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Can complement frames help children learn the meaning of abstract verbs?.

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CAN COMPLEMENT FRAMES HELP CHILDREN LEARN THE MEANING OF ABSTRACT VERBS?

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by

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DEDICATION

To my patient and supporting husband, as he embarks on his new career.

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ABSTRACT

CAN COMPLEMENT FRAMES HELP CHILDREN LEARN

THE MEANING OF ABSTRACT VERBS?

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Theories of language learning postulate a relatively simple, innate link between verb meaning and sentence structure. Syntactic bootstrapping predicts the use of known structure to help discover a novel word's meaning. Sentences containing tensed complements were postulated to be especially useful, since their relationship with belief, communication and perception meanings is strong. The current goal was to test this relationship in a verb learning paradigm.

In Experiment 1, three- to five-year-old children received a battery of tasks to assess their command of different complement structures and their ability to use them to fast map novel verbs from limited exposure in story contexts. In the fast mapping task, ambiguous story contexts introduced a novel verb with either an tensed or an infinitival complement, e.g.

2) Who daxed that the raccoon ate the corn?

3) Who daxed the raccoon to eat the corn?

Five-year-old children succeeded at using the infinitival complement to narrow the meaning of the novel verb. In the case of the tensed complement, Five-year-old children do poorly, although this construction typically comes in a year earlier. For these children, complement structure does not directly predict verb meaning. In fact, the contrast between belief and desire complements is not carried by the structure alone. Unlike English, German desire verbs can also take tensed complements. A combination of understanding of sequence of tense in the complement verb, and the relationship between specific mental verbs and their complement verbs has not yet been acquired by five year old children.

In Experiment 2, only one story was used in the Fast Mapping task, unlike the three in Experiment 1, to see if the number of presentations affected children's learning of novel verbs in the tensed complement condition. However, the results were inconclusive.

The pattern of results from all tasks suggests that the syntactic structure of complementation is not a straightforward predictor of verb meaning. Children do indeed use syntactic information from sentential complements when learning new, abstract verbs. However, the subtleties of the complements must be learned, as well as the relationship between these structures and the verbs that appear in them.

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CHAPTER 1

INTRODUCTION

Word Learning

In everyday life, adult speakers of a language occasionally encounter new words. Learning the meaning of these new words is a complex task, but there are many clues from the surrounding linguistic and extra-linguistic context. First, the listener can gain some meaning from deciphering the word's part of speech (noun, verb, etc.). This is usually done by noting the morphological context of the word. For example certain suffixes (e.g. -ing, -ed) can help establish a word as a verb (Berko, 1958; Brown, 1958). Further clues to meaning can be found in extra-linguistic analysis of the scene and the speaker's intent. If a listener is viewing the same scene as a speaker, they can use the information taken from perceptual and cognitive sources to help find the referent of the word. These perceptual cues are especially helpful when coupled with pragmatic cues. Pointing and eye gaze are some of the simpler cues that help listeners determine the speaker's intent when they uttered the new word (see e.g. Baldwin, 1994). These cues help narrow the perceptual field to the appropriate referent.

Special Issues with Verb Learning

Unfortunately, while identifying words as verbs using morphology shouldn't be any harder than identifying nouns, there are aspects of verb meanings that make them especially difficult to learn. First, verbs are not concepts unto themselves. They are concepts that help relate other concepts to each other (Gentner, 1983). *Putting* as an action requires someone doing the putting, an object being put, and a place where it is put. Without these elements, putting is not complete. The semantic and syntactic analysis of the surrounding sentence are vital to understanding a verb's meaning, whereas it is much easier to learn a noun in isolation.

Also, verbs are rarely uttered when the action is actually taking place. Verbs are usually uttered to request an action, or describe a past action, not a present one (Gleitman & Gleitman, 1992). Even when the verb and the action are coincident, several actions may be occurring at the same time. John may be smiling and kicking at the same time, making a pragmatic gesture toward John a poor clue to the verb's referent (Lederer, Gleitman, & Gleitman, 1995).

Complicating matters even further, it is much harder to look at a scene, even given strong pragmatic cues and only one obvious action, and decide on the exact verb meaning used to describe the scene. There are many circumstances where one action may have several perspectives (Gillette, Gleitman, Gleitman, & Lederer, 1999; Gleitman, 1990). In a scene where there is a giving action, there are many more actions occurring at the same time, like receiving, taking, grasping, releasing, etc. (Gleitman, 1990). Finally, many verbs are nearly impossible to observe in any scene. Abstract verbs that describe the thoughts, feelings, or perceptions of other people are much more difficult to distinguish in a scene than an observable action or state. They require interpretation of social cues and inference of the mental states of others. Any description of verb learning will therefore have to take into account the special relationship between verbs and their contexts.

Mechanisms Available to Adults Learning Verbs

While learning the meaning of a new verb is a complex task, there are many mechanisms available to an adult to aid in this task. These come in two basic types: linguistic mechanisms and more general cognitive mechanisms. There are numerous linguistic mechanisms for learning language, but the focus here is on a subset which have been shown to help a listener learn the meaning of a novel verb.

Linguistic Mechanisms

The rules of language constrain the possible meanings of a word. There are some rules that all languages seem to share. For example, when an adult visiting a foreign land hears *gavagai* and sees a person pointing to a rabbit, they might not be sure if the speaker means rabbit or hopping, but they are certain that the speaker does not mean a set of undetached rabbit parts or brown <u>and</u> hopping (Quine, 1960). Markman proposed fundamental rules that constrain word meaning (Markman, 1994). She describes a set of universal constraints for noun learning that all children seem to demonstrate. For example, the Mutual Exclusivity Bias states that people assume a new word will refer to an object for which they don't already have a name, when presented with multiple objects. Golinkoff, Mervis, & Hirsh-Pasek (1994) have a similar principle called the Novel Name, Nameless Category principle. If a listener hears a novel word or name, she will try to find a category, for which she doesn't currently have a name, to map to the novel name. By extension , if a child knows a word for an action (e.g. giving) and hears a new word used to describe the same action (e.g. snatching) the child can focus on a salient point of view or property of the action that distinguishes snatching from the already familiar action. Both of these constraints on word learning allow children learning words to more easily map novel words to their referents.

Another way verb meanings are universally constrained is in the types of information that can get encoded within a single word. Verb meanings can have a component that describes manner of motion, but not temperature during motion, although adults can contemplate a combination of temperature and motion without difficulty (Pinker, 1989).

Studying the syntactic structure of a sentence (especially the number and types of nouns, participants, or arguments) can also help constrain a verb's meaning (Fisher, 1996; Gillette et al., 1999; Lederer et al., 1995; Lidz, Gleitman, & Gleitman, 2000). To make use of this information, the listener must have an implicit understanding of the projection principle (Chomsky, 1981; Pinker, 1982). This principle states that every noun (or other type of sentential argument) in an utterance must be playing a role in the meaning of the sentence, and, conversely, for every role that the utterance needs, there will be a noun or other argument to fill it. In other words, every argument needs to be linked to a role and vice versa. So, a causative verb like *kicking*, needs to have a "kicker" (agent) and a "thing kicked" (patient) in the sentence. The reverse is also true, if there is a patient and agent in the sentence, the verb is not a verb like *smiling*, which only requires an agent (a "smiler.") Different types of verbs (transitive and intransitive are only two examples) require different arguments partly because of their meaning, and their meaning shapes the argument structure of the sentences in which they appear.

The link between arguments and meaning is not this simple, of course. We can *eat* or we can *eat something*, since *eating* can have one or two noun arguments. However, there are reliable regularities between the types of arguments that a verb can take, and the meaning of the verb. Fisher, Gleitman, & Gleitman (1991) refer to the argument structure surrounding a verb as its subcategorization frame. More specifically they propose that "young learners recruit the semantically relevant surface structures as a primary source of evidence concerning [verb] meanings." In their study, Fisher et. al. compared similarity of verb meaning and grammaticality in a particular type of frame. They found that the verbs with more similar meanings were more likely to be acceptable in the same types of sentences, and conversely, verbs that were grammatical in the same types of frames had the most similar meanings. In fact, their strongest evidence was for a cluster of verbs that included perception, mental and communication verbs (*look, see, listen, hear, think, know, believe, explain, and argue*) and their use in complement sentences.

Adults have extensive knowledge about the types of syntactic frames in their language and the meanings of verbs that appear in those frames. Therefore, when an adult listener is trying to decipher the meaning of a new verb, keeping track of the number and type of arguments in a sentence can pinpoint the verb's perspective regarding an action, or category of meaning (e.g. two arguments means transitive, which means causative action).

Cognitive Mechanisms

The vast cognitive power and experience of adults gives them rich interpretations of the scene and the intentions of a speaker. A parent can understand a child's pointing and plaintive cries quite easily as a request for the object being pointed to. Adults can also understand reference to an ambiguous and absent object by inferring its meaning from other information available in the scene and from previous knowledge. For example, a wife in a two car family, says "Please take the dry cleaning out to the car." The husband knows that the wife wants to drop the clothes off on her way to work, as she does every Tuesday, so infers that the wife is referring to her car. Adult language speakers have a wealth of background information, including scripts for scenes (Graesser & Nakamura, 1982; Hudson & Nelson, 1983), and the ability to understand the intentions of others (Tomasello, 2001; Wellman, 1990).

Unfortunately, analysis of a scene and a speaker's intentions aren't enough to fully constrain the meaning of a new verb. Taken alone, extra-linguistic information is generally a poor clue to a verb's meaning. Gillette et al. (1999) separated sources of information from everyday interactions to see which could be the most useful in discovering the meaning of a verb. Using videotaped interactions of mothers and children, and transcripts of those interactions, they challenged adults to name frequent verbs in six different contexts. If adults were shown silent videotapes of the interactions with a superimposed beep in place of a verb, they correctly guessed the verb less than 10% of the time. In comparison, adults did well on a similar task with nouns, correctly guessing the nouns around 45% of the time. In the verb experiment, if the adults were given a list of the nouns in the sentence containing the target verb but no videotape, their performance was slightly higher (about 15% correct). If silent videotapes and the list of the nouns were combined, adults were still only correct less than one-third of the time. In another condition, adults were given the sentential context, but in a jabberwocky-style presentation (Caroll, 1865). A sample sentence was "Can ver GORP litch on the fulgar?" where GORP was the target verb. Here the percentage of correct answers increased dramatically to about 50%. Providing a complete transcript of the surrounding sentence minus the target verb increased performance again to about 75% correct. Finally, when the videotape was added to the full transcript, the adults correctly guessed the missing target verbs around 90% of the time. Gillette and colleagues conclude that increasing the availability of rich linguistic information greatly facilitates discovery of the meaning of a verb.

Special Issues for Children Learning Verbs

When learning verbs, children have been shown to use several of the mechanisms described above for adults. The same innate constraints in the language seem to operate for children, such as the Novel Name, Nameless Category hypothesis. They also have the ability to analyze at least part of the linguistic context. Even young children can listen to a sentence and gain some meaning from the familiar words, especially the nouns (Fisher, 1996) .

Children learning English have been reported to have difficulty learning new verbs and new verb frames (Olguin & Tomasello, 1993; Tomasello, 1992). Around the age of two, they have a vocabulary of about fifty words. They know the names of many people and objects, and they also know a few routine event phrases like *all-gone*, *more* and *bye-bye*. Importantly, even if the two-year-old uses a verb in a correct or adult-like manner, they tend to use the verb in the same way repeatedly. Tomasello (1992; Tomasello & Brooks, 1999) found that two-year-olds use a verb in a particular frame for quite a while before using it in a new syntactic frame or sentence type. For example, at 17 and 18 months of age, respectively, one child uttered "Maria go" and "Green go," but it wasn't until 20 months that she uttered "Pete go with me garbage-man." Tomasello calls the way children learn verbs the "Verb-Island Hypothesis," since the verb is isolated on its own syntactic frame "island." Moreover, once a new frame is learned, children don't automatically use it with a new verb. In contrast, children at the same age are perfectly willing to insert newly learned nouns into a frame existing for other nouns (Akhtar & Tomasello, 1997; Lieven & Pine, 1997; Tomasello & Brooks, 1999).

Why doesn't Tomasello find that children extend frame use to new verbs they are learning? There are two probable reasons; the first is that these young children have insufficient information to learn the nature of verbs and frames. Tomasello's (1992) diary study of his child only went up to her second birthday. It is possible, and indeed plausible, that as children age and gain experience with their language, they will be more likely to use new words in familiar frames. When fax machines were new, an adult had no problem hearing the verb *to fax* in one context "I'm faxing right now" and extending it to another "He faxed that to me yesterday" (Pinker, 1994b; Zwicky, 1971). We can assume that children gain this ability as well. Tomasello suggests that children do gain a rudimentary understanding of verbs and their frames between two and a half to three years of age (Olguin & Tomasello, 1993).

However, Naigles and her colleagues (Vear, Naigles, Hoff, & Ramos, 2001) recently reported data that suggest even two-year-old children may understand more about verbs and their frames than Tomasello believes. In an extensive diary study with 8 children, mothers recorded the first ten utterances of 35 common verbs. Naigles found, unlike Tomasello, that verbs were being used in new frames at an average of between 11 and 14 days after the first utterance, not a few months later. These children changed the frames used for a particular verb in many ways. They changed the addressee of the sentence, the actor, or the affected object. Therefore, their use of new verbs in new frames seems to be much more rapid and flexible than Tomasello originally stated.

If children are able to use verbs in new frames, why isn't their production of verbs in new frames rapid or automatic, so that it would appear in verb learning tasks? The complexity of the task of learning new verbs may require children to be conservative in their production. Two-year-olds know very few verbs, and are uncertain about which frames and types of verbs are correlated. For example, young children would have trouble differentiating between a verb like *eat*, which can be intransitive or transitive, and a verb like *consume*, which is only transitive. Only experience with verbs and their arguments can tell the child the subtleties of meaning the verb carries that allow *eat* to be both transitive and intransitive, and *consume* only transitive. This does not mean that the child doesn't understand the frame. Naigles & Bavin (2001) found that these young children can learn a novel verb in one frame, and then understand a new utterance that includes the novel verb in another, familiar frame. Children are open to new combinations of verb and frame, but are more hesitant to make new combinations themselves. This may be a better strategy in word learning than extending frame use to any similar verb that the child encounters. Remember that verbs are strongly linked to the frames they appear in, unlike nouns. The child's reluctance to use verbs productively in novel frames shows a remarkable sensitivity on the part of the child to the special nature of verbs.

After the initial period of cautious use, experience with verbs and their frames can allow a child eventually to learn the abstract nature of the frame, and thereby understand when a frame could be used with the new word. Most of this mental work could be done by some kind of pattern associator, or other mechanism that keeps statistical track of the meanings and frames allowed for verbs (Gleitman, 1990).

There is considerable argument about whether children are innately equipped with the rules that link certain simple frames and their meanings (e.g. that verbs with causative meanings should appear with two arguments) (Akhtar & Tomasello, 1997; Fisher et al., 1991; Pinker, 1994a; Tomasello & Brooks, 1999). However, even if researchers disagree about what information may be innately available to the child, there seems to be agreement on two important points. First, whenever children are able to 1) recognize the argument structure and 2) link the argument structure to the verb's possible meanings, children should be able to use syntactic bootstrapping to narrow a verb's possible meanings (de Villiers & de Villiers, 1999). Secondly, all theorists agree that there is much more to learn about sentences frames than is available to the child initially. Only simple correspondences, like the fact that causative actions require two arguments, might not need to be learned. Even the order of the words in a sentence and how words are marked as nouns or verbs varies greatly among languages and must be learned. Pinker (1982) proposed a mechanism by which a child can learn the grammatical structure of his language. Semantic bootstrapping (not to be confused with Gleitman's syntactic bootstrapping) occurs when the child takes what he understands of the semantic content of a sentence and then compares that with the syntactic structure. This way, the child can see, in English, that object names usually have *a* or *the* before them. Later, a child can use this method to figure out that actors in a sentence tend to be in the first position, or that one sentence can be embedded in another in certain specific ways.

