

LEARNING DISJUNCTION

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DOCTOR OF PHILOSOPHY

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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 which 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 in

children’s input, such as intonation and the semantic relation of the alternatives *or* combines with. 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 currently assumed by our theories of word learning.

Dedication

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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 (E. V. 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 (E. V. 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 (E. V. 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. A. Baldwin, 1993; E. V. 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 function 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, 1996). 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 disjunction 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.

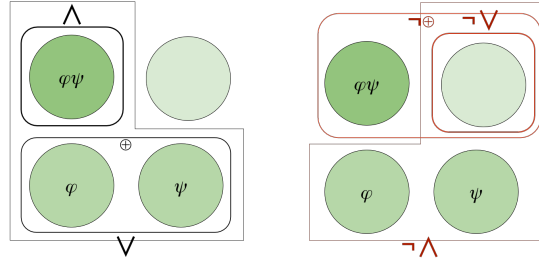


Figure 2.1: The relation between conjunction, inclusive disjunction, exclusive disjunction, and their negations.

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:

$$\neg(\phi \vee \psi) \Leftrightarrow \neg\phi \wedge \neg\psi$$

$$\neg(\phi \wedge \psi) \Leftrightarrow \neg\phi \vee \neg\psi$$

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
$A^T B^T$	Green			Green	Green	Green	Green		Green		Green					Green
$A^T B^F$	Green		Green		Green	Green		Green	Green			Green			Green	
$A^F B^T$	Green		Green	Green		Green		Green		Green	Green			Green		
$A^F B^F$	Green		Green	Green	Green		Green			Green		Green	Green			

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). 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 do 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

Example	IOR	XOR	AND	Ignorance	Indifference
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 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” (con 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

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

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 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 relevant information 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: $\$time = \sim / (+:)(+)(: (+)) ? /$], 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 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 similar to 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’t 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 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(\uparrow) or coffee \uparrow ?	yes/no	\vee
Alternative	Rise-Fall	Would you like tea \uparrow , or coffee \downarrow ?	tea/coffee	\oplus

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 unconditionals 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/or* in parents' and children's speech to answer two questions: 1. At what age do children start to produce *and/or*? 2. How does children's rate of production for *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/or* in child-directed speech. It sought to answer the following questions: 1. What are the most frequent interpretations of *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* & *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 important 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 *chldes-db* and its associated R programming package *chldesr* (Sanchez et al., 2018). *Chldes-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.

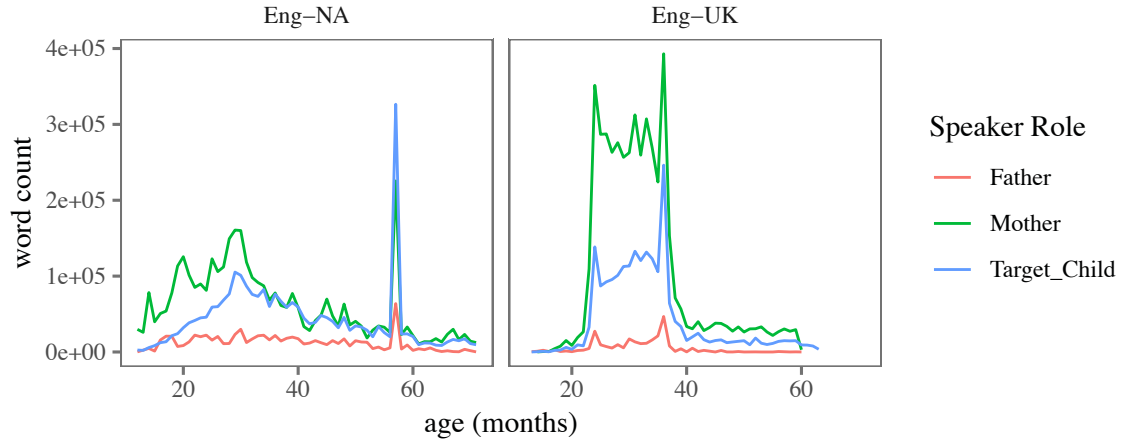


Figure 3.1: Frequency for all the words in the North America and UK corpora of CHILDES.

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, imparative) 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”.

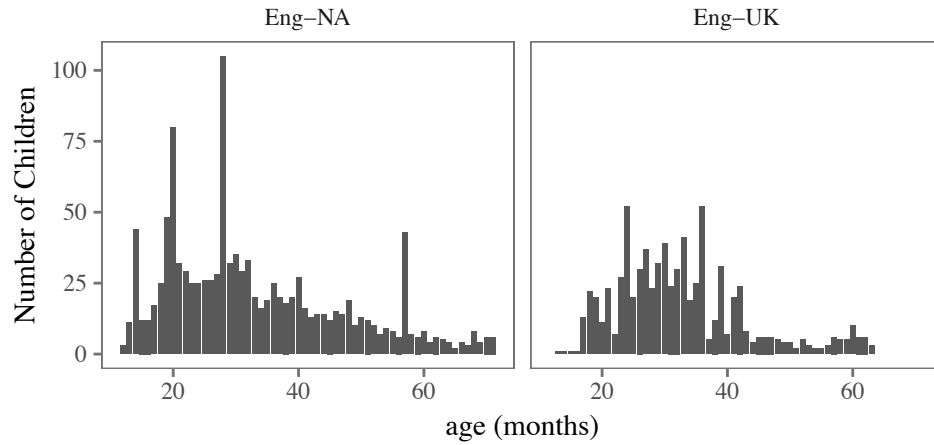


Figure 3.2: The number of children represented at different ages in the North America and UK corpora in CHILDES.

