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Preschool Children's Use of Category Information to Interpret Negations

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ABSTRACT

Two experiments examined 4 and 5 year old children's use of semantic category to interpret negations. In an 'I Spy' game, children were given a hint in the form of a negation then instructed to select a referent in a forced-choice procedure. Children used category information to infer that the referent was semantically related (near-neighbor) rather than semantically unrelated (far-neighbor) to the negated item, though both were logically correct choices. The results suggest that one type of 'pragmatic interpretation' children use for understanding negations is semantic relatedness that reduces the scope and indeterminacy of negations.

An important question in the development of reasoning and communication is how children develop an understanding of logical connectives such as AND, OR, and NOT. Logical connectives are unique problems in language acquisition since they do not directly refer to an object or action but are relational in nature. Negations are particularly vexing since a negation "has no referent…and is inherently indeterminate," (Pea, 1980, p. 156) referring to the absence of an object or set of objects. Negations pose a unique problem in reasoning since they do not specify a clear referent. For example, the statement 'Flipper is not a fish' does not indicate what 'Flipper' is; only what it is not.

A negation is a simple syntactic marker for changing the truth-value of an affirmed statement (Johnson-Laird, 1983). Previous research on understanding negations indicates that processing a negation involves two cognitive operations: creating a representation of an item, then inhibiting this representation (Johnson-Laird, 1983; MacDonald & Just, 1989).

The 'classical' interpretation of a negation is that it refers to anything outside of a designated set equally (Horn, 1989). In a classical interpretation of the previous example, 'Flipper' might refer to a whale, a human, or a car. A classical interpretation of negations presents two main difficulties in communication and reasoning: a) scope, or the limit to the objects or set of objects to which the negation refers and b) indeterminacy of reference, or determining to what a negation refers.

Negations <u>are</u> interpreted classically in formal reasoning- -i.e.; a negation includes all objects except those that have been negated (Horn, 1989). However, cognition is bounded; that is, people consider only a small number of possibilities at any time. Thus, since cognition is bounded, people do not consider <u>all</u> possibilities for a negation since this would create a problem set far too large to be cognitively tractable. Thus, to make operations tractable, children (and adults) must reduce the number of possible solution states, though they are capable of considering more than one possibility (Horobin & Acredolo, 1989). Therefore, either the number of states is reduced randomly or there is a process of determining which states are to be maintained. Such a heuristic must operate within young children's knowledge of negations.

In problem solving, an understanding of logical connectives is necessary to establish the mapping between evidence and form in order to draw a correct conclusion. An understanding of logical connectives is crucial to performance on logic problems. However no current theory gives a principled explanation of how syntactic and semantic information influences their interpretation (Johnson-Laird, 1983).

Young children's knowledge of negation

By the end of preschool, children have some understanding of negations. Children are capable of assigning truth-values for negations (Kim, 1985). For example, when shown a banana and told that the object is not an apple, children are capable of judging the statement as true. Children are also sensitive to syntactic markers and how these markers limit the scope of negations (De Boysson-Bardies, 1977; Rumaine, 1988). For example, children understand that negations refer to particular parts of speech (e.g., noun phrases) due to the position in a sentence. Finally, children have several functional uses for negations such as denying a request ("do you want some juice?" "No") or expressing disappearance ("No juice" when glass is empty) (Bloom, 1970; Pea, 1980).

One question that remains is how children infer a referent for a negation. That is, given a negated noun phrase, syntax alone is insufficient for determining a referent because all 'nouns' could be equally plausible. Another strategy seems necessary inferring a referent. Previous research suggests that children may use linguistic and non-linguistic cues to help them resolve problems of indeterminate reference (Oaksford & Stenning, 1992).

One such cue may be provided by semantic categories. A well-documented finding in developmental research is that young children have the capacity for category-based reasoning because "members of object categories…share deep, underlying commonalties" (Waxman et al., 1997, p. 1074). This category-based information can be used for induction in which the

properties of one entity are extended to another on the basis of similarity.