<u>Children Can use Frames to Learn New Verbs</u>

Recent experiments have shown that children can use syntactic information to learn something about a new verb. Children can gain an initial, incomplete understanding of a word, even upon one hearing. This phenomenon, originally noticed in the domain of nouns, is called fast mapping (Carey & Bartlett, 1978). In some of the studies described below (Fisher, 1996; Johnson, 2001), and in this proposed study, children will be presented a new word for only a few hearings. Despite the meager exposure, children are able to gain a rough meaning of the verb, and use that information to make judgments about other parts of the sentence.

Fisher (1996) proposes that children can use something as vague as the number of arguments in a sentence to select between possible meanings of a verb that are carried by the transitive and intransitive frames the verb appears in. Fisher showed three- and five-year-old children a video of a scene. One example was of Person B sitting on a swivel stool, being spun by Person A pulling off a scarf wrapped around the waist of Person B. This scene was labeled with either a transitive (1a), intransitive (1b), or neutral (1c) sentence. Also, Fisher ambiguously labeled both the agent and patient (or subject and object) of an action as "she."

1a) She's mooping <u>her</u> over there. or

1b) She's mooping over there. or

1c) This is mooping.

If the label for the action was (1a), the action described must be the action of pulling on the scarf, and Person A must be doing the mooping to Person B. If the subject heard (1b), the action described must be the action of spinning on the stool, and this time Person B is mooping. Finally, if the label is (1c), it is possible for either Person A or Person B to be the one mooping. After three presentations, the experimenter brought out a still picture from the video and asked the child to point to the one performing the mooping. In the neutral condition (1c), there was an "agency" bias. That is, both three- and five-year-old children pointed to the agent of an action (e.g. the person pulling on the scarf) as the one doing the mooping a majority of the time (71% and 87% respectively). When given a transitive sentence (1a), all the children performed almost perfectly, selecting the agent as the subject. When given an intransitive sentence (1b), even three-year-olds could override their agency bias to some degree, selecting the patient (e.g. the one sitting on the stool) as the one doing the mooping, almost half the time. Therefore, hearing only one noun argument in the sentence pulled children away from their perceptual bias of viewing the active participant as the subject. Children's ability to use syntactic clues to override perceptual biases will be especially important in their ability to learn abstract verbs.

Sentential Complement Frames

This paper will focus on two particular sentence frames that are much more complex than a simple transitive frame, and that vary in form from language to language. This frame is a sentence-within-a-sentence, and is called a sentence with a sentential complement. These complement frames can either have an infinitive (2a) or tensed (2b) verb in the lower clause.

2a) I told him to eat his dinner.

2b) I said that the sky is blue

Specifically, this paper is only concerned with full complements, where there is a subject, a verb and an object, although the subject in the infinitival complement is not overt. In linguistic accounts the empty subject is labeled PRO, an implicit argument which is controlled by and usually gets its referent from an argument in the upper clause.[1] The infinitival complement sentence (2a) is a complex sentence type that is initially learned as a Verb + "to" combination (e.g. "I don't want to) (Bloom, Tackeff, & Lahey, 1984). To see if children were correctly using the "to" marker at later ages, Bloom and her colleagues examined all obligatory contexts for the "to" marker, where the utterance had an infinitive verb form following a main verb. Using data of children's spontaneous productions, they noted that around two years of age children started to produce infinitival complements with a verb in the lower clause, (e.g. "I want to open it.") Finally, Bloom et. al. found that by age three, children reliably used "to" as a marker in more complex utterances, with a person or object as the subject of the lower clause (e.g. "I want this doll to stay here.") This ability to use a sentence in the embedded clause may represent a significant change in their understanding of desires Instead of expressing a desire for an object, they are now able to express a desire for a future event. Verbs of communication are acceptable in both infinitival and tensed complement sentences, as seen in (2a) and (2b), these complements usually select different individual verbs in the upper clause. For example, switching *said* and *told* in the sentences (2a) and (2b), creates two ungrammatical sentences. Similarly, the infinitival complements are used with verbs of desire (3a), and are less often grammatical with verbs of belief (3b), unlike tensed sentential complements.

3a) I wanted him to eat.

3b) *? I believe him to eat.

---

[1] The control varies with the verb. In many cases, the control of the missing subject is via the object of the upper clause. If a verb like "promise" is in the upper clause, the referent for the subject of the lower clause is the subject of upper clause, not the object. This difference will be discussed later in more detail.

Therefore, since these two sentence types are usually in opposition for the types of verbs they can contain, they make a good comparison set of sentences with complex structure.

Tensed sentential complements (2b) are especially interesting to language researchers. Children don't start using these sentences, or understanding what they mean, until about three and a half to four years of age (Bloom, Rispoli, Gartner, & Hafitz, 1989; J. de Villiers, 2001). Since the frame's structure requires the combination of two separate clauses ("I said X" and "the sky is blue") these sentences are understandably more difficult for children to learn than simple transitive sentences. Another reason these tensed sentential complements are unique, is that they only occur with abstract mental, perceptual and communication[2] verbs, such as *know*, *see*, and *say*. The fact that these abstract verbs are highly correlated with a specific syntax is probably not a complete coincidence. When Fisher et al. (1991) compared verb meanings and the frames they can appear in, their strongest evidence was for the cluster of verbs *look, see, listen, hear, think, know, believe, explain and argue* and their appearance in tensed complement sentences. In other words, these verbs could predictably use tensed sentential complements and, conversely, use in a tensed sentential complement is a strong predictor of this broad type of meaning. Fisher and colleagues postulate that abstract, less observable verbs require a stronger relationship with their syntax for learnability reasons. If you can't easily deduce the meaning from the scene, you need some other clue to learn

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[2] Verbs of communication are admittedly more observable from context than the other two types of verbs. J. G. de Villiers (1995) proposes that since communication verbs share structures with mental verbs, they can serve as a semantic bootstrap to an understanding of complements. The trigger for this new understanding may occur when children hear reports of lying or mistaken utterances by others, pointing children to the nature of the embedded structure.

the word's meaning. The correlation between mental and perceptual verbs and very regular syntax was replicated in several languages, indicating that these abstract verbs appear in sentences that give a strong clue to their type of meaning.

While some mental and perceptual verbs are among the earliest learned, Wellman (1990) argues that a child's conceptual understanding of these verbs is initially incomplete. Under the age of about three and a half, children understand that the behavior of others is directed by their desires. Children at this age don't understand that a person's behavior can be directed by desires, beliefs, and perceptions that are in conflict with reality. In particular, a conceptual advance is necessary in Theory of Mind: the ability to understand that people can have beliefs that are false. An example of a simple False Belief test is called the Unexpected Contents task (Perner, Leekam, & Wimmer, 1987). The child is shown a box of crayons, and asked what she expects to see inside. After she answers "crayons," the experimenter shows her that there is really a turtle in the box. The experimenter closes the box again, and asks the child "When you first came in here, what did you think was in the box?" Then, referring to a stuffed animal or a friend of the child "If Snoopy came in, what do you think he would say is in the box?" Children under three and a half years of age answer "a turtle" to the last two questions, even though a scant few minutes have passed from when they originally said there were crayons in the box.

The results of this False Belief task have two important interpretations. First, at three and a half to four years of age, children show a large increase in their ability to understand a person's thoughts and beliefs, including their own thoughts at previous times. Secondly, when they can answer correctly, children demonstrate that they can hold a proposition that conflicts with their knowledge of reality. One final fact about theory of mind or false belief understanding is that it has been linked to the comprehension of sentential complements (J. de Villiers, 2001; J. de Villiers & Pyers, 1997). The reason the False Belief task seems to be linked to tensed sentential complements, is that these sentences are the only types where a part of the sentence can be false, while the whole remains true.

4a) Bob thinks that the sky is green.

4b) The sky is green.

The sentence (4a) can be completely true even though the proposition in the tensed complement clause (4b) is false. The ability to use and understand these types of sentences typically develops along with, and may indeed be a prerequisite to, understanding false beliefs. In other words, tensed sentential complements are a way for children to hold a false proposition in mind as part of a true proposition (J. de Villiers & Pyers, 1997).

Putting these two pieces of information together, mental and perceptual verbs have been shown to have a very specific syntax that only they can appear in. Their appearance in these tensed complement sentences is not a coincidence. Complement sentences may aid in children's understanding of the mental states of others. While children are able to produce tensed complement sentences before the age of three and a half, they may be treating the two parts of the sentences as separate entities. Only when children understand that the one sentence is embedded in the other, as evidenced by their ability to understand and produce false complements within true sentences, do they seem to treat the tensed complement sentences as a single entity (J. G. de Villiers, 1999).

Can Children use Sentential Complements to Learn Abstract Verbs?

While Fisher (1996) studied children's ability to use argument structure to fast map the meaning of a verb, the study only included transitive and intransitive sentences. A more recent study included infinitival sentential complement frames. Johnson (2001) studied four- to six-year-olds[3] using pictures, and labels for the pictures that included real or novel verbs in four different frames (transitive, intransitive, transfer, and complement). She tested children's ability to understand the verb by asking the children several questions (2 questions for intransitive sentences, 4 for the other types). The first two questions required the children to point out the subject of the main clause, (e.g. 5a & 5b), while the second two questions focused on other elements of the sentence, and varied based on the type of sentence used to learn the novel verb. For example, in the sentence "The girl is sugging the woman to send the ball," the children were asked:

5a) Which one was the sugger? (the girl)

5b) Which one was sugging? (the girl)

5c) Which one did the girl sug the woman to send? (the ball)

5d) Which one did the girl sug to send the ball? (the woman).

A transfer frame condition used the same picture, and the identical questions in (5), but the descriptive sentence presented to the child was "The woman sugged the ball to the girl." The current study also used the subject of a sentence containing a complement clause as its main performance measure, so the results from questions (5a) and (5b) are

[3] The main purpose of Johnson's study was to examine processing differences between speakers of Standard American English (SAE), and African American English (AAE) in order to help design a dialect neutral test of language ability. Here only average results from both populations are reported, but the results were similar for each population separately.

primarily discussed here. The results from the final two questions and their relevance to the current study will be discussed below.

As can be seen in Figure 1, children did quite well with real verbs (e.g. ask) at pointing out the "asker" and the one who was "asking" in both the complement and transfer frame conditions.[4]

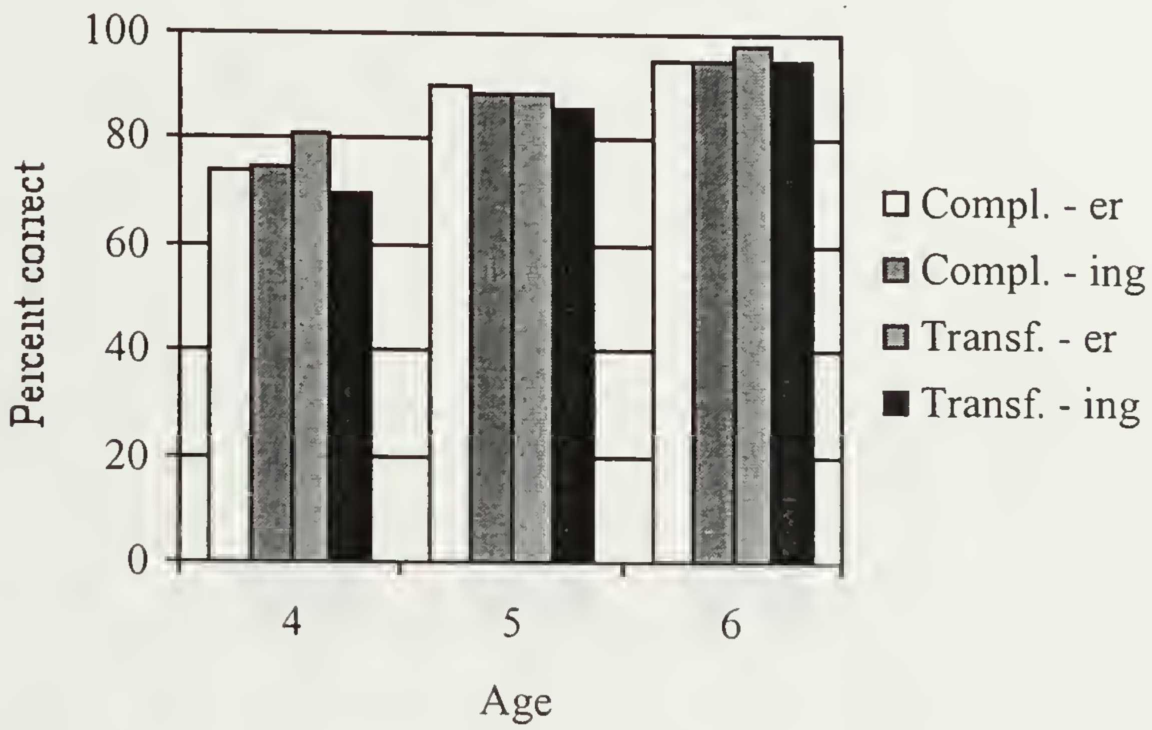

Figure 1: Children's Correct Choices of Subjects in Complement and Transfer Frames with Real Verbs (adapted by permission from Johnson, 2001b).

Even the four-year-old children chose the correct subject for the complement sentences (as measured by their answers to 5a and 5b) 75% of the time. By six years of age, children chose the correct subject 95% of the time. For the three other sentence types, children did as well, or better, at selecting the asker and the one asking (V. E. Johnson, personal communication, August, 2001b).

[4] Since there were three plausible answers to each question (e.g. girl, woman and ball) chance would be 33%.

The data, presented in Figure 2, from the novel verbs used in sentential complement frames in Johnson's paradigm shows a dramatically different pattern. The children did not do well identifying the sugger and the one sugging after hearing the sentences containing verbs they did not know, (e.g. sug). This was especially true in the complement condition.

