Assessing Preschool Children's Knowledge of Compounds from a Logico-Semantic Perspective[1]

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1. Introduction

Research in First Language Acquisition investigates three broad questions: What do children know about language? When does this knowledge emerge? How is children's knowledge of language different from adults' knowledge of language? This study adds to previous research in FLA by investigating the interaction between logic and meaning in child language. This study examines preschool children's comprehension of the logical relation between a compound and its head noun in comparison to adult's logico-semantic interpretation of compounds.

1.1. Background: compounds in English

Compounds are complex words that are composed of at least two root words (e.g., Fabb, 1998). Compounds can have various types of root words, including: adjective + noun (e.g., "blueberry"), verb + noun (e.g., "hangman") and noun + noun (e.g., "fog horn"), and even a derived member, as in noun + derived noun (e.g., "coffee drinker"). The two main types of compounds are endocentric compounds such as "blueberry" and exocentric compounds such as "hogwash". Endocentric compounds are composed of a head and a modifier (Spencer, 1991). In English, endocentric compounds are right-headed and follow the Right Hand Head Rule (RHHR). The RHHR states that the root farthest to the right determines the syntactic and semantic category of the entire compound and its basic meaning (Gagné and Spalding, 2006; Nicoladis, 2003). For example, the endocentric compound "blueberry" can be decomposed into two root words, the modifier "blue" and the head "berry". As the head "berry" is a noun and refers to a type of berry, the entire compound "blueberry" is also a noun and refers to a type of berry. Note that the head is also the right-most root. The compound "blueberry" refers to berries that are blue, because the other root, the adjective "blue", is the modifier. As such, the morpho-semantic representation of English endocentric compounds are said to be transparent. On the other hand, the morpho-semantic representation of exocentric compounds such as "hogwash" is less transparent compared to that of endocentric compounds. As the compound "hogwash" does not refer to a type of hog or a particular method of washing, neither of the roots in this compound seem to operate as a head or a modifier (Spencer, 1991). In this paper, we will focus exclusively on endocentric compounds.

English endocentric compounds can encode a potentially infinite number of semantic relations between the head and its modifier (Downing, 1977). A few semantic relations are LOCATED IN (e.g., "housecat" is a cat that is LOCATED IN a house), MADE OF (e.g.,

"snowball" is a ball that is MADE OF snow), LOOKS LIKE (e.g., "stick figure" is a figure that LOOKS LIKE a stick), and FOR (e.g., "teacup" is a cup that is specifically FOR drinking tea). A single compound can be interpreted with a variety of semantic relations. Thus, the novel compound "cat candy" could be interpreted as candy that LOOKS LIKE a cat, candy that has cats ON its surface or candy that is specifically FOR cats. While one interpretation might be stronger than others in a given context, all of the interpretations are possible. Downing (1977) examined the most frequent semantic relations between the head and the modifier of novel compounds. Her list of the most common relationships include: whole-part (e.g. "duck foot" is a part of a duck), half-half (e.g. "giraffe-cow" is a creature that is half giraffe and half cow), part-whole (e.g. "pendulum clock" is a clock with a pendulum), composition (e.g. "stone furniture" is furniture made of stone), comparison (e.g. "pumpkin bus" is a bus that looks like a pumpkin, time (e.g. "summer dust" is dust in the summer), place (e.g. "Eastern Oregon meal" is a meal from Eastern Oregon, source (e.g. "vulture shit" is shit from a vulture), product (e.g. "honey glands" are glands that produce honey), (e.g. "flea wheelbarrow" is a wheelbarrow for a flea), purpose (e.g. "hedge hatchet" is a hatchet specially designed for hedges), and occupation (e.g. "coffee man" is a man who makes coffee).

1.2. The logico-semantic relation between an endocentric compound and its head

The meaning of an endocentric compound and its head noun, follows the Subcategorization Principle (Downing, 1977; Clark, et al., 1985). This principle states that the denotation of a compound is a subset of the denotation of its head. For the compound "teacup", the head "cup" refers to a set of objects in the world. The compound "teacup", on the other hand, refers to a subset of objects relative to its head, meaning that "teacup" is a subset of "cup". Due to the meaning contribution of the modifier "tea", this subset of objects refers to cups that are made specifically for tea. In ordinary linguistic environments, a valid entailment is created from a subset-denoting expression to its set-denoting expression[2]. Consider (1) below:

(1) a. Tom bought an <u>Italian car</u>.
    b. Tom bought a <u>car</u>.

The denotation of "Italian car" in (1a) is a subset of the denotation of "car" in (1b). The logico-semantic relation between (1a) and (1b) is that (1a) entails (1b) (i.e., if it is true that Tom bought an Italian car, as stated in (1a), then it must be true that Tom bought a car, as in (1b)), but not vice versa (i.e., even if it is true that Tom bought a car, as stated in (1b), it is not necessarily true that Tom bought an Italian car as in (1a), because Tom might have bought a Japanese car). As the relation between a compound and its head creates a set-subset relation, as discussed above, the entailment relation between a proposition with a compound and a proposition with its head should also exhibit the aforementioned entailment pattern.

(2) a. There is a <u>teacup</u> on the table.
    b. There is a <u>cup</u> on the table.

