A Study of Preschool Children's Reasoning with an Exclusive Interpretation of "Or"

By

Katia E. Jorgensen

Supervisor:

Bradley J. Morris Ph.D.
Department of Psychology
Grand Valley State University
Allendale, MI

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Abstract

There is a debate between psycholinguists and logicians about whether people use an *exclusive or* interpretation (XOR) or an *inclusive or* interpretation (IOR), and when an understanding of each emerges in development. In past studies the youngest participants have been 6 yrs old, therefore the present study looks at *or* interpretations in preschoolers ranging in ages from 3 to 6 yrs old, and at how context and negation affect *or* interpretations. Experiment 1, 2, and 3 had the same 35 participants, 12 3 year olds, 18 4 year olds, 4 5 year olds, and 1 six year old. In Experiment 1 participants placed toys in a basket according to a request, in Experiment 2 they watched a video of a teacher and student playing the game and decided whether the student answered correctly, and in Experiment 3 they watched a video without volume and had to decide what the teacher told the student to put in the basket. XOR was used more often than IOR in Experiment 1, whereas in Experiment 2 IOR was used more than XOR. In Experiment 3 IOR was never used to describe two objects placed in the basket. A Wilcoxon signed-rank test was used to analyze the data, and showed that there was a significant difference in distribution of *or* interpretations according to age in Experiment 1 ($W=.000$, $p<.05$) and Experiment 2 ($W= .000$, $p<.05$). These experiments revealed that an understanding of *or* emerges at a much younger age than past research has shown.

Table of Contents

Table of Contents

Tables and Figures

A Study of Preschool Children's Reasoning with an Exclusive Interpretation of "Or"

Language Acquisition

Language acquisition is a well-studied area in psychology and many theories have been proposed about how language is acquired. The view taken here holds that language acquisition can best be explained from a dynamic approach that uses elements from all theories to explain how language is learned. Perhaps the most efficient way of understanding language acquisition is by examining how the emergence of developmental abilities interacts with theories as to how language is acquired. In so doing the concepts of cognitive mapping, overgeneralizations, mutual exclusivity, connectionism, and theories from Piaget and Vygotsky are addressed.

Cognitive mapping is a theory of how words are acquired. Word learning requires three cognitive maps to interact: auditory, articulatory, and conceptual. Newborns start cognitive mapping, or encoding, with the first sounds, or phonemes, they hear (MacWhinney, 1998). When distinctive phonemes and syllabic phrases are remembered, newborns attend to these familiar sounds more than unfamiliar sounds (Saffron, Aslin, & Newport as cited in MacWhinney, 1998). Additionally, infants seem to prefer stressed intonations and listen to them more intently than to non-stressed intonations (MacWhinney, 1998). From this research, it seems the brain prepares for language acquisition with the first sounds it hears.

Articulatory mapping begins at birth and is similar to auditory mapping. A study of infant crying done by Lewis in 1935 showed that articulation begins as early as birth with distinct forms of crying. Newborns start with the birth cry, moving on to pain, hunger, and pleasure crying (as cited in MacWhinney, 1998). Eventually the crying becomes more structured creating what is called cooing. Babbling follows cooing, which starts at about 11 months and approximates the mother language of the infant. The vocal production of infants continues to approximate language until the child can actually speak (Levitt, Utman, Aydelott, as cited in MacWhinney, 1998).

Conceptual mapping cannot be seen until just before word production begins; however, infants have concepts before this point. Because words are arbitrary, concepts get paired with words at the dynamic moment when an infant hears the auditory pattern and sees the visual representation. The connection is then made between the three pre-existing, but separate maps. Parents tend to help these connections to be made because they use "frames" when speaking. Syntactic frames help children to learn words and grammar. A typical structure occurs when a parent says to their infant, "Show me your nose." The infant learns the frame, "show me X"," which enables the infant to learn many other words that fit in the frame (Katz, Baker, & Macnamara, 1974).

The most recent theory of language acquisition is the connectionist perspective, which theorizes that language is learned as a result of neuron connections (Berk, 2003). The connectionist perspective simulates language learning by using computer programs that are organized into three layers: an encoding layer called the input layer, hidden layers that hold the needed information to perform a task, and finally an output layer which gives responses (Berk, 2003). All three layers can work at the same time, much like the brain, and function as if they acquired language (MacWhinney, 1998).

Word Meaning

Piaget and Vygotsky hold opposing views of language acquisition. Piaget's theories were based on the premise that the child is the initiator of learning (Phillips, 1969); whereas, Vygotsky believes that society motivates the child to learn (Vygotsky, 1962). According to Piaget's theory, language is produced in the preoperational stage, which is from two to seven years old. He proposes that children have language before they actually have words, but the language that they use is private and the meaning is embedded in symbols. The children may also hold many meanings to one schema. For example, the name Fido might be the same schema for all animals with fur in addition to the name of a pet. Fido is a symbol for a private set of meanings that only the child knows; therefore a reflection of the private schema occurs when a word is used incorrectly. Thereby showing that word meaning is already developed at the time of word production (Phillips, 1969).

According to Vygotsky, word meaning develops when words are first used, which contrasts from Piaget who viewed words as an expression of already developed schema. This idea is supported by a study he did with block sorting. Children were given blocks of different colors, sizes, and shapes, with a false word (i.e., mur) written on the bottom of it. The children were then told the word and asked to sort the blocks they thought would have mur written on the bottom. After each sorting children were given feedback as to which blocks they selected actually had mur written on them. He found that at first any block seemed to fit mur, a blue triangle, then a triangle that was yellow, followed by a yellow square. Children first sorted by strings of ideas, which then developed into different piles of common blocks, and finally a concept for mur was developed in which all blocks were the same. Despite mur being used as a word, the full concept was developed after the word had been used several times. This task is representative of how word meaning changes as feedback and experience influence the word concept (Wertsch, 1985).

One method by which children learn word meaning is by using a word in different contexts, thereby learning the boundaries of the word (MacWhinney, 1998). Eventually they develop a *confirmed core* of understood usages for the word; however there remains a periphery of potential instances in which the word might be usable. Thus, children make overgeneralizations when they incorrectly use words in the periphery of their potential. Another error children make is called undergeneralization, which occurs when the child does not use a word in an instance in which the word could be used. This type of error is hard to study because it is never produced, so there is no way of measuring when and how often it is made (MacWhinney, 1998). When overgeneralizations are made parents usually correct them, which allows the confirmed core of meaning to strengthen, whereas parents do not present children with all the possible instances for words to be used, and in that way do not help to correct undergeneralizations.

Usually overgeneralizations are corrected as soon as a parent hears the child make an error. Interestingly, this is inconsistent with theories that state word learning and overgeneralizations are corrected innately and not socially, as seen in computer models (Marcus, G.F., Pinker, S., Ullman, M., Hollander, M., Rosen, T.J., & Xu, F., 1992). In fact, the connectionist perspective views overgeneralizations as a logical problem that can be resolved internally, without feedback from parents. Computer programs have been constructed to mimic the process of language acquisition, and indeed even computer programs make overgeneralizations as seen in a study done by MacWhinney, Leinbach, Taraban, and McDonald (1989). They were able to recreate German article learning and found that the computer program overgeneralized the feminine article, as do most German children. It was not until 1992 that Gupta and MacWhinney made a program that could recover from overgeneralizations based on semantic cues (as cited in MacWhinney, 1998). The fact that these computer programs could recover from their own overgeneralizations suggests that humans may have the ability to do the same, and therefore need not rely on parental feedback.

MacWhinney (1998) proposes that children are driven to recover from overgeneralizations from within, not because of parental feedback. He argues that overgeneralizations are corrected from logical reasoning and that humans are innately able to learn the correct responses. The ability to recover from overgeneralizations is built into the system of language learning. Over time the child will continue to hear the correct usage of a word, consequently receiving episodic support, which allows for the word meaning to strengthen. Additionally, the child will continue to have exposure to analogistic support, or the rule the child was using to make the overgeneralization, but the strength of that will eventually decrease in comparison to episodic support. MacWhinney then proposes that children recover from mistakes naturally and with time the mistakes will correct themselves.