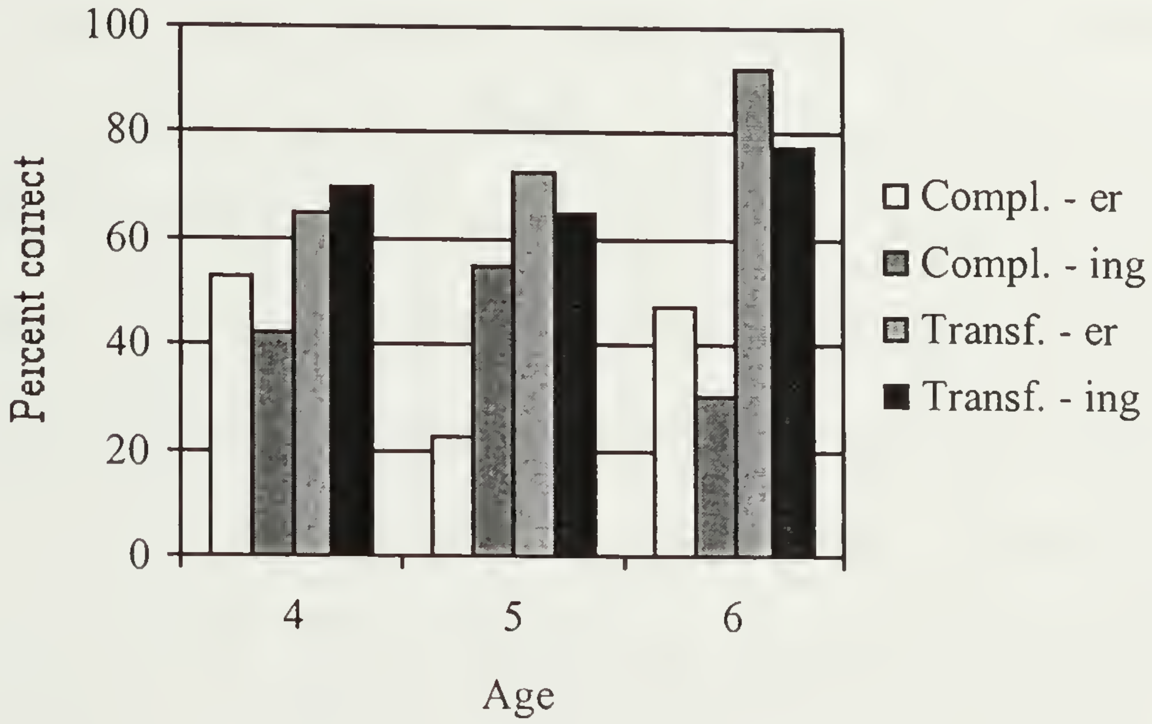

Figure 2: Children's Correct Choices of Subjects in Complement and Transfer Frames with Novel Verbs (adapted by permission from Johnson, 2001b).

The average percentage correct for questions (5a) and (5b) in this condition for each of the three age groups ranged between 25-55%. Even more astonishingly, children showed no age trend in their ability to use complement syntax to learn which subject the verb should select. In all other sentence types (i.e. transfer, transitive and intransitive frames, where transfer is shown in Figure 2), children were at least 53% correct in selecting the subject of the sentence, and sometimes as successful as 93% (V. E. Johnson, personal communication, August, 2001b).

If complement sentences are such good clues to learning abstract verbs, why did the children in this experiment do so poorly at selecting the subject of the sentence? After all, the subject was given to them directly as the first element in the modeled sentence. There are four possible reasons, two are methodological, and two are theoretical. First, since Johnson used the same picture to present the transfer and complement sentences, she used a novel instrument in the picture. Children may have been distracted by the novel instrument, and possibly chose the instrument instead of one of the actors. Johnson (2001) does not include any analysis of the types of errors children made, therefore this possibility cannot be ruled out.[5] Secondly, this task only had one presentation of a picture, had no story along with the picture, and did not use the verb in more than one picture or sentence. Gleitman and her colleagues have used many ingenious techniques to show that verbs with similar meaning tend to cluster in the same types of frames (Fisher et al., 1991), and it is these clusters of frames that help children learn a particular verb (Lederer et al., 1995). They never suggest that only one presentation, or use in only one frame is sufficient to learn the meaning of a verb. In fact, they suggest that presenting verbs in multiple frames is the key in the bootstrapping process. However, it may not be necessary to hear a verb in multiple sentence frames types, if the verb is being used in the frame-meaning correspondence that is the most reliable. The correlation between tensed sentential complements and mental / perceptual verbs should, in multiple presentations, be sufficient to learn the meaning of these abstract verbs. Johnson did not test tensed

[5] Recent data taken from a very large replication of Johnson's task, which was part of a larger test, called the DELV, shows that out of approximately 3000 answers to questions like (5a) and (5b), 427 (15%) chose the instrument as the "sugger", and 424 (15%) chose the instrument as the one "sugging" While this is extremely preliminary data, the results do support the fact that children may be using an instrumental verb, not a mental or communication verb. (de Villiers, Personal Communication; June, 2002)

complements, so it may be that infinitival complements are less able to facilitate bootstrapping.

The fact that children were given only one exposure to each verb may have hampered their ability to learn these new verbs as well. Children were asked to compute a lot of information from only one sentence. The target sentence was given as a description of the picture, and then repeated, but then the children had to answer four questions, and repeat this process 20 times for the real verbs (5 each of 4 sentence types), and 8 times for the novel verbs (2 each of 4 sentence types.)

This leads to the third problem, which is that Johnson presented novel communication verbs in complement structures, but novel transitive and intransitive verbs in the simpler structures. While Gleitman and colleagues (Fisher et al., 1991; Lederer et al., 1995) focus on tensed sentential complements as particularly good cues to verb learning, they also emphasize that these clues need to be clear because of the abstract nature of mental and perceptual verbs. Fisher (1996) found that young children still relied heavily on their perceptual agency bias when interpreting novel verbs, and these were only partially overridden when given opposing syntactic evidence. It seems likely, therefore, that children will choose verb meanings that are more perceptually available to them. The verbs in Johnson's study that appeared in transitive and intransitive frames were much more salient from the picture. Johnson is not comparing bootstrapping across sentences with equally salient verbs. To truly compare the effect of sentence structure on children's ability to fast map the meaning of verbs, the salience of those verbs must be held constant.

Finally, and most importantly, there may be three stages in understanding complement sentences. First, before the age of three and a half, children do not comprehend or productively use sentential complements. They can use sentential frames to learn the meaning of verbs, but only for the sentence frames they already have in their repertoire, like transitive and intransitive frames. Next, around their fourth birthday, they can comprehend sentences containing tensed and infinitival sentential complements, but may have insufficient experience with them to have an abstract representation of their structure. Children may require more exposure to a sentence structure and a semantic bootstrapping (Pinker, 1984) analysis of known sentences to discern the important parts of that structure. In this case, children would understand sentences with known verbs containing complements, but be unable to use them to learn about the verb in a fast mapping situation. Finally, children have fully analyzed the structure, and could use it to learn novel, mental, perceptual and communication verbs. From Johnson's study, it would seem that this final stage takes place after six years of age, since, on average[6], her children did not do well on the complement sentences containing novel verbs. However, the other problems with her design and methods may be responsible for children's failure in this task, leaving still unknown the age that children can first use complement sentences to learn verb meaning.

Prerequisites for Bootstrapping with Sentential Complement Frames

To summarize: Children need several prerequisites to be able to use sentences containing complements to help learn the meaning of a novel verb:

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[6] Johnson's study only reports averages across children. No individual results were reported.

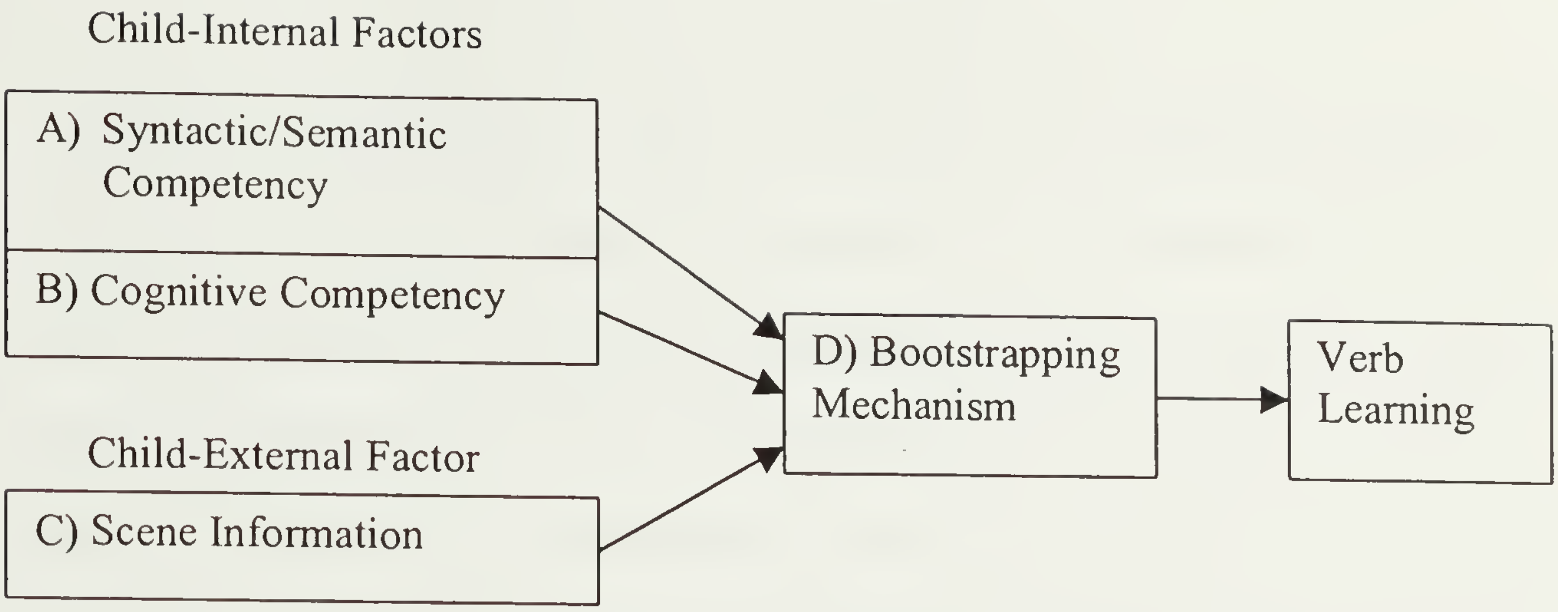

Figure 3: Prerequisites to Learning Verb Meanings Through Syntactic Bootstrapping.

To understand the relationship between syntax and semantics in this case (A), children need to know and understand at a deep level the meaning of verbs that can take complements: those that take infinitival complements, including desire verbs, and those that take tensed sentential complements, including the range of perceptual, mental and communication verbs. They also need to understand the structure of the frames that contain sentential complements. A cognitive understanding of the scene (B) requires that they understand what is happening in the minds of others in a belief or desire scenario. Children may also need multiple presentations in multiple story contexts (C) to better fix the meaning of the novel verb. Finally, children then need to feed all of the predeeding information into a bootstrapping mechanism (D) which can use the semantics / syntax relationship to infer something of the meaning of a verb when they are only presented with a few instances of a verb (i.e. in a fast mapping situation). The prerequisites A and B were tested in Experiment 1, prerequisite C was tested in Experiment 2.

Design of Experiment 1

Syntax/Semantics Prerequisite

The first prerequisite (A) is children's understanding of the syntax and semantics of complement structures. Two separate tasks tested children's understanding of tensed and infinitival complements, and their understanding of sentences containing relative clauses. Relative clause sentences were used since this structure also has two dependent parts, or clauses, and is learned by children quite late, with children still making errors at the ages of four to six years (Solan & Roeper, 1978). Also as seen in (6a) and (6b), the structures of the two sentences are extremely similar on the surface. Relative clause sentences can be created from tensed complement sentences by moving the position of only one word: "that."

6a) The man saw <u>that</u> the cat knocked over the plant.

6b) The man saw the cat <u>that</u> knocked over the plant

However, relative clauses do not entail understanding mental state terms, since they usually occur as a modifier to a noun phrase.

Imitation Task

Lust, Flynn, and Foley (1996) reviewed a method to assess children's sentence comprehension called elicited imitation. A child is simply given a sentence and asked to repeat it. The sentences vary along subtle syntactic dimensions, to allow comparison between types of sentences. The reasoning behind this method is that children will only be able to repeat a sentence if they have syntax sophisticated enough to process it; if a child doesn't understand it, she can't say it.

Phinney (1981) used this method to test children's ability to repeat tensed complement sentences (e.g. "The bear said that the turtle tickled the horse."). She found that her youngest group of children (mean age 3 years, 7 months) responded to these sentences with some kind of simple sentence(e.g. "The turtle tickled the horse."). The next group (mean age 4;9) responded with some type of complement sentence over 90% of the time, although only the group of children a few months older could reliably repeat the sentence retaining the "that" complement marker.

Phinney also used this procedure to present infinitival complement sentences (e.g. "The bear wanted the turtle to tickle him.") to children. Children did extremely well on this task, Only in the youngest age group (again, mean age 3;7) did children respond with a simpler complement sentence, dropping the lower subject (e.g. "The bear wanted to kiss him."). They created these simple complements around 50% of the time. The rest of their responses were correct repetitions. In the older age groups, there were almost no errors in repetition. Less than 10% of all responses were anything but the correct sentence type.

Phinney did not test relative clauses using this method. However, as stated above, children are still having difficulty with these clauses at age six (Solan & Roeper, 1978). Other experiments found that one of the most common errors was difficulty assigning actions to the correct actors in the sentence (Tavakolian, 1981). In an act-out task, children will use the subject of the upper clause to perform the action of the lower clause, or the actions in both clauses. For example, if the sentence is "The duck stands on the lion that bumps into the pig," the child may have the duck bump into the pig and stand on the lion.

In the current experiment, an imitation task was used to measure children's ability to understand these three types of sentences: tensed and infinitival complement sentences, and sentences containing relative clauses. To ensure that the long sentences didn't cause memory load problems for these young children, picture prompts for the concrete nouns accompanied the spoken sentences. Based on earlier work, children should correctly imitate tensed complement sentences by around four and a half years of age. Children as young as four years of age should have no problem repeating infinitival complements. Relative clause sentences, however, should continue to present a problem to all children. If imitation of sentences does indeed represent a relatively complete understanding of the structure of those sentences, and this understanding leads to the ability to use the structure in a bootstrapping context, then children's performance on the Imitation task will correlate with their Fast Mapping performance.

Truth-Value Judgment Task

A variation of the Truth-Value Judgment task (Crain, 1991; Gordon, 1996) was used to assess further children's comprehension of complements beyond their ability to imitate them. In this task, children were asked to make judgments about sentences , which either correctly or incorrectly described a scene. Children were shown two types of scenarios. In the first scenario, someone told someone to do something, that person did it, and another said that he did it. These events were either described by sentences containing an infinitival (7a) or tensed complement (7b).

7a) The bird told the cow to ring the bell.

7b) The dog said that the cow rang the bell.

In the second scenario, someone did something and left behind evidence. One person saw the evidence and the other saw the person before the act occurred. These events were then described by either a tensed complement (8a) or relative clause (8b) sentence.

8a) The cow saw that the bird ate the pudding.

8b) The pig saw the bird that ate the pudding.

Based on the previous work reviewed above, children should be able to perform well on the tensed complement sentences in both types of scenarios at around age four. Accurate judgments about infinitival complement sentences should happen around the same time, or a little earlier, and relative clause sentences may pose a problem, even for five-year-old children. Even though five-year old children may not be able to make perfect judgments about these relative clause sentences, there may be interesting information about the variation in ability between children. Also, using relative clauses in the same scenarios as tensed complements provided an interesting comparison to those used in contrast to infinitival complements.

Cognitive Prerequisite

The second prerequisite (B) is that children need to have cognitive structures in place to understand the portions of the scene. There are two possible cognitive structures that will help children understand scenes that can be described by a tensed complement: understanding that seeing leads to knowing, and understanding false beliefs.

To be able to correctly interpret the mental states of others, children need to know that what a person sees affects their knowledge and beliefs. Pratt & Bryant (1990) showed three- and four-year old children one person lifting a box, and another peering inside it. Nearly all children could correctly chose the person who saw in the box as the one who then knew its contents. Since nearly all children could perform this task, no similar task will be performed. It is assumed that three, four and five year old children understand that seeing leads to knowing.