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[2] An anonymous reviewer pointed out that there are some adjective + noun compounds to which the entailment relation described in this paper does not apply. For example, "John has a fake car" does not entail that "John has a car". Similarly, compounds with roots that have multiple meanings do not follow the described entailment relation. For example, "Mary has an eggcup" does not entail that "Mary has a cup". Such cases were not included in the stimuli. We appreciate the reviewer's contribution.

We see that (2a) entails (2b), but not vice versa: if it is true that there is a teacup on the table as in (2a), then it is necessarily true that there is a cup, as in (2b); however, if it is true that there is a cup on the table, as in (2b), it is not necessarily true that there is a teacup on the table, as in (2a), because the cup on the table might have been a coffee cup, rather than a teacup.

1.3. Children's knowledge about the logic-semantic relation between a compound and its head

From an acquisition perspective, the representation of the compounds discussed above raises an important question regarding whether children's knowledge about compounds includes awareness of the aforementioned logico-semantic relation between a compound and its head. Previous studies have reported children's early coinages of simple nouns, such as "crow-bird" or "taxi-car", and those coined phrases were argued to be used to identify a subset of a set of entities that children already knew (e.g., "crow-bird" was used to refer to a kind of bird; e.g., Berman & Clark, 1989; Clark, Gelman & Lane, 1985). Although these findings indicate that children use a compound to denote a subset of a set denoted by its head, no study has directly tested whether children are indeed aware of the set-subset relation between the compound denotation and its head denotation. If children do possess knowledge about the RHHR, the Subcategorization Principle, and that a compound entails the head but not vice versa, then it should be predicted that children are able to understand that a compound denotation is a subset of its head denotation, and that a compound denotation entails its head denotation but not vice versa. This study thus investigates children's knowledge of these linguistic principles, by assessing children's evaluation of logico-semantic relation between a compound and its head. The following section will be devoted to reviewing previous studies on children's comprehension of endocentric compounds in English, in particular, their comprehension of noun + noun (N+N) compounds.

2. Previous studies

Clark, et al. (1985) investigated preschool children's comprehension of novel N+N compounds in English using two Picture Selection Tasks. This study included 60 monolingual English speaking children, ages 2;0-6;0. The first task, the Head Task, investigated children's knowledge of the RHHR. In this task, the children were presented with a card with four pictures and were instructed to point to the picture that matched the verbally presented stimulus. An example of what this card may look like is included below:
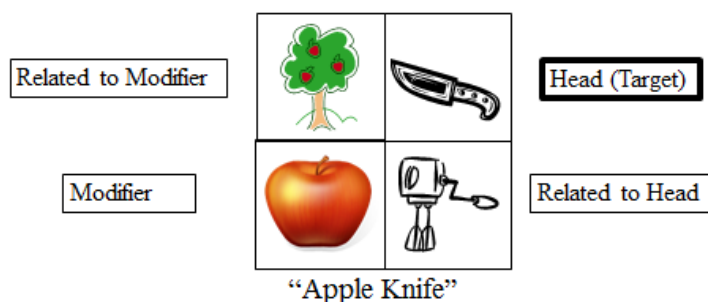

"Apple Knife"
Picture 1: Example of the Head Task[3].

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[3] Clark et al. (1985) created the stimulus "apple knife", but the example picture was created by the first author.

For a compound such as "apple knife", the children were asked to choose from among four pictures including: a referent for the modifier noun (e.g., an apple), a referent related to the modifier noun (e.g., an apple tree), a referent related to the head noun (e.g., an egg beater), and a referent for the head noun (e.g., a knife). The last option, the picture of the knife, is considered the target response in the Head Task, because selecting this picture indicates that the participant can correctly identify the head as the noun on the right and thus the participant understands the RHHR.

The second Picture Selection Task, the Combined Task, investigated children's knowledge of the Subcategorization Principle. An example of what this card may look like is included below:
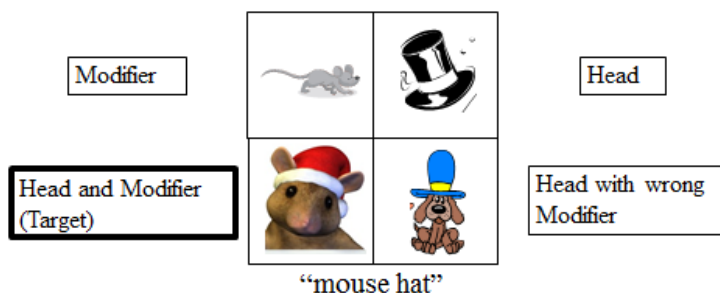
Picture 2: Example of the Combined Task[4].

For the compound "mouse hat", the children were asked to choose from among four pictures including: a referent for the modifier noun (e.g., a mouse), a referent for the head noun (e.g., a hat), a referent for the head with an incorrect modifier noun (e.g., a hat worn by a dog), and the target picture of the head noun combined with the correct modifier noun (e.g., a hat worn by a mouse). By selecting the target picture, the participants would demonstrate that they understand the Subcategorization Principle, because they understand that a "mouse hat" is more likely to refer to a particular subset of "hat" that is related to a mouse instead of a generic hat. The relevant results from Clark, et al (1985) are included in Table 1 below.

Percentage of Target Responses	Age Group		
Task	2;4 group	3;4 group	4;0 group
Head Task	48	82	92
Combined Task	49	85	96

Table 1: Relevant results from Clark, et al. (1985).