Markman (1992) hypothesizes that children place constraints on word meaning, which in turn aids the comprehension of the words. Children first learn words by hypothesizing the meaning of a word and then testing whether the hypothesis is correct. If it is correct the word meaning is strengthened. She proposes a rule of *mutual exclusivity*, meaning that children expect objects to only have one name, and when novel names are given, children assume that the name is for another object or part of the already named object, thereby maintaining mutual exclusivity. Additionally, mutual exclusivity is thought to motivate learning of new words when the novel word does not refer to the object or part of the object. The principle of mutual exclusivity is a comprehensive theory and accounts for the naming of words, learning parts of words, and motivation for learning new words.

Logic or Natural Definition of *Or*

The words *and* and *or* have different meanings in natural language and in logic. There is much debate as to what type of definition children learn first, and which definition people regularly use to interpret the connectives *and* and *or*. In logic the meaning of *and* can be represented by a truth table which is true only when both components of the sentence are true, and false when either component is false (Johansson, 1977). The natural definition of *and* is not concerned with the truth or falsity of the sentence, but with the function of *and* connecting parts of a sentence which are contextually similar. Similar to *and*, *or* has two different truth tables depending on whether it is interpreted *inclusively* (IOR) or *exclusively* (XOR). The truth table for XOR is true when one of the components is true and the other is false, and is false in all other instances (see Table 1). As shown in Table 1 an *inclusive or* (IOR) interpretation is true when one or more of the components are true, and false only when neither of the components is true (Johansson, 1977). Natural language also distinguishes an *alternative or*, which acts as a connective that denotes a choice; however, this is not the same as the XOR in logic (Johansson, 1977).

Johansson (1977) hypothesized that the ability to define the words would facilitate the comprehension of *and* and *or*. His experiment tested both the natural definition of both connectives and the logical definition. His Definition Test had participants (ages 6-12, and 22) define the words *and* and *or*. He hypothesized that children should use concrete examples for definitions, whereas adults should be able to define the words without examples, rather in terms of other concepts. The participants' responses were coded as Cannot define, Example, Definition and Example, and Definition only. Interestingly, he found around age 10 Definition and Example changed to Definition only. In contrast to Neimark (1970) and in accord with Johansson and Sjolin (1975) *and* and *or* were found to develop at equal rates. According to this natural language test *and* and *or* are equal in difficulty.

Johansson (1975) also did a logical testing of *and* and *or* which was in the form shown in Table 2. Johansson had both contracted forms, when a word that could be in both components of the sentence is left out (1 and 3), and non-contracted forms, when the word is repeated in both components (2 and 4), so as not to preclude different interpretations of *or* (Neimark, 1970). If logical reasoning was independent of language skills, then performance on this task should not follow the same patterns as in the natural language study. He found responses to Command 1 were consistent with the natural language definition and not the logical definition because only figures with both characteristics were circled. For Command 2, all figures with any of the characteristics were circled most frequently, which is in accord with both natural and logic definitions. Children responded with more XOR interpretations in Command 3, whereas adults tended to respond with more IOR interpretations. Again, these findings are in accord with the natural definition but not the logical definition. Finally, Command 4 was interpreted exclusively by all participants which agrees with both definitions of the word *or*. The results show logical reasoning is related to understanding of word meaning, thereby supporting the idea of language and thought being connected (Vygotsky, 1962). This finding was furthered supported in the change in performance on both tasks that occurred in the 10 year olds.

The word *or* is a type of connective called a disjunction and it is used in propositional reasoning. *Or* allows people to draw conclusions based on the formal rules of the disjunction (Johnson-Laird, Byrne, & Schaeken, 1992). Johnson-Laird et al. (1992) show that propositional reasoning is not dependent upon syntactic processes requiring formal rules, but upon semantic processes. They distinguish between formal rules of inference (proof-theoretic method) and reasoning based models (model-theoretic method) as two different ways to generate conclusions. Proof-theoretic methods go as follows:

A or B or both

Not A

Therefore B

This disjunction requires formal rules in order to generate conclusions. Contrastingly, the model-theoretic method can be solved using truth tables as seen in Table 1, and is semantically derived. This truth table shows that A or B or Both is only false when both A and B are false and remains true as long as one or both of the propositions remains true, thus it is the truth table for IOR. Formal rules are not required to solve this disjunction instead it is done by eliminating processes. Truth tables are used to define the meaning of a logical connective. Thus, the proof-theoretic model uses syntactic rules of inference while the model-theoretic method concludes semantically, based on the potential meanings of the disjunction (Johnson-Laird et al., 1992).

If one only looked at the syntactic information of disjunctions then the following conclusion would never be derived (Johnson-Laird, Byrne, & Schaeken, 1992):

A

Therefore, A or B or Both.

An untrained reasoner would never come to that conclusion, because it would take more work than just accepting A. However, when semantic information is added the conclusion is drawn. Imagine a baseball player who knew that if it was raining or snowing the game would be cancelled, then:

It is snowing

Therefore, the game is cancelled.

Clearly, one can see that people reason semantically. The model-theoretic method thus assumes that humans reason with as little explicit information as is needed, thus instead of thinking in terms of truth tables, people reason with as much implicit information as possible that aids the explicit information in reasoning (Johnson-Laird et al., 1992).

Effects of Negation on Disjunction

Evans and Newstead (1980) did a study of disjunctive reasoning and found that negated disjunctions were more difficult than affirmative disjunctions. In Experiment 2 of their study participants were given a rule in the form of letter-number pairs, such as A6. Other forms of letter-number pairs then flashed on a computer screen and participants had to decided whether the new pair agreed or disagreed with the rule. Question difficulty was measured by comprehension times (CT) and verification times

(VT) in seconds. The most difficult questions seemed to be *either p or not q*, and *either not p or q* as opposed *to either p or q* and *either not p or not q*. Interestingly, more correct responses were found for the double negative rules than for the single negative rules. It seems participants were converting *either not p or not q* into the affirmative equivalent, *either p or q* and then responding to the question. However, this conversion cannot be made for the single negative sentences, thus the response times increased as the problem solving process became more complex.

Johnson-Laird and Tridgell (1972) found that making inferences from pairs of propositions was more difficult with affirmatives than it was for negatives. This contrasts with the literature stating that negation is more challenging than affirmation (e.g. Roberge, 1976; Evans & Newstead, 1980). This study was criticized because all statements had a negated second component and an affirmative first component. Similarly, Roberge (1976) found that when the affirmation of the first component required the negation of the second as in, "Either there is a P or there is a Q, but not both. There is a P, therefore there is not a Q," was easier than when the negation of the first component required the affirmation of the other component. These results are limited because they occurred only when the second component referred to the first component. Roberge (1976) found a significant interaction between type of disjunction and first component. He found that IOR sentences with affirmative components were easier than with negative components. This seemingly agrees with Paris' (1973) finding that IOR is easier than XOR. Further analysis showed that XOR with like components (affirmative affirmative, or negative negative) were easier than non-alike components (negative affirmative, affirmative negative) (Roberge, 1976). When comparing XOR to IOR, Roberge found XOR was significantly easier than IOR. Additional statistics were performed looking at the effects of negation on IOR and XOR showed that negation placement for IOR interpretation facilitated responses when it was in the second component. Still, the XOR interpretation remained the easiest, as further statistical analysis did not show any significant differences in performance based upon the placement of negation.

Inclusive or Exclusive *or*

There is a debate in developmental psychology, logic, and linguistics about whether *or* is interpreted inclusively or exclusively, which is more natural and correct, and at what ages comprehension of *or* occurs. Studies in support of IOR will be will be presented first, followed by studies of XOR. On the basis of these studies, it is hypothesized that the *exclusive or* is used more easily by younger children.

Evans and Newstead (1980) did a study of disjunctive reasoning of adults and found that IOR interpretations were the most frequent. In Experiment 2 participants were given a letter-number rule such as, "either the letter is A or the number is 4", and asked to find verifications and contradictions of the rule, when other pairs were flashed on a computer screen. They found that the participants used an IOR interpretation more often than an XOR. The IOR interpretation in this instance may be caused by the absence of context. Newstead and Griggs (1983) called attention to the fact that 20% of respondents only used an XOR interpretation. Evans and Newstead (1980) did not explain why 20% of their participants only used XOR. Although their experiment favors the IOR it also has strong evidence for an XOR interpretation. Additionally, the study was done in an experimental setting, thus perhaps participants adopted strategies that would aid in their performance and increasing the number of IOR interpretations. For example, participants might see the rule "Either the letter is A or the number is 3," and search as far as the first A or 3 they saw and verify the rule without looking further. Hence, it is not clear whether the IOR was due to strategic responding or due to a consistent IOR interpretation. As seen earlier, Johnson-Laird et al (1992) found that semantics aid in reasoning and because the letter-number pairs used in this experiment are arbitrary, this reduces the comprehension of the rule and biases responses towards IOR interpretations. Additional criticism of this experiment is that it was a forced choice task, which also leads to IOR responses that might not have been present if participant were allowed not to respond.