A second cognitive prerequisite is an understanding of false beliefs. As stated above, not only is this important in the understanding of the mental states of others, but also may be linked to the understanding of tensed complement structures. Therefore, two classic false belief tasks were performed: Unexpected Contents (Perner et al., 1987) and Unseen Displacement (Wimmer & Perner, 1983). The Unexpected Contents task has been described previously. The Unseen Displacement task shows a person hiding an object, and that object being moved after he leaves the room. If children understand that people's beliefs can contradict reality, they will say that the person will search for the object in the location they left it, not where it is currently located. As found in much previous research, these two tasks should be difficult for the three year olds, but four and five year olds should be able to pass them quite easily. Also, these tasks should be measuring the same false-belief understanding, and so should be correlated.

No similar cognitive prerequisite for infinitival complements is known. While false-belief performance and tensed complements have been strongly linked, no cognitive ability has been directly linked to infinitival complements. Therefore, none was tested in the current experiment.

Bootstrapping

The overarching goal of this experiment is to compare children's syntactic and cognitive abilities to their ability to bootstrap the meaning of novel verbs (D). Therefore, this experiment examined children's ability to learn abstract verbs in complement frames, especially tensed complements which have not previously been tested. Based partially on the work by Fisher (1996) and Johnson (2001), children's ability to learn a novel verb was tested by using a Fast Mapping task that examined their knowledge of the arguments surrounding the verb. Fisher (1996) used ambiguous referents (pronouns of like gender) as argument place-holders in her sentences. This allowed the listener to have a complete picture of the syntactic frame, without knowing the specific referents to the arguments. Then, the listener was asked about the referents, which were dependent on the meaning the listener had assigned to the verb. In this experiment a variation of the ambiguous referent was used, namely using "someone" as the place-holder.

While testing the referents of arguments does not examine the child's full understanding of the new verb they have learned, it tests an important part of the meaning. Remember that a significant part of a verb's meaning is its relationship to the arguments in the sentence (Gentner, 1983). To be more specific, the syntactic structure surrounding a verb can tell us the category of meaning (e.g. causative, stative, mental / perceptual, modal, etc.) to assign to the verb. Gleitman and her colleagues (Fisher, Hall, Rakowitz, and Gleitman, 1994) describe the information gained from the syntax as a "zoom-lens" which helps the child take the correct perspective on the verb. This experiment will use the same procedure, since Fisher et al. (1991) and Lederer et al. (1995) suggest that tensed complement frames may be enough to "zoom" in on the category of mental, perceptual, and communication verbs.

Each child was presented with three stories that had the following basic structure: someone who invited someone to act (enticer), someone who acted and left evidence of the act (actor), and someone who discovered the evidence (discoverer). Each story was then followed by a target sentence which contained a novel verb and either a tensed (9a) or infinitive (9b) complement.

9a) Someone daxed that the raccoon ate the corn. (i.e. the discoverer)

9b) Someone daxed the raccoon to eat the corn. (i.e. the enticer)

After three stories and three target sentences of the same type, children were reintroduced to each story and asked the matching target question, e.g. "Who daxed that the raccoon ate the corn?"

If children are indeed able to bootstrap something of the meaning of this novel verb, "dax," they should be able to select the correct character in the story. Based on what children know of tensed complements, and the fact that these complements may provide an especially good clue to meaning, children should be able to select the correct character in all three stories by age five. Also, children's ability to pass the syntactic measures of tensed complements, and the false belief task should be a precursor to or occur simultaneously with their ability to pass the fast mapping task.

On the other hand, while infinitival complements may be learned at around the same age as tensed complements, their relationship to meaning has not been tested. Children may or may not be able to select the correct actor using infinitival complements as a cue. If they are able to pass the fast mapping task in this condition, they should have passed the infinitival complement portions of the imitation and Truth-Value Judement tasks.

In using both infinitival and tensed complement sentences, this experiment will be able to compare the two sentence types for their age of acquisition, and their ability to serve as a cue for bootstrapping.

Design of Experiment 2

Sufficient Scene Information Prerequisite

The final proposed prerequisite for bootstrapping the meaning of abstract verbs from complement frames is sufficient scene information (C) to allow for discrimination of the verb. Previous research on bootstrapping nearly always presented novel verbs in a single, simple context (Fisher, 1996; Johnson, 2001; Naigles, 1990). There are two main reasons for this single context. First, researchers were trying to create novel verbs, to ensure that children don't have a label for the action already. However, for this experiment, verbs were chosen that were similar to slightly obscure adult verbs, namely enticing and discovering. While children may know synonyms for these words, synonym acquisition happens as a regular part of word learning, and so should not interfere. Also, most studies have been with very young children and transitive or intransitive actions, not abstract mental states.

The inspiration for Experiment 2 came mostly from pilot work done in preparation for Experiment 1. In piloting, children had great difficulty from three to five years old when presented with only one story in which to learn a novel verb in complement syntax. However, when given three stories, children from five to seven years of age did very well. It was then hypothesized that three stories helped the children learn the meaning of the novel words, over just presentation with one story and test sentence. To test this hypothesis, both the three and one story versions of the Fast Mapping task had to be run.

So, in Experiment 2, novel abstract verbs were presented in only one of the stories found in the Fast Mapping task. Also, only the tensed complement condition was used in this experiment. It is possible that just one good example with a clear structural cue, and strong contextual information is sufficient for learning verb meanings, even with abstract verbs that are difficult to depict in a story or scene. If so, children participating in Experiment 2 should learn these verbs as well as children learning them in the Fast Mapping task of Experiment 1. If one story is not sufficient, children in Experiment 1 might be more successful because of multiple instances and contexts in which to place the verb's meaning. Thus a comparison of performance in the Fast Mapping tasks of experiments 1 and 2 should show whether children at an age where they have difficulty learning verb meaning in a single context can derive meaning from three contexts.

CHAPTER 2

METHODS

Experiment 1

Experiment 1 was designed to test children's ability to use tensed and infinitival complement frames to help learn the meaning of abstract verbs. It also compared children's bootstrapping ability to their competency with these two types of sentences, and their understanding of Theory of Mind. To ensure that children didn't confuse the two types of complement within the Fast Mapping task, a between subjects design was utilized. In other words, children either received one novel verb presented in three tensed complement sentences, or one novel verb presented in three infinitival complement sentences. Also, to keep children from possibly learning more about the structure of these types of sentences, the Fast Mapping task was performed first for all children.

Participants

Three age groups of English-speaking monolingual children were tested: 12 three-year-olds (mean age 3;5, range 3;0-3;9) 12 four-year-olds (mean age 4;6, range 4;0-4;11) and 12 five-year-olds (mean age 5;3, range 5;0-5;6). With one exception, all participants were tested at local preschools. These schools serve the primarily white, middle-class families found in the community. One three-year-old girl attended a local preschool which had no testing space available, so she was tested at the Psychology Department Child Study Center.

Procedure

Following a warm-up period, in which children were given crayons and a page from a commercial coloring book, five separate procedures were followed. Children were presented the tasks in the following order: Fast Mapping task, Imitation task, Unseen Displacement task, Truth-Value Judgment task, and Unexpected Contents task. To minimize fatigue and encourage participation, the final two tasks were presented on a second day[6]. All tasks were completed by all subjects in two testing days.

All tasks were coded independently by two researchers. Very few differences were found except in the transcription of answers in the Imitation task. Any discrepancies in the judgments were reviewed by both researchers together, and a final decision was made. In a rare occasion, a word or syllable in the Imitation task was unintelligible, even after review by both coders. In these cases, children were given the highest possible credit for the word; the coders assumed the child inserted the correct word from the target sentence.

Fast Mapping Task

In this task, children were presented with stories and novel verbs in either tensed or infinitival complement sentences, and then asked to label the referent of the ambiguous subject "Who?" Children either received a series of tensed complement sentences containing one novel verb, or a series of infinitival complement sentences, creating a group design with two conditions. Also, two orders were used: one as in Appendix A and the other presented the stories in reverse order. Each child was told a story with three events, and shown pictures to match each event. As stated above, the stories consisted of an enticing event, an acting event, and a discovering event. For example, a boy waved an ear of corn in front of a raccoon, the raccoon ate the corn, the farmer discovered the

[6] The only exceptions to this order occurred in two circumstances. If children stopped participating on the first day, one or two tasks were moved to the second day; if children were responsive but not verbal on the first day, the Imitation task was moved to the second day.

empty cobs and raccoon tracks. Three memory questions, one for each event in the story were then asked to help solidify the details of the story in memory. The experimenter next explained that she would use a new word, (e.g. dax) and that the child needed to pay attention to the next sentence. The child was then given one of two types of sentences. The first sentence type (10a) includes the new verb in an infinitival complement structure, and the second sentence type (10b) includes the new verb in a tensed complement structure.

10a) Someone daxed the raccoon to eat the corn. or

10b) Someone daxed that the raccoon ate the corn.

Each sentence had the ambiguous label "someone" as the subject of the sentence. This subject was never identified directly through language or gesture. All three stories and picture sets, with the corresponding target sentence, were presented to the child to introduce him fully to the new word and its usage across different stories. The target sentence structure remained the same across contexts (i.e. the child received three examples of type 10a, or three examples of type 10b).

When all three stories were complete, the experimenter then reintroduced the pictures from the first story. The child was then asked a "who" target question that was parallel to the earlier sentence the child heard, replacing the word "someone" with the word "who."

11a) Who daxed the raccoon to eat the corn? or

11b) Who daxed that the raccoon ate the corn?

Children responded verbally or by pointing to a character in the pictures. While some children needed a few prompts, such as "who do you think?" "Can you guess" or "You can point", all children eventually selected some object in the story. Stories two and three were also reintroduced and the corresponding "who" target question was asked for those stories. Only one novel verb, and only one sentence type (10a and 11a <u>or</u> 10b and 11b) was presented to each child. Children received a final score of 0-3 on this task, with one point for each correctly labeled referent. Finally, the child was asked what he thought the novel word meant.

<u>Imitation Task</u>

In this task, the children were asked to repeat sentences that contain infinitival (12a) and tensed (12b) complements like the ones in the Fast Mapping task, and sentences containing relative clauses (12c) as a comparison.

12a) The cow told the dog to push the pumpkin.

12b) The bird said that the cow stood on the fence.

12c) The horse hugged the pig that touched the barn.

Again, the items were presented in two orders, one as in Appendix B, and in reverse. After brief training on the task, the experimenter uttered a sentence and simultaneously showed a page that had pictures of the nouns/objects in the sentence. The child was then asked to repeat the sentence. If the child failed to respond, or asked the experimenter to repeat the sentence, the experimenter did so, once.

Categories for coding the responses from the children were created after reviewing their transcripts. Therefore, the coding system will be explained when the results are presented.

<u>False-Belief - Unseen Displacement Task</u>

The final task on the first day consisted of a common False-Belief task known as the Unseen Displacement (Wimmer & Perner, 1983). The entire script is in Appendix C.

Children were presented with a miniature kitchen with table, chairs, refrigerator, and cupboard. On the table was a piece of cake. They were then introduced to Bobby and his dad. The experimenter then enacted a scene where Bobby put the cake in the cupboard and left the house. While he was gone, his father moved the cake to the refrigerator, and then also left. At this point, the child was asked two memory questions

13a) Where did Bobby put the cake before Bobby went out to play?

13b) Where is the cake now?

Then, the experimenter brought Bobby back to the kitchen, and the children were asked:

14a) Where will Bobby **first look** for the cake?

14b) Why will Bobby look there?

If children answered (14a) by mentioning or pointing to the cupboard, they were given one point. Acceptable answers for (14b) came in two varieties: ones without a mental verb, e.g. "Because he put it there." and ones that included a mental explanation, e.g. "Because he thinks it is in there." Either of these two types of answers also received one point. If a child answered both questions incorrectly, or only one correctly, this was considered failure. Only if children answered both questions correctly was their performance considered passing for this task.

<u>Truth-Value Judgment Task</u>

The first task presented on the second day required children to make a judgment about a sentence uttered by a puppet. The script and materials may be seen in Appendix D. Children were presented with scenarios acted out by the experimenter using small plastic animals. Then a puppet uttered a sentence supposedly describing the scenario. If the puppet's statement was judged correct by the child, the child could reward him by giving him his favorite object. If the puppet's statement was judged incorrect, the child could punish the puppet by giving him a disliked object.

There were two types of scenarios, and each scenario had four possible puppet statements. For the first type of scenario, the statements were either a tensed or infinitival complement sentence, and were true or false. The statements were made false by simply changing the subject of the sentence to agree with the opposing sentence type. An example of a scenario and the four possible puppet statements is as follows (only material in quotes was spoken aloud):

> There are three animals (a cow, a bird and a dog), and a bell rests near the cow. The bird says to the cow "Ring the bell, cow." The cow rings the bell. The dog says "The cow rang the bell."
>
> The puppet then uttered one of the following:
>
> 15a) "The bird told the cow to ring the bell." (true, infinitival complement)
>
> 15b) "The dog told the cow to ring the bell." (false, infinitival complement)
>
> 15c) "The bird said that the cow rang the bell." (false, tensed complement)
>
> 15d) "The dog said that the cow rang the bell." (true, tensed complement)

Only one story/sentence pair was actually used, creating four stories, one for each of the preceding sentence types (15a-15d).

This design mimicked the Fast Mapping task almost exactly. There were three actors in each story, the story was consistent with both infinitival and tensed complement sentences, and the children had to make a judgment about the subject of the sentences.

A second type of scenario was also included as a contrast to the previous scenario. Scenarios of this type were consistent with tensed complement sentences and transitive sentences with relative clauses. An example follows.

> A small table is present, with a bowl of pretend pudding (play-doh). A bird and a pig walk toward the table. The pig says "Look at that pudding. That makes me hungry. I'm going to go home for lunch." The pig then leaves. The bird eats some of the pudding (presses his nose in the play-doh) and then leaves. The cow enters, walks up to the table and says "Look at my pudding, it has bird beak marks in it!"
>
> Possible puppet sentences
>
> 16a) The cow saw that the bird ate the pudding. (true, tensed complement)
>
> 16b) The pig saw that the bird ate the pudding. (false, tensed complement)
>
> 16c) The cow saw the bird that ate the pudding. (false, relative clause)
>
> 16d) The pig saw the bird that ate the pudding. (true, relative clause)

Each child received a set of eight items: four for each scenario type, one for each of the four possible types of puppet sentences. Therefore, each combination of scenario and sentence type had two items, one that required a reward response, and one that required a punishment response. Again, there were two orders for the items, one as in Appendix D, and one in reverse. Children were given a score of 1 or 0 for each item, based on their choice of reward or punishment for the puppet. The scores were separated by sentence and scenario type; thus there were four scores with possible maxima of 2.

<u>False Belief - Unexpected Contents Task</u>

The last task was a simple theory of mind task that was pioneered by Perner, Leekam, & Wimmer (1987), and has been used in numerous studies. (See Appendix E for the full script.) Each child was shown a container that marked the contents in a seemingly obvious way: a Crayola™ 24-crayon box. The child was asked what she thought was in the box. The experimenter then showed the true contents of the box (e.g. a turtle), and replaced the contents in the box. The child was then asked two target questions.