Clark, et al. (1985) found that the youngest group, with a mean age of 2;4, was significantly less likely to choose the target picture in both the Head and Combined Task in comparison to the second youngest group, which had a mean age of 3;4. When comparing the results between the second youngest group (mean age 3;4) and the oldest group (mean age 4;0), however, no significant difference was found. Thus, Clark, et al. (1985) concludes that children seem to be able to comprehend N+N compounds correctly by 3 years old, because they found the greatest increase in accuracy between ages 2 and 3 on both the Head and Combined Task. This conclusion is supported by Mellenius (1996), which concluded that Swedish children learn to correctly comprehend N+N compounds between ages 2 and 3.

Like Clark, et al. (1985), Nicoladis (2003) used the Picture Selection Task to investigate preschool children's knowledge of the RHHR and the Subcategorization Principle in regards to N+N compounds in English. They tested a similar group of participants, which included 35

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[4] Clark et al. (1985) created the stimulus "mouse hat", but the example picture was created by the first author.

monolingual English speaking children, ages 3 and 4. Nicoladis (2003), however, also questioned whether preschool children know that compound nouns in English are more likely to refer to two interacting objects than two juxtaposed objects that are merely side by side. Thus, this study's Picture Selection Task investigated children's knowledge of the RHHR, the Subcategorization Principle, and the preferred inherent relation for compounds. A picture of what a card may have looked like in Nicoladis (2003) is included below:

Picture 3: Example of the Picture Selection Task[5].

For the stimulus "sun bag", the children were asked to choose from among a picture of the head noun (i.e., a bag), a picture of the modifier noun (i.e., a sun), a picture of the head noun juxtaposed with the modifier noun (i.e., a bag and a sun next to each other), and a picture of the head noun inherently related to the modifier noun (i.e., a bag with multiple suns printed on it). Thus, the target choice is the picture with the head and the modifier noun combined (a bag with multiple suns printed on it). The relevant results from Nicoladis (2003) are discussed in Table 2 below.

Rate of Selection	Picture		
Age	Target	Juxtaposed Picture	Single Object Pictures
3 years	52.2	35.4	14.6
4 years	67.5	30.2	2.2

Table 2: Relevant results from Nicoladis (2003).

Nicoladis (2003) found that 3 year olds selected the target picture significantly less than 4 year olds and that 3 year olds selected the incorrect single object picture significantly more than 4 years olds. No significant difference between the selection of the picture with only the modifier noun and the picture with only the head noun was found for either group. From this comprehension task, Nicoladis (2003) concluded that 4 year olds understand that N+N compounds refer to two interacting objects more so than 3 year olds. Importantly, while Clark, et al. (1985) concluded that 3 year old children comprehend N+N compounds correctly, Nicoladis (2003) concludes that 3 year olds' comprehension of N+N compounds is still developing. This conclusion is supported by Clark, et al. (1987), which investigated Hebrew speaking children's production of compounds and found the greatest increase in accuracy between the ages of 3 and 4 years.

3. The current study

Because of the discrepancy between the results of Clark, et al. (1985) and Nicoladis (2003) in regards to 3 year old children's comprehension of compounds, it remains unclear when the ability to interpret compounds in an adult-like manner emerges. The current experiment tests

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[5] Nicoladis (2003) created the stimulus "sunbag", but the example picture was created by the first author.

a similar age group in the hope of finding converging evidence with either Clark, et al. (1985) or Nicoladis (2003). Furthermore, since previous studies have investigated children's comprehension from a structural perspective, it is still unknown whether children understand the logico-semantic entailment relationship between a compound and its head. The Picture Selection Task cannot be straightforwardly used to investigate children's comprehension of this relationship, because it tests children's understanding of one item at a time instead of the relationship between two items. We thus used an alternate task, which will be discussed in detail in the following section. Because children's logico-semantic knowledge of compounds is unknown, this experiment addresses the following question: Can preschool children comprehend the logico-semantic relationship between compounds and their heads in an adult-like manner?

4. Method

4.1. Participants

Thirteen English speaking children with ages ranging from 3;3-4;6 and a mean age of 3;10 participated in this study. The adult control group consisted of 32 native speakers of English with ages ranging from 18-25 years and a mean age of 19.6 years. The adult control participants were undergraduate students at the University of Kansas and received extra credit for their participation.

4.2. Stimuli

The target stimuli consisted of 8 novel N+N compounds (e.g., "dog hat"). Following the design of previous studies, novel compounds were created, to reduce the likelihood that the participants had encountered the stimuli before and had simply memorized the compound as a single lexical unit (Clark, et al., 1985; Nicoladis, 2003). By presenting the participants with novel compounds in a controlled context without visual cues, the participants need to decompose the compounds into the modifier and head root in order to generate an interpretation of the compound. The target compounds were composed of nouns selected from the CHILDES corpus to insure that 3 year old children are familiar with these words (MacWhinney, 1991). The nouns were combined into novel compounds that have a strong FOR interpretation, in which the compound is 'an object (head noun) that is FOR another noun (modifier noun)'. An example of this would be "dog hat", which is likely to elicit a "hat for a dog" interpretation. It is important to note, however, that the same logical entailment pattern would be generated regardless of how the participants interpret the semantic relationship between the modifier and the head, because all endocentric compounds follow the Subcategorization Principle and have the same set-subset relation with their heads.

