more likely to consider the disjunctive guess right when both disjuncts were true, rather than only one. They concluded that children - the majority of them in their sample - interpreted disjunction as conjunction.

However, a recent replication of Tieu et al. (2016) by Skordos, Feiman, Bale, & Barner (2018) suggests that the conjunctive interpretations were most likely due to experimental design. They

tested 126 preschoolers in three conditions: replication ($N=43$, 4;0-5;9, $M=5;0$), modified script ($N=41$, 4;0-5;10, $M=5;0$), and three-alternatives ($N=42$, 4;0-5;11, $M=5;0$). The first condition was a direct replication of Tieu et al. (2016). The second, modified script, removed some experimenter comments right after the puppet's guess that could potentially confuse children. The comments were: "Look! The chicken pushed that! She didn't want to break that one. So she didn't touch it. So was [the puppet] right?" The third condition, three-alternatives, was similar to modified-script but provided three objects; for example a plane, a bus, and a bicycle. The reasoning was that if there are only two alternatives, a disjunction is trivially true, and consequently children may consider that unacceptable. The results replicated Tieu et al. (2016)'s findings in the replication condition, but showed that conjunctive interpretations of disjunction disappeared almost completely in the third condition with three alternatives. Skordos et al. (2018) concluded that children's conjunctive interpretations are most likely due to non-linguistic strategies applied when they are uncertain about some aspect of the experimental task. This conclusion is similar to that of earlier studies on conjunctive interpretations of disjunction in the 70s and 80s.

Table 5.8: The summary of studies on disjunction words in the nativist or Gricean accounts.

Study	Age	<i>N</i>	Language	Environment	Interpretation
Chierchia et al. (1998)	Not Reported	23 + 10	English + Italian	Past Declarative Future (<i>will</i>)	⊕ ∨
Gualmini et al. (2000b)	4;1-6;1 (M=4;11)	16	English	<i>can</i>	∨
Gualmini et al. (2000a)	3;2-5;9 (M=4;8)	14	English	<i>if</i> (antecedent)	∨
Crain, Gualmini, & Meroni (2000)	3;5-6;1 (M=4;1)	13	English	<i>will not</i>	∨
Chierchia et al. (2001)	3;7-6;3 (M=4;11) 3;5-6;2 (M=5;2)	15	English	<i>every</i> restriction <i>every</i> nuclear scope	∨ ⊕

Study	Age	N	Language	Environment	Interpretation
Gualmini & Crain (2002)	3;10- 5;10 (M=4;7)	30	English	<i>none</i> nuclear scope	∨
Chierchia et al. (2004)	5;1-6;0 (M=5;5)	9	Italian	Future Tense	∨
Goro & Akiba (2004)	3;7-6;3 (M=5;3)	30	Japanese	Negation (<i>nakat</i>)	∨
Notley et al. (2012)	3;4-5;1 (M=4;4)	24	English	<i>before</i>	∨
	4;6-5;4 (M=4;7)	20	Mandarin	<i>before</i>	∨
Notley, Thornton, & Crain (2012)	4;2-5;2 (M=4;8)	17	English	<i>not every</i> restriction	∨
				<i>not every</i> nuclear scope	∨
Su & Crain (2013)	3;11- 5;11 (M=4;10)	31	Mandarin	<i>mei</i> (every restriction)	∨
				<i>mei</i> (every nuclear scope)	⊕
(DO construction)	4;1-5;8 (M=4;11)	34	Mandarin	<i>mei</i> (every restriction)	∨
				<i>mei</i> (every nuclear scope)	⊕
Su (2014)	2;6-5;0 (M=3;9)	32	Mandarin	<i>ruguo</i> (if antecedent)	∨
				<i>ruguo</i> (if consequent)	∨
	3;11- 5;11, (M=4;11)	23	Mandarin	<i>ruguo</i> (if consequent)	∨

Study	Age	N	Language	Environment	Interpretation
				<i>ruguo</i> (if consequent)	∨
Hochstein et al. (2014)	4;0- 5;11	43	English	<i>each</i> (nuclear scope)	∨
Singh et al. (2016)	3;9-6;4 (M=4;11)	56	English	Present Declarative	∧, ∨, ⊕
				<i>every</i> (nuclear scope)	
Tieu et al. (2016)	3;7-6;6 (M=4;5)	28	French	Past Declarative	∧, ∨, ⊕
	4;7-6;6 (M=5;5)	18	Japanese	Past Declarative	
Geckin, Thornton, & Crain (2018)	4;1-5;8 (M=4;07)	24	German	Negative Past	∨
	4;1- 5;11 (M=4;7)	26	Turkish	Negative Past	

5.5 Conclusion

Previous studies have highlighted the importance of linguistic context and task demands in preschool children's interpretation of disjunction. Early studies such as Johansson & Sjolin (1975) suggest that in commands or imperative sentences, children are more likely to interpret a disjunction as exclusive. That is, they comply with the command by just making just one of the disjuncts true. However, other studies show that in declarative sentences, disjunction often receives an inclusive interpretation. That is, children judge a sentence "right" when both disjuncts are true, as well as when only one is true. Conjunctive interpretations may appear with declarative sentences too where children respond to statements with *or* in a manner similar to statements with *and*. They may accept the disjunctive statement when both disjuncts are true and reject it when only one is true. However, such responses can also be present in adults and seem to result from aspects of the experimental design. In tasks with relatively high cognitive demands or high levels of uncertainty with respect to the goal of the

task, participants may apply non-linguistic strategies that disregard the meaning of the connective and simulate a conjunctive interpretation.

Therefore, when studying children's interpretation of disjunction, it is important to control for these factors: complexity of the linguistic stimuli, complexity of the task, ignorance of the speaker, interpretation of the conjunction word (e.g. *and*) in the same task, and finally interpretation of adults in the same task. Previous studies have sometimes used complex linguistic stimuli, relatively complex design, had the speaker utter the disjunction when the truth of the propositions were known to the speaker, did not use the conjunction word in a control trial, or did not use adults as control participants. In the next chapter, I present an experiment that addresses these issues.

Chapter 6

Adults' and Children's Comprehension of Disjunction

6.1 Introduction

In this chapter, I examine the proposed differences between adults and children's interpretation of the disjunction word *or*. Previous research has suggested that adults and children might differ in their interpretation of *or* in two ways. First, unlike adults, children might interpret *or* as logical conjunction, akin to *and* (Singh et al., 2016; Tieu et al., 2016). Second, children might interpret *or* as inclusive disjunction while adults interpret it as exclusive (Crain, 2012). In this chapter, I present three studies that assess adults and children's understanding of *and* and *or* in a guessing game paradigm. These studies show that four-year-olds' interpretation of conjunction and disjunction may not be as different from adults as previously supposed.

Study 1 tested adults' interpretations of logical connectives in the context of a guessing game using Two and Three-Alternative Forced Choice judgment tasks (2AFC and 3AFC). The results showed that adults interpret *and* and *or* differently. They interpreted *and* as conjunction and *or* as inclusive disjunction. However, in the task with three alternatives (3AFC) adults did not consider a disjunction felicitous when both disjuncts were true. Comparing the 2AFC and 3AFC results, we find that the felicity of disjunctive statements is sensitive to the measurement. 2AFC task systematically underestimated judgments of felicity and better approximated truth judgments compared to the

3AFC task. This finding is intuitive given that more options provide a better opportunity to express nuances of linguistic interpretation.

Study 2 investigated children's judgments in the same guessing game as study 1 using a 3AFC task. I used three alternatives to give children a better chance of expressing their pragmatic knowledge and judgments of felicity (Katsos & Bishop, 2011). The study also analyzed and categorized children's open-ended spontaneous feedback to the guesser. Both the 3AFC judgments and the categories of open-ended responses showed that four-year-olds differentiated *or* from *and*. While children's judgments in the 3AFC task showed no sign of infelicity for disjunctive guesses when both disjuncts were true, their open-ended feedback showed that children find such guesses infelicitous. In their open-ended feedback, children's comments showed that use of a conjunction in such cases would be more appropriate.

Study 3 used the same paradigm as study 2, but focused on replicating children's open-ended responses and contrasting them with the results of a 2AFC task. As in study 2, both truth judgments and open-ended feedback showed that children differentiated *or* from *and*. The 2AFC task showed no evidence that children find disjunctions with true disjuncts infelicitous. However, children's judgments did not differ significantly from those of adults in the 2AFC task of study 1. As in study 2, children's open-ended feedback suggested that when both disjuncts are true, children find a disjunctive statement infelicitous and the conjunctive alternative more appropriate. Overall, the results of study 2 and 3 show that forced-choice judgement tasks underestimate children's pragmatic competence. Therefore, using open-ended elicitation and analysis of children's feedback **along with** forced choice judgment tasks may provide a better understanding of children's true semantic and pragmatic knowledge.

The studies reported here build on previous studies, and fill two gaps in the literature as well. First, most previous research focused on children's interpretation of *or* in complex sentences – for example with other logical words such as quantifiers *every* and *none*. Here, I test children and adults' understanding of *and* and *or* in simple existential sentences like "*There is a cat or a dog*." To my knowledge, only Braine & Romain (1981) used simple existential constructions before, but their experimental paradigm was relatively more complex than the paradigm used here. As discussed before, simplifying the paradigm is an important step in reducing conjunctive interpretations that arise due to non-linguistic strategies. Second, most previous research tested children and adults

using 2AFC truth value judgment tasks (Crain & Thornton, 1998). Here, I report adults and children's judgments on both 2AFC and 3AFC tasks. I also use children's open-ended spontaneous feedback to develop relevant analytical response categories and I replicate the findings in a following pre-registered study. Katsos & Bishop (2011) argued that 3AFC judgment tasks are better suited for assessing children's pragmatic competence. I present results that suggest even a 3AFC task can underestimate children's pragmatic knowledge and that children's spontaneous and open-ended elicited responses provide valuable insights not available in forced choice judgments.

6.2 Study 1: Adult Judgments

The goal of this study was to examine adults' interpretations of *and* and *or* as a benchmark for children's interpretations. I designed the study as a guessing game. Participants saw a card, read a description, and had to evaluate the description with respect to what they saw on the card. In test trials, the descriptions contained the conjunction word *and* and the disjunction word *or*. I tested adults in both two-alternative and three-alternative forced choice tasks (2AFC and 3AFC). The results suggested that adults interpreted *and* as a conjunction and *or* as an inclusive disjunction. Adults also considered statements with *or* infelicitous when both disjuncts were true. The study also found that the 2AFC and 3AFC tasks registered different aspects of adult interpretations: the 2AFC task captured adult intuitions on the basic semantics of the connectives while the 3AFC task was sensitive to pragmatic infelicities as well.

6.2.1 Methods

Materials and Design

The study used six cards with cartoon images of a cat, a dog, and an elephant (Figure 6.1). There were two types of cards: cards with only one animal and cards with two animals. There were three types of guesses: simple (e.g. *There is a cat*), conjunctive (e.g. *There is a cat and a dog*), and disjunctive (e.g. *There is a cat or a dog*). In each guess, the animal labels used in the guess and the animal images on the card could have no overlap (e.g. Image: dog, Guess: *There is a cat or an elephant*), partial overlap (e.g. Image: Cat, Guess: *There is a cat or an elephant*), or total overlap (e.g. Image: cat and elephant, Guess: *There is a cat or an elephant*). Crossing the number of

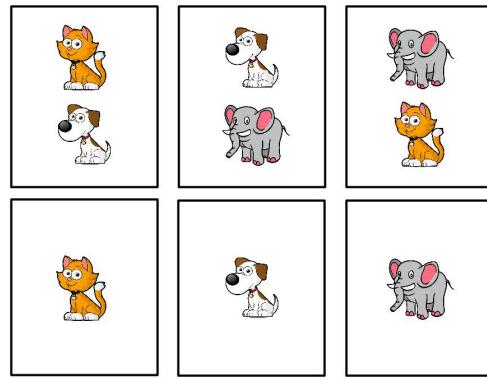


Figure 6.1: Cards used in the connective guessing game.

elephant	cat	cat and dog	cat or dog

Figure 6.2: Trial types represented by example cards and example guesses.

animals on the card, the types of guesses, and the overlap between the guess and the card yields 12 different possible trial types. I chose 8 trial types (Figure 6.2), to balance the number of one-animal vs. two-animal cards, simple vs. connective guesses, and expected true vs. false trials.

Participants and Procedure

I used Amazon's Mechanical Turk (MTurk) for recruitment and the online platform Qualtrics for data collection and survey design. The task took about 5 minutes on average to complete. 109 English speaking adults participated. 57 of them were assigned to a 2AFC judgment task and 52 to a 3AFC judgment task. In the 2AFC task, participants had to judge using the options "wrong" and "right". In the 3AFC task they had to choose between "wrong", "kinda right", and "right".

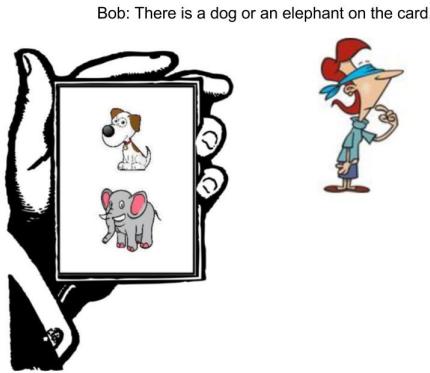


Figure 6.3: An example trial in Study 1.

The two conditions were otherwise identical. There are many possible labels for the middle option “kinda right”, including “kinda wrong” or “neither”. In a later experiment (not reported in this dissertation) I tested different intermediate labels and found that adults consider “kinda right” to be the most suitable option for capturing pragmatic infelicity (Jasbi, Waldon, & Degen, submitted). I expect similar behavior from labels like “a bit right” and “a little right” which refer to non-maximal degrees of being right.