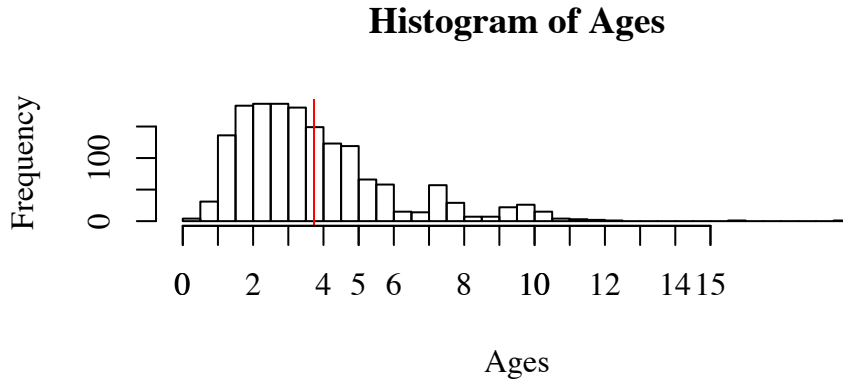


Figure 3.3: Distribution of children's ages at recording times. Mean age is shown using a red vertical line.

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 a better 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

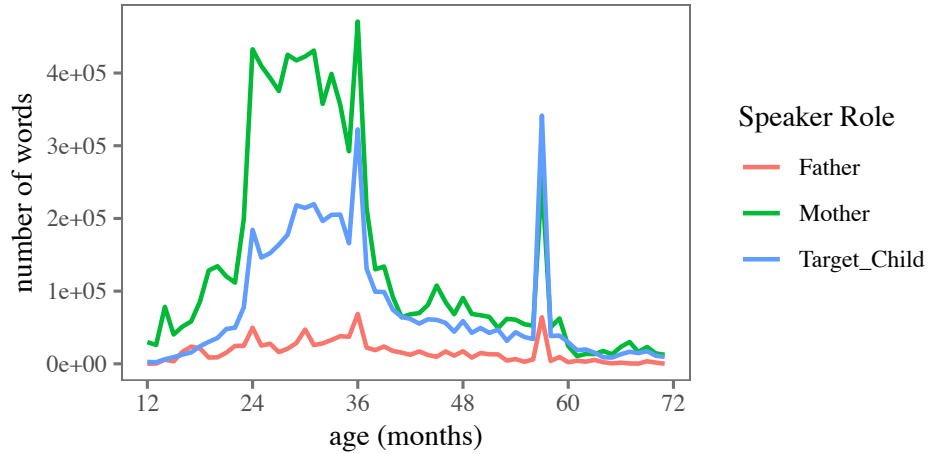


Figure 3.4: The number of words in the corpora for parents and children in each month of children's development.

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 on 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

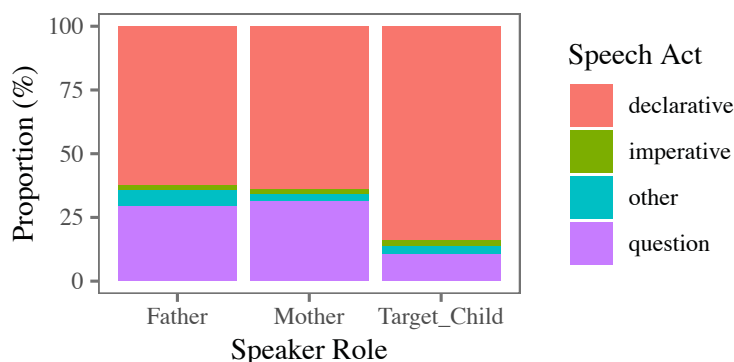


Figure 3.5: The proportion of declaratives and questions in children's and parents' utterances.

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 our 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 our 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.

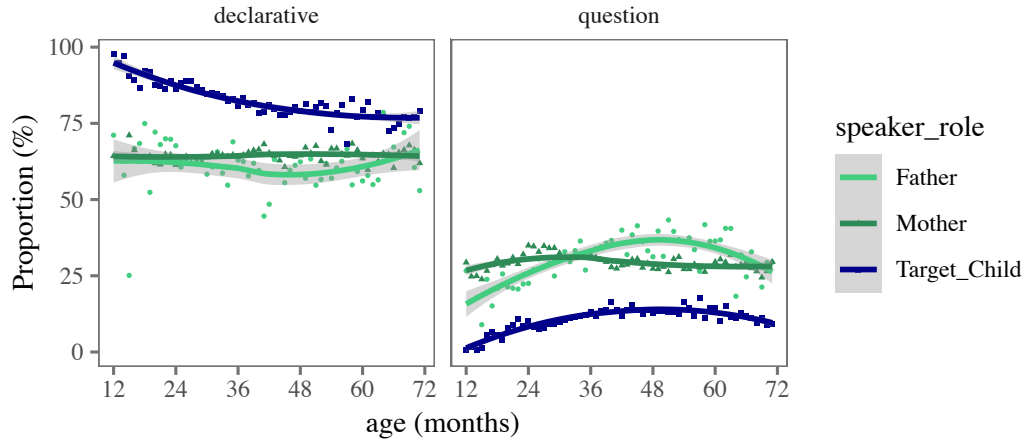


Figure 3.6: Proportion of declaratives to questions in parent-child interactions by age.