17a) Before, when you first saw the box, what did you think was in it? and

17b) If I asked XXXX (a friend of the child) to come in here, what would he/she think is in the box?

If the child answered with the expected contents (e.g. the crayons) to either question her answer was marked correct. As in the Unseen Displacement task, only children who produced two correct responses were considered to have passed this task.

Experiment 2

A second experiment was simultaneously conducted to allow comparison of the effects on word learning of having a novel verb presented in one or in several stories. The Fast Mapping portion of the Experiment 1 presented children with a novel verb in three stories and three target sentences before hearing the first target question "Who daxed that the raccoon ate the corn?" In the second experiment, children and adults were instead only presented with one story and one target sentence before hearing the target question.

Participants

Four age groups of English-speaking participants were tested, 9 three-year olds (mean age 3;6, range 3;2-3;11), 9 four year olds(mean age 4;8, range 4;1-4;11) and 9 five year olds (mean age 5;7, range 5;4-5;10), and 9 college-age adults. The three- and five-year-old participants were tested at local preschools. The remaining participants were tested at the University of Massachusetts. Adults were recruited from undergraduate psychology classes at the University, and given credit for their participation.

Procedure

Following a warm-up period, which included coloring for the children, all participants were presented with the raccoon story and memory questions from the Fast Mapping task in Experiment 1 (Appendix F). After hearing the target sentence (10b), all participants were given a coloring task to fill approximately the same amount of time as it took to present the additional stories in Experiment 1. This time was measured from video tapes of pilot subjects for the three-story version of the Fast Mapping task, and was about 2 1/2 minutes. Then, just as in Experiment 1, the participants were reintroduced to the raccoon story and asked the target question (11b). Only tensed sentential complements were tested in this second study. Finally, participants were asked to describe what "daxed" means. Scoring was identical to Experiment 1.

CHAPTER 3

RESULTS AND DISCUSSION

Experiment 1 - Results

Individual Task Results

Fast Mapping Task

The critical measure of whether or not children were fast mapping the meaning of the novel verb is the number of correct answers to the question "Who daxed...?" In Figure 4, the number of correct responses is presented for each condition (tensed complement and infinitival complement) and each age (3,4,5). Preliminary analysis showed no order or gender effects.

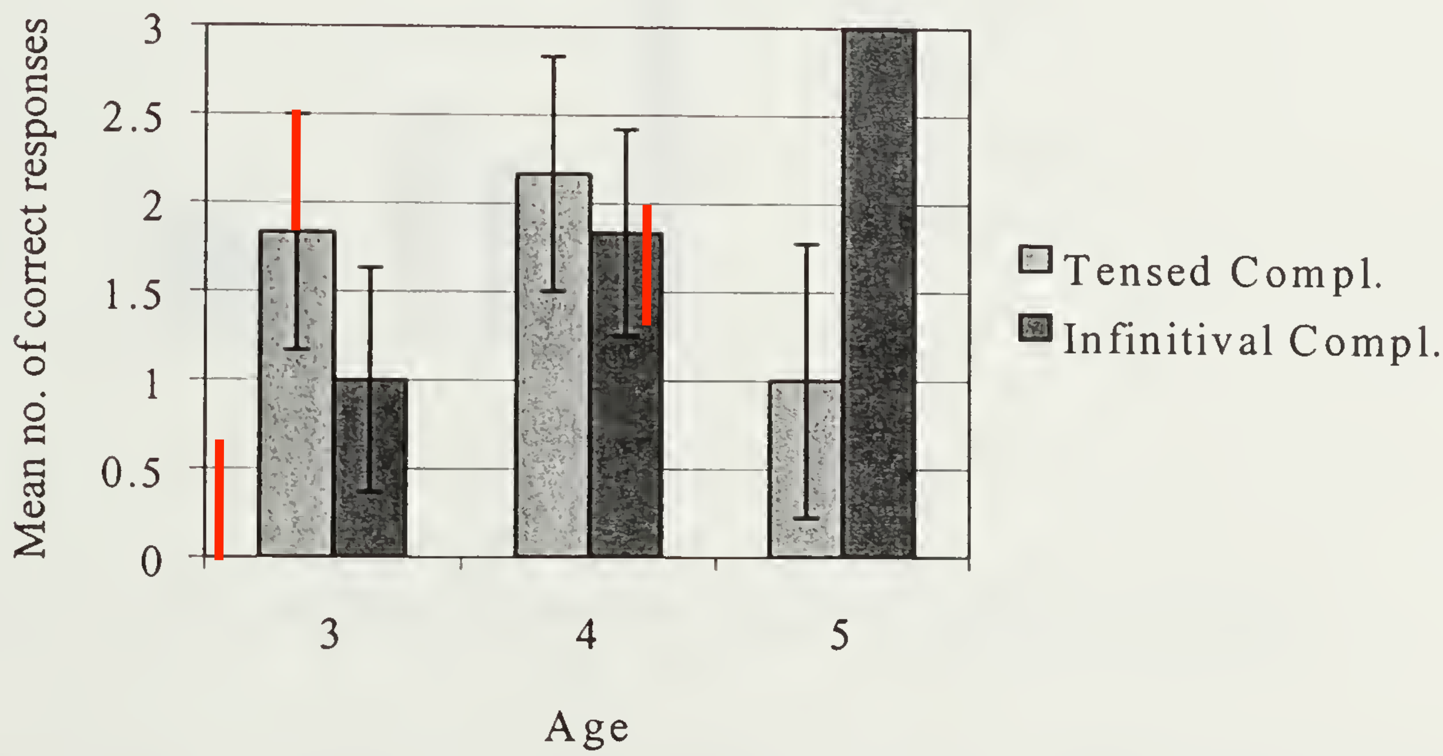

Figure 4: Performance on the Fast Mapping Task

Older children's performance was better in the infinitive complement condition than younger children's performance in that condition and all children's performance in the tensed complement condition. An ANOVA carried out on the answers in the infinitival complement condition revealed a significant age effect, $F(2,17) = 6.124$, $p = .011$. A similar ANOVA in the tensed complement condition found no such age effect, $F(2,17) = 1.096$, $p = .360$. The fact that even the five-year-old children were not able to pass the Fast Mapping task in the tensed complement condition was unexpected, given previous reports and theorizing.

A more detailed inspection of the answers given by the children in each condition shows which actor they chose in the story. Figure 5 presents the results in the infinitival complement condition, and Figure 6 those in the tensed complement condition.

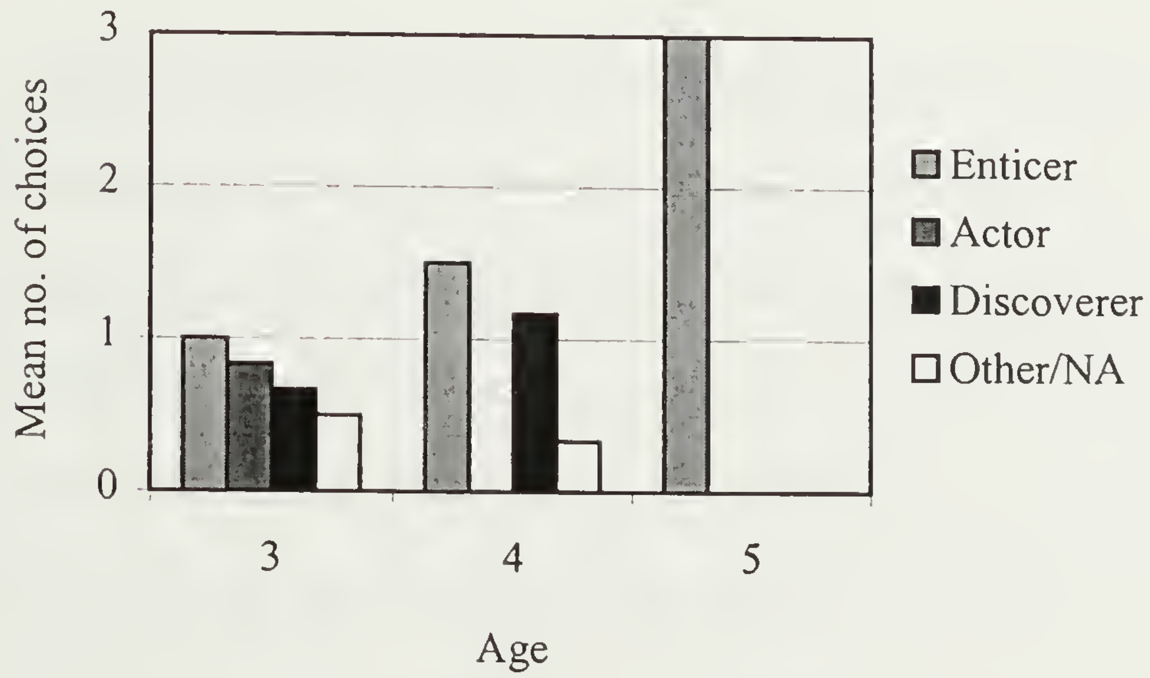

Figure 5: Analysis of Roles Chosen in the Infinitival Complement Condition.

In the infinitival complement condition, children at age three seem to be nearly random in choosing which character in the story was the daxer. At age four, they start to rule out the actor, maybe due to pragmatic reasons, but still cannot choose which one daxed the raccoon to eat the corn. Finally at age five, all children are completely consistent in choosing the enticer as the daxer. They go from complete non-understanding to very clear understanding of the role that the infinitival complement selects.

Figure 6: Analysis of the Roles Chosen in the Tensed Complement Condition.

Children's answers in the tensed complement condition (Figure 6) present a very different picture. Three- and four-year-old children are doing relatively well at choosing the discoverer as the daxer. Their answers of the actor also go down with age, as seen in the infinitival complement condition. However, at age five, children strongly entertain the enticer as the daxer. In fact, an examination of individual answers shows that except for one answer of the actor, if a child chose the enticer, they did so for all three stories, and the same was true for the discoverer. Thus, children at age five are not randomly choosing, as the younger children in both scenarios might be, but have a consistent pattern for selecting their answers. This may mean that the five year olds have two possible interpretations of the novel verb presented in the tensed complement sentence.

The children's answers to the final question: "What do you think dax means?" were also analyzed, and the results may be seen in Figure 7.

Figure 7: Correct Definitions for the Novel Word.

Performance here was very low, and only children in the infinitival complement condition answered the question correctly at all. The four correct answers (given by one four year old, and three five year olds) included answers like "you telled" and "tell them that they can eat it." Most incorrect answers in both conditions were no responses or "I don't know." Almost all other wrong answers were too general (e.g. "made" or "somebody did something"). While it does appear that children in this condition are improving with age, the age effect is not significant, $F(2,17) = 2.5$, $p = .116$.

Finally, children's scores on the memory questions were analyzed. As is apparent from Figure 8, all children performed well.

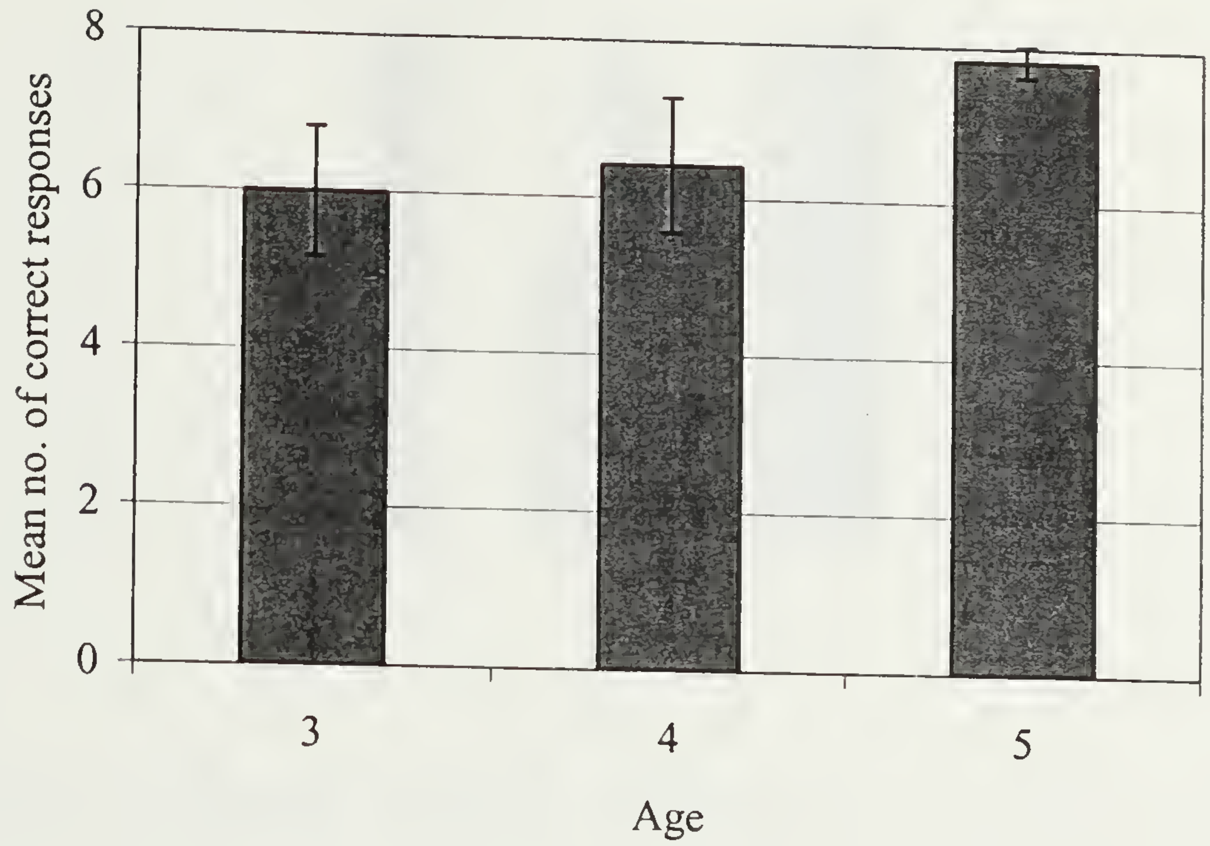

Figure 8: Performance on the Memory Items in the Fast Mapping Task.

After assuring that there were no gender, order, or condition effects, a simple ANOVA found that there was a significant age effect on number of correct answers to the memory questions, $F(2,35) = 5.663$, $p = .008$.

During testing, the experimenters noted that the memory question relating to the enticer in the first picture (e.g. "What did the boy do?) was much harder for the children than the other memory questions, which related to the actor (e.g. "What did the raccoon do?") or the discoverer (e.g. "What did the farmer see?"). Since one of the test items only had two memory questions, relating to the enticer and discoverer, a post-hoc analysis was done to see if there were differences in children's ability to answer these two question types. These two questions were the most important, since they relate to the scenes that are described by the two target sentences containing the novel verb. The results are presented in Figure 9.