The adult control experiment also included 8 adjective noun (Adj+N) phrases (e.g., "blue house")[6] as fillers. No nouns were repeated throughout the stimuli, and only count nouns were used. The novelty of the compounds was verified with the Corpus of Contemporary American English (COCA; corpus.byu.edu/coca/). In the COCA, all the compounds had a

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[6] Our original goal was to include the filler items in the preschool experiment, however, pilot testing showed that conducting the experiment with both target and filler trials was too lengthy for young children. We wanted to decrease the likelihood that the children would discontinue the experiment or that they would respond with "yes" without evaluating the logical relation between the demand and the fulfiller in the attempt to finish the experiment faster. Thus, the filler trials were excluded from the experiment for preschool children. Note that in the previous study utilizing the Demand Fulfillment Task (Minai, 2007), filler trials were not included for a similar feasibility reason.

frequency of zero; the frequency of the filler phrases was within the range of 0 to 60 entries. The adult experiment also included two practice trials at the beginning of the task (the Demand Fulfillment Task, discussed in Section 4.3 below). During the practice trials, the experimenter explained to the adult participants the demand-fulfillment context, what an expected response would be, and how to record their responses on the response sheet. The stimuli in these practice trials consisted of simple nouns such as "lamp" and "shell", thus they did not include the constructions used in the experimental trials (compounds and Adj + N phrases).

4.3. Task

We utilized the Demand Fulfillment Task (Minai, 2007), a linguistic comprehension task that allows us to directly and deductively examine children's knowledge of the logical relationship between two propositions. This task adopts a particular demand-fulfilling context as follows: among two propositions whose meaning relation is to be evaluated, one is presented as a demand and the other is presented as a fulfilling response (e.g., Demand: "Bring me a cup"– Fulfillment: "I brought a teacup"). In order for the demand to be logically satisfied by the fulfillment, the logico-semantic relations between these two propositions must be such that *the fulfillment entails the demand*. An example of when the demand is logically fulfilled is included below in (3):

(3) a. Demand: Bringing a cup   "Bring me a cup."
    b. Fulfillment: Bringing a teacup   "I brought you a teacup."

In this example, the demand includes a set of items ("cup") and the fulfillment includes a subset of those items ("teacup"). Because bringing a "teacup" necessarily means that a "cup" was brought, this creates a valid entailment pattern from the fulfillment to the demand; therefore, the demand is logically satisfied. Note that, among the two propositions, (3a) and (3b), (3b) entails (3a). If these propositions are reversed, however, the demand would not be logically satisfied, as shown in (4):

(4) a. Demand: Bringing a teacup   "Bring me a teacup."
    b. Fulfillment: Bringing a cup   "I brought you a cup."

In (4), the demand includes a subset of items ("teacup"), and the fulfillment includes a set of items ("cup"). Bringing a "cup" does not necessarily mean that a "teacup" was brought, therefore, an invalid entailment pattern from the fulfillment to the demand is created and the demand is logically unfulfilled.

Taking advantage of this particular context, in which the direction of the valid entailment is clearly reflected in whether the demand is satisfactorily fulfilled, the Demand Fulfillment Task is designed as a 'story' to accommodate young children's participation and to make the demand-fulfillment presentations pragmatically felicitous. The story features two characters: a bossy demander and a forgetful fulfiller. In the task, the demander requests that the fulfiller bring a certain item. The fulfiller is a forgetful, silly character, and he sometimes brings a correct item, but other times he brings an item that is very close to, but not exactly, what is demanded. Crucially, at this point, the fulfiller states the fulfillment proposition ("I brought X") verbally, without showing the actual item that he brings, and asks the child whether that item is good enough to satisfy the demander. The measurement is whether or not each child decides the item the fulfiller verbally declared is good enough; if the child judged a fulfillment in response to its preceding demand to be good enough, it is interpreted that

he/she evaluated the entailment licensed from the fulfillment to the demand as valid; if the child does not judge a fulfillment in response to its preceding demand to be good enough, then it is interpreted that the child has concluded the entailment from the fulfillment to the demand was not valid.

In the current experiment, the demander is Cruella De Vil, who has stolen the animals from the zoo. Because she is a collector who wants to continue to build her collections, she has agreed to free the animals if she receives certain items. The fulfiller character is Winnie the Pooh, who is trying to find the items that will satisfy Cruella's demands. These characters were chosen, because they are likely to be familiar to the child and they resemble their "bossy" and "forgetful" roles in the demand-fulfillment contexts.

In the beginning of the experiment, Cruella declares that she has stolen animals from the zoo. She further states that she would agree to free those animals, if she receives certain items from Winnie the Pooh. These lines by Cruella set up a discourse, into which a subsequent demand-fulfillment is naturally introduced. The plot for presenting each trial was presented in (5) below.