The experiment had three phases: introduction, instruction, and test. In the introduction, participants saw the six cards and read that they would play a guessing game. Then a blindfolded cartoon character named Bob appeared on the screen. Participants were told that in each round of the game, they would see a card and Bob was going to guess what animal was on the card. I emphasized that Bob could not see anything. I asked participants to judge whether Bob’s guess was right. In the instruction phase, participants saw an example trial where a card with the image of a dog was shown with the following sentence written above Bob’s head: *There is a cat on the card*. All participants, who correctly responded with “wrong”, proceeded to the test phase.

In the test phase, participants saw one trial per trial type. Within each trial type, the specific card-guess scenario was chosen at random. The order of trial types was also randomized. At the end of the study, participants received \$0.4 as compensation. Figure 6.3 shows an example test trial.

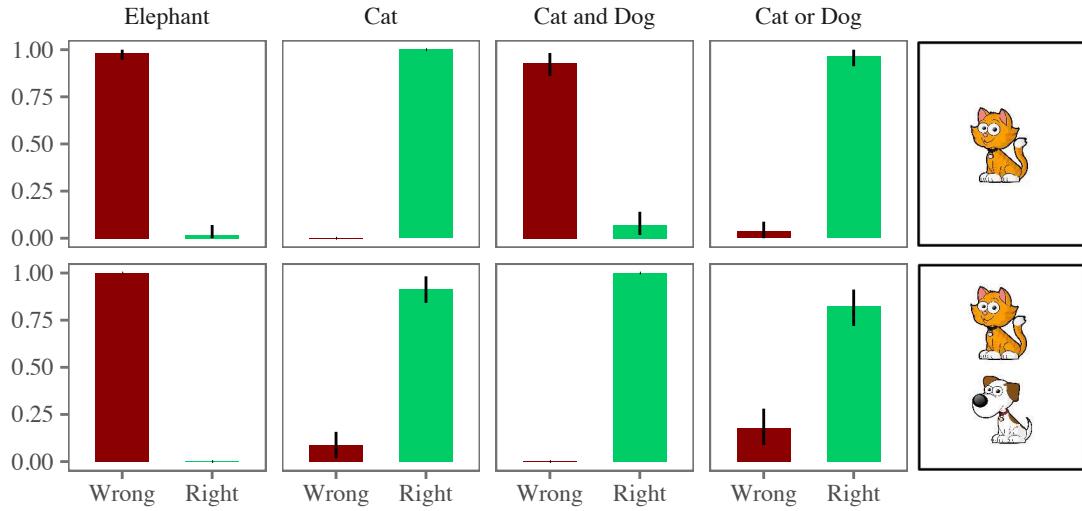


Figure 6.4: Adults' two-alternative forced choice judgments.

Table 6.1: Summary of Study 1 Methods

Study	N	Age	Mode	Response Options
Study 1 - Part 1	57	Adults	Online (Mturk)	Wrong, Right
Study 1 - Part 2	52	Adults	Online (Mturk)	Wrong, Kinda Right, Right

6.2.2 Results

In this section, I first present the results of the 2AFC and 3AFC tasks with adults. Then I discuss how these results can be interpreted with respect to the semantics and pragmatics of disjunction in the context of the guessing game.

Judgments with Two Alternatives (2AFC)

Figure 6.4 shows the results for the adult 2AFC task. The two left columns show the simple guesses and serve as controls. The results show that if the animal mentioned in the guess was not on the card (e.g., elephant), participants judged the guess to be “wrong”; if the animal was on the card (e.g., cat), participants judged the guess to be “right”. The next two columns of Figure 6.4 show the results for the test conditions, namely conjunction and disjunction. They match the expectations for logical conjunction and (inclusive) disjunction: an *and*-guess (e.g. cat and dog) is “wrong” if only

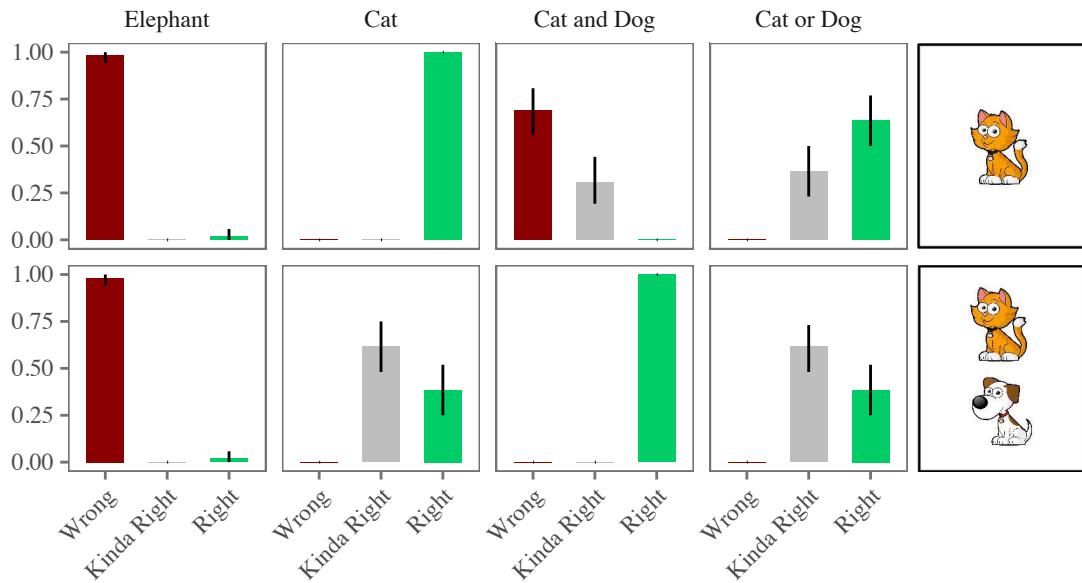


Figure 6.5: Adults' three-alternative forced choice judgments in the connective guessing game.

one of the animals is shown on the card, and “right” if both are on the card. An *or*-guess (e.g. cat or dog) is “right” whether one or both animals are depicted on the card.

Judgments with Three Alternatives (3AFC)

Figure 6.5 shows the results for the 3AFC judgment task. For four trial types, the results are identical to the 2AFC task: if the animal mentioned in the guess was not on the card (e.g. elephant), participants judged the guess “wrong”. If the animal mentioned (e.g. cat) was the only animal on the card, participants judged the guess “right”. Finally, if there were two animals and the puppet mentioned them using *and* (e.g. cat and dog), all participants considered the guess “right”.

The four remaining trial types showed different patterns of judgments than the ones in the 2AFC task. If the animal mentioned (e.g. cat) was only one of the animals on the card, participant judgments were divided between “right” and “kinda right” (See Table 6.2, row 1 for the statistical test). Also, most adults considered a conjunctive guess (e.g. cat and dog) “wrong”, when only one of the animals was on the card (Table 6.2, row 2). However, some considered it “kinda right”, perhaps suggesting that the intermediate option was used to express the notion of “partial truth”. When both animals were on the card everyone agreed that the conjunctive guess was “right”.

With respect to disjunctive guesses like “cat or dog”, if the card had only one of the animals, most adults consider the guess “right” while some considered it “kinda right” (Table 6.2, row 3). It is possible that the adults who considered such guesses “kinda right” were sensitive to the under-informative nature of a disjunctive guess when a simple guess like “cat” would have been more appropriate. If both animals were on the card, adults were split between “kinda right” and “right” responses (Table 6.2, row 4). The choice of “kinda right” over “right” in such trials can be interpreted as a sign that adults were sensitive to the infelicity of a disjunction when conjunction was more appropriate. However, the scalar reasoning with *and* and *or* is subtle and in section 6.2.3, I discuss the nature of this reasoning in the context of this guessing game.

Table 6.2: Exact One-Sided Binomial Test

Trial Type	n_{right}/n_{total}	\hat{p}_{right}	p_{null}	P-value	95% CI
Two Animals - Simple	32/52	0.62	0.5	0.06	0.49-1
One Animal - AND	16/52	0.69	0.5	0.004	0.57-1
One Animal - OR	19/52	0.63	0.5	0.04	0.51-1
Two Animals - OR	32/52	0.62	0.5	0.06	0.49-1

6.2.3 Discussion

The example sentences below show the common interpretations of conjunctive and disjunctive assertions (Aloni, 2016).

- Bob is sad *and* angry.
 - Both are true. (Truth Conditional Meaning)
- Bob is sad *or* angry.
 - At least one of the two is true. (Truth Conditional Meaning)
 - Speaker doesn't know which is true. (Ignorance Inference)
 - At most one of the two is true. (Exclusivity Inference)

A conjunctive assertion implies that both propositions are true while a disjunctive assertion implies that at least one is true. These two inferences follow from the classical truth-conditional account of conjunction and disjunction. They constitute the semantics of *and* and *or*. However, a disjunctive

assertion often has two additional inferences: an ignorance inference and an exclusivity inference. These additional inferences are often classified under pragmatic meaning. This section discusses the semantics and pragmatics of *and* and *or* in the context of the guessing game in Study 1.¹

The Semantics of AND and OR

Let's assume that the semantics of *and* and *or* in simple declarative sentences like “there is a cat or (and) a dog” is captured by the logical operators conjunction and inclusive disjunction respectively. A conjunction is true when both conjuncts are true and false otherwise. An inclusive disjunction is true when at least one disjunct is true and false otherwise. Let's also assume a simple linking function in which false statements are judged as “wrong” and true statements as “right” (see Jasbi et al. (submitted) for a discussion of linking assumptions in this task). In the context of study 1, this purely semantic (i.e. truth-conditional) account has two main predictions: 1. Conjunctive guesses like “cat and dog” are wrong when only one of the animals is on the card. 2. Disjunctive guesses are always right because in all such trials at least one of the animals is present on the card. Figure 6.4 shows that in 2AFC judgments, both predictions are borne out. In other words, judgments with two alternatives seem to match the predictions of a purely semantic account of the connectives *and* and *or* with a linking function that considers “right” and “wrong” roughly as “true” and “false”.

However, in the 3AFC task, judgments deviated from a purely semantic account in four trial types: 1. disjunction trials with one animal 2. disjunction trials with two animals, 3. conjunction trials with one animal, and 4. trials with simple guesses when two animals were shown on the card. Participants often used the third option “kinda right” in these trial types. Other trial types obtained identical results in 2AFC and 3AFC tasks. The comparison of forced choice judgments with two and three alternatives suggests that two alternatives better captured the truth-conditional meaning of the connectives, but underestimated adult pragmatic reasoning in the guessing game.

The Pragmatics of AND and OR

A disjunctive assertion like “cat or dog” gives rise to an ignorance inference and an exclusivity inference. The ignorance inference is the inference that the speaker does not know which disjunct actually holds. For example in figure 6.6, the disjunctive guess is uncertain between three outcomes:

¹See Gutzmann (2014) for a comprehensive discussion of the definitions and boundaries of semantics and pragmatics. Here my definitions and assumptions are close to those of Gazdar (1979).

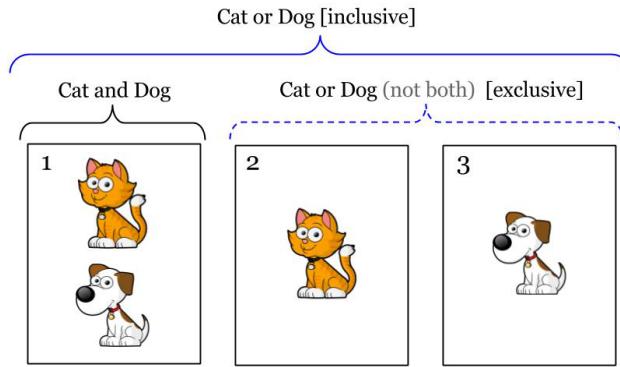


Figure 6.6: Example of cards referred to by a conjunction, inclusive disjunction, and exclusive disjunction.

cards 1, 2, and 3. As pointed out in Chapter 2, a disjunction is infelicitous when the outcome is known to discourse participants. For example, Tarski mentioned that a disjunction like “the grass is green or blue” is odd because we already know that it is green. The guessing game in this study controls for this ignorance effect by keeping the guesser blindfolded. Therefore, all the disjunctive guesses are evaluated in a context where participants know that the guesser is ignorant of the animals on the cards - both the number of them on the card and their identity. The exclusivity inference is the inference that only one of the disjuncts holds and **not both**. In figure 6.6, a disjunction like “cat or dog” only refers to cards 2 and 3 if it is accompanied by an exclusivity inference.

Since Grice (1989), this exclusive interpretation of *or* has been (at least partly) attributed to pragmatic reasoning about the speaker’s connective choice. The reasoning goes like this: conversational participants are required to make their utterances as informative as possible. In the context of making predictions and guessing, a guesser is required to make any guess as specific (i.e. informative) as possible.² A conjunction is more specific and informative than a disjunction (Horn, 1989). For example in Figure 6.6, “cat and dog” picks card 1 while “cat or dog” refers to cards 1, 2, and 3. If speakers intend to refer to card 1, they should use *and* and say “cat and dog”. If they use *or* instead of *and*, they probably do not intend to refer to card 1. Following this line of reasoning, I can exclude the possibility that a speaker intends to refer to card 1. The term “exclusivity implicature” captures this pragmatic reasoning that results in excluding the possibility of both disjuncts being true.