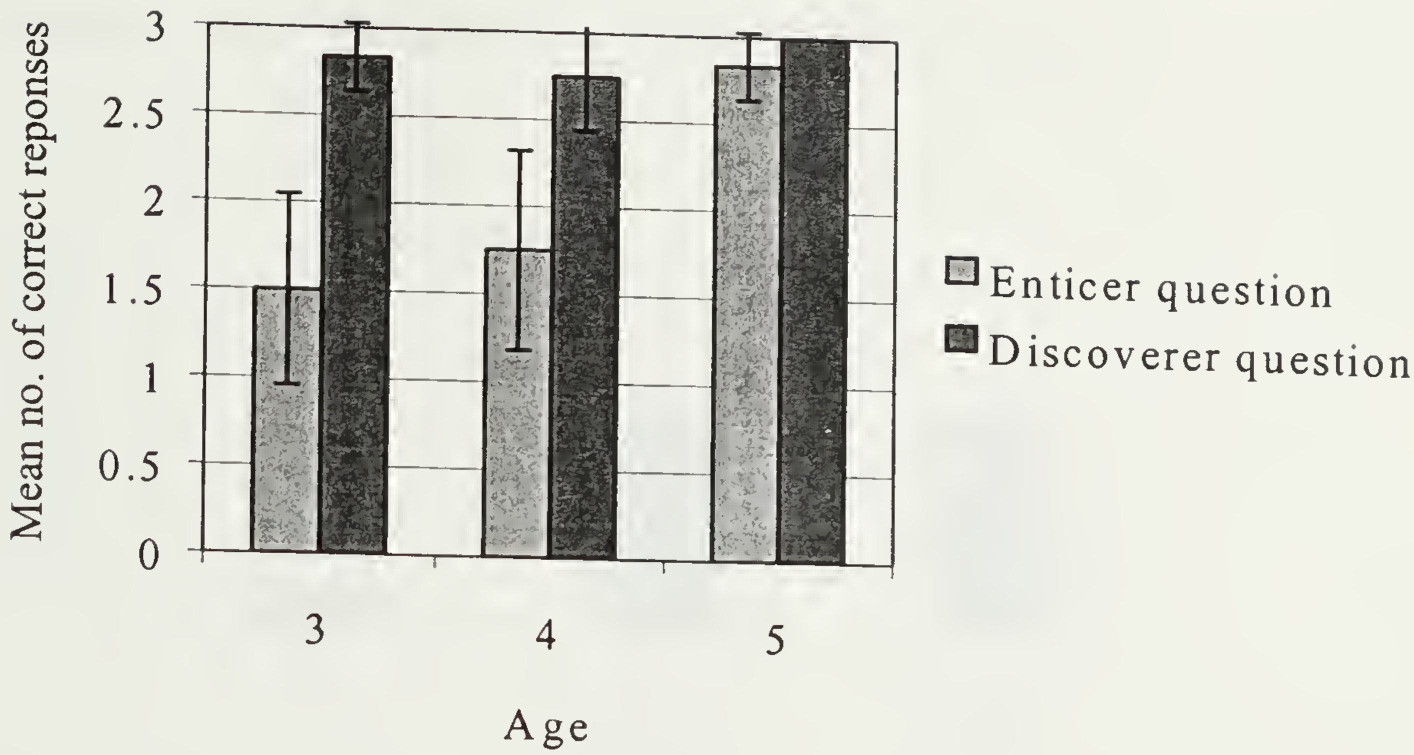

Figure 9: Comparison of Memory Items by Type.

A paired samples Bonferroni t-test revealed a significant difference between the two question types across all three stories, $t(35) = -5.149$, $p < .01$. Yet this difference in performance on the two questions was clearly larger for the younger children. A repeated measures ANOVA found a significant Age X Question interaction, $F(2,33) = 5.877$, $p = .007$.

Theory of Mind

During the Unexpected Contents task children were having difficulty answering the very first question "What do you think is in this box?" Many initially refused to answer the question. Even after multiple prompts, 14% of the children reported a content that was not "crayons." In these cases, the subsequent test questions were scored based on children's initial content choices. However, even with this adjustment, children still gave a large number of off-base answers (14 out of 72 possible answers, or 19%), that were neither the object they originally said was in the box, nor the object they saw in the box.

As may be seen in Figure 10, only 50% of the 5 year olds passed the Unexpected Contents task, no better performance than that of the four-year olds.

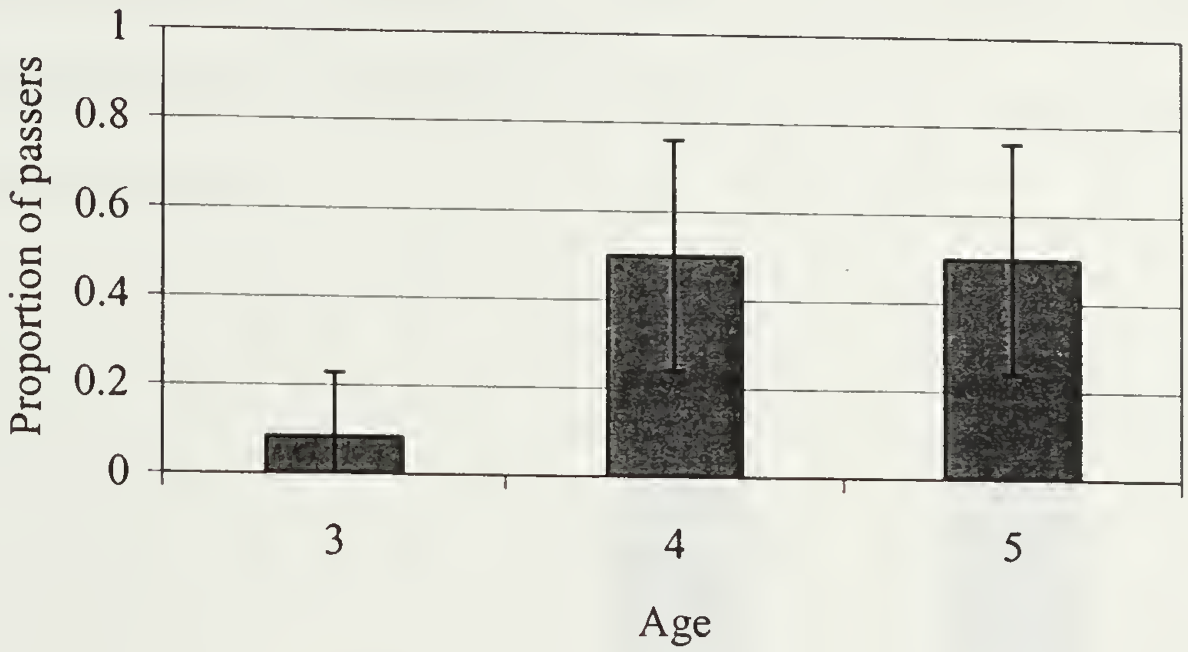

Figure 10: Passing Performance on the Unexpected Contents Task.

At least two possible reasons for the children's poor performance and off-base answers are apparent. First, the box might not have been obviously a crayon box for the children. While the standard yellow box for 24 Crayola™ crayons was used, crayons now come in many different size and shape boxes. Possibly the larger 64-count Crayola™ box with the flip-top lid and sharpener on the back might have been a more effective box for predicting crayons as a content. Secondly, this theory of mind task was the final task of a large five task series. Children might have had fatigue effects, or might not have been willing to make an incorrect guess with the experimenter that had just given them so many tests.

Moreover, the scores for the Unseen Displacement and the Unexpected Contents tasks were not correlated, $r = .051$, $p = .769$. These two tasks are supposedly ones that tap the same construct of false belief understanding, and normally have a significant correlation. In a comprehensive meta-analysis, (Wellman, Cross, & Watson, 2001) found no significant difference between these two types of tasks, $F(1,359) = .63$, $p > .42$. Since these two tests are supposed to show similar results, and do not, probably for procedural and design reasons, only the Unseen Displacement task was used for later comparison with other tasks.

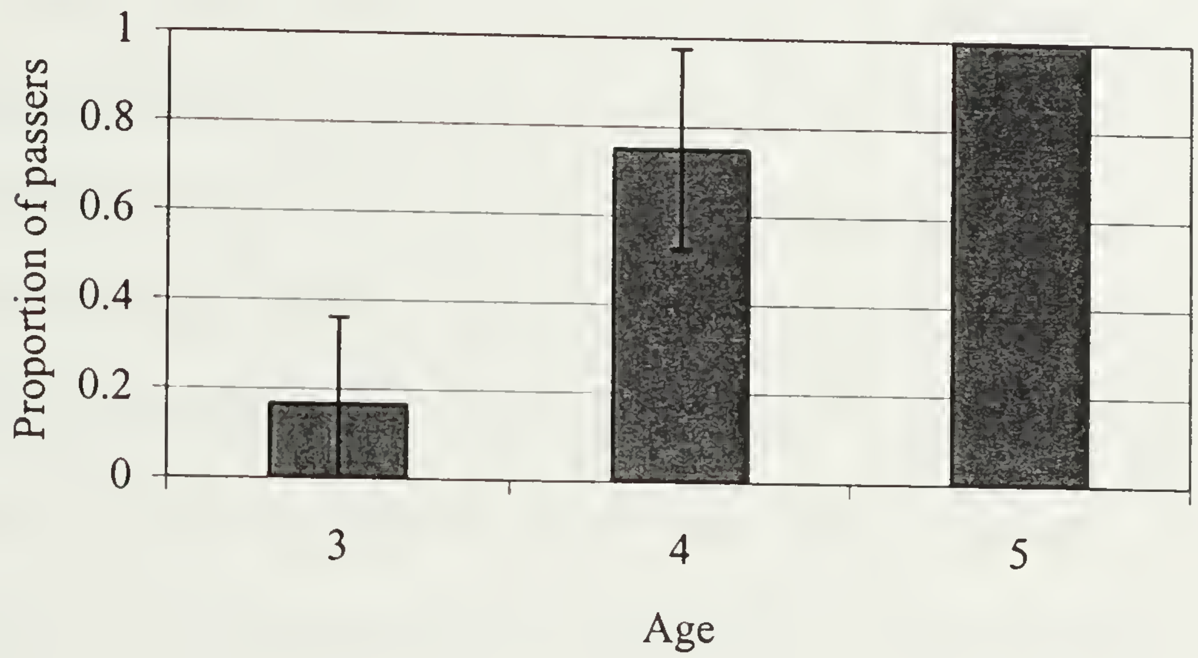

Figure 11: Passing Performance on the Unseen Displacement Task.

Results from the Unseen Displacement task are shown in Figure 11. The proportion of children passing the test increased with age, and an ANOVA revealed a significant age effect for this task, $F(2,35) = 18.489$. $p < .001$. A test for gender effects was not significant. Post-hoc t-tests found that while 3-year-olds' performance differed from that of 4-year olds, $t(22) = -3.386$, $p < .01$, and 3-year-olds' performance differed from that of 5-year-olds,$t(22) = -7.416$, $p < .01$, 4 and 5 year olds' performances did not differ, $t(22)$ - 1.915, $p > .10$. This age pattern is compatible with earlier literature that shows the major change in performance occurs between three and four years of age.

Imitation Task

This task involved pure imitation of sentences containing three types of clauses: infinitival complements, tensed complements, and relative clauses. Each child received three sentences of each type. After all the responses to the imitated sentences were transcribed, careful inspection and analysis revealed that the responses fell naturally into four types: Exact, structure exact, meaning preserved, and meaning changed. The *exact* category contains all responses that were exact repetitions of the target sentences. Allowances were made for self-correction, or unintelligible utterances that had the required number of words or syllables. The *structure exact* category allowed for children's frequent errors in dropping the determiner "the", or changing the actual nouns and verbs used, but required that children have the skeletal structure of the sentence intact. So for the three sentence types, infinitival and tensed complements and relative clauses, *structure exacts* were counted if children had the following structures (18a, 19a, 20a) that matched the target sentences (e.g. 18b, 19b, 20b):

18a) Noun Verb-ed Noun to Verb-inf Noun
18b) The cow told the dog to push the pumpkin.

19a) Noun Verb-ed that Noun Verb-ed Noun
19b) The bird said that the cow stood on the fence.

20a) Noun Verb-ed Noun that Verb-ed Noun
20b) The horse hugged the pig that touched the barn.

Meaning preserved was counted for only three special circumstances. In the infinitival complement sentences, if the "to" was moved in front of the medial noun (e.g. "The cow told to the dog push the pumpkin."), this was counted as meaning preserved.[7]

[7] While this might signify a slight meaning change, this only occurred in 5 of the 108 infinitival complement sentences repeated by the children, and will not significantly affect later analyses.

In the tensed complement sentences, if the "that" complementizer was left out, this created a grammatical sentence in English, but altered the structure, so was counted as meaning preserved. Finally, in the relative clause sentences, if the child said "who" instead of "that" this also counted as meaning preserved.

The final category of *meaning change* included all other utterances by the children. This category will be discussed separately below. Finally a *no response* was listed in its own category.[8]

In Figures 12, 13, and 14, the incidence of the four response categories for infinitival complement sentences, tensed complement sentences, and sentences containing relative clauses are presented separately for each age group. No analyses were done on these four categories per se.

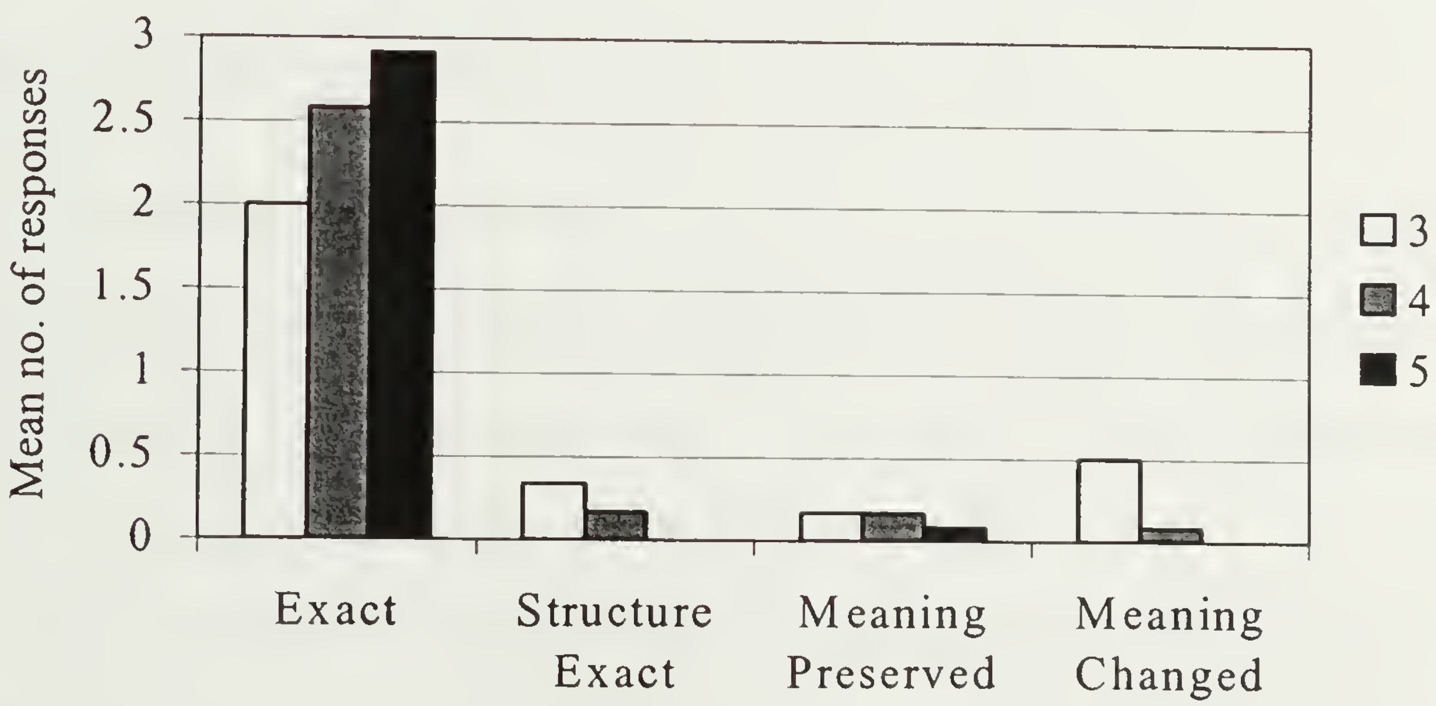

Figure 12: Imitations of Infinitival Complement Sentences by Age.