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

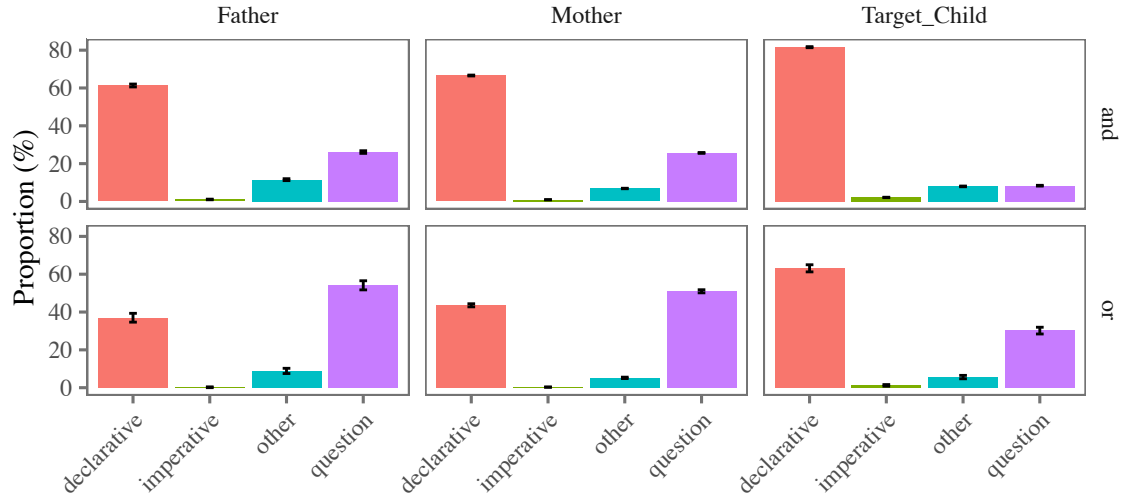


Figure 3.7: The proportion of *and/or* in different utterance types in the speech of parents and children.

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 our 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

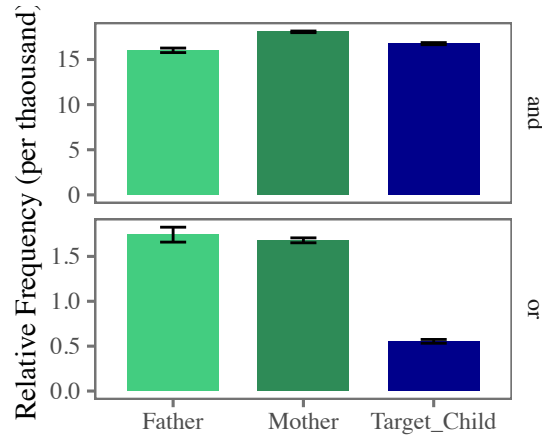


Figure 3.8: The relative frequency of *and/or* in the speech of fathers, mothers, and children. 95% binomial proportion confidence intervals calculated using Agresti-Coull's approximate method.

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 this

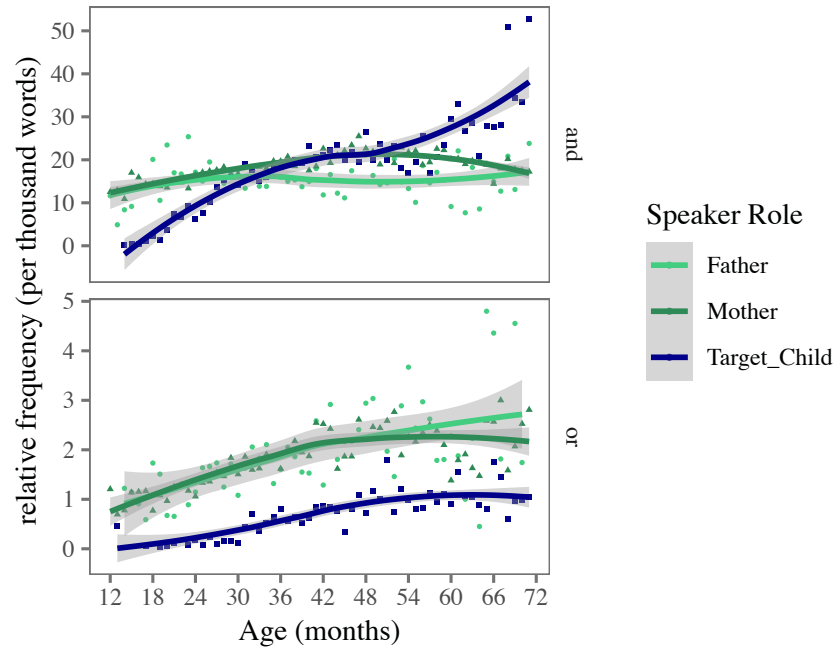


Figure 3.9: The monthly relative frequency of *and/or* in parents and children's speech between 12 and 72 months (1-6 years).