My goal here is to lay out the structure of pragmatic reasoning in the experimental setup and

²When you ask someone to predict the outcome of a coin toss, a guess like “it will be heads or tails” does not count as a felicitous guess or prediction, presumably because it will always be true.

explain how it is manifested in the results of the experimental studies. There are three main components to the pragmatic reasoning in the guessing game: 1. the assumptions of the game. 2. sensitivity to (under)informativity, and 3. the pragmatic reasoning about the speaker's choice of connectives. Like Katsos & Bishop (2011), I have considered "sensitivity to informativeness" as a precondition for "derivation of scalar implicatures". I begin with the assumptions of the guessing game.

- **Guessing Game Assumptions:**

- **Ignorance:** the guesser does not know the number or identity of the animals on the card.
- **Specificity:** A guesser is required to be as specific as possible, ideally referring to a single card.

As explained before, ignorance of the guesser was explicit and part of the instructions in the study. However, specificity was an implicit assumption³. All the guesses used in the experiment can pick a single card except for disjunctive ones. Conjunctive guesses like "cat and dog" pick specific cards. The simple ones like "cat" can be strengthened pragmatically to mean "only a cat", and pick a specific card. However, Disjunctive ones like "cat or dog" pick two cards in their most specific (exclusive) sense. Therefore, they are always under-informative and violate the specificity assumption.

- **Sensitivity to Informativeness:** The guesser said "cat or dog" which is under-informative and picks card 1, 2, and 3.

- **Violation Assumption:** the guesser is violating the specificity requirement.

Participants can detect the underinformativity of disjunctive guesses, notice the violation of specificity, and then decide whether they would like to tolerate this violation or punish it. It should be pointed out that it is hard to distinguish between "tolerating the specificity violation" and simply revising the specificity assumption of the game to avoid a violation. For example, participants may assume that the goal of the game is saying something true about the cards rather than being as specific as possible. In either case, the prediction is that adults who tolerate violation or revise specificity would judge disjunctive guesses as "right". However, if participants assume specificity and decide to not tolerate its violation, they will judge all disjunctive guesses to have some degree of infelicity. Since an under-informative guess is still technically correct, participants may not

³Making this assumption explicit is both hard for young children and almost impossible when disjunctive guesses are used. Disjunctive guesses are always underinformative and never pick out a specific card.

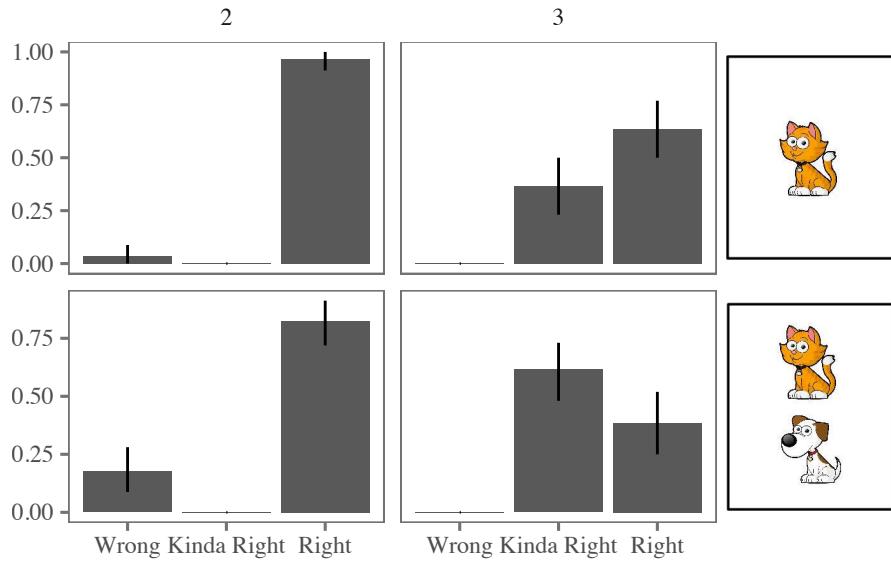


Figure 6.7: Adult responses to disjunction guesses like *cat or dog* with 2 and 3 options.

punish such a guess with a “wrong” response and prefer an intermediate option like “kinda right”. This is what study 1 shows. With two alternatives, not many adults judge infelicity with disjunctive guesses and there are almost no “wrong” responses. With three alternatives, “kinda right” responses pop up. Adult responses are split between “kinda right” and “right”. If detecting and reacting to underinformativity is the whole story, then disjunctive guesses should show similar degrees of infelicity, regardless of how many animals there are on the card. However, the results of the 3AFC task suggest otherwise. A logistic mixed-effects model with the random intercepts and slopes for subjects and fixed effect of disjunction type found that when comparing disjunctive guesses in the 3AFC task, participants were more likely to choose “kinda right” than “right” when both animals were on the card ($\beta=-1.22$, $z=-2.25$, $p=0.02$). In other words, participants judged further infelicity with disjunctive guesses that had both disjuncts as true. Therefore, it is possible that when both disjuncts were true, some participants went through the following pragmatic reasoning:

- **Reasoning on Alternatives:** Why did the guesser choose the under-informative connective *or* rather than the more informative *and*?
 - **Resolution Assumption:** speaker is trying to be as specific as possible by resolving the issue of how many animals are on the card.

* **Exclusivity Implicature:** Given the resolution hypothesis, if the speaker had decided that two animals were on the card, they should have said “cat *and* dog”. They did not, so they had decided that only one animal is on the card and **not both**.

How does the exclusivity implicature affect participant judgments in the experimental setting? One possibility is that excluding the correct response pragmatically is treated like cases of excluding the right response semantically. For example, guessing “elephant” when there is a cat on the card. The prediction is that disjunctive trials with true disjuncts should receive “wrong” responses. However, this prediction was not borne out. Such disjunctive trials are almost never judged as “wrong”.

Alternatively, it is possible that adults differentiate incorrect pragmatics from incorrect semantics (i.e. falsehood) and punish incorrect pragmatics less than incorrect semantics. This conclusion is supported by the response patterns across trial types (figure 6.5). Trial types that received a “wrong” response were those that were false. Pragmatically infelicitous trial types, namely simple guesses like “cat” or disjunctive guesses like “cat or dog” when both animals are on the card, receive “kinda right” responses. In other words, adults consider false utterances as “wrong” guesses but infelicitous utterances do not reach the level of being “wrong”; they are still right even though not completely right. This would explain why the rates of infelicity (avoiding the “right” alternative) differ between 2AFC and 3AFC tasks in disjunctive trials with true disjuncts (0.18 vs. 0.62).

6.3 Study 2: Children’s three-alternative judgments and open-ended feedback

The goal of this study was to examine children’s interpretations of *and* and *or* in the guessing game and compare them to those of the adults. Since the 3AFC judgment task in study 1 proved better at capturing the nuances in adults’ pragmatic reasoning, I decided to first test children using three alternatives. I also analyzed children’s open-ended comments about the guesses in the experimental context. Both three-alternative judgments and the analysis of children’s open-ended responses showed that children differentiate *and* and *or* statements. The judgment task suggested that children do not consider disjunctive guesses with true disjuncts as infelicitous. Yet, the analysis of their open-ended feedback suggests otherwise. Children took issue with such guesses and corrected them. I conclude that the 3AFC judgment task may have underestimated children’s pragmatic



Figure 6.8: The puppet, Jazzy, with and without the sleeping mask.

competence.

6.3.1 Methods

Table 6.3: Summary of Study 2 Methods

Study	N	Age	Mode	Response Option
Study 2	42	3;1-5;2 (M = 4;3)	Study Room	Circle (wrong), Little Star (little right), Big Star (right)

Materials and Design

I used the same set of cards and linguistic stimuli as the ones in study 1. There were 8 trial types and 2 trials per trial type for a total of 16 trials. I made two changes to make the experiment more suitable for children. First, instead of the fictional character Bob, a puppet named Jazzy played the guessing game with them. Jazzy wore a sleeping mask over his eyes during the game (Figure 6.8). Second, a pilot study showed that a scale with three alternatives is better understood and used by children if it is presented in the form of rewards to the puppet rather than verbal responses such as “wrong”, “a little bit right”, and “right”, or even hand gestures such as thumbs up, middle, and down. Therefore, I placed a set of red circles, small blue stars, and big blue stars in front of the children. These tokens were used to reward the puppet after each guess. During the introduction, the experimenter explained that if the puppet is right, the child should give him a big star, if he is a little bit right, a little star, and if he is not right, a red circle.

Participants and Procedure

I recruited 42 English speaking children from the Bing Nursery School at Stanford University. Children were between 3;1 and 5;2 years old (Mean = 4;3). The experiment was carried out in a quiet room and all sessions were videotaped. There was a small table and two chairs in the room. Children sat on one side of the table and the experimenter and the puppet on the other side facing the child. The groups of circles, small stars, and big stars were placed in front of the child from left to right. A deck of six cards was in front of the experimenter. As in study 1 with adults, the children went through three phases: introduction, instruction, and test.

The goal of the introduction was for the experimenter to show the cards to the children and make sure they recognized the animals and knew their names. The experimenter showed the cards to the children and asked them to label each animal. All children recognized the animals and could label them correctly. In the instruction phase, children went through three example trials. The experimenter explained that he was going to play with Jazzy (the puppet) first, so that the child could learn the game. He removed the six introduction cards and placed a deck of three cards face-down on the table. From top to bottom (first to last), the cards had the following images: cat, elephant, cat and dog. He put the sleeping mask on the Jazzy's eyes and explained that the puppet is going to guess what animal is on the cards. He then picked the first card and asked the puppet: "*What do you think is on this card?*" Jazzy replied with "*There is a dog*". The experimenter showed the cat-card to the child and explained that when the puppet is "not right" he gets a circle. The pilot study had shown that some children struggle with understanding the word "wrong", so "not right" was used instead. He then asked the child to give the puppet a circle. Rewards were collected by the experimenter and placed under the table to not distract the child. The second trial followed the same pattern except that the puppet guessed "right" and the experimenter invited the child to give the puppet a big star. In the final trial, the puppet guessed that there is a cat on the card when the card had a cat and a dog on it. The experimenter said that the puppet was "a little right" and asked the child to give him a little star.

Table 6.4: Instruction Trials.

Card	Guess	Reward
CAT	There is a cat!	Circle

Card	Guess	Reward
ELEPHANT	There is an elephant!	Big Star
CAT-DOG	There is a dog!	Little Star

In the test phase, the experimenter removed the three instruction cards and placed a deck of 16 randomized cards on the table. The experimenter explained that it was the child's turn to play with the puppet. The test phase followed the pattern described in the instruction phase. The randomization code as well as the details of the methods are in the online repository for this study at https://github.com/jasbi/jasbi_dissertation_LearningDisjunction.

Offline Annotations

During analysis of the videos, children's linguistic feedback to the puppet after each guess was categorized into four types: 1. None, 2. Judgments, 3. Descriptions, and 4. Corrections. The first category referred to cases where children did not say anything and only rewarded the puppet. Judgments referred to linguistic feedback such as *you are right!*, *yes*, *nope*, or *you winned*. Such feedback only expressed judgments and complemented the rewards. Descriptions were cases that the child simply mentioned what was on the card: *cat!*, *dog and elephant!*, *There is a cat and a dog!* etc. Finally, corrections referred to feedback that provided additional linguistic elements that acted like corrections to what the puppet had said. Examples include: *Just a cat!*, *Both!*, *The two are!*, *Only cat, cat AND dog* (with emphasis placed on *and*). In trials where the child provided both judgments as well as descriptions or corrections, I placed the feedback into the more informative categories, namely description or correction.

6.3.2 Results

Figure 6.9 shows the results for children's 3AFC judgments. Starting from the left column, if the mentioned animal was not on the card (e.g. elephant), children judged the guess as "wrong". If the animal mentioned (e.g. cat) was the only animal on the card, children judged the guess to be "right". Here I will ignore the results for trial types in which the animal mentioned was one of the animals on the card. The reason is that such trials were used in the instruction phase to introduce the "little bit right" guesses, and the results are potentially biased by the instructions.

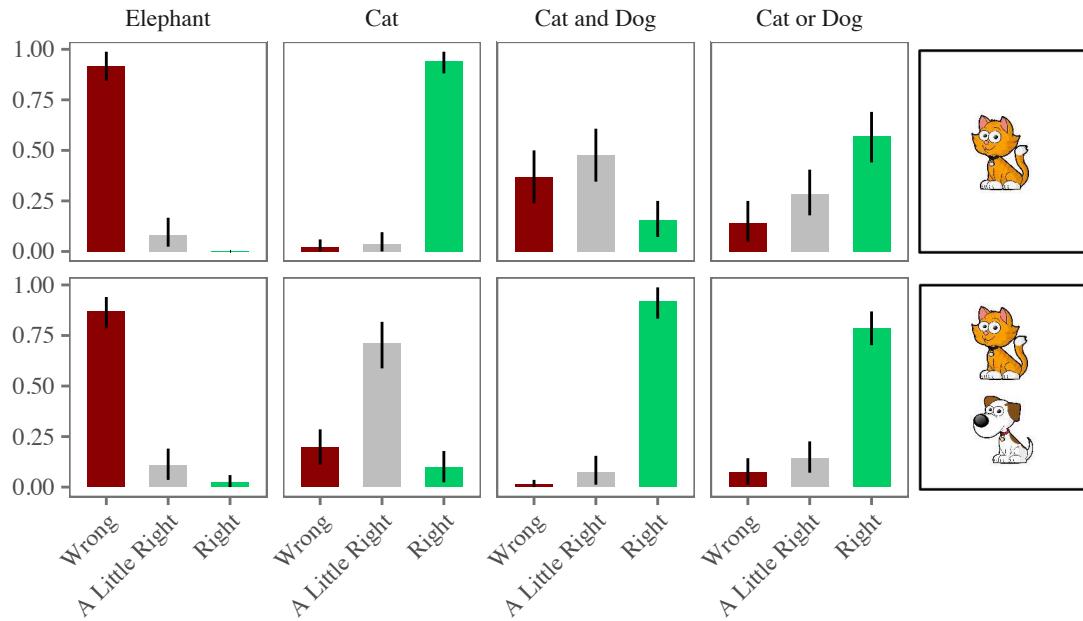


Figure 6.9: Children's ternary judgments in the connective guessing game.