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[8] If the experimenter repeated the sentence twice (three total examples) the child's answer was counted as a *no response*. This only occurred once in the 324 sentences repeated in the Imitation task.

Children were highly capable at imitating sentences with infinitival complements. Even the three-year old children were able to exactly repeat an average of two out of three sentences. This aptitude stands in stark contrast to their ability to repeat sentences that have tensed complements (see Figure 13).

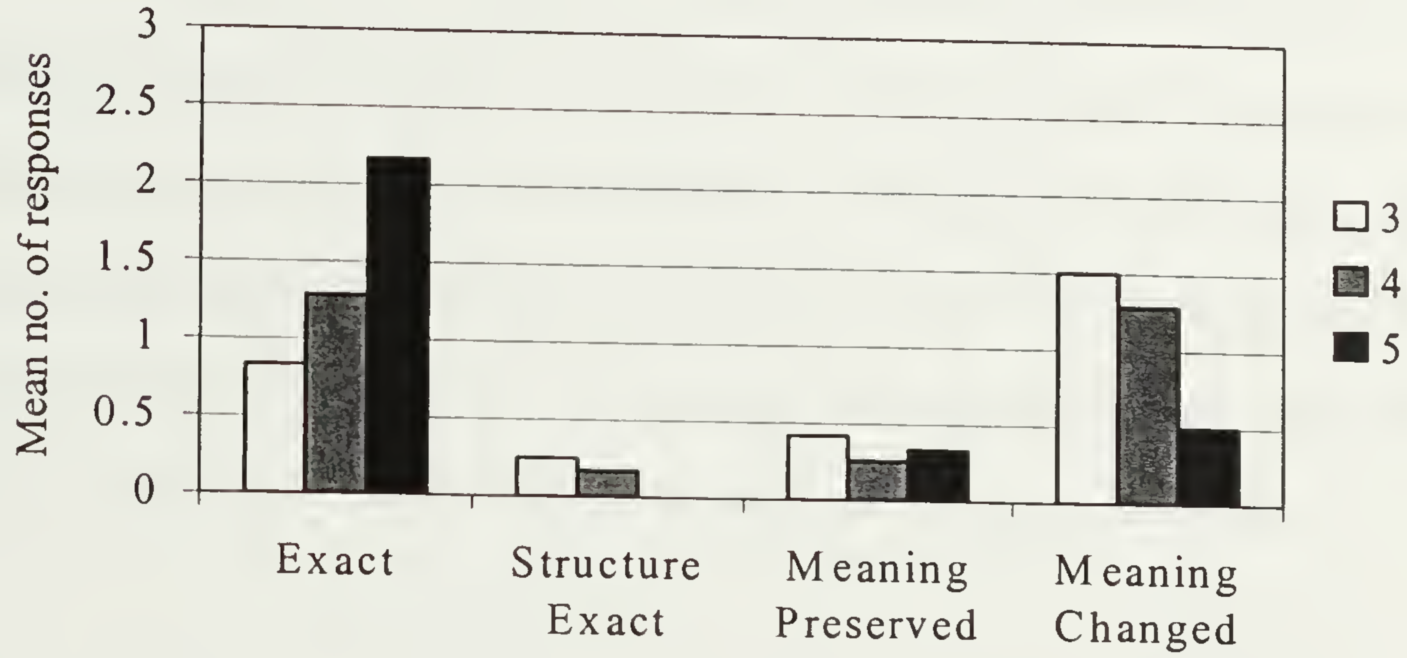

Figure 13: Imitations of Tensed Complement Sentences by Age.

Here, three-year old children were able to repeat an average of less than one sentence exactly, and five-year olds averaged only slightly above two. This is not just due to children dropping the complementizer "that". The *meaning preserved* category is much smaller for all age groups than the *meaning changed* category.

In fact, one of the most common errors in repeating sentences of this type was to change the sentence into one of another type. When examining the sentence (19b), it was easy to see if the children were marking the tense on the embedded verb "stood."[9] For

[9] The other two sentences with tensed complement syntax had "kicked" and "rolled" as the embedded verbs. Therefore it was very difficult to distinguish whether the tense marker "-ed" was present, given the beginning of the next word, "the."

sentence (19b), which had a response from all of the 36 subjects, 11 total sentences were classified as *meaning changed.* Out of these 11 instances, three had a "to" inserted but the tense in the lower clause was kept the same (e.g. "the bird said to the cow stood on the fence"), two had a change of the tense in the lower clause, but didn't have the infinitive marker "to" (e.g. "the bird said the cow stand on the fence") and two had both the tense marker missing and the "to" added (e.g. "the bird told him to stand on the fence"). The other four utterances changed the sentence into a simple sentence of some kind, with no embedded clause (e.g. "the bird stood the cow on the fence"). So it seems that when children had difficulty repeating this sentence, they did one of two things: they either shortened the sentence, removing all embedded structure, or they tried to change the tense or structure to match an infinitival complement sentence, as in (18b).

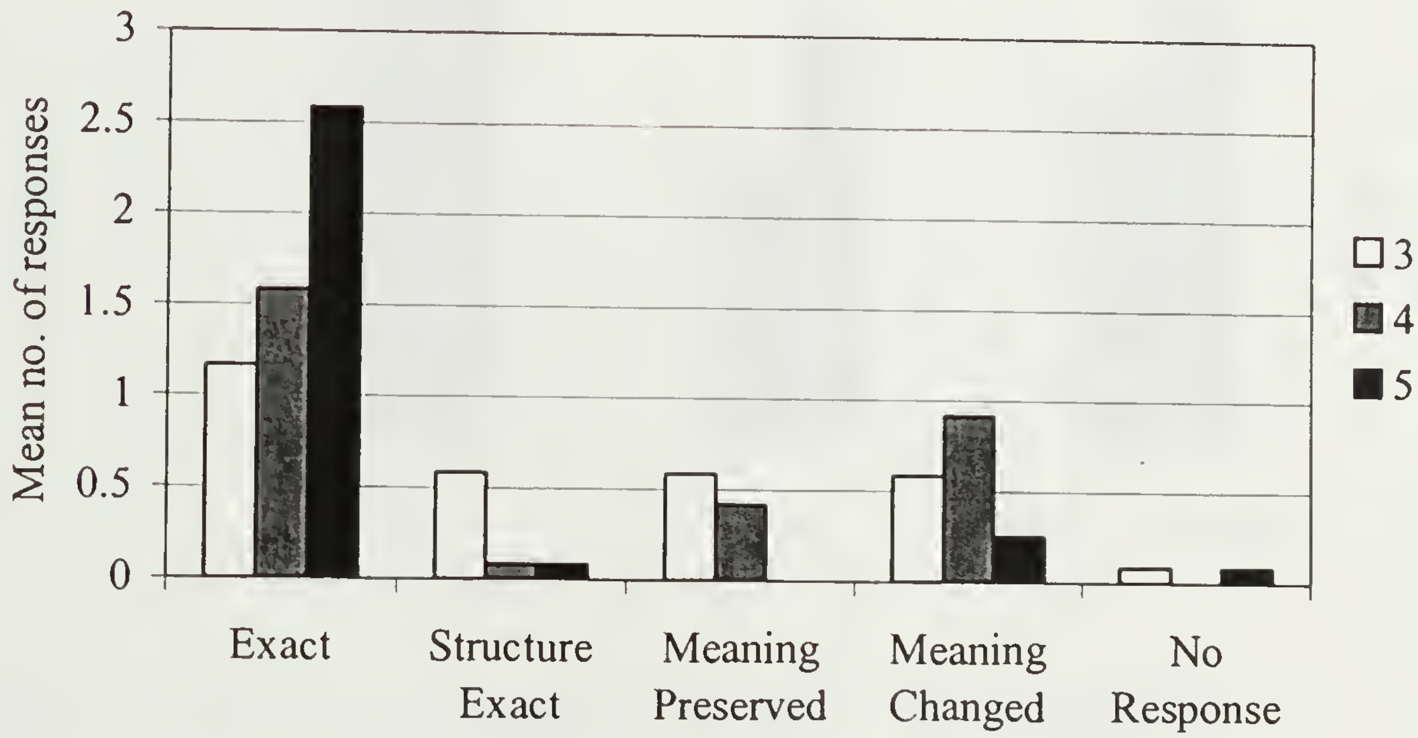

Figure 14: Imitations of Sentences Containing Relative Clauses by Age.

Finally, as seen in Figure 14, children were also not as adept at imitating sentences containing relative clauses as they were at imitating infinitival complements. Again, performance across ages ranged from just over 1 sentence correct to two and a half out of three. Most responses that were not exact repetitions fell in the *Meaning changed* category, but in this case, *structure exact* and *meaning preserved* responses were more prevalent than in the tensed complement imitations. Many children either switched two content nouns, creating a *structure exact*, or replaced the "that" with "who," creating a *meaning preserved* response.

A statistical comparison of the three sentence types was made possible by converting the categories into a 1, 0 score. If a response was in the *exact, structure exact*, or *meaning preserved* categories, it received a 1. If a response was in the *meaning changed* category, or had been given after three repetitions of the target sentence, it received a 0. A no response also received a 0. The data can be seen in Figure 15.

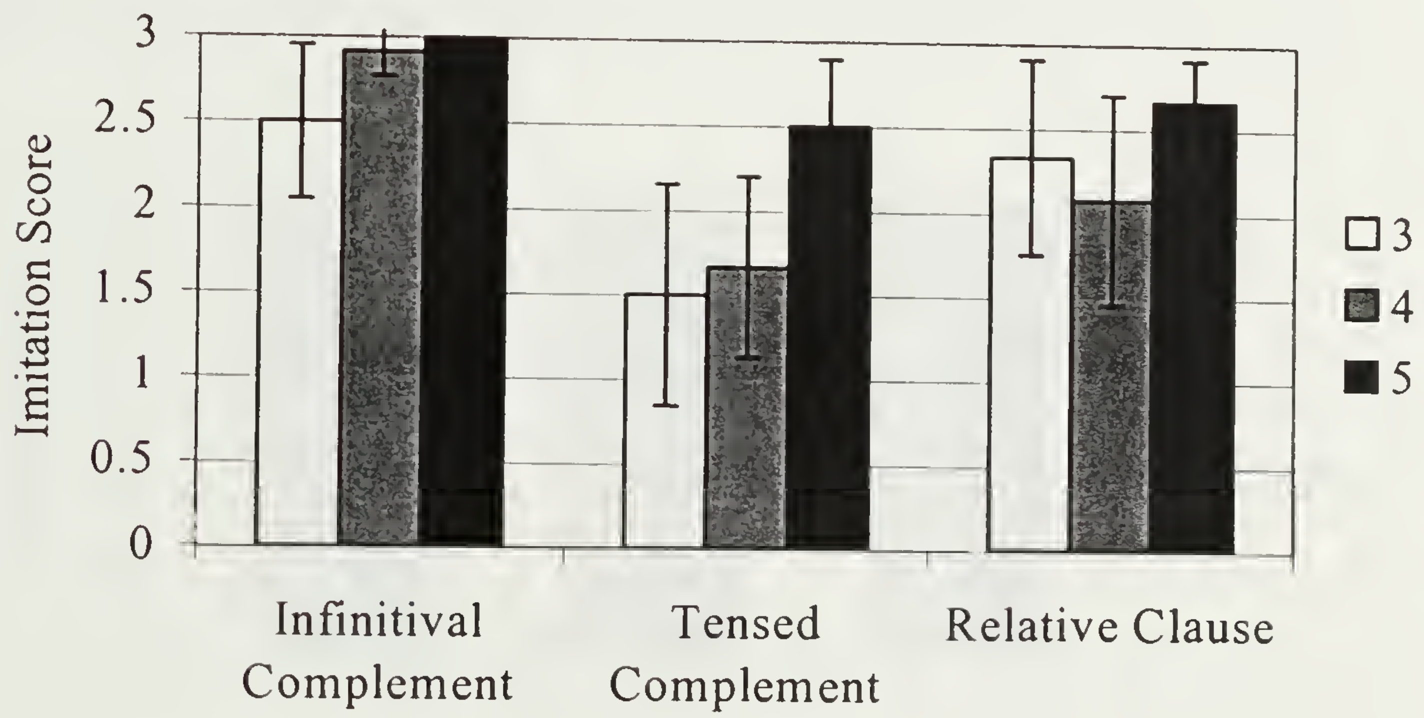

Figure 15: Imitation Scores as a Function of Sentence Type and Age.

Older children in general tended to perform better. However, separate ANOVAs for each sentence type revealed an age effect only in the infinitival complement sentences $F(2,35) = 3.780$, $p = .034$, although the age effect in the tensed complement sentences was marginally significant F(2,35) = 2.749, p = .079. Several uninterpretable order effects were found. These patterns may be seen in Figures 16 and 17.

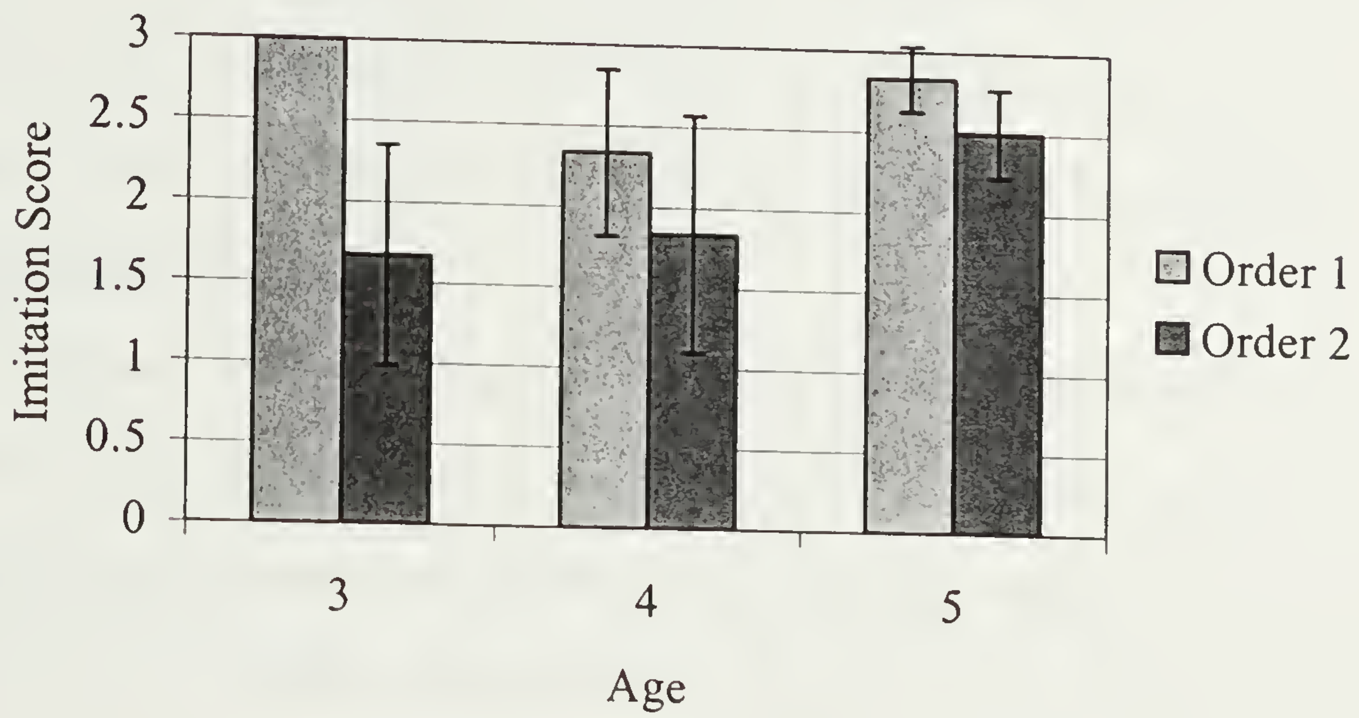

Figure 16: Order Effects in Imitating Sentences with Infinitival Complements.