Semantic Category and Memory

Previous research has also indicated that there is a reciprocal relationship between semantic categories and the structure of memory (Brainerd, Reyna, & Kneer, 1995; Ackerman, 1997). Encoding and recall of items in memory are related to semantic category because accessing an item tends to activate items within the same category more strongly than functionally related items (Brainerd, Reyna, & Kneer, 1995). Category-based information may also function as context, making similar items more salient, aiding retrieval because the process of categorization itself may form associations between concepts (Ackerman, 1997).

Category information may also interfere with retrieval. In the False Recognition Paradigm when similar items are activated increases in errors are directly related to the level of similarity between the distracter and the negated item (Brainerd, Reyna, & Kneer, 1995). Further, negating an item does not seem to reduce the salience of related items. Activation levels of similar items were increased when a target item was negated; even when the items themselves were contextually suppressed (MacDonald & Just, 1989).

To summarize, understanding negations involves a combination of syntactic and semantic/pragmatic processes. Syntax determines the part of speech that a negation modifies (e.g., noun phrase) providing a limit on the scope of a negation. Semantic understanding of negations is a two-step cognitive operation in which an item is represented, then inhibited. When the represented items are accessed in working memory, they activate similar items (i.e., other category members). Because activated items are inhibited in negations, then it is possible that category information guides induction of possible referents by providing a contextual 'frame' in which pragmatic inferences can be drawn. Thus, negating an item may provide a cue to the range of items to which a negation refers by providing context.

There is indirect evidence that category information may provide context for interpreting a negation. First, in a study examining conditional reasoning, phonological cues focused reasoners on intended contrasts (Oaksford & Stenning, 1992). For example, in the sentence *Tim did not travel from Chicago to Pittsburgh by car,* if one stresses the word *c a r* participants tended to infer probabilities of the mode of transportation *Tim* used mediated by the knowledge of the trip (i.e., plane, train).

A second example is taken from an early study of young children's understanding of negation. In a series of class-inclusion experiments, children were given a collection of objects that could be classified on various dimensions such as shape or color and given instructions (phrased as negations) to sort these objects on one dimensions (e.g., things that are NOT green) (Inhelder & Piaget, 1964). The results indicated that 5-9 year old children did not sort objects using class-inclusion rules (e.g., failing to understand the hierarchical inclusion of 'blue triangles' within the class of 'triangles'). A closer examination of the data indicates that a prominent error pattern was to sort objects on one dimension (e.g., shape). For example, when told to select objects that were 'NOT red circles,' children would often select only red triangles, ignoring other possible responses (such as other circles or non-red triangles). Perhaps 'circle' guided participants to infer that they should focus on a shape-based set of objects. A final example is drawn from a semi-structured interview in which a child implicitly states how such category-based inferences are useful for interpreting negations (from Inhelder & Piaget, 1964, p. 141):

Piaget: "And is it more correct to say that a cow isn't a bird, or that a house isn't. Or are both equally correct?"
Ros: "It's a little ridiculous to say that a house isn't a bird."
Piaget: "And a cow?"
Ros: "Well, it is an animal!"

There seem to be three possibilities for how young children might use category information to interpret negations. The first is that they simply do not use this information. However, if children do use this information, then there are (at least) two possibilities that reflect contrary pragmatic interpretations. One interpretation infers that the referent is something like the negated item. This would result in a 'near-neighbor' inference in which children would look for something within the same category as the negated item. A second interpretation infers that the referent is something unlike the negated item. This would result in a 'far-neighbor' inference in which children would infer that the referent is something outside the category of the referent. Using category information may help reduce the number of possibilities corresponding to a negation by providing a framework for evaluating which items may be relevant- - either items that are closely related to the negated item (near-neighbor) or items that are unrelated to the negated item (far-neighbor). Using the category information to infer either type of relationship between the negated item and the referent demonstrates a structured understanding of pragmatics and an attempt to infer the meaning of the speaker.

The present study examines two questions. First, do young children use category information to infer a probable referent for a negation? If children do not use category information then the number of far-neighbor and near-neighbor choices should not differ from chance.