(5) a. Introduction:
    Cruella: "*I am collecting hats of all kinds, but my collection is still small.*"
  b. Demand Presentation (Cruella verbally describes the demand.):
    Cruella: "*If you want me to free one of your friends, bring me a <u>hat</u>. So bring me a <u>hat</u>!*"
  c. Fulfillment Presentation (Winnie the Pooh comes back with an item inside a box and verbally describes to the child what he has brought. The object is not shown to the child at this time.):
    Pooh: "*I brought a <u>dog hat</u>.*"
  d. Fulfillment Evaluation I - "Without Picture" Evaluation (In order to elicit the child's logical judgment on whether the fulfillment entails the demand, Pooh asks the child whether the object is "good enough*"*):
    Pooh: "*Will this be good enough to free my friend when I bring it to Cruella*?"
  e. Fulfillment Evaluation II - "With Picture" Evaluation (After the child provides his or her original judgment, the object is revealed to the child, and Pooh repeats the demand. If needed, the experimenter prompts the child to evaluate the demand-fulfillment again):
    Pooh: "*I brought a <u>dog hat</u>.*"
    Experimenter: "Will this be good enough?"
  f. Final outcome presentation (If the child answers "yes", Pooh immediately brings the item to Cruella. If the child answers "no", the child is asked to help Pooh correct his mistake, so the animal can be freed)

The introduction in (5a), where Cruella states that she is a collector who is looking for "hats of all kinds" [7], provides the participant with the appropriate pragmatic context for Cruella's demand in (5b). Winnie the Pooh, once the demand is presented, leaves the scene and searches for the item that Cruella described in her demand. Crucially, Pooh is very forgetful and sometimes retrieves an item that is similar to, but does not exactly match, the original demand. In the Fulfillment Presentation (5c), Pooh may state that he brought "a dog hat", and asks the child if it is good enough to make Cruella happy as in (5d). After the prompt

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[7] Through pilot testing with adults, we found that the line "of all kinds" was necessary to suppress pragmatic information that interferes with adult participant's ability to interpret the stimuli logically. When this line was not included, some adults only considered items that Cruella was likely to use in the real world as acceptable items.

question in (5d), the child determines whether or not the item logically satisfies the demand, thinking they are helping Winnie the Pooh find an item that is "good enough" to free the animals. Crucially at this point, Winnie the Pooh brings the item to the child in a closed box, so the child judges the fulfillment based on Pooh's verbal description of the item before the item is revealed to the child. After the child gives his or her initial judgment, the item is then removed from the box and revealed to the child. At this stage (5e), Winnie the Pooh restates the fulfillment and the child is asked to determine whether or not the item is "good enough" once again. Thus, the children's judgments are elicited before they see the object and after they see the object. The purpose of this two-stage evaluation process is to ensure that the children are using their deductive reasoning to judge the fulfillment based on the linguistic description of the object instead of its visual features. The Final Outcome in (5f) is included so that the animal is ultimately freed on every trial. For each trial, Cruella accepts the item that the child approves, regardless of whether or not the demand is logically fulfilled.

4.4. Experimental conditions

There were four types of logical relationships between the demand and the fulfillment which form the four levels of the independent variable in this experiment. The four conditions were Fulfilled, Unfulfilled, Exact Match, and Non-head Mismatch. In the Fulfilled Condition, the demand includes the head noun and the fulfillment includes the compound.

(6) a. Demand: Bringing a hat   "Bring me a <u>hat</u>."
    b. Fulfillment: Bringing a dog hat   "I brought you a <u>dog hat</u>."
    c. "I brought a <u>dog hat</u>" (Fulfillment (6b)) → "Bring me a <u>hat</u>" (Demand (6a))

Remember that the head noun denotes the set of items and the compound denotes the subset of items relative to the head. Thus in (6), "a hat" in the demand (6a) denotes a set of items, and "a dog hat" in the fulfillment (6b) denotes a subset of "hat". These propositions create the valid entailment pattern from the fulfillment to the demand, as in (6c), and the demand is logically satisfied. The expected response would be "Yes, the item is good enough". If a participant incorrectly says that the demand is unfulfilled, this is an indication that the participant has not fully acquired the Subcategorization Principle or entailment pattern generated by compounds[8].

The Unfulfilled Condition is the reverse of the Fulfilled Condition, in which the demand includes the compound and the fulfillment includes the head noun.

(7) a. Demand: Bringing a dog hat   "Bring me a <u>dog hat</u>."
    b. Fulfillment: Bringing a hat   "I brought you a <u>hat</u>."
    c. "I brought a <u>hat</u>" (Fulfillment (7b)) → "Bring me a <u>dog hat</u>" (Demand (7a))

In (7), "a hat" in the fulfillment (7b) denotes a set of items, and "a dog hat" in the demand (7a) denotes a subset of "hat". The propositions arranged in this way create the invalid entailment pattern from the fulfillment to the demand as in (7c), and the demand is not logically satisfied (Cruella clearly stated that she wants a "dog hat", so bringing a "hat" does

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[8] An anonymous reviewer pointed out an alternate possibility regarding how one could interpret children's rejection in the task. It may also be possible that children may reject the fulfillment as in (6b) because they thought that Cruella would not want a dog hat. In order to minimize such a possibility, we provided a richly controlled context in which Cruella was introduced as a desperate, eccentric collector who desires *any* kind of hat. With this context, it is not likely that our child participants rejected the demand-fulfillment like (6b) reasoning that Cruella did not want a dog hat.

not *logically* satisfy her demand). An expected response would be "No, the item is not good enough". The participant, however, may recognize that there are possible scenarios in which the item, that Winnie the Pooh vaguely described using the head noun "a hat", is actually a member of the subset denoted by the compound "a dog hat". Thus, the responses "maybe" or "need more information" would also be accepted as adult-like. A "yes" response would not be accepted as a logical response, however, because a "hat" does not entail "dog hat". Recall that the fulfillment must entail the demand, in order for the fulfillment to logically satisfy the demand. If a participant incorrectly says the demand is satisfied, this would be an indication that the participant has not fully acquired the Subcategorization Principle or entailment pattern generated by compounds.