Braine and Rumain (1981) did a study in which both IOR and XOR interpretations were used. Their participants ranged in ages from five to ten years of age and adults. In Task 1 they had blocks of varying size, shape, and color. Participants were asked to "give me all the green things or all the round things." It was found that usually the first of the propositions was fulfilled, lending to an XOR interpretation. IOR interpretations increased with age. Also, in Task 4 which had participants reason about the contents of a box based on given premises, XOR interpretations were used more frequently. Braine and Rumain state that the participants were reasoning with the understanding of *or* being, "choose one." Task 3 was a task that required participants to judge whether what a puppet said was in the box was consistent or inconsistent with what they saw was in the box. In this task they found IOR interpretations. However, Braine and Rumain theorize as to why IOR interpretations were used. Two mental processes should have occurred for Task 3: the first is the participant should match the named objects to the objects in the box, thereby evaluating the truth of the propositional phrase;

and second, they should evaluate the puppet's correctness based on the meaning of the connective. They found that five to six year olds were only doing the first step in solving the problem, thus leading to an IOR interpretation when both objects were in the box. It therefore cannot be inferred that IOR was used because of comprehension but was used because of a lack of thinking through the entire problem. Using a truth table to code the responses, Newstead and Griggs (1983) found that only 20% of the five and six year olds answers were IOR. Sternberg (as cited in Newstead, S.E., & Griggs, R. A., 1983) did a similar study and found less than 10% were IOR responses. Additionally, adults were found to use IOR 32% of the time, while an XOR interpretation was used 41% of the time. The results of the study seemed to show a mixed interpretation of *or*, with an XOR interpretation used more frequently than the IOR.

Braine and Rumain (1980) argue that truth table determining requires more logical skills than young children possess, thus explaining why their results had IOR interpretations. However, Johnson-Laird, Byrne, and Schaeken (1992) show that information for truth table reasoning is available implicitly and leaves the working memory with as little explicit information as possible that is required to reason. Additionally, when the responses are looked at in the form of truth tables the responses are XOR (Newstead, S.E., & Griggs, R.A.,1983). Braine and Rumain (1980) explain that IOR interpretations occur because people use proof-theoretic reasoning before model-theoretic methods. Although Braine and Rumain claim that IOR reasoning is predominant when their data was examined according to more rigid guidelines, the frequency of XOR increased to more than IOR interpretations (Newstead, S.E., & Griggs, R. A., 1983). Thus, the conclusion that inference reasoning leads to IOR interpretations at a younger age, and XOR at older ages is erroneous according to further analysis of their data.

Paris (1973) did a study of disjunctive reasoning, and found that IOR interpretations decreased with age. The participants were in second, fifth, eighth, and eleventh grades. They were told the statement, "The boy is riding a bike or the dog is lying down," followed by an image of the events. When the picture and the sentence matched, "yes" responses were coded as IOR interpretations, and "no" as XOR. Paris provides convincing evidence for IOR usage in young children. The children's responses in this study were considered IOR based only on the "true true" components of the study, therefore biasing it toward the IOR interpretation. In "true false" or "false true" instances, children also responded true, which suggests that the comprehension of the connective was as a conjunctive rather than a disjunctive (Newstead, S.E., & Griggs, R. A., 1983). Paris (1973) is criticized because his sentence components are not related and Fillenbaum (1974) subsequently established that a common topic was necessary for the comprehension of disjunctives. Therefore the results of Paris' study could be skewed due to the participants' confusion of the dissimilarity of the components.

Pelletier (1977) showed that an XOR interpretation could never exist. He suggests there is one way to see if XOR could exist, which is to imagine if both the disjunctives were made true, and if their truth would imply the falsity of the disjunction. Thereby, a disjunction could never have an interpretation other than that of IOR. He uses an example sentence, "I'll be with Arlene or Suzy tonight." If he goes out with just Arelene, the disjunction is true, and same with Suzy. But what happens if he goes out with Arlene, and Suzy meets them at the bar? If he goes out with both of them, they are both true, and thus the disjunction is true. In justification, he proposes that his intention implied one or the other, but both actually happened, thus an IOR interpretation is all that could exist. Newstead and Griggs (1983) criticize Pelletier (1977), stating that his criterion of logical implication is too strict. They propose a counterexample in which he went out with neither Arlene nor Suzy because he got in a car accident. What occurs then is that the "false false" instance on the truth table would function like "true true" on a truth table, thereby violating the one rule always applied to disjunctives that the "false false" part of the truth table makes the disjunction false (Newstead, & Chrostowski, 1984). Therefore Pelletier's unusual argument is too rigid, and does not allow for situations in which an XOR interpretation could be used.

In order to remedy logical situations like the aforementioned, Grice proposed a *maxim of quantity* that speakers should give as much information as possible in their speech (as cited in Newstead, S. E. & Griggs, R.A., 1983). Based on the maxim of quantity, the listener could infer an XOR interpretation and the statement would be understood that the person would be with one of Arlene or Suzy but not both.

Neimark (1970) conducted a study of contracted and non-contracted statements. For example, "choose the caramels or the coffee creams," is a non-contracted sentence; a contracted sentence would be, "chose the caramels or coffee creams." Neimark found that contracted forms lead to more IOR responses. Johansson (1977) did a similar experiment finding equal usage of XOR and IOR in the contracted version and XOR interpretations in the non-contracted versions. Thus it is important to regard which contracted or non-contracted sentence forms are used as it indicates preference toward an IOR interpretation.

Fillenbaum (1974) found XOR interpretations to be the most common, however he recognizes that the IOR interpretation does exist in certain circumstances. He had participants rate the strangeness of a series of sentences that were well and poorly formed *or* sentences, perverse threats (stop that or I won't hit you), disjoints, and inclusive disjoints. Ninety-four percent found disjoints strange, 89% found perverse threats strange, and 25% found IOR interpretations strange.

In the second experiment participants were given "yes" or "no" answers to sentences and were asked to judge whether the answer was informative or uninformative. Two groups answered the questions, one group was time pressured, and the other group had no time pressure. The sentences were divided into four categories, Exclusive and Exhaustive (EE), Exclusive (E), Inclusive (I). EE statements such as, "Did he accept or reject the offer?" the "yes" answers were seen as uninformative in 88% of the responses without time pressure and in the time pressured version 95% of the time. This is similar to the "no" answers that were seen as uninformative 92% of the time in the non-time pressured group, and 94% of the time in the time pressured group. Both answers are considered correct, as a yes or no response could not provide any further information about the sentences. E statements such as "Did he stay or go to New York" with "yes" answers were considered uninformative 64% of the time, and "no" answers uninformative in 40% of the cases of the non-time pressured participants. The time pressured participants found "yes" answers uninformative in 70% of the cases, while "no" was found to be uninformative in 61% of the cases. On the exclusive example 60% of the non-time pressured respondents found "no" answers to be informative, this is because it ruled out both part of the disjunction, thereby providing the participant with more information. For an I question, "Did he see Mary or talk with John at the party?" was found informative with "yes" answers 70% and 60% of the time in non-time pressure and time pressured groups. "No" answers were found informative 82% and 64% of the time in non-time pressure and time pressured groups respectively. Participants seemed to understand IOR in this example when it was affirmative, meaning both parts of the disjunction occurred, and informative when neither of the components occurred. This study shows that there are different forms of the word *or* and that it is understood in many contexts (Fillenbaum, 1974).

Fillenbaum (1974) examined the understanding of *or* a little further when he asked his participants to paraphrase the EE, E, and I examples he had given them. He found that people tended to paraphrase *or* statements by making them exclusive, thereby using *either or* 40% of the time. Additionally, the I statements were paraphrased using the word *and* instead of *or*, which occurred less than 1% of the time for the E and EE sentences. This study showed that *or* interpretations favored the exclusive sense of the word, and when it was used inclusively people had more difficulty remembering to use *or* in this unnatural sense and thereby changed it to *and*. Across all experiments in this study it was found that *topical coherence* (as seen in reverse order perverse threats) between the two disjunctives is needed for comprehension of the word *or*, thus any study done previous to this finding (e.g. Paris, 1973) should be re-examined to see if topical coherence was used.