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 such an 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

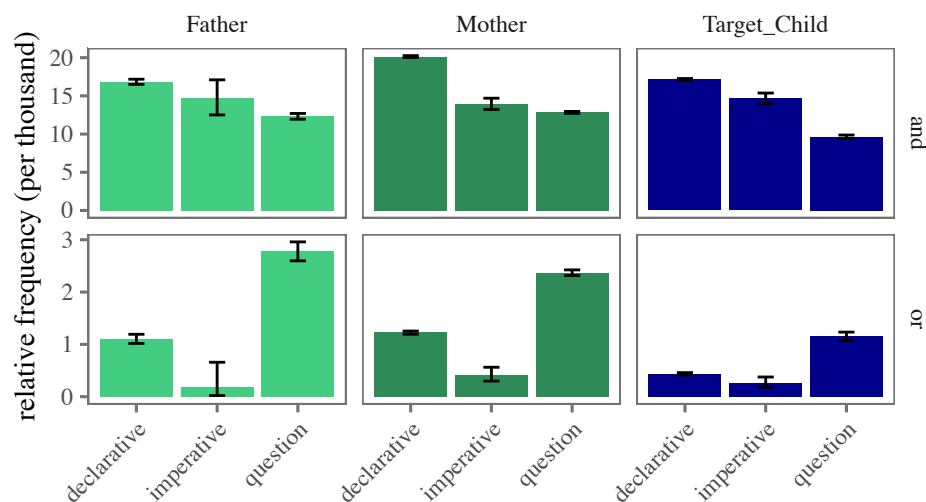


Figure 3.10: Relative frequency of *and/or* in declaratives, imperatives, and interrogatives for parents and children

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 are developed 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*. Looking at the monthly relative frequencies of *and* and *or* in the speech of parents and children, the study also found that

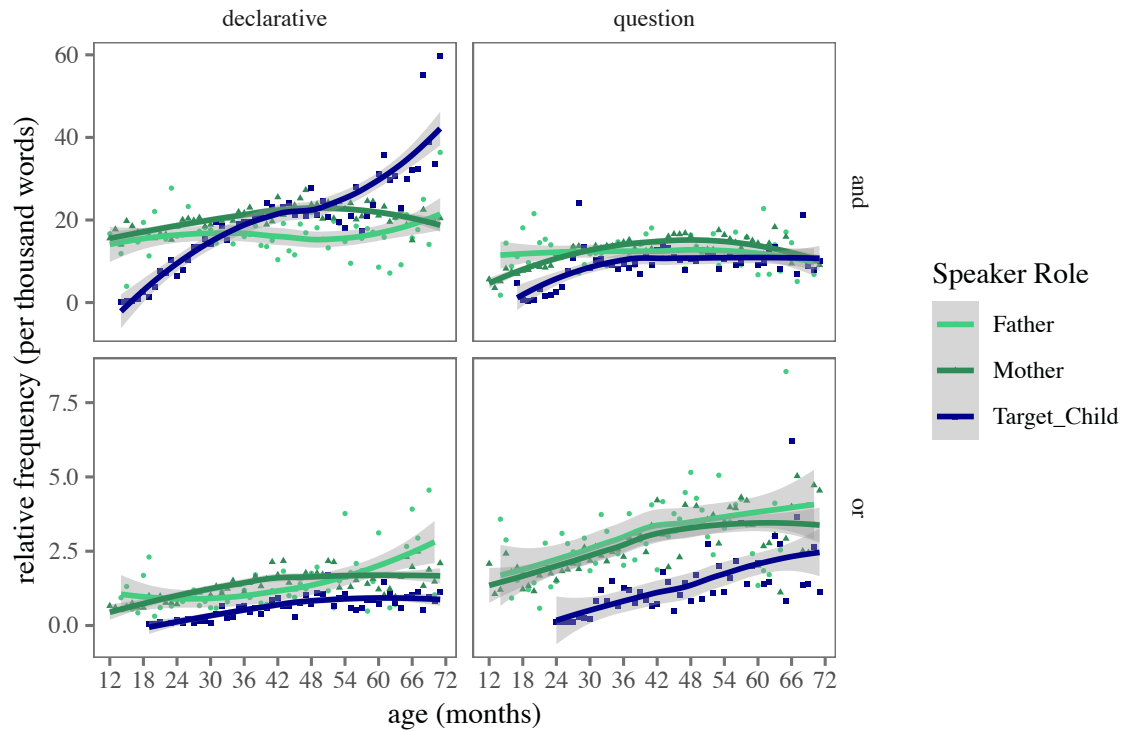


Figure 3.11: Relative frequency of *and/or* in declaratives and questions for parents and children between the child-age of 12 and 72 months (1-6 years).

children reach the 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* – can 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 in 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 from children than children from 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 show their own developmental trends. For example, the study found that children start with 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 is important to understand to what extent 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

Name	Age Range	Sessions
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, or 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 focussed on the coordinated construction as a unit 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 *ands* than *ors*, 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 sports (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, 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

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		Green	Green		Green	Green			Green			Green	
$A^F B^T$	Green		Green	Green		Green		Green		Green	Green			Green		
$A^F B^F$	Green		Green	Green	Green		Green			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.