In the Exact Match Condition, the fulfillment and the demand were identical, as in (8).

(8) a. Demand: Bringing a dog hat   "Bring me a dog hat."
   b. Fulfillment: Bringing a dog hat   "I brought you a dog hat."

For this condition, the excepted response would be "yes, the item is good enough". Any other response would be an indication that the participant does not understand the task.

The Non-head Mismatch Condition is a context in which the demand contains the modifier noun and the fulfillment contains the full compound. An example of the Non-head Mismatch Condition is shown in (9).

(9) a. Demand: Bringing a dog   "Bring me a dog"
   b. Fulfillment: Bringing a dog hat   "I brought you a dog hat"

The denotation of "dog" and the denotation of "dog hat" do not yield a set-subset relation, and the demand-fulfillment is not satisfactory due to a mismatch of the basic category of the demanded item (dog) and the fulfilled item (a kind of hat). The expected response would be "No, the item is not good enough". If a child does not yet know that the head of an N+N compound in English is the one on the right, he/she may wrongly associate "dog" and "dog hat" as if there were a set-subset relation. Hence, children's failure in this condition may be taken as an indication that the participant has not acquired the RHHR. The four experimental conditions were summarized in Table 3 below.

Condition	Demand	Fulfillment	Status	Expected Answer
Fulfilled (6)	Bring me a hat	I brought a dog hat	**Satisfactory**	**Yes**
Unfulfilled (7)	Bring me a dog hat	I brought a hat	**Unsatisfactory**	**No, Maybe, Need more information**
Exact Match (8)	Bring me a dog hat	I brought a dog hat	**Satisfactory**	**Yes**
Non-head Mismatch (9)	Bring me a dog	I brought a dog hat	**Unsatisfactory**	**No**

Table 3: Summary of logical relationship conditions.

The comparison between the Fulfilled and the Unfulfilled conditions is critical in this experiment, because knowledge of the entailment pattern generated by the set-subset relation between the compound and its head noun is required in order to evaluate whether the fulfillment is "good enough" to satisfy the demand.

4.4. Procedure

Each child participant was tested individually in a quiet room at a preschool. The Demand Fulfillment Task stories were presented as a Microsoft PowerPoint presentation on a laptop computer (see Appendix B for a sample full script). An experimenter viewed the story presentation with the child, prompting the child as indicated in the script, while a second experimenter recorded the child's responses manually.

A modified version of the Demand Fulfillment Task was administered to the adult participants by a Microsoft PowerPoint presentation projected on a screen. For time-efficiency, the fulfillment objects were not revealed visually to the adults. Instead, the adults were asked to answer whether the fulfillment would be "good enough" to free the animal, if Pooh were to give the object to Cruella. The adults were given a response sheet in which to record their responses to the trials. The adults were asked to circle either "Yes" the animals will be freed (meaning that the fulfillment satisfied the demand), "No" the animals will not be freed (meaning that the fulfillment did not satisfy the demand), or "Need to see inside the box" (meaning that the participants need to physically view the item to assess whether the demand is satisfied). The adult participants would circle this last option if they recognize that the fulfillment would satisfy the demand in particular circumstances where the object that Pooh brought happened to be the desired object. The adults were also asked to provide their reason for choosing a certain response for each trial, in order to ensure that the adults chose each response for the intended reason. All experiments took place in a classroom at the University of Kansas. In some cases, multiple adults were tested at one time, but were observed by the experimenter to ensure that none of the participants collaborated in filling out their response sheets.

4.5. Data coding

Both the adult and children's responses were coded as either "yes" responses or "non-yes" responses. Responses such as "yes" and "I think so" were coded as "yes" responses, and responses such as "no", "maybe", and "need more information" were coded as "non-yes" responses. Both the participants' responses and comments were taken under consideration. For the adults, if the circled response and the reasoning behind the adult's choice did not match, then the circled response was treated as a coding error, and the response that matches the participant's reasoning was recorded. Coding errors such as this by the adult participants only occurred once. Also, data from two adult participants were excluded from the analysis, because their comments revealed that they judged the objects on the basis of whether they would be physically useful in helping the animals escape instead of whether they would satisfy Cruella's demand. Participants that did not complete all the trials were excluded from the quantitative analysis, but their comments were taken into consideration during the qualitative analysis.

4.6. Predictions

In order to determine whether preschool children exhibit adult-like interpretations of the logical relationship between compounds and heads, we tested the following predictions:

(1) If children understand the task, then children will robustly accept items in the Exact Match condition.
(2) If children understand the RHHR, then children will robustly reject items in the Non-head Mismatch condition.

(3) If children understand the entailment pattern generated by compounds, then children will robustly accept items in the Fulfilled, and will robustly reject items in the Unfulfilled conditions.