In conjunctive guesses (e.g. *cat and dog*), when only one of the animals mentioned was on the card, children judged the guess as “wrong” or “a little bit right”. However, if both animals were on the card, they judged the conjunctive guess as “right”. In disjunctive guesses (e.g. *cat or dog*), when only one of the animals mentioned was on the card, children considered the guess “right” or “kinda right”. If both animals were on the card, the disjunctive guess was considered “right”.

The comparison of conjunction and disjunction trials (last two columns of figure 6.9) shows that overall, children distinguished between *and* and *or* when one animal was on the card. Given that the one-animal conjunction trials are false but the one-animal disjunction trials are true, the difference in response patterns may suggest that children understood the truth-conditional differences between *and* and *or*. The truth judgments did not provide evidence that children differentiated *and* and *or* when two animals were on the card. Since in the majority of examples with *or* and two animals, children responded with “right”, it is possible to conclude from the judgment data that children did not generate exclusivity inferences in this task.

Figure 6.10 compares the results for children and adults' 3AFC judgments in the conjunction and disjunction trials. The major difference between adults and children's responses was disjunctive trials with two animals on the card. Most children considered such trials as “right” while adults

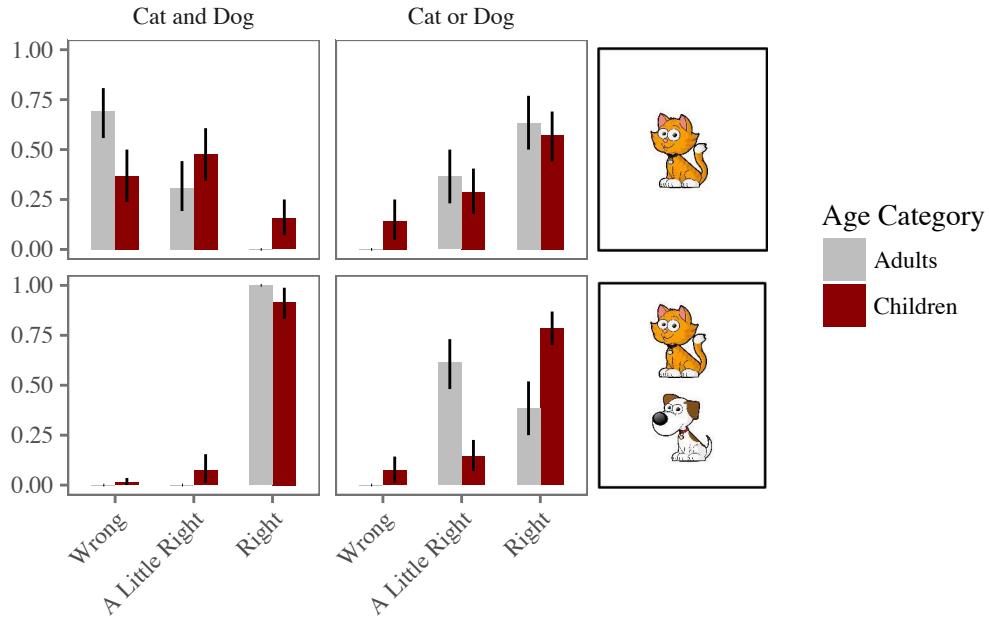


Figure 6.10: Comparison of Adults' and Children's ternary judgments.

considered them as “kinda right” or “right”. In the next section, I use Bayesian regression modeling to compare adults’ and children’s three-alternative responses more systematically.

Analysis and Statistical Modeling

I used the R package RStan for Bayesian statistical modeling to fit separate ordinal mixed-effects logistic models for the children’s and adults’ judgments. The response variable had three ordered levels: *wrong*, *kinda right*, and *right*. The trial types *One-Animal-OR*, *Two-Animals-OR*, *One-Animal-AND* constituted the (dummy-coded) fixed effects of the model with *Two-Animals-AND* set as the intercept. The model also included by-subject random intercepts. The priors over trial types and the random intercepts were set to $\mathcal{N}(0, 10)$. I also included parameters C_1 and C_2 , the two cutpoints delimiting the logistic for 1) *wrong* and *kinda right* and 2) *kinda right* and *right* responses, drawn with the prior $\mathcal{N}(0, 1)$.⁴ All four chains converged after 3000 samples (with a burn-in period of 1500 samples).

I made inferences based on the highest-posterior density (HPD) intervals for the coefficients estimated from each model. Because predictors are dummy-coded, it’s possible to examine contrasts

⁴I used a tight prior in this case to decrease posterior correlations between cutpoints and intercept.

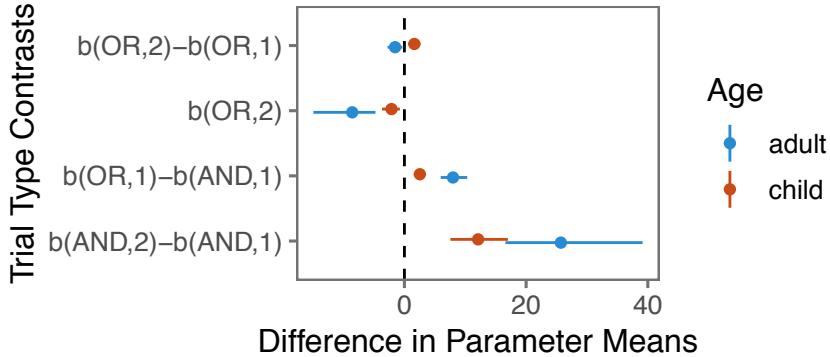


Figure 6.11: Coefficients capturing the relevant comparisons across conditions in ternary judgments in Study 1 and 2. In naming the coefficients like $b(\text{OR},2)$, OR/AND represents the connective used and the number 1/2 represents the number of animals on the card. Error bars represent 99% regions of highest posterior density.

of interest by computing the difference between coefficients for pairs of conditions I wish to contrast. In naming the coefficients like $b(\text{OR},2)$, OR/AND represents the connective used and the number represents the number of animals on the card. Figure 6.11 shows the contrasts of interest: $b(\text{OR},2)-b(\text{OR},1)$ represents the difference between the estimated coefficients for the disjunction trials with two animal on the card and those with only one; $b(\text{OR},2)$ represents the difference between the estimated coefficients for the conjunction trials with two animals and the disjunction trials with two animals; and so on.

Overall, adults' and children's estimated coefficients are similar in sign to one another, though adults' are more extreme. In the conjunction trials ($b(\text{AND},2)-b(\text{AND},1)$), children and adults showed a strong preference for the cards with two animals rather than one. At the same time, given two animals on the card, children and adults showed a preference for *and* rather than *or* ($b(\text{OR},2)$). However, with only one animal on the card, children and adults preferred a disjunctive guess ($b(\text{OR},1)-b(\text{AND},1)$). These results are compatible with the truth conditions of conjunction and disjunction.

The main difference between adults and children shows up in the contrast between the disjunctive trial types: two animals vs. only one ($b(\text{OR},2)-b(\text{OR},1)$). On average, children rated disjunction trials with two animals higher than those with only one. Adults on the other hand showed the opposite pattern: they rated disjunction trials with two animals lower. This pattern is compatible with current accounts of pragmatic development that suggest an absence of implicatures in children's

interpretations. The idea is that while adults strengthen the disjunctive guess “cat or dog” to “cat or dog but not both”, children simply interpret it as “cat or dog or both”. Adults are therefore going to rate trials with both disjuncts true lower.

The slight preference children show for cards with two animals when the guess is disjunctive is also compatible with the account proposed by Singh et al. (2016) and Tieu et al. (2016). However, the effect is much smaller here than was reported in their studies. The comparison with conjunction trials makes it clear that overall, children are not interpreting *or* as having a conjunctive meaning. The effect in this study can be more accurately described as a preference in judgment for both disjuncts being true rather than a conjunctive interpretation of disjunction. The results from children’s spontaneous linguistic feedback make it less likely that children interpretive *or* as a conjunction. I will discuss this issue further in section 6.5.1.

Children’s open-ended feedback

Table 6.5: Definitions and Examples for the Feedback Categories.

Category	Definition	Examples
None	no feedback provided to the puppet, only reward	
Judgment	the child said yes/no, you are right, etc.	“No!”, “You are right Jazzy!”
Description	mentioned the animal(s) on the card	“elephant”, “cat and dog”
Correction	used focus particles like <i>only/just</i> , emphasized <i>and</i> or used <i>both</i>	“only cat”, “just elephant”, “both!”, “cat AND dog!”

As explained in section 6.3.1, I also categorized and annotated children’s spontaneous and free form verbal reactions to the puppet’s guesses. Table 6.5 summarizes the definitions and examples for each category and Figure 6.12 shows the results. I should first point out that each trial type has a similar number of “None” cases, for feedback. Some children remained more or less silent throughout the experiment and only provided rewards to the puppet. In the next study I focus on children’s open-ended feedback. In the discussion and analysis here I will not comment further on the “None” category but focus on the other three categories.

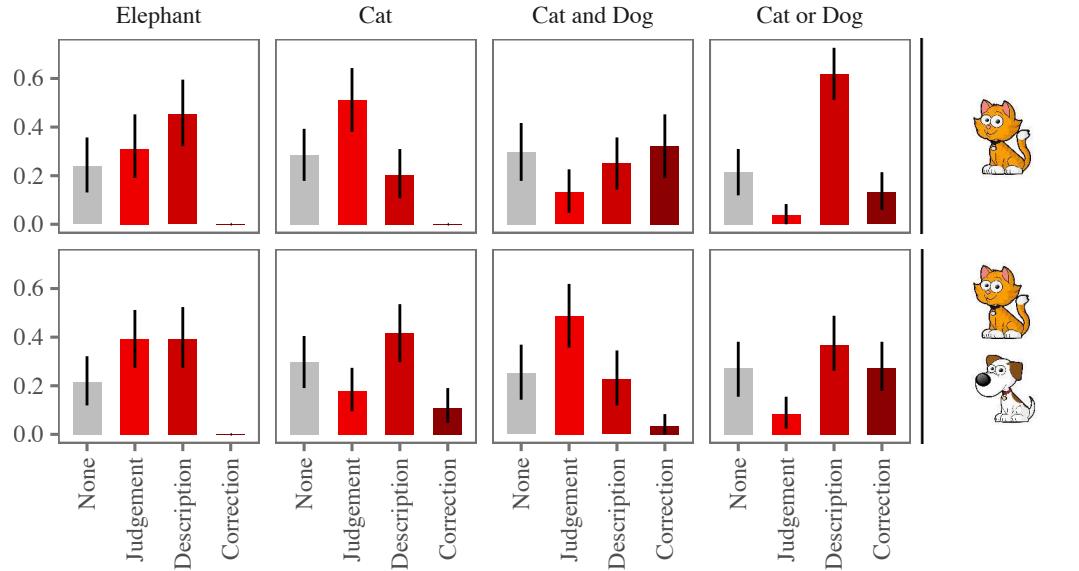


Figure 6.12: Children's open-ended Feedback. Error bars represent 95% confidence intervals.

In the leftmost column, when the animal guessed (e.g. elephant) was not on the card, children either provided judgments like “No!” or described what was on the card like “cat” or “cat and dog”. However, when the animal guessed was the only animal on the card (e.g. cat), most children provided a positive judgment like “Yes”. When the animal guessed was only one of the animals on the card, children described what was on the card, say, “cat and dog”. Corrections were rare for all these four control trial types.

In the critical trial types with conjunction and disjunction, children showed a high rate of corrections and description when the guess used *and* but there was only one animal on the card. In their corrections, children used the focus particles *just* and *only* like “just a cat” or “only a cat”. However, in trial types where conjunction was used and both animals were depicted, children predominantly provided positive judgments like “Yes!” and “You are right”. Considering disjunctive guesses like “cat or dog”, when only one of the animals was on the card, most children simply described what was on the card, for example “cat”. However, when both animals were on the card, children corrected the puppet by saying *both* or emphasizing *and* as in “cat AND dog”.

I performed chi-squared goodness-of-fit tests to compare the feedback distributions in the critical conditions with *and* and *or*. Here I focus on those trials (the four bar charts on the right of Figure 6.12). Children's linguistic feedback showed three patterns. First, the one-animal conjunctive and

two-animal disjunctive (top left and bottom right) trials contained a higher proportion of Corrections than the other trial types. These were trials where the guesses were either false or infelicitous. In the conjunction trials, a comparison of the feedback distribution in one-animal and two-animal conditions was statistically significant ($\chi^2(3, 83) = 201.65, p < .0001$), suggesting that children gave different feedback to true and false guesses. A similar numerical trend was present in the disjunction trials, but it was not significant ($\chi^2(9, 4) = 12, p = 0.21$).

Second, the one-animal disjunctive trials (top right) showed the highest proportion of *Descriptions*. These are trials in which the guess is correct but not specific enough: it leaves two possibilities open. These trials were significantly different from the one-animal trials for conjunction ($\chi^2(3, 83) = 62.16, p < .0001$). Finally, the two-animal conjunctive trials (bottom left) showed the highest proportion of *Judgments* such as *You are right!*. This was not surprising given that these trials represented the optimal guessing scenario. These trials had a significantly different feedback distribution from the matching disjunction trials ($\chi^2(3, 84) = 184.98, p < .0001$).