Second, if children use category information, do they infer that the referent is something <u>like</u> the negated item (near-neighbor) or something <u>unlike</u> the negated item (far-neighbor)? If the number of choices differs from chance, then this tendency reflects one of two possibilities. Above chance selection of near-neighbor items suggests that the child inferred that referent is something <u>like</u> the negated item. An above chance selection of far-neighbor items suggests that the child inferred that the referent is <u>unlike</u> the negated item.

Two experiments were conducted to examine young children's use of category-based inferences to induce the referent of a negation. A forced-choice paradigm was used for all experiments in which participants were presented with three objects: a negated item and two choices. Children were instructed that they were playing an "I Spy" game. Children were given a hint as to what the experimenter was "spying" phrased as a negation. They were then asked to infer the referent of the negated item by making a choice between the objects and placing it into a basket. The objects represented *logically correct* choices but differed only in the *degree of relatedness* to the negated object.

Three semantic categories were used for both experiments: animals, vehicles, and foods. Three objects were chosen from each category. Three factors were examined in the series of experiments: the impact of the familiarity of the objects, the number of near-neighbor choices, and the reference set.

In Experiment 1, the experimenter provided three familiar objects from each category and presented a 'hint' in the form of a negation. Children were then asked to choose between two objects: one from within the same category of the negated item and one from a different category. Experiment 2 used the same design as Experiment 1 but used objects that were unfamiliar yet fell into the categories.

Experiment 1

Methods
Participants

The participants were twenty-one 4-year-olds and 20 5-year-old children from two preschool classrooms. Children ranged in age from 4.1 to 5.5 years (25 girls, 16 boys). Most children were from middle class, white families. Children were selected on the basis of receipt of parental permission.

Materials

A total of nine objects were used. The objects were chosen to represent three semantic categories: <u>foods</u>- apple, banana, orange; <u>animals</u>- dog, cat, bunny; <u>vehicles</u>- car, plane, boat. The objects were chosen as familiar based on rankings taken from the MacArthur Communicative Development Inventory (CDI) that established each object as being in receptive vocabulary before year 2 (Fenson et al., 1994). Each object was similar in size. All children named each object spontaneously.

Procedure

The procedure was a forced-choice selection task framed as an "I spy" game in which children were presented three objects: two within the same semantic category and one outside the semantic category. Children were told to guess to which object the experimenter was referring and to place that object in a basket. The child was told "What I spy is *NOT* (emphasized) the (negated object)" and asked to place one object in the basket. Each child was tested individually in a quiet room and took approximately 10 minutes. There were two phases: a warm-up and an experimental phase. The warm-up phase consisted of three questions intended to familiarize each participant with the game and to check understanding of basic negations.

Warm-up

The warm-up phase began by asking participant to name all objects and to correct any mistakes. Most participants named each object correctly and all correctly named the object set before warm-up tasks began. The same objects were used in the warm-up and experimental phases. Participants were then presented with three warm-up questions to learn the rules of the 'I spy' game. All children demonstrated an understanding of negations by not choosing target object on three of three trials and continued into the experimental phase.

Experimental Phase

Once the child was familiarized with the procedure, each array was presented and the child was told "What I spy is NOT the x" and instructed to place one object in the basket. Once the question was asked, eye contact with the participant and materials was avoided until after the selected object was placed in the basket in order to minimize nonverbal cues. The negated object (A1) always was one of two within the same category. The two possible choices included one from <u>within</u> the semantic category of the negated object (A2) and one from <u>outside</u> the semantic category of the negated object (B1). A total of nine trials were performed in which each object was negated only once and appeared in two other arrays, once as a near-neighbor choice and once as an far-neighbor choice. The placement of the negated object and possible referents was systematically varied. Order of

presentation was counterbalanced. All participants completed all nine trials.

Coding

Responses were coded in one of two categories: within the same category as the negated item (near neighbor) or outside the category of the negated item (far-neighbor). Children could pick one or two objects per trial. If one object was chosen, then it was coded as either within the same category or outside the category of the negated object

Results

Children's choices were examined two ways: across-individuals and within-individuals. Across-individual analyses examined overall response trends while within-individual analyses examined patterns of responses for consistency across the experiment. Responses were coded in one of two categories: near-neighbor or far-neighbor. Preliminary analyses indicated no gender or age differences thus were combined for further analysis.