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>“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.”</i>
IOR	One or both propositions are true	<i>“You should use a spoon or a fork.” – “Ask a grownup for some juice or water or soy milk.”</i>
XOR	Only one proposition is true	<i>“Is that a hyena? or a leopard?” – “We’re gonna do things one way or the other.”</i>
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>

Class	Meaning	Examples
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>
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 coordinand 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 drink 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>
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 much 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.” – “berries like blueberry or raspberry”</i>
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>

Function	Definitions	Examples
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>
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.” – “Come over here and I’ll show you.”</i>

Function	Definitions	Examples
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>

Type	Definitions	Examples
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 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

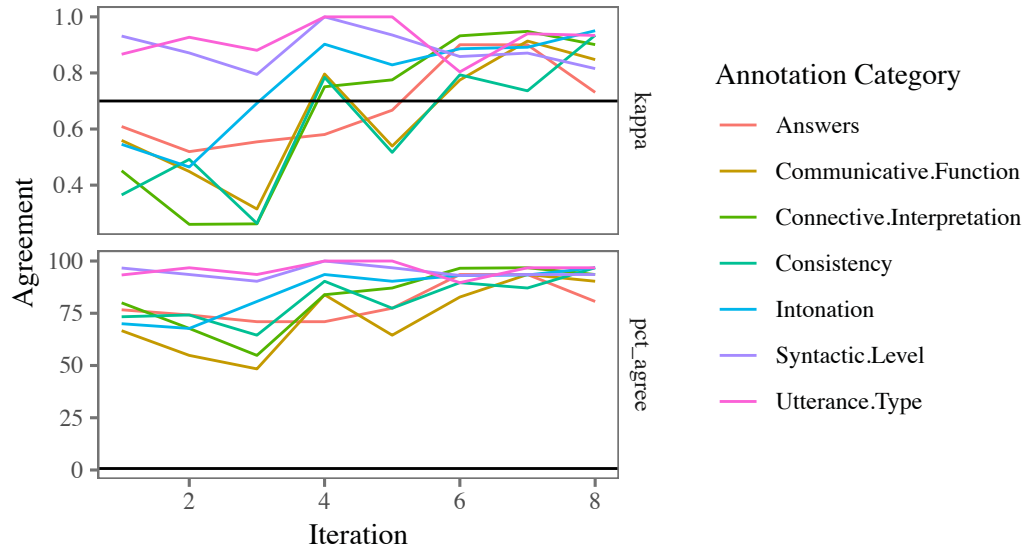


Figure 3.13: Inter-annotator agreement for disjunction examples.

flat intonation. Then the annotator would listen to the actual utterance and see which one better resembles 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 and 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 similar to disjunction examples. 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 the value of kappa. When one category is extremely common with high agreement while other 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 much 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,

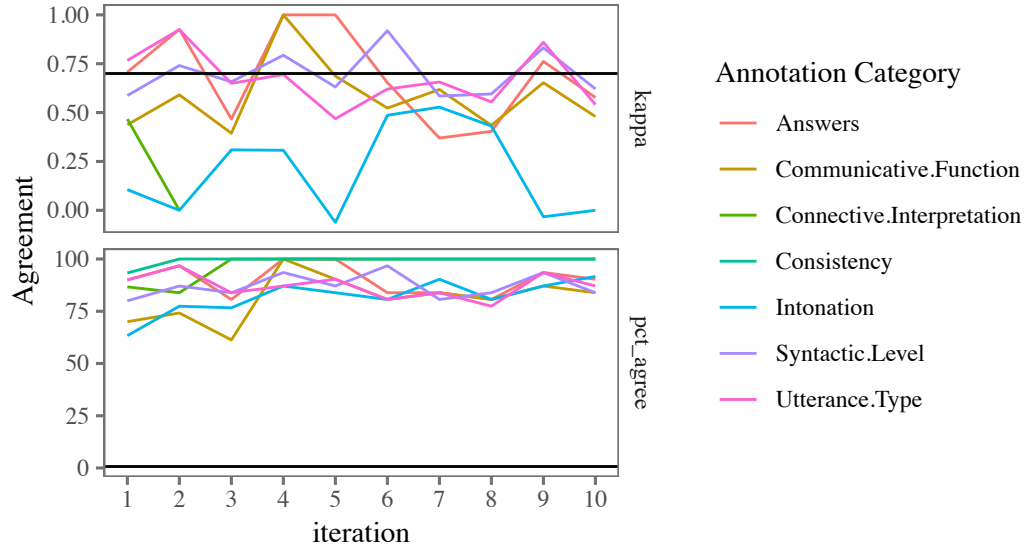


Figure 3.14: Inter-annotator agreement for conjunction examples.