6.3.3 Discussion

In study 2, I used a 3AFC judgment task to test children's comprehension of logical connectives *and* and *or*. I compared these results to those found in the 3AFC judgment task of study 1 with adults. The general comparison showed that adults and children had similar patterns of judgments, except when both disjuncts were true. In such cases, adults judged the disjunctive guess as not completely right while most children found it completely right. There was even a slight preference among children to reward the puppet more in such cases, compared to cases of disjunction when only one disjunct was true.

To consider another measure of children's comprehension, I also looked at children's spontaneous open-ended feedback in response to the guesses. My analysis suggested that children recognized false and infelicitous utterances with the connectives and provided appropriate corrective feedback. As expected from an adult-like understanding of connectives, children corrected the puppet most often when there was only one animal on the card and the guess was conjunctive, or when there were two animals on the card and the guess was disjunctive. Perhaps the most important finding was that children increased their corrective feedback in disjunctive guesses where both disjuncts were true, compared to those with only one true disjunct. These findings differ from the results of

the 3AFC judgment task which suggested that children did not find any infelicity with disjunctive guesses when both disjuncts were true.

The analysis of children's open-ended feedback raises two important issues. First, as I mentioned before, it runs counter to what the 3AFC judgment task suggests with respect to exclusivity implicatures (i.e. trials with disjunction when both disjuncts are true). The forced-choice judgment task suggests that children find such cases unproblematic while analysis of their spontaneous feedback shows that they provided more corrections to the puppet. Second, a common explanation for why children fail to derive0 implicatures is that they cannot access the stronger alternative to the disjunction *or*, namely *and* (Barner et al., 2011). However, in the context of the guessing game, some children explicitly mentioned the word *and* as what the puppet should have said instead of *or*. Interestingly, these children continued to reward the puppet and considered the guess "right". This raises the possibility that children's forced-choice truth value judgments, whether with two or three alternatives, do not fully reflect their pragmatic knowledge. In study 3, I used both a 2AFC truth judgment task and an analysis of children's open-ended feedback. If the findings of study 2 were on the right track, I expected to replicate the same pattern in study 3: the analysis of children's spontaneous linguistic feedback provides more evidence that children are sensitive to pragmatic violations than the results of the 2AFC judgments.

6.4 Study 3: Children's 2AFC judgments and open-ended feedback

This study used the same paradigm as study 2 but focused on children's open-ended feedback and aimed at replicating the findings in study 2. The main hypothesis was that four-year-olds provide corrective feedback to the puppet if both disjuncts are true, but they do not consider this infelicity to be grave enough to render the guess itself "wrong". The main hypothesis along with relevant analyses and predictions were preregistered in an "As Predicted" format⁵. The study used a 2AFC judgment task to compare with the open-ended feedback results. The prediction was that children would provide corrective feedback to the puppet when both disjuncts were true, yet consider the guess "right" and not reflect this infelicity in their truth value judgments. This is what the study

⁵The As Predicted pdf document is accessible at <https://aspredicted.org/x9ez2.pdf>.

found.

6.4.1 Methods

Table 6.6: Summary of Study 1, 2, and 3 Methods

Study	N	Age	Mode	Response Options
Study 1 - Part 1	57	Adults	Online (Mturk)	Wrong, Right
Study 1 - Part 2	52	Adults	Online (Mturk)	Wrong, Kinda Right, Right
Study 2	42	3;1-5;2 (M = 4;3)	Study Room	Circle (Wrong), Little Star (Little Right), Big Star (Right)
Study 3	50	3;6-5;9 (M = 4;7)	Study Room	Yes (Right)/No (Wrong) - Open-ended Feedback

Materials and Design

Study 3 was similar to Study 2 but differed in how children provided their judgments. Based on the findings in Study 2, I focused on verbal judgments and feedback, instead of rewards. I used two different ways of measuring children's judgments. First, I encouraged children to provide verbal feedback to the puppet. They were asked to say "yes" when the puppet was right, and "no" when he was not. They were also encouraged to help the puppet say it better when he was not right. After children were done with this initial open-ended feedback, for each trial I asked a forced choice yes/no judgment question: "Was Jazzy (the puppet) right?". This question elicited a "yes" or "no" response for each trial independent of their earlier open-ended response. These two measures allowed me to compare open-ended and forced-choice judgments.

Participants and Procedure

I recruited 50 English speaking children from the Bing Nursery School at Stanford University. Children were between 3;6 and 5;9 years old (Mean = 4;7). The setup and procedure were similar to Study 2, except there were no rewards on the table. As before, participants sat through three phases:

introduction, instruction, and test. The introduction phase made sure children knew the names of the animals on the cards. In the instruction phase, they received four training trials, as shown in Table 6.7.

As in Study 2, the experimenter put a sleeping mask over the puppet's eyes and explained that Jazzy (the puppet) was going to guess what animal was on the cards. He then picked the first card and asked the puppet: “*What do you think is on this card?*” The puppet replied with “*There is a dog*”. The experimenter showed the cat-card to the child and said: when Jazzy is *not right*, tell him “no”. He then asked the child to say “no” to the puppet. The second trial followed the same pattern except that the puppet guessed *right* and the experimenter invited the child to say “yes” to the puppet. There were two more instruction trials before the test phase began. This contained 16 randomized trials, half of which contained guesses with the words *and* and *or*. The randomization code as well as the details of the methods are on the online repository for this dissertation at https://github.com/jasbi/jasbi_dissertation_LearningDisjunction.

Table 6.7: Instruction Trials for Study 3.

Card	Guess	Response
CAT	there is a dog!	No!
ELEPHANT	there is an elephant!	Yes!
DOG-ELEPHANT	there is a cat!	No!
DOG	there is a dog!	Yes!

6.4.2 Results

I first look at the results of the 2AFC judgement task for each trial type and compare them to those of the adults' in Study 1. Then I analyze children's open-ended responses and compare them to the forced choice responses obtained in the same trial types. For the 2AFC judgments I excluded 26 trials (out of total 800) where children either did not provide a Yes/No response or provided both (i.e. “Yes and No”). The exclusions were almost equally distributed among different types of guesses and cards. In the analysis of children's open-ended feedback, I excluded 8 trials (out of total 800) where children either did not provide any feedback or their feedback could not be categorized into the existing categories.

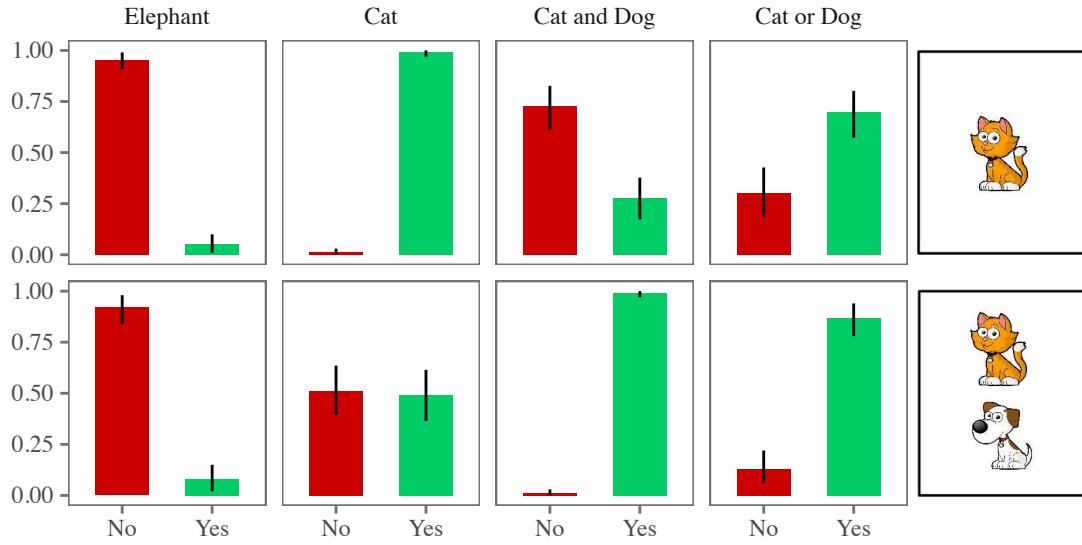


Figure 6.13: Children's binary truth value judgments.

Two-Alternative Forced Choice Judgments

Figure 6.13 shows children's 2AFC judgments. In the leftmost column, when the animal guessed was not on the card (e.g. elephant), children considered the guess "wrong". When the animal guessed was the only animal on the card (e.g. cat), children considered the guess "right". However, if the animal guessed (e.g. cat) was only one of the animals on the card, children were equally split between "wrong" and "right" judgments. On the other hand, almost all adults considered such guesses "right" in their 2AFC judgments (Figure 6.4). In such trial types, children seem to interpret the guess "there is a cat" as "there is **only** a cat", while adults do not. This difference between children and adults is unexpected for a theory of meaning acquisition that assumes children are overall more logical or literal as interpreters than adults (Noveck, 2001).

In the trials with *and* and *or*, children's judgments were similar to those of adults. Figure 6.14 compares adults' and children's 2AFC judgments. In trials with conjunction, when only one of the animals was on the card, most children considered the guess "wrong". This is similar to adults' judgments, but different in extent: adults were more consistent and unanimous in rejecting such guesses. A mixed effects logistic regression with the fixed effect of age category (adult vs. child) and random effect of subject found no significant difference between adults' and children's responses in such trials (see Table 6.8, Conjunction - One Animal).

Table 6.8: Mixed effects logistic models for conjunction and disjunction trials when only one disjunct was true, in 2AFC judgments of adults and children, using `glmer` in R's `lme4` package. Formula: $\text{Response} \sim \text{AgeCategory} + (1|\text{Subject})$.

Trial Data	Coefficient	Standard Error	Z-Value	P-value
Conjunction - One Animal	-2.05	2.86	-0.72	0.47
Disjunction - One Animal	1.34	1.79	0.75	0.45

In conjunctive guesses where both animals were on the card, both children and adults were unanimous in considering the guess “right”. In disjunctive trials when only one of the animals was on the card, most children considered the guess “right”. This is again similar to adults but differs from them in extent: adults more consistently and unanimously judged such guesses as “right”. Yet again, a mixed effects logistic regression with the fixed effect of age (adult vs. child) and random effect of subject found no significant difference between adults' and children's responses in such trials (see Table 6.8, Disjunction - One Animal). Adults and children showed almost identical patterns of judgments in trials where there was two animals on the card and the guess used the connective *or*. Children and adults did not differ in their rate of rejecting disjunctive guesses when both disjuncts were true. Finally, there is a small but significant preference in children's judgments of disjunctive statements for both disjuncts to be true. Comparing the disjunctive trials with one animal and two animals on the card, a mixed-effects logistic model with the fixed effect of disjunction type and the random effect of subjects found that children had a slight preference for both animals to be on the card ($b = 1.85$, $se = 0.56$, $z = 3.32$, $p < 0.001$). There was a similar small trend in children's three-alternative judgments in study 2. While this was quite small compared to the other effects observed in these studies, it nevertheless indicated a difference between children's and adults' judgments. I return to this in more detail in section 6.5.1 of the General Discussion.

Open-ended Feedback

Figure 6.15 shows the distribution of children's feedback to the puppet in Study 3 (see Table 6.5 for the definitions and examples of feedback categories). There were no “None” responses in this study since the experimenter explicitly asked children to provide feedback to the puppet. The distribution of the responses in the other three categories (Judgment, Description, and Correction) revealed a

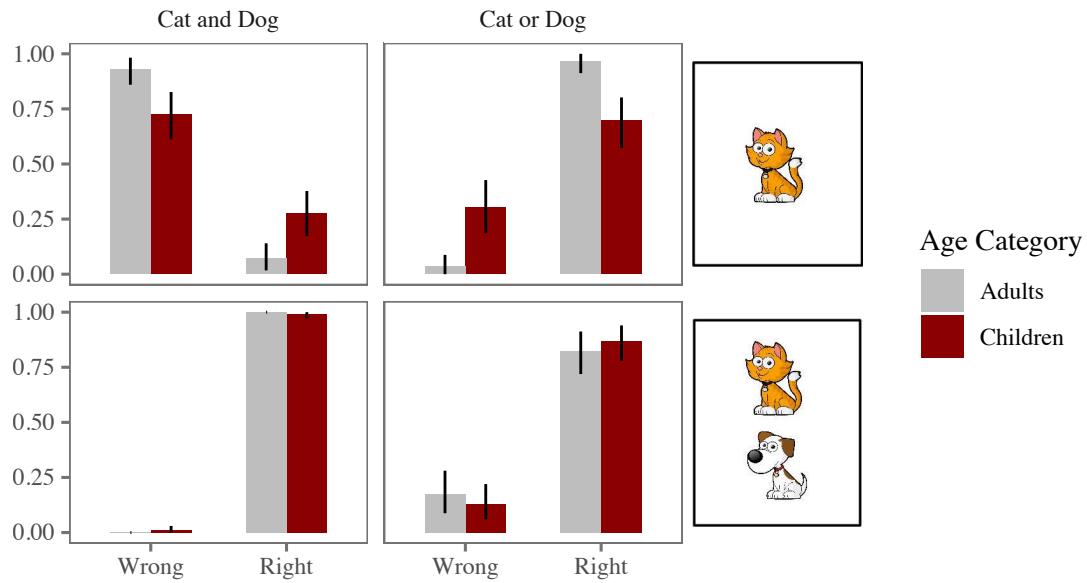


Figure 6.14: The comparison of the 2AFC judgment task for conjunction and disjunction trials in adults (study 1) and children (study 3).

successful replication of Study 2.