Moreover, Newstead and Chrostowski (1984) found that *or* interpretations depended on different contexts, similar to the findings of Fillenbaum (1974). The disjunctive contexts in their experiment were: Threat, Promise, Choice, Qualification, Abstract, and Concrete. They provided their participants with different syllogisms that established the context from which participants had to respond correct or incorrect. Participants significantly preferred XOR interpretations to IOR across both participant responses and across contexts. However, Qualification had significantly more IOR interpretations than did Threat, Promise, Abstract, Uncertainty and Choice. Additionally, Abstract and Concrete had more IOR than Choice. Still, XOR remained the preferred interpretation. Newstead and Chrostowski suggest that *or* should be viewed on a continuum of XOR and IOR interpretations with Threat and Qualification being on opposite ends of the continuum.

Additionally, in Experiment 2 and 3 Newstead and Chrostowski (1984) examined the types of inference that participants used to solve the syllogisms. Denial Inference, which occurs when a deduction is made, based on the denial of one of the components of the disjunctions. This type of inference can lead to the truth of the statement only in XOR interpretations and is not the case with IOR interpretations. The other type of inference examined was Affirmation inference, which is deducing the truth of a statement based on the affirmation of one component. In Experiments 2 and 3 the inference patterns, which are indicative of XOR or IOR interpretations, consistently followed patterns of interpretation as found in Experiment 1. For example, Qualification had the most number of IOR interpretations. This study supports Fillenbaum (1974) who states *or* meanings are generally XOR but interpretation may change due to contexts.

Johansson and Sjolin (1975) studied connectives and found no instances of IOR in children's speech. They defined *and* and *or* based on linguistic definitions: *and* is the combining of two components and *or* designates a choice between the components. They did not define them based on their logical definitions. In this experiment participants were in three experiments, a Story Test, a Put up Pictures Test, and a third which the participant told a story. The first experiment had participants put cutout animal shapes on a board in accordance with how they were narrated in the story (e.g. He brings the bear and (or) the boat). The Put up Pictures test was similar to the Story Test, only instead of a hearing a story the participants only heard commands (put up the dog and (or) the cat). Based on what cutouts the participants put on the board, the researcher could see how the participants understood the connectives. The results showed that participants did not have difficulty with *and* and with *or* statements, according to their linguistic definitions. Interestingly, the third experiment showed no spontaneous uses of IOR in the participants' stories.

Many studies that have been done support both ideas of an *inclusive or* (e.g., Pelletier, 1977; Paris1973; and Braine and Rumain, 1980) and an *exclusive or* (e.g., Fillenbaum, 1974; Johansson and Sjolin, 1975; and Newstead and Griggs, 1983). However, these studies were conducted mainly with participants over the age of six, and in order to answer the developmental question of which *or* interpretation develops first, it is essential to study children still forming the concept of *or*. Because previous studies lack young enough participants, the proposed study targets participants between the ages of three and six. Additionally, past research used abstract contexts by which to test *or* comprehension, and as Fillenbaum (1974) showed, ambiguous contexts lead to IOR interpretations. The present study will examine behaviors across a series of three different experimental contexts that are not abstract, thereby allowing for true *or* interpretations to be observed. This experimental design facilitates the identification of common overgeneralizations in young children, as well as reveals the boundaries children use in their understanding of *or*.

The present study is divided into three experiments to assess behaviors across tasks. In Experiment 1 the independent variable is the type of sentence the child hears (simple, complex, conjunction, disjunction, affirmative, negative) and the dependent variable is which toy(s) the child places in the basket. In Experiment 2 the participants watch a video of a teacher making requests of the student. The independent variable is the toy(s) the student places in the basket and the dependent variable is whether the participant thinks the student has correctly responded. It is hypothesized that in Experiments 1 and 2 the child will comprehend *and* requests by placing both toys in the basket, and *or* requests will be interpreted exclusively (Fillenbaum, 1974; Johansson and Sjolin, 1975; Johansson, 1977; Newstead, & Chrostowski, 1984). Additionally, Johansson and Sjolin (1975), Johansson (1977), and Braine and Rumain (1980) show that XOR interpretations are used more with younger children, therefore it is hypothesized that XOR interpretations will be used by the younger preschoolers in this study and IOR interpretations will increase with age. Based on the findings of Evans and Newstead (1980), Johnson-Laird and Tridgell (1972), and Roberge (1976) it is hypothesized that the mixed negative disjunctions in Experiment 1 and Experiment 2 will be more difficult than double negative disjunctions and affirmative disjunctions. Experiment 3 requires that children guess what the teacher asks the student to put in the basket based on what they see the student actually putting in. It is hypothesized that Experiment 3 will not have spontaneous uses of IOR which is consistent with findings from Fillenbaum (1974) and Johansson and Sjolin (1975).

Experiment One

Participants. Thirty-five participants, ranging in ages from three to five years in age, were recruited from four local preschools. There were 20 females and 15 males. Parental consent was given, as was each participant's assent. Upon completion of each experiment, the participants chose a sticker and then were escorted back to their classrooms.

Apparatus. The following nine toys were used in this experiment: banana, bird, book, car, cat, cup, cupcake, dog, and a spoon. The toys were purposefully chosen to be common toys because a study by Fillenbaum (1974) showed that arbitrary contexts biased responses toward an IOR interpretation. A small basket was used as a place for participants to put the requested toys into. The experimentation was conducted in a semi-private room (e.g. office, small gymnasium, hallway, staff lounge) to avoid distractions.

Procedure. To prevent ordinal effects each experiment had two versions, the second being the reverse of the first. Sixteen different order series of the three experiments were given to the participants in a random order (e.g., order series number 1 would be given the experiments in the following order: 3a, 1a, and 2b, and order series number 2 would be: 1b, 2b, and 3b). Additionally, the toys were randomly assigned to different possible truth table responses for each type of sentence structure. Each toy was used equally. Each participant was seen three times, completing one experiment at a time.

The participants and experimenter talked for about one minute to help ease any potential anxieties of the participants. Then the experimenter showed nine toys to the participant and had him name each object as it was presented; this was to ensure that all toys were familiar objects so as to prevent problems during the experimentation.

Participants then played a game called "Toy in the Basket." The independent variable in this experiment was the type of sentence the participant heard. The game had a total of thirty-six sentences consisting of two simple affirmative requests (e.g., put the cat in the basket), two simple negative requests (e.g., don't put the cat in the basket), four affirmative connectives (e.g. put the cat and put the banana in the basket), four connectives negated in the first component (e.g., don't put the cat and put the banana in the basket), four connectives negated in the second component (e.g., put the cat and don't put the banana in the basket), four connectives negated in both components (e.g., don't put the cat and don't put the banana in the basket), four affirmative disjunctives (e.g., put the cat or put the banana in the basket), four disjunctives negated in the first component (e.g., don't put the cat or the banana in the basket), four disjunctives negated in the second component (e.g., put the cat or don't put the banana in the basket), and four disjunctives negated in both components (e.g., don't put the cat or don't put the banana in the basket). The dependent variable was the actual toy(s) the participant put in the basket, as this demonstrates how he or she understood the request.

In order to ensure comprehension and reduce ambiguity in responses, the participant was told to listen to the request, repeat back what the experimenter said, go ahead and do the request, and once finished with the request to say, "I'm done." The experimenter started the game by reading four practice requests starting with a simple affirmative request (e.g., put the book in the basket), an affirmative connective (e.g., put the cat and put the banana in the basket), a connective negated in the second component (e.g., put the cup and don't put the spoon in the basket), and a simple negative sentence (e.g., don't put the spoon in the basket). The experimenter never gave any feedback on the responses. After the warm-up was finished the experimenter asked the participant if he wanted to continue playing. The experimenter recorded which toys the participant put in the basket. For negated questions, the experimenter waited to hear "I'm done," or considered constant eye contact and playing with non-mentioned objects as cues that the participant was finished with the request. At the end of the experiment the participant chose a sticker and was escorted back to their classroom.

Experiment Two

Method

Participants. Thirty-four participants, 20 females and 14 males, were recruited as stated in Experiment 1. Their ages ranged from three to five years old.