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 very 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 very high agreement for these dominant classes.

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

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

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

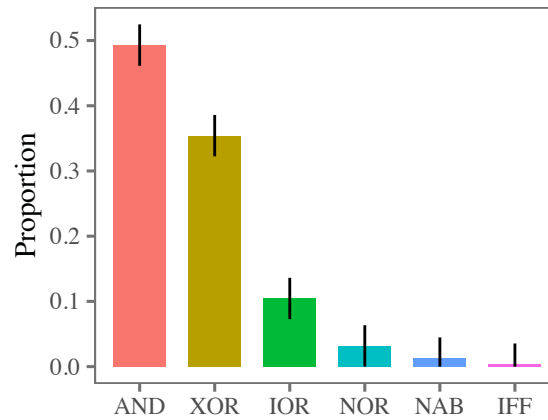


Figure 3.15: The proportion of different interpretations of the connectives *and/or* in child-directed speech

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 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

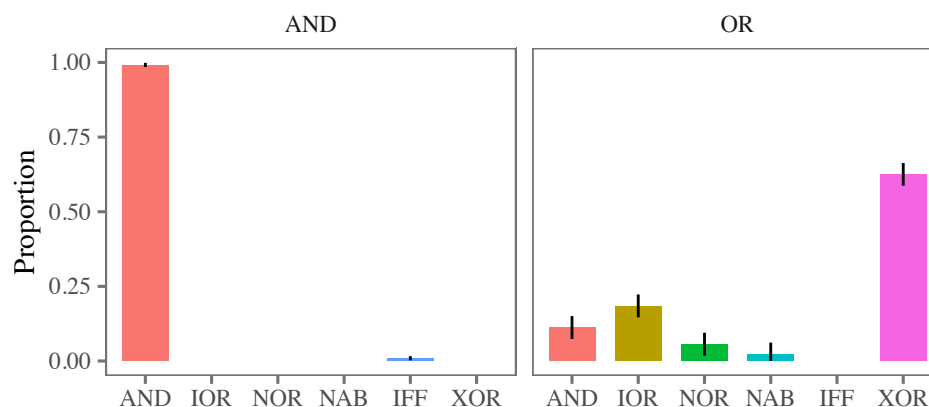
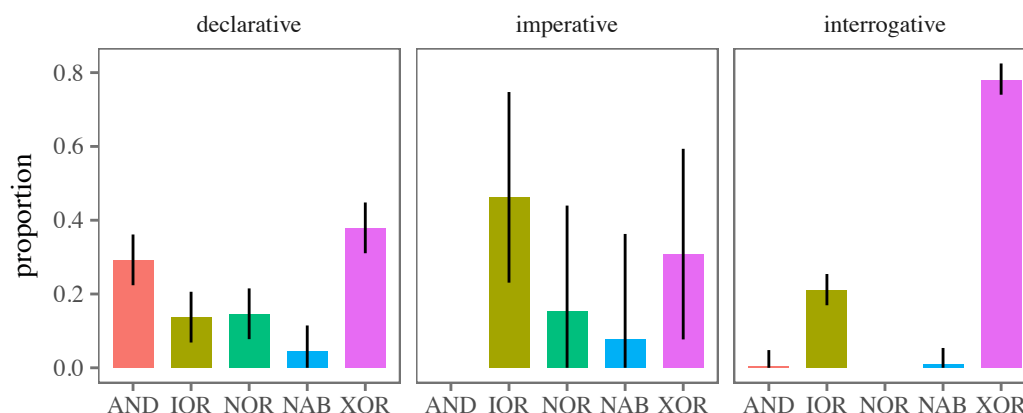
Figure 3.16: Interpretations of *and/or* in child-directed speech

Figure 3.17: Connective interpretations in different sentence types.

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. 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

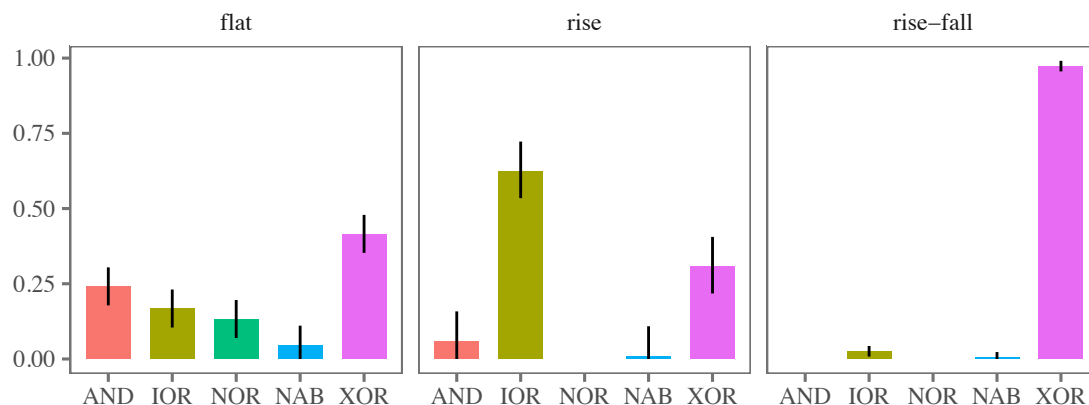


Figure 3.18: The distribution of connective interpretations in flat, rising, and rise-fall intonation.