Children's feedback showed four main patterns. First when the puppet guessed an animal not on the card (e.g. elephant), there is a split pattern between negative judgments like "no!" and simple descriptions of what was on the card, e.g. "cat!". Children provided no corrections on such trials. Second, almost all children responded with positive judgments like "yes" when the puppet's guess accurately matched what was on the card. This was the case in trials where there was only one animal on the card (e.g. cat) and the puppet mentioned it, as well as trials where there were two animals on the card and the puppet mentioned both with a conjunction (e.g. cat and dog). Third, children provided the largest number of corrective feedback in trials where the guess was either false or infelicitous. These included three trial types: (a) the ones where there were two animals on the card but the puppet only guessed one (e.g. cat); (b) the ones where the puppet guessed two animals with conjunction (e.g. cat and dog) but only one of them was on the card; and (c) the ones where there were two animals on the card, and the puppet guessed both but used a disjunction (e.g. cat or dog). The fourth general pattern was unique to disjunctive trials with only one animal on the card. In such cases, almost all children simply named the animal on the card (e.g. "Cat!"). Figure 6.16 breaks down children's open-ended feedback based on whether children said "yes", "no", or

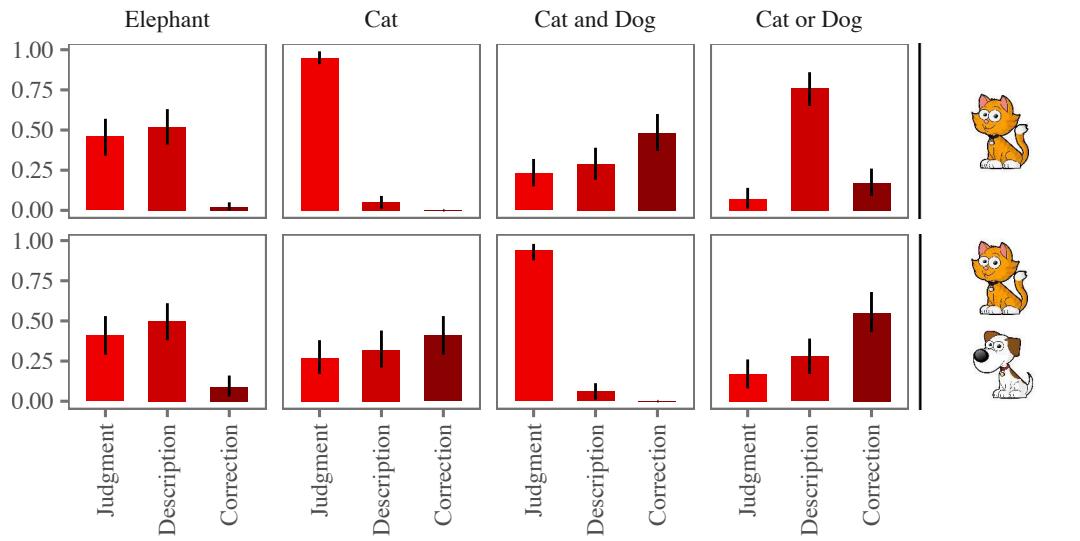


Figure 6.15: Children's Open-ended Feedback in Study 3. Error bars represent 95% confidence intervals.

said something else. Responses that were not “yes/no” judgments are grouped in a middle category shown with a dash. The goal here is to compare children’s open-ended judgments with their forced choice judgments shown in Figure 6.13. Children’s open-ended judgments and their forced choice judgments in study 3 show similar patterns for all types of guesses except for disjunctive ones. In trials that the puppet guessed with *or*, the vast majority of children refused to provide a “yes/no” judgment when they were not forced to. Instead, they described the animal on the card or provided corrections to the puppet’s infelicitous disjunctive guess.

One way to interpret these results is that disjunctive guesses (with at least one disjunct true) are considered neither right nor wrong by almost all children. When children were forced to provide wrong-right responses in the experimental context, some conformed to the adult patterns of judgment and some did not. However, it is possible that such deviations from adult judgments do not reflect differences in the comprehension of disjunction, but rather differences in how children map their adult-like comprehension onto the notions of “right” and “wrong” in a forced choice judgment task. In other words, it is possible that children and adults only differ in how they behave when they are forced to respond with a fixed set of options. Figure 6.17 is similar to Figure 6.16 but it uses color-fill to show what children said in addition to “yes/no”. The gray color represents the trials where children only said “yes/no” and nothing else. The yellow-fill represents descriptions where

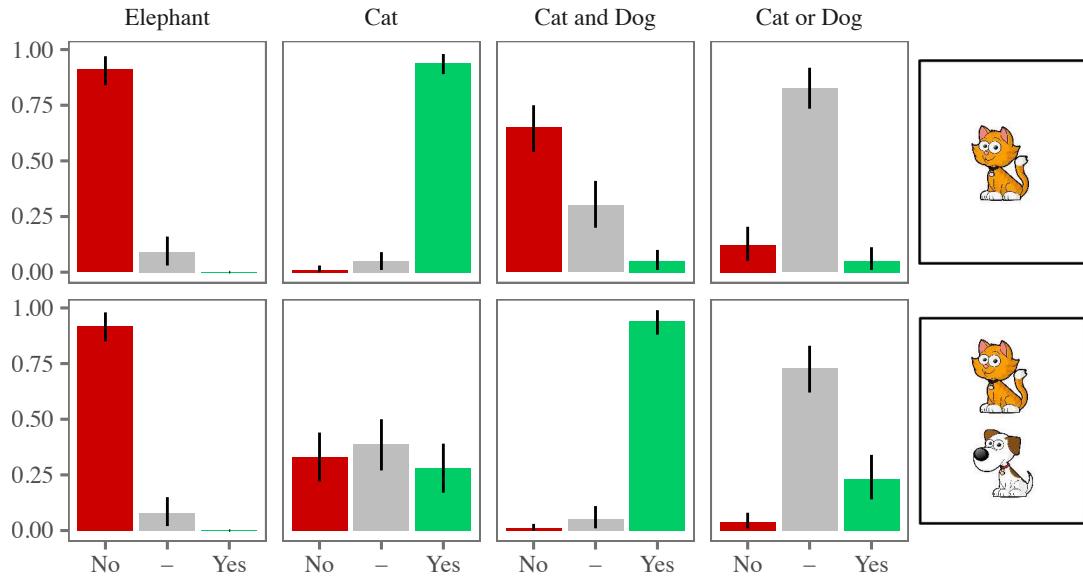


Figure 6.16: Children's open-ended feedback to the puppet's guesses. The x-axis shows whether children spontaneously provided a yes (green), no (red), or other response (grey).

children mentioned the animal on the card (e.g. “cat!”). The blue fill represents children’s corrective feedback that used the exclusive focus particles *just* or *only* (e.g. “just a cat!”). Such a corrective feedback suggests that the guess included an animal that did not belong and should have been excluded. Finally the red fill represents the inclusive corrective feedback that emphasized the word *and* or said *both* (e.g. “Both!”, “cat AND dog!”). Such corrective feedback indicated that both animals should have been mentioned.

As shown in the leftmost column, when the puppet mentioned an animal that was not on the card (e.g. elephant), children responded with a simple “no” or “no” followed by what was on the card (e.g. no! elephant!). When there was only one animal on the card and the puppet mentioned the animal (e.g. cat), children responded with a simple “yes”. However, when the card had two animals (e.g. cat and dog) and the puppet only mentioned one of them (e.g. cat), children were likely to provide inclusive feedback. They said *both* or emphasized *and*, as in “cat AND dog”. However, in such trials children were equally split between saying “yes”, “no”, or neither.

In the trials with conjunctive and disjunctive guesses, when there was only one animal on the card (e.g. cat) and the puppet used a conjunction (e.g. cat and dog), children were likely to say a simple “no” or say “no”, followed by “only/just” (e.g. no, just a cat). Some children did not say “no”

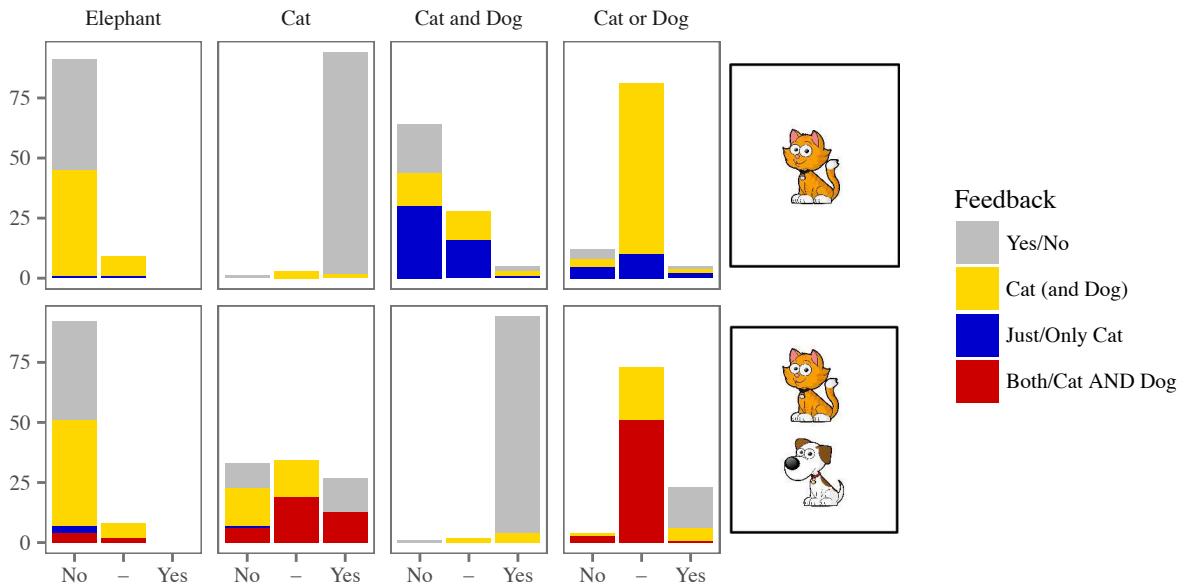


Figure 6.17: Children's open-ended feedback. The x-axis shows whether children said yes or no and the color fill shows what children said other than yes/no.

but did respond with “only/just”. When the card had two animals on it and the puppet mentioned both using *and*, children responded with a simple “yes”. In trials with disjunctive guesses like “cat or dog”, children avoided yes/no responses. Instead, when the card had only one animal, children mentioned that animal. When the card had both animals, children said *both* or emphasized the word *and*, as in “cat AND dog”. Figure 6.18 shows the same feedback data in Figure 6.17 but uses the x-axis to also show the proportion of feedback categories other than yes/no judgments. My goal here is to display the trial types with corrective feedback (blue and red). These trial types include: (1) conjunction when only one conjunct is true, (2) disjunction when both disjuncts are true, and (3) simple guesses (e.g. “there is a cat”) when two animals were on the card. These trial types involved guesses that are either false or infelicitous. Furthermore, the type of corrective feedback children provided matched the type of mistakes made in the guesses. With conjunctive guesses like “cat and dog” when there was only one animal on the card (e.g. cat), children provided exclusive corrections (e.g. just/only a cat), suggesting that the other animal (e.g. dog) should have been excluded. When two animals were on the card and the puppet used a disjunctive guess like “cat or dog”, or simple guess like “cat”, children provided inclusive feedback, suggesting that another animal should have been included. This is particularly notable in the case of disjunction since both

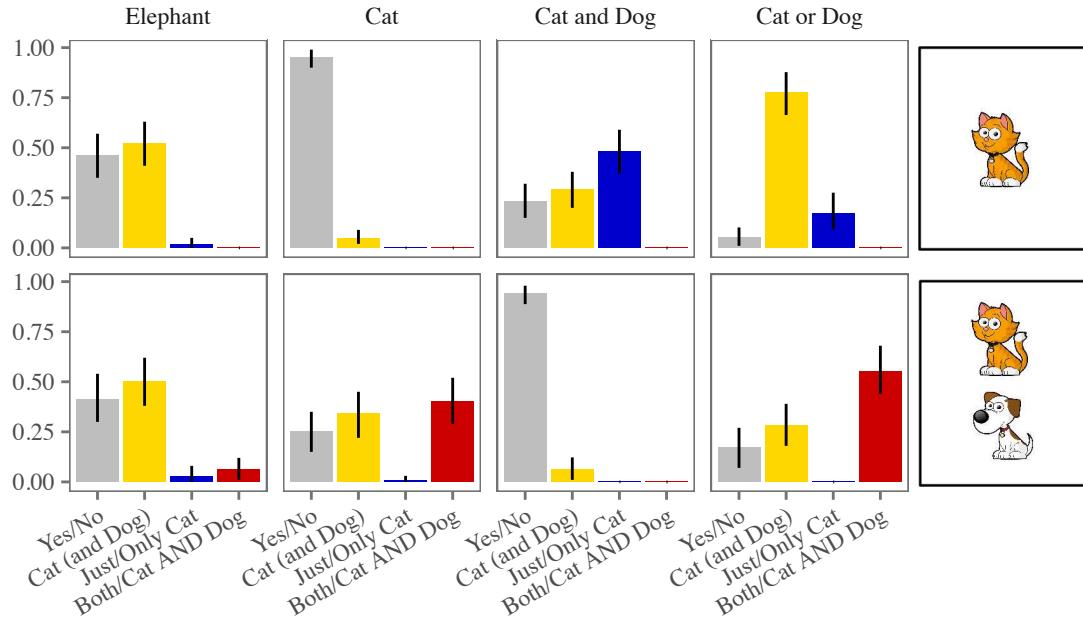


Figure 6.18: Children's feedback categories in disjunction trials.

animals were mentioned, but children still emphasized that the connective *and* should have been used, or that both animals mentioned were on the card.