5. Results

5.1. Results from adults

Table 4 displays the information on the mean percentages of the "yes" responses from the adult participants for each condition. The standard deviations are given in parentheses.

Condition	Target N+N compounds	Filler Adj + N phrases
Fulfilled	100 (0)	98.4 (8.8)
Unfulfilled	4.69 (14)	3.13 (12.3)
Exact Match	98.44 (8.8)	100 (0)
Non-Head Mismatch	1.56 (8.8)	0 (0)

Table 4: Mean percentage of "yes" responses (and standard deviation) for Target and Filler trials by condition.

A one-way ANOVA was conducted to analyze the data with Condition (Fulfilled vs. Unfulfilled vs. Exact Match vs. Non-head Mismatch) as the within-subject factor. The dependent variable was the mean percentage of "yes" responses for each condition per participant. Recall that adults were presented with 8 target stimuli (novel N + N compounds) and 8 filler stimuli (Adj. + N phrases). The data from the Target and Filler trials were analyzed separately. The one-way ANOVA revealed a significant main effect of Condition for both the target N+N compound trials (F (3, 124) = 1049.908, $p < .001$) and the filler Adj + N phrase trials (F (3, 124) = 1775.403, $p < .001$). For the target trials, post-hoc pair-wise comparisons revealed significant differences between Exact Match and Non-head Mismatch ($p < .001$), Exact Match and Unfulfilled ($p < .001$), Fulfilled and Non-head Mismatch ($p < .001$), and Fulfilled and Unfulfilled ($p < .001$). No significant differences, however, were found between Exact Match and Fulfilled (p=.999) and Non-head Mismatch and Unfulfilled (p=.999). Thus, the Fulfilled and Exact Match conditions elicited significantly higher rates of yes-responses than the Unfulfilled and Non-head Mismatch Conditions. Similarly for the filler trials, post-hoc pair-wise comparisons revealed significant differences between Exact Match and Non-head Mismatch ($p < .001$), Exact Match and Unfulfilled ($p < .001$), Fulfilled and Non-head Mismatch ($p < .001$), and Fulfilled and Unfulfilled ($p < .001$). No significant differences, however, were found between Exact Match and Fulfilled (p=.999) and Non-head Mismatch and Unfulfilled (p=.608). Importantly, in the filler trials, the Fulfilled and Exact match conditions elicited significantly higher rates of yes-responses than the Unfulfilled and Non-head Mismatch conditions. Thus, the adults participants exhibited similar response patterns for both target and filler trials. These results, revealing adults' near-ceiling accuracy in all conditions, confirmed that our experimental setting did elicit the intended entailment evaluations from the adult control group.

5.2. Results from children

Table 5 displays the information on the means and the standard deviations for the children.

Condition	Without Picture	With Picture
Exact Match	100 (0)	96(13.9)
Fulfilled	88.5(21.9)	92(18.8)
Non-Head Mismatch	96.1(13.9)	92(18.8)
Unfulfilled	84.6(31.5)	84(37.6)

Table 5: Mean percentage of "yes" responses (and standard deviation) by condition.

As with the adult data, a one-way ANOVA was conducted to analyze the data with Condition (Fulfilled vs. Unfulfilled vs. Exact Match vs. Non-head mismatch) as the within-subject factor. Children's responses from the Without Picture and With Picture evaluations were analyzed separately. The dependent variable was the mean percentage of "yes" responses for each condition per participant. The one-way ANOVA showed that the the main effect for logical relation was not significant for either the Without Picture responses (F (3, 48) = 1.538, p = 2.7) or the With Picture responses (F (3, 48) = .538, p = .665). Thus, the children were equally likely to respond with "yes" in all four conditions regardless of the logical relationship between the demand and the fulfillment.

In sum, the results revealed that, while adults exhibited sensitivity to the validity of the entailment created between the demand and the fulfillment, children did not apparently do so. We will discuss these findings in the following section in detail.

6. Discussion

In this study, we tested whether preschool children can comprehend the logico-semantic relationship between compounds and heads in an adult-like manner. Based on the quantitative data, it is clear that the child participants did not show the same response pattern as adult participants. While the data from adults clearly shows that the adult participants generated logical entailment patterns in order to evaluate whether the fulfillment proposition logically satisfied the demand proposition, the data from children reveals a strong bias for "yes" responses. The child participants were equally likely to respond with "yes" to every condition regardless of logical relationship between the two propositions. From these data alone, it would seem that neither 3 nor 4 year old children can interpret the logical relationship between the meanings of sentences with compounds, heads, and modifiers.