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). A disjunction is more likely to be interpreted as inclusive (IOR) if the intonation is rising. 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 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

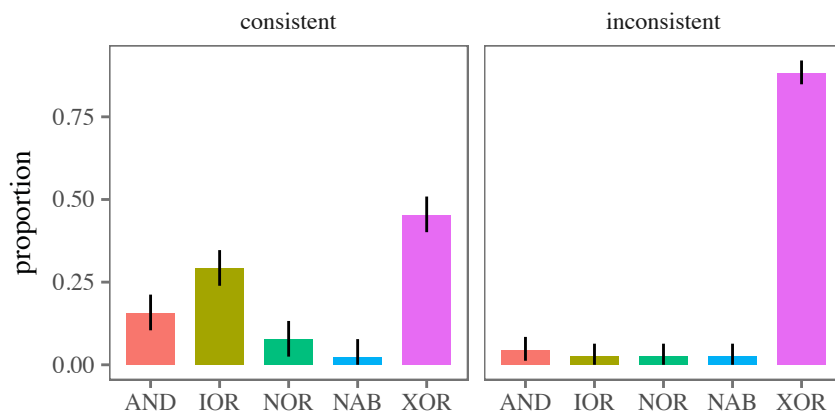


Figure 3.19: Connective interpretations in disjunctions with consistent and inconsistent disjuncts.

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 lists 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 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

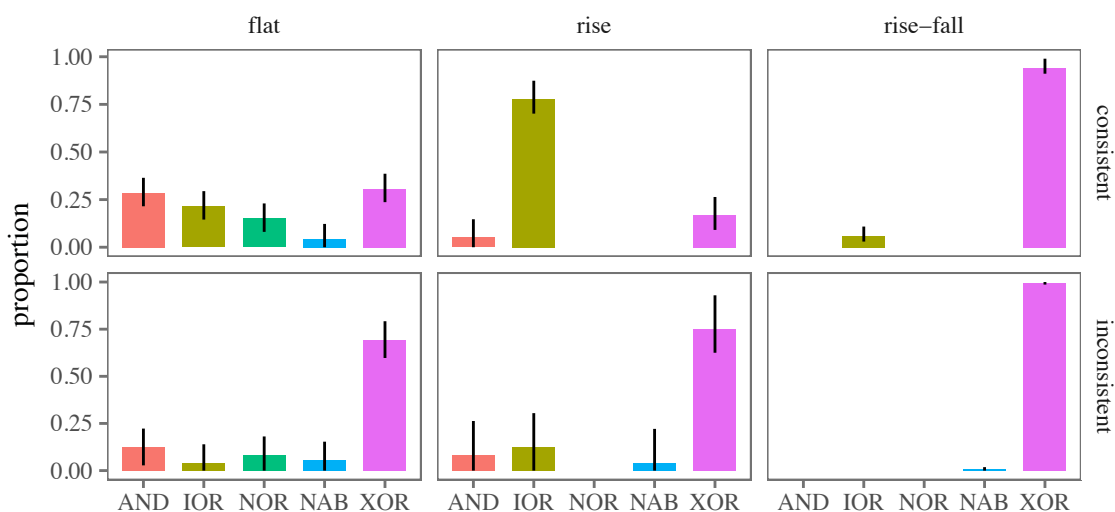


Figure 3.20: Interpretations of and/or in the three intonation contours flat, rising, and rise-fall.

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* 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

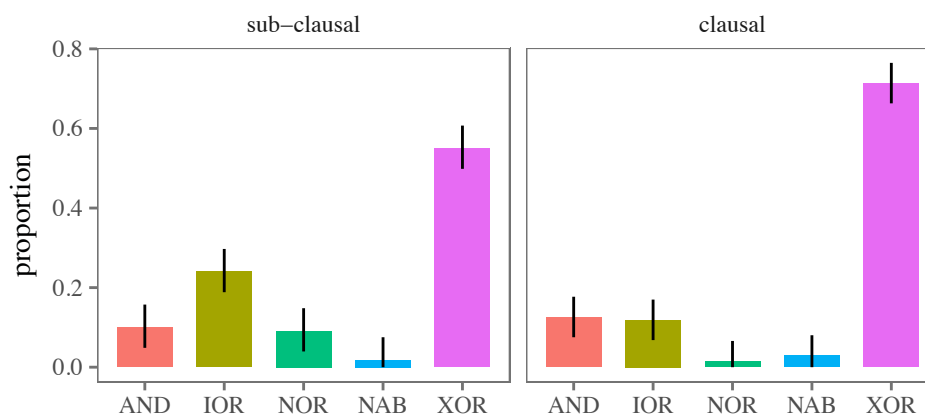


Figure 3.21: Connective interpretations in clausal and sub-clausal disjunctions.