6.4.3 Discussion

Study 3 measured children's comprehension of logical connectives by asking them to judge a puppet's guess in two ways: with open-ended feedback and with a two-alternative forced choice task. First, I asked children to say "yes" to the puppet if he was right and "no" if he was wrong. However, children could provide any form of feedback they wanted. Second, I followed children's open-ended feedback with a two-alternative forced choice question: "Was the puppet right?" This way, I could measure children's comprehension in two different ways in the same trial. Ideally, both measures should show similar results. However, the findings were similar for conjunctive guesses, but not disjunctive ones. Children avoided binary right/wrong feedback with disjunction and preferred to provide more nuanced feedback when they could.

The 2AFC responses followed the predicted pattern: conjunctive guesses were judged wrong if only one conjunct was true, and right if both were true. Disjunctive guesses were judged right whether one or both disjuncts were true. There was no significant difference in the 2AFC task

between the responses of children and those of adults in Study 1.

Children's open-ended feedback in Study 3 replicated the findings of Study 2. Children provided more corrective feedback in false and infelicitous trials than in true and felicitous ones. The corrective feedback was tailored to the puppet's mistake. If the puppet used a conjunction when there was only one animal on the card, children pointed out that the other animal should have been excluded using the exclusive adverbials *just* and *only*. If the puppet used a disjunction when both animals were on the card, children stressed *and* or *both*, implying that both animals should be included.

While the 2AFC results suggested that children take no issue with disjunctive guesses when both disjuncts are true, the analysis of their corrective feedback showed that they provide appropriate corrections in such cases and emphasize that the connective *and* would have been a better guess. Taking both measures together, I conclude that even though children are aware of the problem with such guesses, they do not consider them *wrong*. These results are similar to those I reported for adults in Study 1.

6.5 General Discussion

I reported three studies on adults and four-year-olds' comprehension of the logical connectives *and* and *or*. The first study used two- and three-alternative forced choice judgment tasks with adults. In the 2AFC task, adult interpretations closely matched the semantic accounts of *and* and *or* as conjunction and inclusive disjunction. The judgments did not register robust signs of pragmatic infelicities. However, the 3AFC judgment task, showed signs of pragmatic infelicities, especially in disjunctive guesses with true disjuncts. When both disjuncts were true, participants were more likely to choose "kinda right" rather than "right".

The second study used a 3AFC judgment task with four-year-old children. It also included an exploratory analysis of children's open-ended verbal feedback to the puppet in the experimental setting. Children's interpretations were similar to those of adults in the 3AFC task and only differed for pragmatically infelicitous disjunctions. When both disjuncts were true, adults tended to judge disjunctive guesses as "kinda right". This was evidence for the pragmatic infelicity of such guesses. While, children judged such disjunctive statement as "right", the analysis of their open-ended feedback showed that they took issue with such statements as well, and provided appropriate corrective feedback.

In the third study, I focused on eliciting open-ended verbal feedback from children and followed it with a 2AFC task. In the 2AFC task, children's responses reflected the semantics of connectives as conjunction and inclusive disjunction. There was no significant difference between children and adults in the two-alternative judgments. Since the 2AFC task appeared to be a good indicator of semantic knowledge, it seemed reasonable to conclude that adults and four-year-olds displayed similar semantic knowledge of the connectives. Analysis of the children's open-ended feedback replicated the findings in study 2. Children provided more corrective feedback in false and pragmatically infelicitous trials with logical connectives than in felicitous trials. The comparison of the 2AFC task and children's open-ended responses shows that children are sensitive to the infelicity of disjunctions with true disjuncts, even though they consider them to be "right" guesses.

Overall, I did not find any major differences between adults' and four-year-old children's interpretations of logical connectives *and* and *or* in the context of the guessing game. However, there were two minor differences. First, I found that in both 2AFC and 3AFC judgment tasks, children showed a small preference for disjunctions with both disjuncts true rather than only one. Adults on the other hand showed the opposite pattern: they preferred disjuncts with only one disjunct true. Second, in both 2AFC and 3AFC judgment tasks, children rated disjunctions with both disjuncts true higher than adults did. That is, they considered utterances like "there is a cat or a dog" when both animals were on the card "right" more often than adults. Here I will discuss these two differences and their possible causes in more detail.

6.5.1 Preference for True Disjuncts

First for some children, there was a small preference for both disjuncts being true, compared to only one. This effect is similar in kind but not magnitude, to an effect that Singh et al. (2016) and Tieu et al. (2016) reported. In my study this effect is quite small while Singh et al. (2016) and Tieu et al. (2016) seem to have found bigger effects. Based on this, Singh et al. (2016) proposed that many children at this age-range have a pragmatically driven conjunctive interpretation of disjunction. In short, due to a non-adult like alternative set to the connective *or*, children strengthen a disjunctive statement pragmatically and derive a conjunction. The studies reported here provide no support for this proposal. In both 2AFC and 3AFC judgments, children clearly differentiated between disjunctive and conjunctive guesses. Furthermore, analysis of children's open-ended feedback showed distinctly

different response patterns for conjunction and disjunction. More importantly, the open-ended feedback to disjunctive guesses showed the opposite pattern to that predicted by the conjunctive hypothesis. Children took issue with disjunctions that had both disjuncts true and provided more corrective feedback in such cases. Therefore, the findings from Singh et al. (2016) and Tieu et al. (2016) appear to be a product of experimental design rather than a real reflection of children's comprehension of the connectives.

However, even if this small preference for true disjuncts is not due to the method of measurement, it can be accounted for in several other ways that have not yet been successfully ruled out. First, the conjunctive interpretation may not be due to a faulty pragmatic computation, but rather a default conjunctive interpretation when the connective is not properly heard, understood or is unknown. To check this hypothesis, it should be possible to test children's comprehension of novel or noisy connectives. A novel coordination like *cat dax dog* with *dax* as a nonce connective could well be interpreted as a conjunction. Such a result would suggest that in studies with high cognitive demand, children may default to a conjunctive interpretation if they miss the relevant connective. Second, the conjunctive preference could be due to some children's preference for the linguistic labels to match the animals on the card (or more generally a match between linguistic description and the state of the world). This hypothesis is consistent with the results in the other trial type that had a mismatch in the number of animals and the guess, where the guess was still technically true: simple guesses (e.g. there is a cat) with two animals (e.g. cat and dog). Children were equally split between "wrong" and "right" in their judgments here, while adults considered such guesses "right". In light of these alternative explanations, I am hesitant to attribute this small preference to a pragmatically driven conjunctive interpretation of disjunction.

6.5.2 Lack of Infelicity with True Disjuncts

The second difference between adults and children emerged in the 3AFC judgment task: in disjunctive trials (e.g. "cat or dog") with two animals (e.g. cat and dog), adults were more likely to choose "kinda right" than children were. Children mostly chose "right". This response pattern has been taken to mean that children found no infelicity with such disjunctions or that they did not "derive an exclusivity implicature". The absence of an infelicity/implicature is consistent with the generalization that children are more likely than adults to interpret scalar terms literally, and that children

do not compute implicatures or judge infelicity to the same **rate** that adults do (Pouscoulous & Noveck, 2009, Katsos (2014)). But why is that?

There have been three major proposals to account for children's low rate of implicatures: 1. processing (Pouscoulous, Noveck, Politzer, & Bastide, 2007; Reinhart, 2004) 2. non-adult-like lexical entry (Barner et al., 2011; Horowitz, Schneider, & Frank, 2017) and 3. pragmatic tolerance (Katsos & Bishop, 2011). Here I show that none of these accounts can provide a satisfactory explanation of the results in this study.

1. Processing. First, the processing accounts locate the problem in children's processing capacities such as working memory. They suggest that pragmatic computations are cognitively taxing and children lack the appropriate processing resources to carry them out appropriately. A prediction of processing accounts (at least in their current format) is that children will show reduced implicature computations for all types of implicatures – scalar or ad-hoc. This prediction was not borne out in my experimental results. In Study 3, children were much more likely than adults to call a simple guess (e.g. “cat”) “wrong” in the 2AFC task if there were two animals on the card (e.g. “cat and dog”). Processing accounts do not predict that children would derive more implicatures than adults but this is what I found for the traditional interpretation of the judgment task.

2. Non-adult-like Lexicon. Several proposals blame the structure of the child's lexicon for the alleged failure in deriving implicatures. The assumption is that the child's lexical entry for scalar items must include three elements for successful derivation: 1. the semantics of the weak term (e.g. *some, or*) 2. the semantics of the strong term (e.g. *all, and*); and possibly 3. a scale that recognizes the stronger term as an alternative to the weaker one (e.g. *<some, all>, <or, and>*). Each of these elements have been pinpointed as the source of the problem in previous studies (Barner et al., 2011; Horowitz et al., 2017; Katsos & Bishop, 2011). However none of them seem to apply to the results reported here.

If children in this study lack the semantics of the connective *or*, I would expect them to either perform at chance or default to a conjunctive interpretation. Neither prediction was borne out in studies 2 and 3. Furthermore, children's free-form linguistic feedback suggests good understanding of disjunction. So this explanation seems unlikely. The problem cannot be that children do not know the meaning of *and* either. Children's performance in both study 2 and 3 for conjunction trials show that they understand its meaning very well. Finally, while it is possible that children

lacked the appropriate lexical scale and could not access the stronger alternative, this explanation cannot be the whole story. Several children in both studies stressed the word *and* suggesting that the puppet should have used the stronger term instead. However, they judged the puppet's guess as "right". If children could not access the stronger term, they would not have mentioned it in their feedback either.

3. Pragmatic Tolerance. Katsos & Bishop (2011) suggested that children tend to tolerate pragmatic infelicities more than adults. They showed that when children are provided with a 2AFC judgment task, they tolerate the infelicity of *some* when *all* applies but when they are presented with a 3AFC task they choose the middle option and report this infelicity. As in a processing account, the pragmatic tolerance account predicts that scalar and ad-hoc implicatures will be similarly affected. However, my results did not match those of Katsos & Bishop (2011). When children were presented with a 3AFC task, they chose the highest reward (and not the middle option) for uses of *or* when *and* applied. Second, and more importantly, I found different patterns for ad-hoc and scalar implicatures as mentioned before. This is not predicted by the tolerance account unless children are assumed to be more tolerant towards violations of scalar implicatures than they are towards ad-hoc ones. While tolerance may not be the source of the problem here, I believe that a number of discussions including those by Katsos & Bishop (2011) and later Katsos (2014) do point to an important factor: the role of measurement in estimates of children's pragmatic capacity.

Several observations in the current studies provide support for the hypothesis that methodological issues, and more specifically issues of measurement contribute to the differences found between adults and children in pragmatic capacity. First, Study 1 showed that even for adults, the estimates of adult infelicity rates may differ based on the number of alternatives in the forced choice task. A 2AFC task tends to underestimate adults' rate of response to pragmatic infelicity. Second, children's open-ended linguistic feedback in the experimental context better reflected their sensitivity to pragmatic nuances than the forced-choice judgment tasks. Third, children showed a higher rate of infelicity judgments for cases of ad-hoc implicatures (simple guesses with two animals on the card) than adults did. While a difference in sensitivity to ad-hoc vs. scalar implicatures has been reported and argued for before (Horowitz et al., 2017; Stiller, Goodman, & Frank, 2015), a higher sensitivity than adults is not predicted by any of the current accounts.

In order to better understand the differences between adults and children's pragmatic capacities,

it is necessary to have a good understanding of how measurements affect estimates of adults and children's performance in the experimental tasks. Children may be no more capable of making exhaustive inferences than adults and no less capable of making scalar inferences either. They may simply have a different construal of the wrong-right scale and of what the forced-choice task is about. The concepts "right" and "wrong" are as much subject to developmental change and differences between adults and children as are scalar items in general. It is reasonable to assume that children's understanding of what constitutes as "right" or "wrong" does not fully conform to that of adults. However, it remains to be established what these differences are and how they affect the estimates of children's pragmatic abilities. It is important to point out that such issues of measurement could be the culprit behind both children's seemingly slight preference for true disjuncts described earlier and the lack of infelicity judgments when both disjuncts are true.

A General Approach for Measuring Implicature/Infelicity Rate

Methodological issues are nothing new in studies of children's semantic and pragmatic development. Developing better measures of children's linguistic capacities has always been a major concern for researchers in the field. My goal here is to propose some future steps that can address the methodological concerns in measuring children's pragmatic development.