A qualitative analysis of children's responses, however, suggests that children's linguistic knowledge of compounds may have been somewhat underestimated. Several children made comments during the course of the experiment that suggest that they possess some aptitude in interpreting compounds in an adult-like manner. When the fulfillment "I brought a <u>monkey drum</u>" was uttered, one child (male, 4;6) made the observation that "monkeys like drums that are…" and then stated the qualities monkeys prefer. Importantly, it can be inferred from this comment that the child correctly interpreted a "monkey drum" as a *drum that a monkey would use* and thus monkeys might develop a preference for a particular type of drum. In addition, another child (female, 3;9) made the comment that "diapers are for babies" when the stimulus was "doll diaper". It can be inferred that the child had difficulty imagining a "doll diaper" or a "diaper for a doll", because babies typically use diapers, instead of dolls. Hence, the child might have correctly interpreted "doll diaper" as a "diaper for a doll", but some "real world" knowledge about diapers conflicted with this interpretation. Thus, the child's comment may be taken as the result of trying to reconcile the adult-like semantic interpretation of "doll diaper" with pragmatic knowledge about diapers and who typically uses them. Lastly, when the target stimulus was "cookie spoon" and the experimenter asked "What did Cruella want?" to support the prompt question, another child (female, 3;4)

responded with "a spoon for a cookie". "A spoon for a cookie" is an adult-like description for the demand "cookie spoon", and it is the intended interpretation of "cookie spoon"; therefore, it can be interpreted that the child may have possessed the linguistic knowledge to interpret a compound such as "cookie spoon".

If children possess some ability to interpret compounds like adults, why did they fail to respond like adults in the demand-fulfillment context presented in this experiment? One possibility is that the novelty of the stimuli may have been difficult or distracting for the children and masked children's knowledge of compounds. While novel stimuli are commonly used in studies investigating compounds to decrease the likelihood that the participant has encountered the item before, novel stimuli have not been tested in demand-fulfillment contexts like that used in this study; it is possible that the task, in combination with the novelty of the stimuli, presented a significant burden for the children. Children's comments support this notion; for example, children frequently made comments such as "What's a cat brush?" (male, 3:5) or "Bunny chair is so funny" (male, 3;11). These comments indicate that the novelty of the stimuli was salient to the children and possibly that the children were having difficulty formulating an interpretation for these novel compounds.

7. Conclusion

In order to investigate the interaction between logic and language in child language, this experiment tested native English speaking preschooler's and adults' comprehension of the logical relationship between the meaning of a compound and the meaning of its component parts, the head or the modifier. The current study was successful in demonstrating sensitivity to the entailment patterns between compounds and their constituents by adult native speakers, while children, on the other hand, did not show response patterns suggesting sensitivity to these entailment patterns. Modifications to the experimental approach utilized here are called for in order to further investigate whether children are indeed able to evaluate meaning relations among compounds and their heads.

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Appendix A: List of Stimuli

Target Items: novel N + N compounds	**Filler Items: Adj + N phrases**
(1) monkey drum	(1) blue house
(2) bird pillow	(2) green pot
(3) cat brush	(3) gray jar
(4) doll diaper	(4) pink ball
(5) cookie spoon	(5) yellow train
(6) door towel	(6) purple book
(7) dog hat	(7) brown car
(8) bunny chair	(8) red boat

Appendix B: Full Script

Experimenter: Would you like to play a game with me? In this game, Cruella de Villa has stolen animals from the zoo, and Winnie the Pooh is trying to free them. Would you like to start?... Ok let's meet Winnie the Pooh.

Pooh: Well hello there! My name is Winnie the Pooh or Pooh for short. I am glad you are here, because I need your help. All of my animal friends at the zoo have been stolen by Cruella De Vil. Look, they really need our help! Cruella has said that she will free my animal friends, if I find certain items for her. Will you help me decide which things will free my friends?

Experimenter: Will you help Pooh figure out which things will free the animals?

Child: Yes

Pooh: O good, I was hoping you would say that. Now, let's go find out what Cruella will ask for….

Experimenter: Cruella is a huge collector that collects lots of different things. She will describe to Pooh what he needs to bring, then Pooh will try looking for it, and will bring back what he has found in a box. Then you will decide whether or not it is good enough to free the animals. Are you ready to hear what Cruella will ask for?.. Ok, let's see what she says...

Cruella: Now Pooh Darling! Listen Carefully! I am collecting hats of all kinds, but my collection is still small. So, if you want me to free one of your friends, bring me a <u>hat</u>. So bring me a <u>hat</u>!

Pooh: Ok, I'll try looking for it.

Experimenter: Pooh is looking. Let's find out what he will bring…

Pooh: O bother! I found something that might free my friends and I have it in this box! I plan to give it to Cruella, but I am a very forgetful bear, and I just can't remember everything Cruella said to me.

Experimenter: O No! Pooh doesn't remember what he was supposed to bring. Will you help him figure out if he brought something that is good enough to free his friend? ...Ok. Let's find out what Pooh brought

Pooh: I brought a <u>dog hat</u>. Will this be good enough to free my friend, when I bring it to Cruella?

<u>Child gives first response without visual information</u>
Experimenter: Ok, let's open the box

Pooh: Let me show you what I found... *picture of the object appears* I brought a <u>dog hat.</u>

Experimenter: When Pooh gives Cruella the item, will it be good enough for the animal to be freed?

<u>Child gives second response with visual information</u>
<u>If the child says yes:</u>
Experimenter: Let's see what Cruella says…

Pooh: Here you go Cruella

Cruella: You are such a hard worker Pooh. I will let your friend go.

Animal released

<u>If the child says no:</u>
Experimenter: Will you tell Pooh what would be good enough then?

Child suggests an object

Experimenter: Pooh, I think you should bring that

Pooh: Ok, I'll try looking for it

Experimenter: Pooh is looking for what you said…

Pooh: I found what you said. I will take it to Cruella now…Here you go Cruella

Cruella: You are such a hard worker Pooh. I will let your friend go.

Animal released