Across-Individual Results

Seventy-one percent of choices were within the category of the negated object leaving twenty-nine percent outside the category. A confidence interval test was conducted to compare whether children's item selection was at a level different than would be expected if they were choosing items randomly. Seventy-one percent of item choices were within the category of the negated item leaving twenty-nine percent of choices outside the category of the negated item. The selection pattern was significantly different than would be expected by chance ($p < .01$, confidence interval 66-75%). This indicates that children selected items from within the same category as the negated item at an above chance level.

Within-Individual Responses

In order to evaluate the consistency of individual participants, a within-individual analysis was performed. A participant was coded as adhering to a pattern if they used the same selection pattern on seven of nine trials. Seven of nine trials represent an above chance pattern of responses whose conditional probability was less than .10. Twenty-eight children were coded as using a consistent response pattern and of these participants, 23 used a near-neighbor selection pattern while 5 used a far-neighbor pattern.

Discussion

The results indicated that young children demonstrated a preference for choosing an object from within the same category as the referent for a negation (though both choices were logically equal). For example, given an apple and a boat and asked "What I spy is NOT a banana", children overwhelmingly selected the apple. Individual analysis revealed a large number of children responded consistently across tasks, primarily using a near-neighbor strategy, in which a near-neighbor object was chosen 7 of 9 times. No age-related differences were found between the 4 and 5 year olds.

These findings suggest that children are sensitive to the semantic information provided in a negation as providing a context for pragmatic interpretation. This information was used most frequently to infer a near-neighbor relationship between the item negated and the referent. Thus, inferring that 'not a cat' is a dog was more frequent than inferring that 'not a cat' referred to a car. It is also plausible that this same marker may indicate that the object is outside of the category of the referent, as demonstrated by the five children who made such an interpretation. However both are clearly category based inference patterns.

Although the results of the study are clear their interpretation could be limited by the familiarity of the materials. Perhaps with familiar objects there are thematic relationships (e.g., dogs and cats are often in the same house) along with the taxonomic relationships, and these additional links increased near-neighbor choices. Thus, a second study was designed to examine the influence of less familiar materials to eliminate the possibility that labels and thematic relations may have influenced the results.

Experiment 2

In order to address the familiarity bias that may have influenced the results of Experiment 1, Experiment 2 extended the same procedure and categories of Experiment 1 using unfamiliar stimuli. A similar procedure was utilized using novel materials (yet within the same semantic categories as Experiment 1) to reduce the possibility that the familiarity of materials might be influencing the results. A second procedural change was introduced to reduce the focus on familiar labels: only naming the target object only during the experimental phase.

Methods
Participants

The participants were 21 4 and 21 5-year-old children from two preschool classrooms in a different preschool than in Experiment 1. Children ranged in age from 4.4 to 5.3 years (22 girls, 20 boys). Most children

were from middle class, white families. Children were selected on the basis of receipt of parental permission.

Materials

Nine objects were chosen as unfamiliar, within the same three semantic categories as Experiment 1: <u>food</u>-eggplant, zucchini, cabbage; <u>animals</u>- lynx, tapir, gazelle; <u>vehicles</u>- diving bell, seacopter, hovercraft. Each object was similar in size.

Procedure

The basic procedure was similar to Experiment 1. The procedure was slightly different in that only the target objects were named. This procedure was used to reduce the emphasis on labels. Responses were coded as in Experiment 1.

Results

Across-Individual Results

Preliminary analyses indicated no significant differences between four and five-year-olds and the two ages were combined for further analysis. A confidence interval test was conducted to compare whether children's item selection was at a level different than would be expected if they were choosing items randomly. Seventy percent of choices were within the category of the negated item and thirty percent of choices outside the category of the negated item. The number of within-category selections was above chance (p< .01, confidence interval 64-76%).

Within-Individual Responses

As in Experiment 1, a participant was coded as adhering to a pattern if the same selection pattern was used on seven of nine trials. Twenty-two of 42 participants used a near-neighbor selection pattern on at least 7 of 9 trials.