As Pouscoulous & Noveck (2009) and Katsos (2014) have suggested, the central issue is "the rate" at which children and adults manifest pragmatic reasoning in the experimental setting. No one doubts children's capacity to perform such computations. At issue is the extent to which children and adults compute specific implicatures. The claims are that children perform such computations less often than adults; or that children do not perform such computations where adults normally do. In the previous section, I discussed some factors that might account for these differences including processing demands, the structure of the lexicon, tolerance, as well as issues of measuring adults and children's comprehension. As Katsos (2014) pointed out, it seems reasonable to assume that all these factors play some part here. What matters is the degree to which each contributes to the outcome. Figure 6.19 shows the factors that affect pragmatic computations as well as the observations of the rate of pragmatic computations in an experiment. First it is important to distinguish between factors that affect pragmatic computations and those that affect the observed rate in an experimental setting. As I showed in Study 1, given the number of alternatives in the forced choice task (2AFC vs. 3AFC), I may get different estimates of adults' infelicity judgments, yet it is unreasonable to

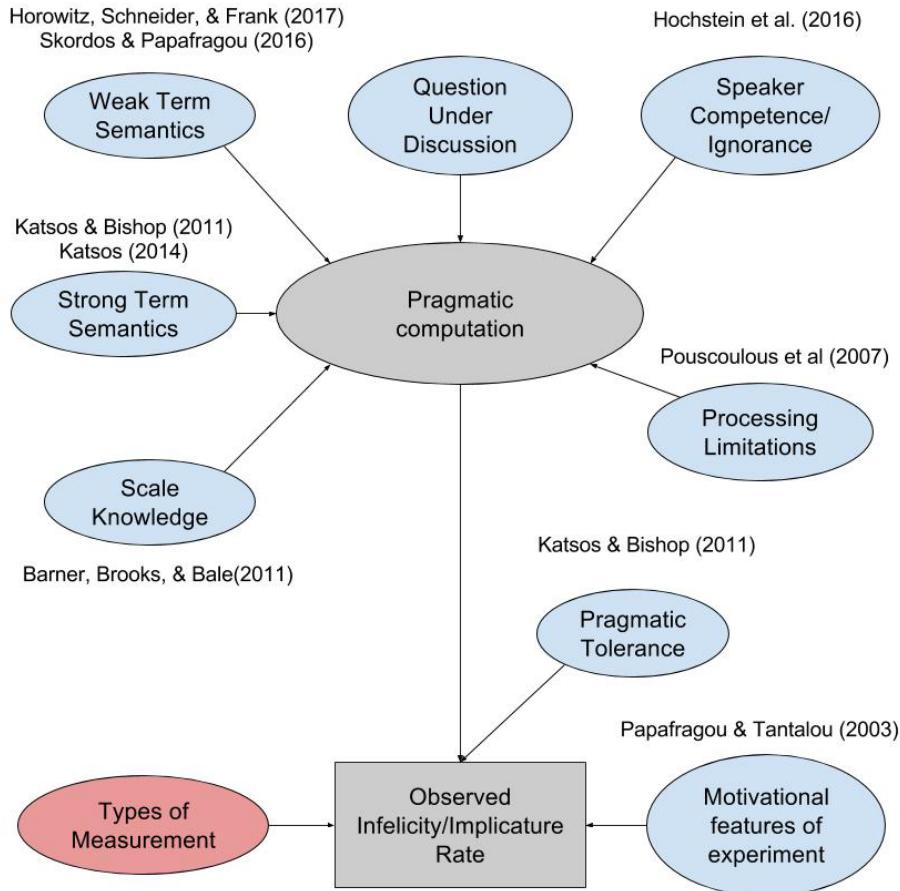


Figure 6.19: Factors that could affect pragmatic computations and the estimates of these computations in the experimental settings

assume that there is a difference in adults' pragmatic capacities in these two tasks. A similar situation exists when I compare children's forced choice measures of infelicity and their open-ended feedback. In disjunctive trials where both disjuncts are true, the forced choice tasks show no sign of children detecting infelicity while the open ended responses show that children are sensitive to the infelicity of disjunction when a conjunction would have been more appropriate.

6.6 Conclusion

To conclude, I have shown that children and adults do not differ substantially in their **semantic** knowledge of the logical connectives *and* and *or*. The results were highly consistent with the current accounts that posit the semantics of *and* as logical conjunction and *or* as logical (inclusive) disjunction. With respect to pragmatic knowledge, the three-alternative forced choice judgment task showed that adults are sensitive to the infelicity of disjunctive statements when both disjuncts are true. I also showed that while the three-alternative judgment task failed to register such a sensitivity for children, my systematic analysis of children's verbal open-ended verbal feedback showed that children are sensitive to pragmatic infelicities and can provide appropriate corrections to infelicitous utterances containing logical connectives.

Chapter 7

Conclusion

This dissertation engaged with two questions at the intersection of meaning and development. First, how do children learn the meaning of function words? Second, how do children learn the meaning of a disjunction word like *or* in English? The first question is broad and can be answered by investigating children's acquisition of different types of function words across languages. That is what the second question is about, focusing on the word *or* in English. In addressing the second question, my goal was to engage with the broader question of function word acquisition in children and build on previous research in this area. In this section, I first summarize how this dissertation addressed the narrower question of learning disjunction in English. Then I show how the findings can shed light on the broader issue of learning function words.

I started this dissertation with a summary of the research in semantics and pragmatics on disjunction. In language, disjunction can give rise to a number of implications. These implications include truth-functional ones such as inclusivity, exclusivity, and conjunctivity, as well as non-truth-functional ones like ignorance, and indifference. On the face of it, what a disjunction implies may seem arbitrary. Since Grice (1989), however, decades of research have provided mounting evidence that the implications of a disjunction arise systematically through its interaction with other linguistic and sociopragmatic factors that shape the overall interpretation of an utterance. Chapter 2 discussed a non-exhaustive list of these factors, including the intonation of the disjunction, the semantic relation of the disjuncts themselves, the linguistic environment of the disjunction, as well as the communicative intention of the speaker. I argued that the interpretive factors discovered and

discussed in theoretical semantics and pragmatics inform research in child language acquisition by providing a list of cues that may help children interpret a disjunction and learn the meaning of *or*.

How often do children hear examples of *or*? Chapter 3 used a large body of child-directed speech to address this question. It found that compared to *and*, *or* is relatively rare in child-directed speech. Per one thousand words, parents produced about 15 instances of *and* and only 1.5 instances of *or*. The study also found that on average, children produced *or* less often and later than *and*. Per thousand words, children produced about 15 instances of *and* but only 0.5 instances of *or*. Children started producing *and* between 1;0 and 1;6 years of age, but began to produce *or* only at 1;6 to 2;6 years. Furthermore, children reached their parents' rate of *and*-production around age 3, but did not reach their parents' rate of *or* production in the first six years of their lives. Morris (2008) had suggested that this developmental asymmetry between *and* and *or* was due to the differences in the frequency and usage of these connectives in child-directed speech. Chapter 3 provided another possible factor, namely the asymmetries in the social and conversational roles of parents and children. Parents and children do not communicate the same types of messages to each other. For example, it is not surprising to hear a parent say "go to your room" to a child. However, a child saying the same phrase to a parent is surprising and unexpected!

My large scale corpus study found that parents ask more questions of children than children do of parents. In addition, the disjunction word *or* is more likely to occur in the context of questions than of declaratives. Therefore, parents may be producing more instances of *or*, simply because they ask more questions. When I compared the production of *or* in declaratives and questions, I saw that children were closer to the parents' rate of *or* in declaratives. This finding suggests that the asymmetry between *and* and *or* may be due at least in part to the differences in speech acts produced by parents and children, and not necessarily to added difficulty for the disjunction word *or*. More generally, since the presence or absence of a function word depends on the overall communicative function of the utterance, it is important for production studies to control for the types of speech acts produced. Children may not produce a function word at the same rate as their parents simply because they do not produce the types of speech acts where that function word is typically used. Not reaching the parents' rate of production, therefore, does not necessarily imply incomplete acquisition. The large scale corpus study of Chapter 3 showed that on average, children start producing the connectives *and* and *or* around 1 to 2 years of age, and continue until they reach

a relatively steady rate of production around age 4.

The findings of the large scale corpus study are in line with comprehension studies that suggest children can interpret both connectives at the age of 4 years. Several studies in the past decade have shown that at age 4, children can interpret *or* as inclusive disjunction (Crain, 2012). However, Morris (2008) reported that the vast majority of examples children hear, and in fact produce, receive an exclusive interpretation. How can we reconcile these two findings? How can children learn an inclusive interpretation for *or* if they rarely hear it? I referred to this as the puzzle of learning disjunction. To answer this question, Chapter 3 also provided an annotation study. Examples of *or* were annotated for their interpretations, as well as several other features such as intonation, the semantic relation of the disjuncts, and their communicative functions. This study replicated the finding of Morris (2008): exclusive interpretations of *or* are more common than the inclusive ones in child-directed speech. However, the study also found that exclusive interpretations are systematically accompanied by certain cues, most notably, a rise-fall intonation or the presence of inconsistent disjuncts like “stay or go”. When these cues were absent, *or* received an inclusive interpretation.

From the findings of the annotation study, I derived a learning account that addressed the puzzle of learning disjunction. I referred to this account as the cue-based context-dependent acquisition of *or*. Previous literature on disjunction seem to assume that *or* is mapped to its most likely interpretation as observed by the learner. I called this the default account. Morris (2008) found exclusive disjunction to be the most common interpretation of *or* in child-directed speech, and proposed that children initially learn its meaning as exclusive. To support this, he showed that *or* is also exclusive in children’s early productions. As mentioned before, comprehension studies found that preschool children (in the same age range) were more likely to interpret a disjunction as inclusive. How can this be?

An important property of the default account is that it disregards the context of *or* when learning its meaning. In Chapter 4 I argued that such a context-independent mapping of *or* to its meaning is the source of the learning puzzle for disjunction. I suggested that a small change to the default account could solve this problem. Instead of mapping the word *or* directly, independent of context, to its interpretations, disjunction as a whole can be mapped along with any available contextual cues to an interpretation. This way, it is not *or* that is interpreted as exclusive, but rather *or*

with a rise-fall intonation or with inconsistent disjuncts. In the absence of these cues, the most likely interpretation of a disjunction would be inclusive. When contextual cues are used to learn the interpretation of a disjunction, the learner can know which contexts favor an inclusive inclusive, and which an exclusive one. The modeling experiments of Chapter 4 showed that such a cue-based context-dependent learning is successful in classifying examples of disjunction as inclusive versus exclusive. Crucially, inclusive interpretations were more likely in the context of declarative sentences with flat intonation and consistent disjuncts. These are the types of sentences that comprehension studies used to test children's knowledge of disjunction. This account, therefore, shows how children can learn an inclusive interpretation for disjunction from an input dominated by exclusive examples.

In Chapter 5, I provided a review of the developmental research on children's comprehension of disjunction. Early studies in the 1970s and 1980s suggested that children and even adults struggle with understanding a disjunction. They either interpret it as exclusive or conjunctive. However, further investigations suggested that conjunctive interpretations might be attributable to non-linguistic strategies deployed when the task is too demanding or perhaps confusing to participants. More recent studies within a Gricean framework have suggested that children interpret *or* as inclusive disjunction. However, it is hard to compare the results between recent findings and earlier ones because they differ along several dimensions. The review concluded that future studies should control for the complexity of the linguistic stimuli, the complexity of the task, the ignorance of the speaker, the interpretation of the conjunction word (e.g. *and*) in the same task, and finally the interpretation of adults in the same task. Chapter 6 presented a set of experiments with children and adults that controlled for these factors.

In Chapter 6, I tested adults and children's interpretation of conjunction and disjunction in English existential constructions in the context of a guessing game. In each trial, participants saw a card and a blindfolded character guessed what animals were on the card. For example, the character guessed "there is a cat or a dog" when there was a cat and a dog on the card. Participants were asked to judge if the guess was right. In one set of experiments children and adults provided binary responses of "right" and "wrong"; in another set, ternary responses of "right", "a little right", and "wrong". The binary results found no statistically significant difference between children's and adults' truth judgments. The results of the ternary task found only that children were more accepting of disjunction when both disjuncts were true. For example, when the character guessed "cat or dog"

and both animals were on the card, children were more likely to say “right” and adults were more likely to say “a little right”. Overall, both adults and children provided inclusive interpretations for disjunction in the existential sentences of the guessing game. The results are compatible with the prediction of the cue-based context-dependent account presented in Chapter 4.

The studies in Chapter 6 also investigated children’s spontaneous feedback to the guesser, a puppet, in the experimental setting. Children’s feedback was divided into three categories: judgments (yes/no), descriptions (naming the animals), corrections (focusing what the puppet should have said). The results showed that children provided corrections when the guess was either false or infelicitous. Most notably, in trials where a disjunction like “cat or dog” was used and both animals were on the card, children judged the guess as “right” but provided corrections to the puppet. For example, they said “cat and dog”, emphasizing the word *and*. Some also mentioned the word *both*. The analysis of children’s linguistic feedback suggested that truth value judgments may underestimate children’s linguistic competence. I ended this chapter with the discussion of the methodological challenges in assessing and measuring children’s semantic and pragmatic knowledge.

What does the acquisition of *or* teach us about function words in general? First, the case of *or* in English shows that theories of word learning should not ignore the context of form-meaning mapping. Previous approaches to the acquisition of the lexicon often rely on isolating a word form, isolating a meaning, and mapping the form to the meaning. The case of *or* shows that “word form” can extend beyond the word to encompass the intonational contour on the whole disjunction. It also shows that “meaning” can extend to include the semantic relations of the disjuncts themselves, for example, whether they are consistent or inconsistent with each other. In order to successfully learn the interpretation of *or*, the learner must attend to the cues available in the context of the word.

The second lesson is methodological. The case of *or* shows that the development of function words is better understood if evidence is gathered from three sources: child-directed speech, children’s comprehension, and children’s production. In the case of *or*, each source provides invaluable and complementary insight about how children learn the meaning of *or*. Each source individually provides information that may miss crucial aspects of the full development. It is only when all three are taken into account together and reconciled, that a coherent developmental account emerges. Ideally, we construct formal models that use child-directed speech to predict children’s comprehension and production at a specific age. The aim of this dissertation was to take a first step in this direction.

My hope is that future work on similar functions words will extend, improve, and standardize this methodology to result in a general theory of function word acquisition.

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