Apparatus. A digital video camera was used to make a video of a "teacher" and a "student." A video was made of the teacher making the same requests as in Experiment 1 along with an additional three affirmative IOR disjunctives. The teacher said the request twice with a pause between the first and the second time, allowing for the participants to repeat back what the teacher had said. Then the video showed the student responding (either correctly or incorrectly) to the teacher's request. The same nine toys and basket as mentioned in Experiment 1 were used in Experiment 2. A television and VCR were used to play the edited video.

Procedure. Experiment Two was a game titled "Okay or Silly." It was a home video of a teacher and a student requesting and fulfilling a total of 39 requests. Two practice clips were shown in the beginning of the experiment. The first was a simple affirmative, "Put the book in the basket" and the student put the book in the basket, and the second was a simple negative request (e.g., don't put the spoon in the basket). If the participant answered, "ok" the experimenter went on to the second practice question. If the participant answered, "silly," the experimenter stated, "The teacher said 'put the book in the basket' and the student put the book in the basket. That was okay. Great job, let's practice another one." Each participant answered both practice questions and then answered all 39 other questions. Once the participant had finished the game, he or she was given a sticker and was escorted back to his classroom.

Experiment Three

Method

Participants. Thirty-three participants, 16 male and 17 female, were recruited as in Experiment 1.

Apparatus. A home video was made just as in Experiment 2, with a teacher, student, and the same nine toys and basket. This time instead of having 39 questions, Experiment 3 had 16 questions consisting of two simple affirmatives requests, two simple negative requests, four affirmative connectives, two connectives negated in the first component, four affirmative disjunctives, and two disjunctives negated in the first component. A television and VCR was used to show the video, however the sound was turned off.

Procedure. Experiment 3 was a game called "What did the teacher say?" and did not have any sound. The participant saw the student putting a toy(s) in the basket and was asked, "What did the teacher tell the student to put in the basket?" The independent variable was the absence of sound and the dependent variable was the sentence the participant said the teacher had said. The responses were then recorded as to what objects the participants named and what type of connective was used (if any). Upon completion of the experiment the participant chose a sticker and was escorted back to the classroom.

Hypotheses

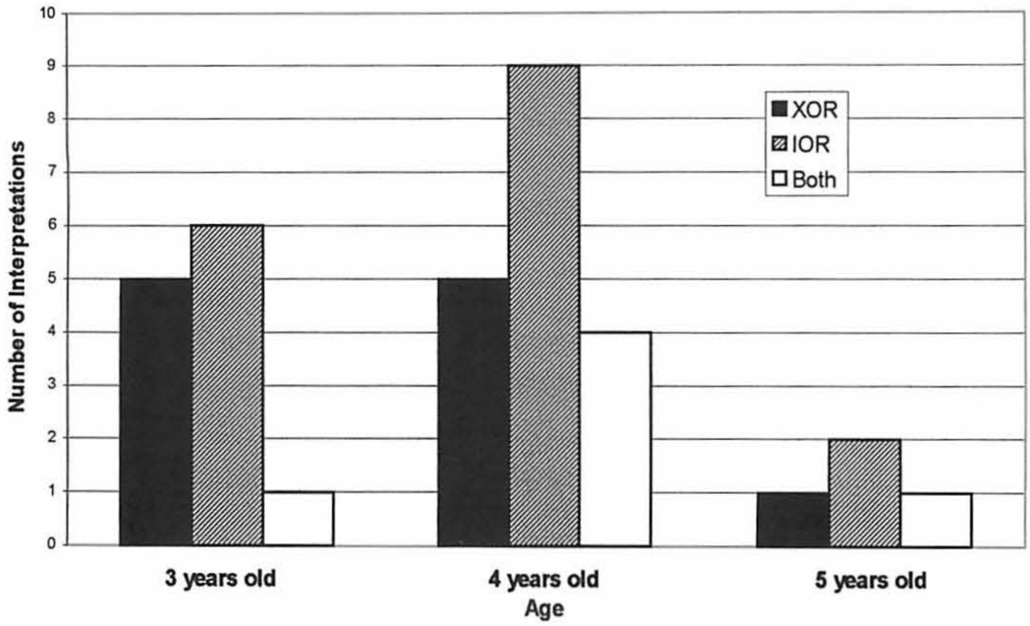
It is hypothesized that in Experiments 1 and 2 the child will comprehend *and* requests by placing both toys in the basket, and *or* requests will be interpreted exclusively by placing one toy in the basket (Fillenbaum, 1974; Johansson and Sjolin, 1975; Johansson, 1977; Newstead, & Chrostowski, 1984). Additionally, Johansson and Sjolin (1975), Johansson (1977), and Braine and Rumain (1980) show that XOR interpretations are used more with younger children, therefore it is hypothesized that XOR interpretations will be used by the three and four year olds and IOR interpretations will increase with age. Based on the findings of Evans and Newstead (1980), Johnson-Laird and Tridgell (1972), and Roberge (1976) it is hypothesized that the mixed negative disjunctions in Experiment 1 and Experiment 2 will be more difficult than double negative disjunctions and affirmative disjunctions. Experiment 3 requires that children guess what the teacher asks the student to put in the basket based on what they see the student actually putting in. It is hypothesized that Experiment 3 will not have spontaneous uses of IOR which is consistent with findings from Fillenbaum (1974) and Johansson and Sjolin (1975).

Experiment One

Results

The mean number of correct *or* responses was 14.7 out of 16. The mean number of correct *and* responses was 14.3 out of 16. A paired means Wilcoxon signed-rank test was performed to examine significant differences between correct responses to *or* statements and *and* statements. This test showed that there were eight cases when *or* scores were lower than *and*, and 15 cases when *or* scores were higher than *and*. Additionally, there were 12 cases when the *or* and *and scores* were the same. There was not a significant difference between the number of correct *or* responses and *and* responses, $T = .085$, $p > .05$.

Frequency measures were used to further examine performance on *or* statements. Twenty-four children consistently used XOR interpretations, which comprises 68.6% of responses. In contrast, only six children consistently used IOR meaning that IOR interpretations consisted of 17.1% of responses. Additionally, five children did not favor IOR or XOR consistently which made up 14.3% of all cases. Figure 1 shows how each age group used *or*. Nine three-year olds, eleven four year olds, three of the four five year olds and the one six year old all favored an XOR interpretation. The XOR interpretation was used most widely among all age groups, but it is important to notice that 27% of four year olds used an IOR interpretation. A Wilcoxon signed-rank test showed a significant difference in distribution of XOR and IOR interpretations by age $T = .000$, $p<.05$. This means that changes in interpretation styles occurred at each of the ages.


Number of Interpretations
10
9
8
7
6
5
4
3
2
1
0
XOR
IOR
Both
3 years old
4 years old
5 years old
Age

Another factor that could influence performance on statements and *or* interpretation is the addition of negation to the sentence. The mean number of correct responses to affirmative sentences was 3.98 out of four possible responses; whereas sentences with negation in both components of the sentence (e.g. don't put the cat and don't put the banana) had a mean number of 3.4 correct responses to the possible four. A Wilcoxon signed-rank test shows there were no cases when the responses to negated components were correct more than the number of correct responses to affirmative sentences. Also, the test shows there were seven cases when the affirmative sentences were correct more than the responses to the negated components. Finally, there were 28 cases when the number of correct responses to both sentence types was the same. A Wilcoxon signed-rank test shows there was a significant difference between number of correct affirmative *or* responses compared to the number of correct sentences negated in both components, $T = .016$, $p < .05$. There were more correct affirmative responses than responses to negation in both components of the sentence.

When using a paired means Wilcoxon signed-rank test to compare affirmative sentences to sentences negated in the first component (e.g., don't put the cat and put the banana) there were no cases when the number of correct responses to sentences negated in the first component was greater than the number of correct responses to affirmative sentences. The mean for sentences negated in the first component was 3.5 out of four. A Wilcoxon signed-rank test shows there were ten cases when the number of correct responses to affirmative *or* sentences was greater than the number of correct responses to *or* negated in the first component. Additionally, there were no cases when the number of correct responses to sentences negated in the first component was greater than the number of correct responses to affirmative sentences. There were 25 cases when the number of correct *or* responses were the same in both categories. A Wilcoxon signed-rank test shows there was a significant difference in the number of correct responses to affirmative sentences than to sentences negated in the first clause, $T = .004$, $p<.05$. Affirmative statements were answered correctly significantly more than sentences negated in the first component.