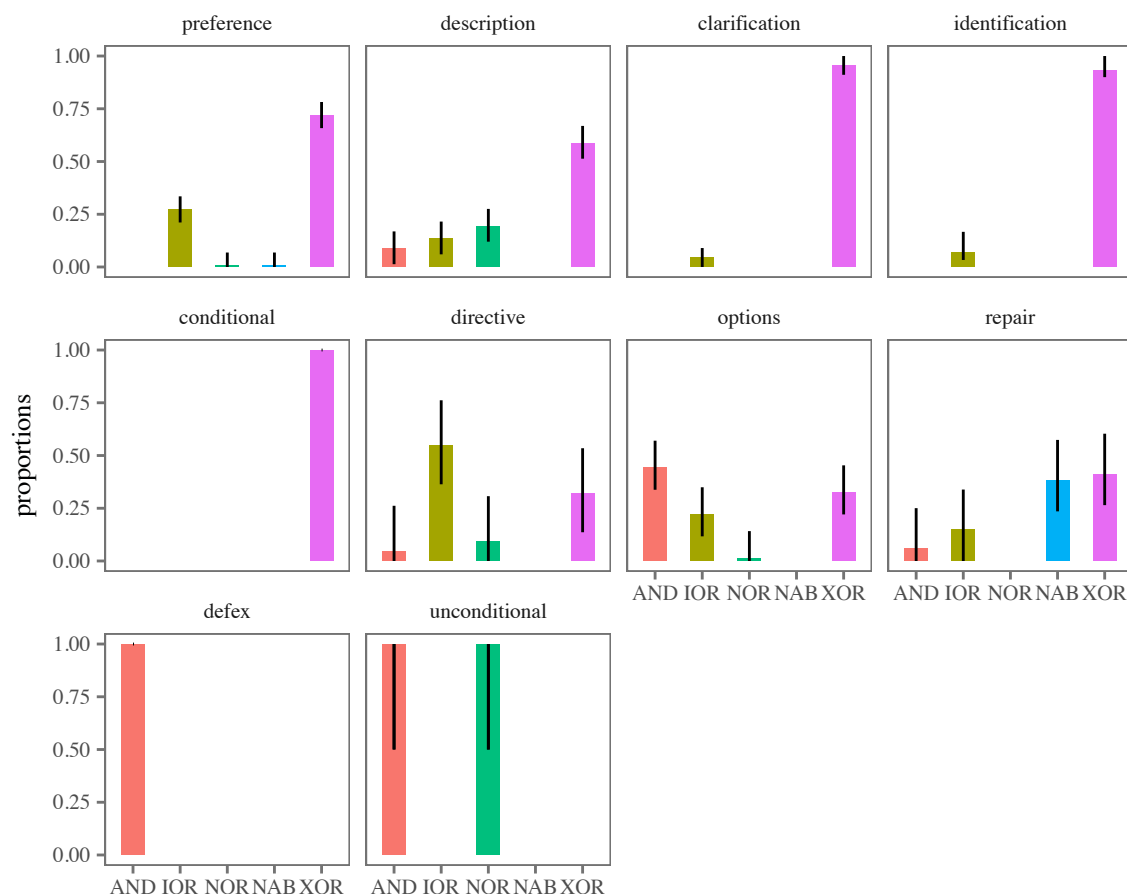


Figure 3.22: Connective interpretations in different communicative functions.

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 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

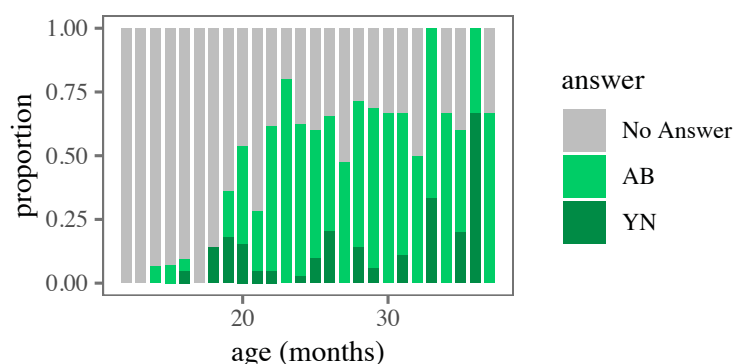


Figure 3.23: The proportions of children's answer types to polar questions containing the connective *or* at different ages (in months).

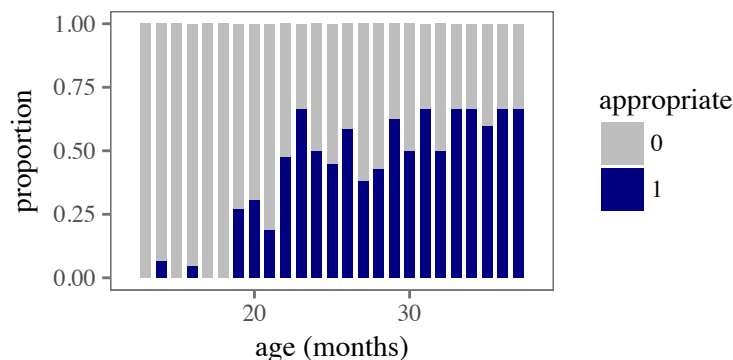


Figure 3.24: Proportion of children's appropriate responses

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*.