Discussion

Experiment 2 was conducted to replicate the findings of Experiment 1 and examined the possibility that the results of Experiment 1 may have been influenced by the familiarity of the materials. As in Experiment 1 almost all children chose only one object per trial and this object was most often (66%) within the same taxonomic category as the target. Once again there was considerable individual consistency, with 22 children choosing the near-neighbor objects at least 7 of 9 trials. One interesting difference from the previous experiment was that no child consistently chose the far-neighbor object.

These data suggest that when given a choice among unfamiliar objects as the referent of a negation, there is a tendency to choose an object from the same taxonomic category. Thus, the semantic information in a negation provides one clue as to how the negation might be interpreted.

General Discussion

The findings indicated that most children used category information to interpret negations and they used this information to infer that a referent was related to the item negated rather than unrelated. The findings suggest that children tend to make these inferences regardless of whether objects are familiar or unfamiliar.

The first research question investigated the possibility that children used category information to infer the intended referent of a negation. Children selected items at levels above chance; that is, they demonstrated a preference for one type of item, presumably due to category information.

The second research question examined the type of selection preference. There were two possibilities for a selection preference: selecting items within the category of the negated item (near-neighbor) or selecting items outside the category of the negated item (far-neighbor). The two patterns involve different assumptions about the pragmatics of negation. A near-neighbor pattern uses category information to find an item similar to the negated item. For example, NOT CAT would mean DOG (rather than CAR) since both are animals. A far-neighbor pattern uses category information to find an item unrelated to the negated item. Using the previous example, NOT CAT would mean CAR (rather than DOG). The results clearly demonstrated that children selected an object from within the same category as the negated item. Individual analyses indicated that children's near-neighbor selection patterns were quite consistent across the problem set with roughly half of the children selecting near-neighbor items on at least 7 of 9 trials.

The findings suggest that semantic information may help reduce the scope and indeterminacy of negations by providing a contextual 'frame' for pragmatic inference. That is, choosing to negate an item may provide a cue to its interpretation: by choosing to negate item x, some property of item x may be relevant to understanding the referent. For example, the sentence 'Whiskers is not a cat' provides a clue that there is something about this object (cat) that is relevant to figure out what 'Whiskers' is- otherwise another object might have been negated. For example, we would probably be more surprised if 'Whiskers' was a book than if 'Whiskers' was a hamster since a near-neighbor interpretation favors the latter. Thus, the pragmatics of a near-neighbor interpretation may reduce the search for

possible referents to items within the category of the negated item (e.g., other pets). This strategy can be formalized using a simple inference rule: given NOT X, then search for items within the category of X as possible referents. Thus, this inference rule combined with semantic category information may provide a powerful tool for inferring the referent for a negation.

The findings suggest a principled explanation of interpreting negations. Since the structure of categories and memory are well established by previous research (Brainerd, Reyna, & Kneer, 1995; Ackerman, 1997), all that is required is a simple pragmatic rule easily derived from experience in which a negation indicates a near-neighbor relationship between the negated item and referent. These findings suggest that the semantic information from negations may provide one source of information with which one reduces the scope and indeterminacy of negations, thus reducing the number of possibilities while maintaining information. A near-neighbor relationship may be common in young children's language environments in word acquisition. For example, when children overextend labels onto unfamiliar objects (e.g., labeling a CAT a DOG) adults often implicitly utilize a near-neighbor negation in correcting the error ("No, that is not a dog, it is a cat).

Finally, these findings may provide one explanation for the interaction between pragmatics and deviations from normative reasoning lacking in current theories of logical development. Understanding children's interpretations of negations is important since children and adults do not appear to use classical logical reasoning (Johnson-Laird, 1983; Sharpe et al., 1996). That is, children and adults rarely solve logical problems as a trained logician would solve them. As noted earlier, current theories of logical development rely on pragmatics to explain performance, yet do not provide explanations of how pragmatics is achieved. Therefore, understanding how pragmatics influences reasoning solutions and strategies is useful for understanding performance and how to improve performance through instruction. This study provides evidence for one type of pragmatic interpretation- a near-neighbor interpretation of negations in which the category of the negated item provides context that guide item selection to an item within the same category.

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