The mean number of correct responses to affirmative statements was 3.9, whereas the mean number of correct responses to negation in the second component (e.g., put the cat and don't put the banana) was 3.7. A Wilcoxon signed-rank test shows that when comparing affirmative sentences to sentences negated in the second component there was one case when the number of correct affirmative responses was less than the number of correct responses to sentences negated in the second component. There were five cases when the number of correct responses to affirmative sentences was more than the number of correct responses to sentences negated in the second components. Interestingly, there were 29 cases when the number of correct responses was the same. There was not a significant difference of correct responses in affirmative *or* sentences compared to sentences negated in the second component, $T = .068$, $p>.05$.

Negation in the first component was significantly different than affirmative sentences, however negation in the second component was not. When comparing negation in the first component compared to negation in the second component the mean number of correct responses for first component negation 3.5 compared to 3.7 for negation in the second component. A Wilcoxon signed-rank test showed in two cases sentences negated in the first component had a higher number of correct responses than in the sentence with the second component negated. There were 10 cases when the number of correct responses to sentences negated in the second component was more than the number of correct responses to sentences negated in the first component, and 23 cases when the number of correct responses was the same. There was a significant difference in the number of correct responses to sentences negated in the second component to the number of correct responses to sentences negated in the first component, $T = .020$, $p < .05$. This suggests that the components that were negated in the second component had more correct responses.

The average number of correct responses to *or* sentences negated in both components was 3.4 compared to the average of 3.7 correct responses in sentences negated in the second component. A Wilcoxon signed-rank test shows there were seven cases when the number of correct responses to sentence negated in both components was greater than to sentences with negation in the second component. Only one case had a greater number of correct responses to sentences negated in the second component and there were 27 cases when the number of correct responses was the same. There was a significant difference in the number of correct responses in sentences negated in both components than in the second, $T = .023$, $p < .05$. It seems to be easier to find the correct answer when the negation is directive and in both components.

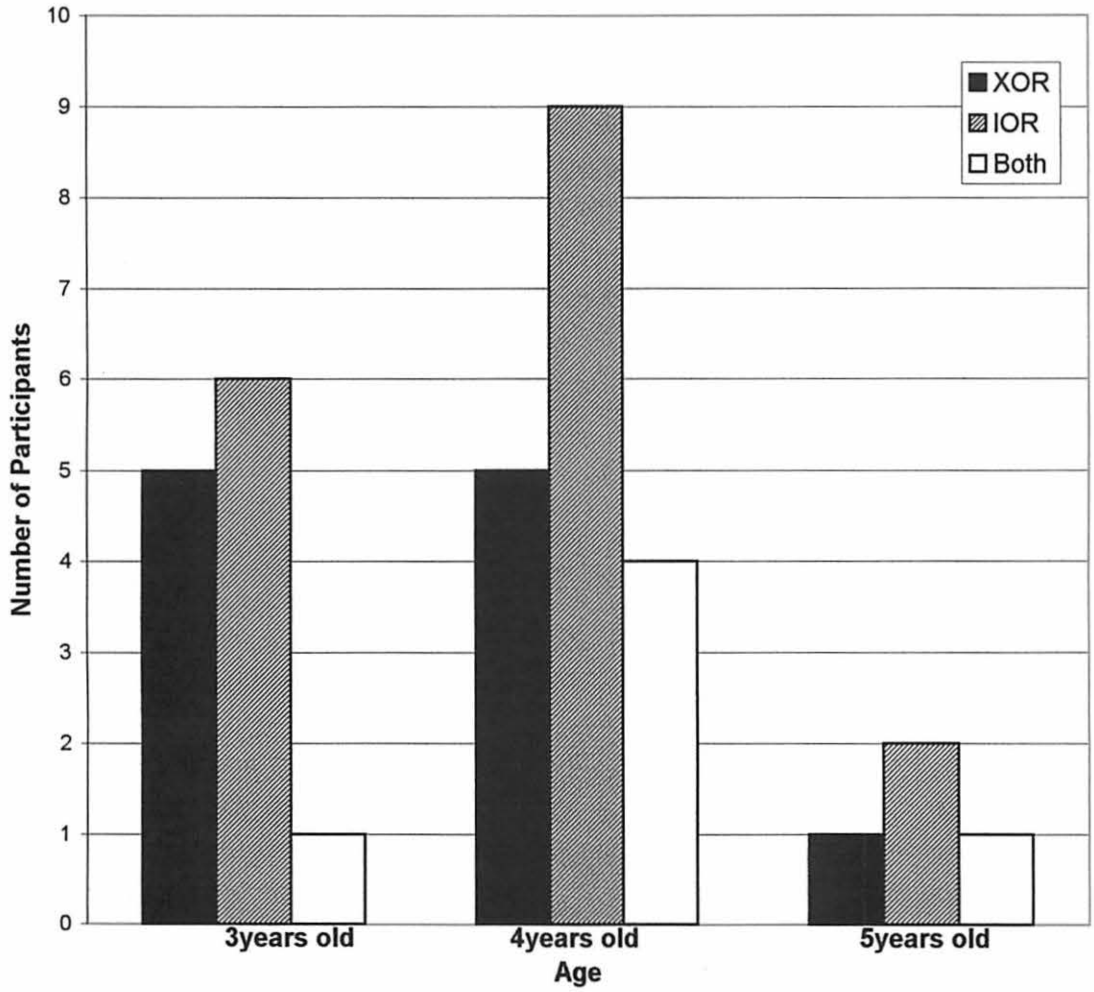
Experiment 2

Results

The mean number of correct responses to *and* sentences compared to the average number of correct responses to *or* sentences is 9.6 out of 16 and 14.2 out of 19, respectively. A Wilcoxon signed-rank test shows there were no cases when the number of correct and responses was more than the number of correct responses to *or* sentences. There were 33 times when the number of correct responses to *or* sentences was greater than the number of correct responses in *and* sentences. The test also shows significant difference between the number of correct *or* and *and* responses, T = .000, p<05.

In contrast to Experiment 1 only 11 children consistently used XOR interpretations which comprises 32.4% of responses. Further differing from Experiment 1, IOR interpretations were used in 17 cases accounting for 50.0% of responses. Similar to Experiment 1 six children, or 17.6% of the cases, did not favor one interpretation rather they used both equally. The change of task in Experiment 2 influenced how children used the different *or* interpretations; however, a Wilcoxon signed-rank test shows the difference of task performance between Experiment 1 and Experiment 2 is not significant, T = .394, p>.05. Additionally, a Wilcoxon test shows that *or* interpretations did have significantly different distributions within age groups, T = .000, p< .05. Figure 2 shows the distributions of interpretation by age. Three year olds seem to use XOR and IOR ambivalently, whereas four year olds clearly favored IOR. Figure 2 starts to show that five year olds favor IOR too, however there were not enough five-year-old participants to truly demonstrate this pattern. The one six year old of the study did not complete this experiment. It appears that IOR interpretations increased within the four and five year olds.

The mean number of correct responses for affirmative *or* sentences was 6.6 out of seven, whereas the mean number of correct responses for sentences negated in both components was 2.5 out of four. A Wilcoxon signed-rank test shows there were not any cases when the number of correct responses to sentences negated in both components was



10
9
8
7
6
5
4
3
2
1
0
Number of Participants
XOR
IOR
Both
3years old
4years old
5years old
Age

greater than the number of correct responses to affirmative *or* sentences; however, all cases showed that affirmative *or* sentences were correct more than the number of correct responses to sentences negated in both components. Therefore, the Wilcoxon test shows that there was a significant difference in the number of correct affirmative *or* sentences, $T = .000$, $p < .05$. Affirmative *or* sentences elicited more correct responses than sentences with negation in both components.

The average number of correct sentences negated in the first component was 2.5 out of four compared to the average of 6.6 out of seven for affirmative *or* sentences. In all instances the number of correct affirmative sentences were greater than the number of correct *or* sentences negated in the first component, a Wilcoxon signed-rank test shows this difference to be significant, $T = .000$, $p < .05$.

The mean number of correct *or* responses to sentences negated in the second component was 2.6 out of four. Again, in all cases the number of correct responses to affirmative *or* statements was greater than the number of correct *or* responses to sentences negated in the second component. A Wilcoxon signed-rank test shows that the number of correct affirmative *or* responses was significantly different than the number of correct responses to *or* sentences negated in the second component, $T = .000$, $p < .05$. Affirmative sentences were correct more than sentences negated in the second component.

The mean for negation placement in the first and second components was 2.5 and 2.6 respectively. A Wilcoxon signed-rank test shows there were eight cases when negation in the first component had more correct responses, eleven cases when the negation in the second component had more correct responses and fifteen cases when the number of correct responses was the same. There was not a significant difference between first component negation and second component negation, T = .457, p>.05.

A Wilcoxon signed-rank test shows there were 11 cases when both negated components had more correct responses than first component negation, and 14 cases when negated first components had more correct responses. There were nine cases when the number of correct responses was the same. There was not a significant difference between negation in both components and first component negation, T = .889, p >.05 Similarly, the mean number of correct responses to negation in the second clause was 2.6 compared to negation in both clauses, which had a mean of 2.5. There were 10 cases when the number of correct responses to sentences wit both components negated were greater than the number of correct responses to sentences with the second component negated. There were nine cases when the number of correct responses to sentences negated in the second component was greater and 15 cases when the number of correct responses in both categories was the same. A Wilcoxon signed-rank test shows no significant difference, T = .564, p>.05. The data show that negation placement did not have a significant effect on the number of correct responses to *or* statements; however, the effect of any negation in the sentence compared to affirmative sentences was significant.

Experiment 3

Results

Experiment 3 was designed to see what type of connective children used to describe what the teacher said when they saw the student place two objects into the basket. The data were analyzed using frequencies measures. Thirty-three children completed Experiment 3 and three children did not complete the experiment. Twenty-six children used the word *and* every time that two objects were placed in the basket. There were four cases when *and* was used six out of the seven times that two objects were placed in the basket. There were two cases when *and* was used four of the seven times it was used, and one case when *and* was used three times of the seven times when children saw two objects placed in the basket. When the children did not use *and* as a connective no other word was used in its place (i.e. Cat, dog). *Or* was never used in place of *and.*

General Discussion

In Experiment 1 and Experiment 2 it was hypothesized that the number of correct *and* responses would be greater than the number of correct *or* responses; however, this hypothesis was not supported in Experiment 1. This finding is consistent with research done by Johansson (1977), who found that adults and children ages six through twelve did not differ significantly in comprehension of *and* and *or* based on how they defined the words. However, Experiment 2 showed that correct *and* and *or* responses did differ significantly. Similar to Experiment 2, in Experiment 3 children only used the word *and* as a description of what the teacher said when two toys were put in the basket. In Experiment 3 when two things were put in the basket there were no cases when *or* was used. In accordance with finding by Niemark (1975) the findings of Experiment 2 and Experiment 3 support the idea that *and* is understood before *or*. Additionally these findings contradict those of Experiment 1 as well as findings by Johansson (1977) and Johansson and Sjolin (1975) which found no significant difference of comprehension between *and* and *or*.

It is important to examine the possibilities as to why Experiment 1 and Experiment 2 differ from each other and past research. One factor that could account for the difference of the present study from past studies could be in the way the data were coded. They were coded for correctness using truth tables that are naturally skewed so the number of correct *or* responses could be correct 75% of the time at random and the number of *and* responses could be correct 25% of the time at random (see Table 1). Cognizant of this fact, the number of correct *and* responses should be lower and statistically different than the number of correct *or* responses. Despite the tendency for skewed results, the current data does not show a significant difference between *and* and *or*. This implicates a similar number of *and* responses and *or* responses. Returning to the tendency for skewed results, this indicates that *and* performance was better than *or* performance. Consequently, it could be concluded that the *and* concept was understood before the *or* concept. Then this data supports the findings of Neimark (1975) who found that *and* statements were significantly easier than *or* statements and contradicts findings by Johansson and Sjolin (1975) and Johansson (1977). Depending on which way the data are analyzed (e.g. accounting the difference in correct performance due to chance, or analyzing as is) the data could show two different outcomes. Since I am unable to adjust the scores to account for the difference, the discussion will address the potential implications of finding a significant difference between *and* and *or* in addition to the implications of the unadjusted data.

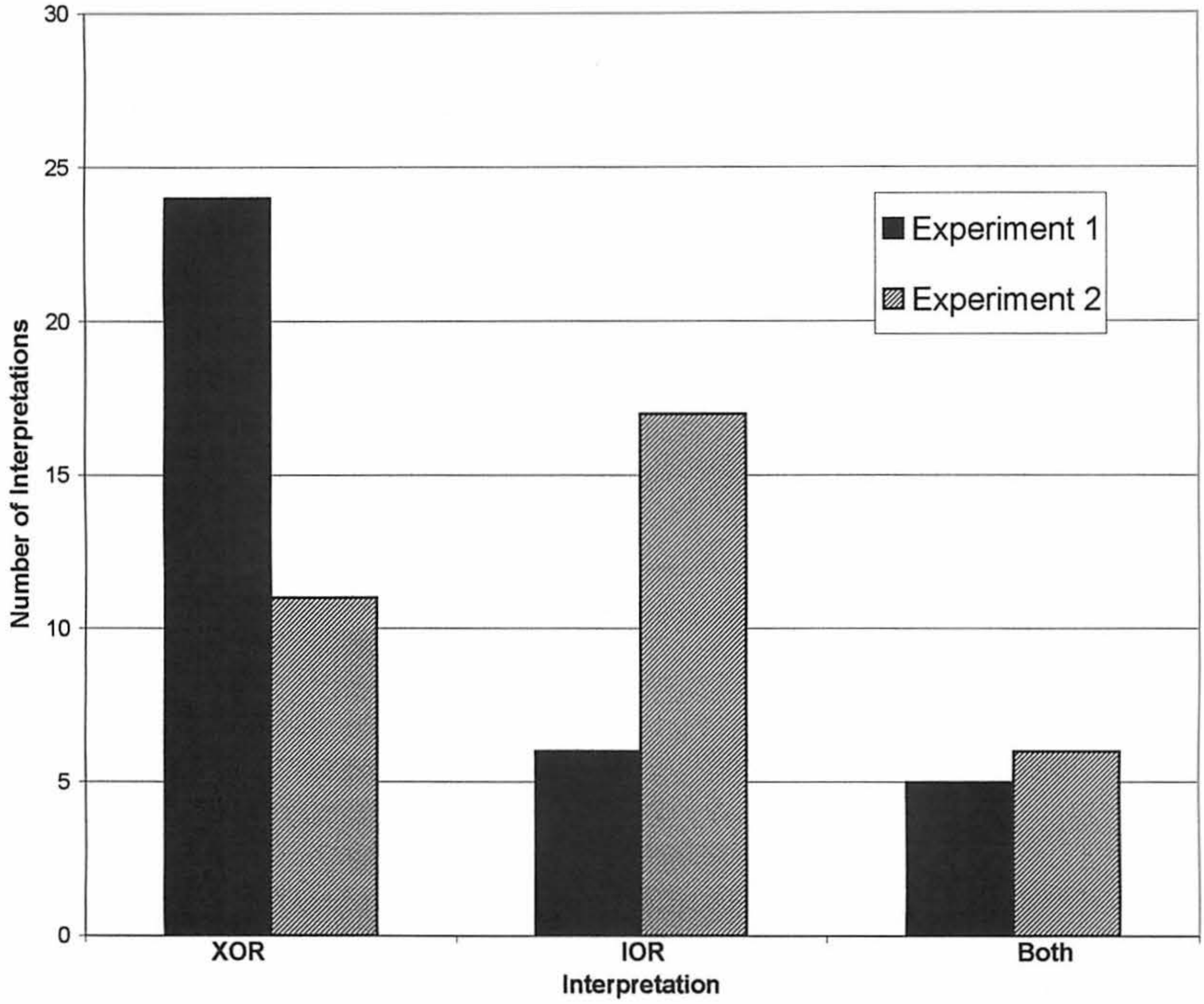
Conceptually *and* statements should be easier than *or* statements because the definition of *and* is easier (Johansson, 1977). MacWhinney (1998) discusses cognitive mapping as an association paired between an auditory and a visual stimulus.

Additionally, Markman (1990) proposes a rule of mutual exclusivity when children make the mistake of thinking that objects, or in this case concepts, have one label or use. Therefore, the meaning of *and* and *or* may not fully be established by the ages of three to six years old and their boundaries are therefore blended. The children are consistently testing their hypotheses about the words to find instances when *or* is acceptable and unacceptable, and the same is true for the word *and*. Therefore, they are erring by overgeneralizing the use of *and* and *or*. This would explain why the data in Experiment 1 do not show significant differences in the number of correct *and* and *or* statements because the children are still trying to define what constitutes *and* and *or*. However, in Experiment 2 and Experiment 3 it seems the children can evaluate situations when *and* should be used and when *or* should be used.

Perhaps the context of the different experiments influenced the children's understanding, thus accounting for the difference in XOR and IOR performance between the experiments. Fillenbaum (1974) showed certain semantic contexts (e.g., Threat, Promise, Choice..) influence the type of *or* interpretations people used. In this same manner, tasks that require the production of *and* and *or* interpretations (i.e., Experiment 1) may be different than evaluating someone's performance (i.e., Experiments 2 and Experiment 3), and bias the type of *or* interpretation used. Consequently, the data for Experiment 1, Experiment 2, and Experiment 3 reflect the nature of the context the *or* sentences were presented, as seen in Fillenbaum's experiment, as well as showing how *or* is understood. This reflects MacWhinney's (1998) concept of a confirmed core of knowledge – knowledge that is strengthened with appropriate word usage. Therefore, if children still have incorrect concepts for the words *and* and *or* then the data are representative of the core of peripheral potential; children are still testing word-meaning hypotheses and making performance errors. The lack of statistical difference of correct responses in Experiment 1, and the difference between Experiment 1 and Experiment 2 and Experiment 3, supports the assertion that the concepts have yet to be fully established.

In contrast, if the data are evaluated given the probability at random for correct *and* and *or* statements, and if they show that *and* is statistically different than *or*, then it shows that the *and* concept is fully mapped by age three. This is because there would be more cases when *and* responses were correct more than *or* cases, perhaps showing that the *or* concept is still being tested. This proposal illustrates Markman's (1990) theory of mutual exclusivity that through a series of hypotheses testing, the meaning of and has been strengthened into a confirmed core of meaning, thereby differing from the similar IOR concept, which still seems to be in the process of forming.

Based on past research it was hypothesized that younger children would use XOR interpretations more than older children, and older children would increasingly use an IOR interpretation due to the complex nature of IOR (Johansson and Sjolin, 1975; Johansson, 1977; and Braine and Rumain, 1980). This hypothesis was partially supported as three and four year olds used XOR 69.8% of the time in Experiment 1, which suggests that even by age three XOR was understood. It was also hypothesized that IOR uses would increase with age, but as Figure 3 shows, IOR interpretations decreased with age; in Experiment 1 five and six year olds rarely used IOR (see Figure


30
25
20
15
10
5
0
Number of Interpretations
Experiment 1
Experiment 2
XOR
IOR
Both
Interpretation

1). These data, though contrary to past findings (e.g., Braine and Rumain, 1980) and our hypothesis, establishes a trend between age and *or* interpretation – as age increases the ambiguity between IOR and XOR interpretations fades, tending toward a XOR interpretation. The discordance with past research could be a result of a low number of participants for that age group, but data are still being collected. However, in Experiment 2 this clear trend in responses was not present, which is further support that *or* interpretations are context dependent, which supports Fillenbaum's (1974) findings. In Experiment 2 XOR interpretations were used 32.4% of the time and IOR 17.5%. Despite this ambiguity of interpretation between Experiment 1 and Experiment 2, Experiment 3 concretely shows that an IOR interpretation was not used. In this experiment, no child spontaneously used the word *or* to describe what the teacher requested when two items were placed in the basket. If IOR was a common interpretation, it could be used interchangeably with the word *and*; however, because *or* was never spontaneously used in Experiment 3, it can be concluded that preschool aged children favor an XOR interpretation, despite the slight ambiguities found in Experiment 2.

The change in performance of *or* statements in Experiment 2 is interesting because the nature of the task changed. Children in this task were expected to hold two ideas simultaneously: the request of the teacher, and what the student actually placed in the basket. Next, in order to say if the student was "Okay" or "Silly" the child had to evaluate whether the student followed directions, requiring that the children solve by using a theory of mind for the teacher. Furthermore, the children may have used a formula, or what Johnson-Laird (1992) named proof-theoretic reasoning, to decide correctness. They evaluate what was placed in the basket with similar constraints to how one reasons B, when given the statement, "A or B or Both. Not A." This task is complex in nature, thus the decrease in XOR interpretations could be explained by uncertainty of correctness of the student's response and complexity of reasoning involved. Consequently the child may have guessed more, or there was more room for errors in Experiment 2, than in Experiment 1 and Experiment 3, thus accounting for the difference in performance in Experiment 2.

Based on findings from Evans and Newstead (1980) it was hypothesized that negation placement in either the first or the second component would be significantly different from negation in both components and different from affirmative sentences. The data from Experiment 1 and Experiment 2 show a significant difference between performance of affirmative sentences and sentences negated in both components and between affirmative and first component negation. In Experiment 1 there was no significant difference between affirmative sentences and second component negation, however, the T value was .018 away from being significant, which could become more significant with more participants. In contrast, Experiment 2 showed a significant difference between affirmative sentences and second component negation. Based on performance on affirmative statements compared to performance on sentences with any type of negation, the affirmative responses were generally more correct. This pattern indicates that negation used during disjunctive reasoning adds to the complexity of the task and decreases performance. This decrease in performance is consistent with findings from Evans and Newstead (1980) and Roberge (1976).

Negation adds an extra step in the process of disjunctive reasoning, increasing the complexity of the problem. Roberge (1976) showed that negation in both components has the same difficulty as affirmative sentences, but the data do not support these findings. In fact, in most cases any type of negation decreased the number of correct responses in comparison to affirmative sentences. Also it is important to notice that there is a significant difference in performance within the negated groups in Experiment 1 but not Experiment 2. First component negation was significantly different from second component negation, but not from negation in both components. Finally, second component negation was statistically different from negation in both components. The data show that second component negation was difficult for children to understand. There seems to be a hierarchy of difficulty, from easiest to most difficult being: affirmative components, negation in both components, first component negation and then second component negation.

The present study shows concept formation for disjunctive and conjunctive reasoning is still developing at the preschool age. There were clear tendencies for an XOR interpretation across all experiments, despite the difference of *or* performance across the experiments, which is evidence that younger children are still forming the concept for *or*. These findings contradict past research that IOR interpretation is most prevalent in young children (e.g., Pelletier, 1977; Evans and Newstead, 1980;) and shows preschool children most frequently use XOR reasoning. The concrete difference between XOR and *and* may also help the core concept formation of the word *or* to become more solidified. Change in reasoning was found when children were asked to evaluate the student's responses, suggesting that the nature of the task is more complex and demanding of children's memory systems. The changes in performance could also be a result of the length of time it took to complete Experiment 2, which was about 10 minutes longer than Experiment 1. The change in performance due to task changes is similar to the change in *or* interpretation that Fillenbaum (1974) said was due to context differences. Additionally, error increased when the components were negated, which shows that negated sentences require more complex reasoning than affirmative. The present study evaluates comprehension on three levels: performance, evaluation, and interpretation.

Based on the findings one can see that disjunctive reasoning abilities in preschool children are still in a state of hypotheses testing and overgeneralization errors are made, as seen in the difference of performance based on task. If one applies Vygotsky's perspective of word meaning, then the children are performing how they should be for their age and are learning how to use the words *and* and *or* (Wertsch, 1985). The current findings contradict past research because the data suggest *and* and *or* concepts are already distinct in children three to six years old, which is much sooner than once hypothesized. Due to the array of findings in support of and differing from past research, the present study shows that more research should be conducted with younger populations, and that *or* interpretations should be evaluated according to context. The present study provides more information on disjunctive reasoning at younger ages than past research, and shows that XOR is used at younger ages than past research has shown.

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Figure Captions

Figure 1. Age trends of XOR, IOR, and Both interpretation styles based on performance in Experiment 1.

Figure 2. Age trends of XOR, IOR, and Both interpretation styles based on performance of Experiment 2.

Figure 3. Number of XOR, IOR, and Both interpretation styles in Experiment 1 and Experiment 2.

Table 1

Truth Table for Exclusive (XOR) and Inclusive (IOR) Or

A	B	XOR (A or B)	IOR (A or B, or both)
True	True	False	True
True	False	True	True
False	True	True	True
False	False	False	False

Table 2.

Contracted and Non-contracted commands used in logical test by Johansson in 1975.

Command	Sentence given
Command 1	Encircle all figures that are blue and square
Command 2	Encircle all figures that are blue, and all that are square
Command 3	Encircle all figures that are blue or square
Command 4	Encircle all figures that are blue, or all that are square