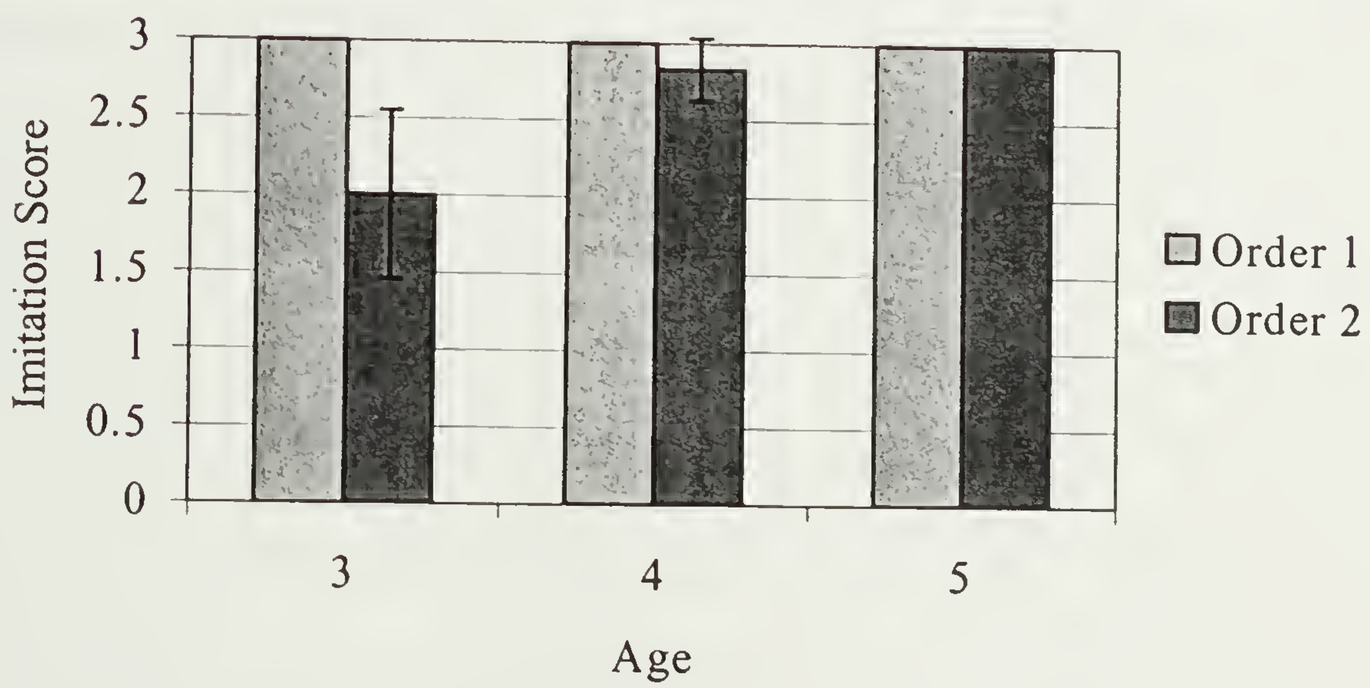

Figure 17: Order Effects in Imitating Sentences with Relative Clauses.

In Figure 16 we seen that performance on infinitival complement sentences in the order found in Appendix (B) was at ceiling for all ages, but the reverse order was

F(1,35) = 5.976, p = .021, and an Age X Order interaction F(2,35) = 3.780, p = .034. Figure 17 shows the effect of order on imitating sentences containing relative clauses. An ANOVA again showed a significant effect of order, F(1,35) = 5.060, p = .032, but there was no interaction with age in this case. In general the order effects were most apparent for the three year olds. There is no theoretical reason that the orders should have produced different effects; thus order effects will be ignored in future analyses.

Truth-Value Judgment Task

In this task, children were presented three types of sentences in two different scenarios, with one sentence type included in both scenario types. The tensed complement sentences were presented in scenarios whose contents also allowed for the construction of infinitival complement sentences or sentences containing relative clauses. For this reason, the two types of tensed complement sentences will be considered separately by their type of scenario. Children were given a percentage correct score within each sentence type.[10]

[10] There were three times the experimenter controlling the puppet made an error in presenting a sentence to the child. All of the errors changed the sentence from one type to another, moving the "that." To avoid losing this valuable data, these items were scored for their matching sentence type.

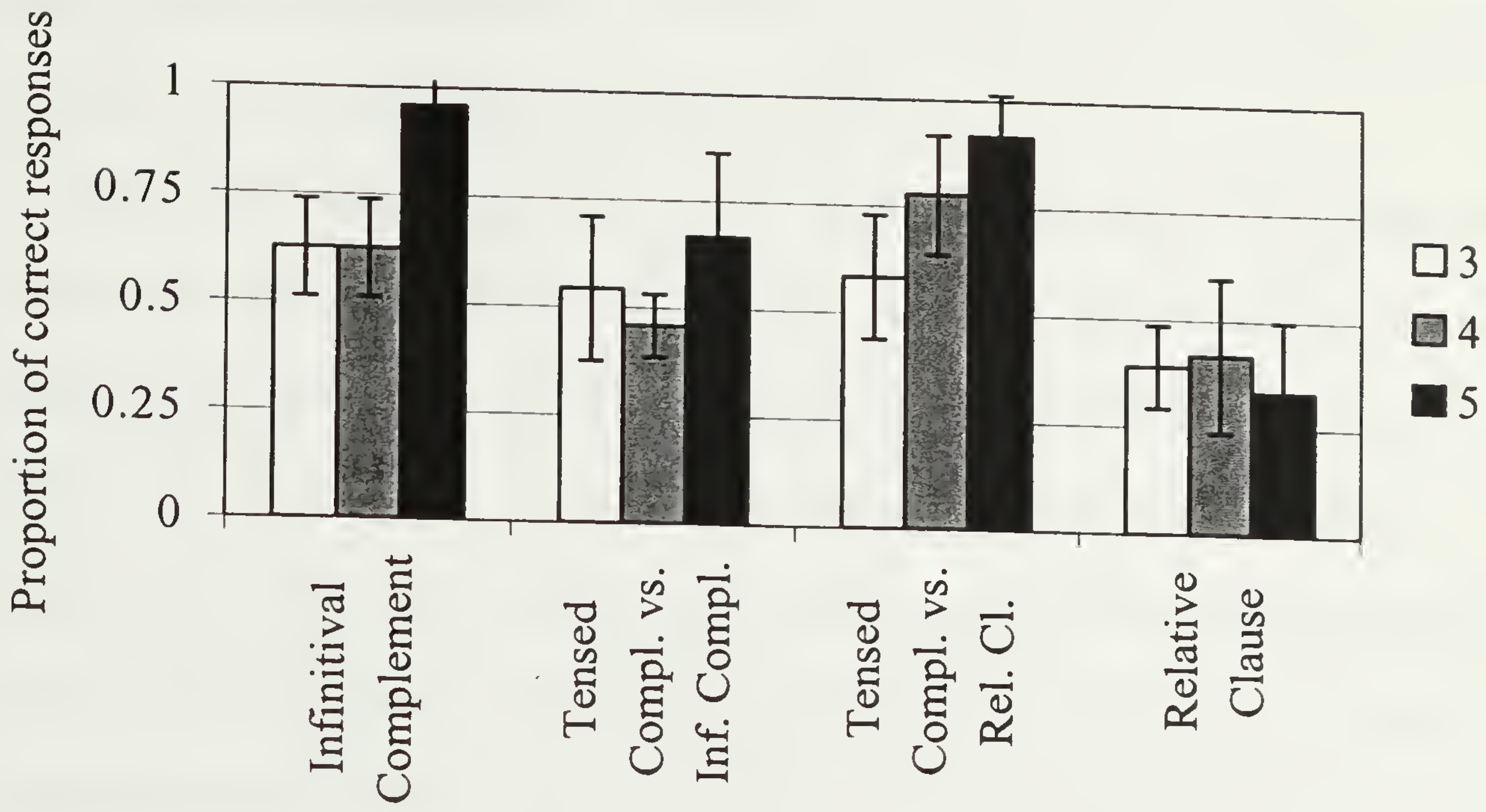

Figure 18: Performance on the Truth-Value Judgment Task by Age.

As Figure 18 shows, performance on almost every sentence type was around chance (.5) for almost all of the age groups. For the infinitival complements, only the five-year-olds performed above chance, $t(11) = 11.00$, $p < .001$. For the tensed complements that were in scenarios that contained events which could be interpreted using relative clauses, both the four- and five-year-olds performed significantly above chance (four-year olds, $t(11) = 3.458$, $p = .005$, five-year-olds, $t(11) = 7.416$, $p < .001$). No age group did better than chance on the sentences containing relative clauses, or on the tensed complement clauses that were in scenarios containing events also consistent with the infinitival complements.

Since no effects were found for gender or order of presentation, a multivariate ANOVA was run on the four sentence types. Significant age effects were found for only the infinitival complement sentences, $F(2,35) = 10.831$, $p < .001$, and the tensed complement sentences that were in scenarios allowing relative clauses, $F(2,35) = 5.081$, $p = .012$, as could be expected from the earlier results.

Finally, a repeated measures analysis of differences between the types of scenarios the tensed complements were found in, revealed a significant effect of scenario type on whether or not children were correctly interpreting the tensed complement sentences, $F(1,33) = 10.308$, $p = .003$. In other words, understanding tensed complements in scenarios that provided for a contrast with a relative clause was easier than understanding tensed complements contrasted with infinitival complements. However, there was no interaction between scenario type and age, $F(2,33) = 1.730$, $p = .193$.

One more post-hoc analysis was performed. Since a common error in the tensed complement portion of the imitation task was to create an infinitival complement sentence, a more careful examination of the tensed complement items that appeared in scenarios that could also contain an infinitival complement was undertaken. To see if tensed complement sentences were being treated as infinitival complement sentences, it was important not only to see how many items were correct, but which ones. In the design, the item that had a false subject in a tensed complement was made false by inserting the true subject for the infinitival complement. In other words, when a bird told a cow to ring a bell, and a dog said that the cow rang the bell, the false tensed complement sentence used as a stimulus was "The bird said the cow rang the bell." This was compared to the true tensed complement sentence "The dog told the cow to ring the bell. If the children are indeed allowing the tensed complement sentences to have an infinitival reading, they should have a large number of false positives (a large number of reward responses) in the false tensed complement, and should not have as many false negatives in the true tensed complements. If the children simply are failing the tensed complement sentences overall, there should be no effect of question type (true or false). To test this, the number of reward responses was compared in the two test items containing the false tensed complement and the true tensed complement. Indeed, the predicted effect of question type was obtained as may be seen in Figure 19.

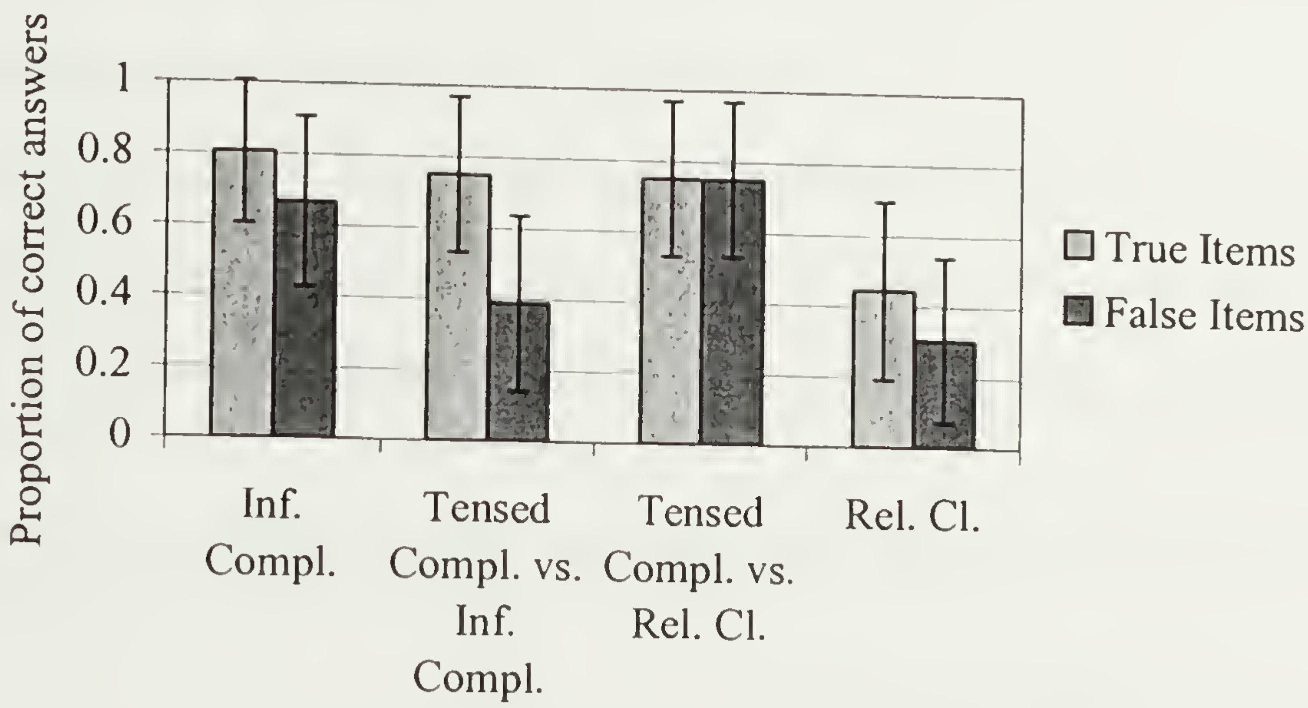

Figure 19: Analysis of True and False Test Items Across Sentence Types in the Truth-Value Judgment Task.

Repeated measures ANOVAs were conducted on all four combinations of sentence type/question type (true or false). In only the tensed complement sentences that were contrasted with infinitival complements was the type of question significant, $F(1,33) = 10.158$, $p = .003$. No effects of questions being true or false were found in the other types of sentences. This means specifically that children often allowed the tensed complement sentences to have something like an infinitival complement reading, and rewarded the puppet when the subject matched that of the corresponding infinitival complement sentence.

Comparisons Across Tasks

For the remaining analyses, four tasks were compared with each other: Fast mapping, Imitation, Unseen Displacement, and Truth-Value Judgment. For each of these comparisons, age was partialed out of all correlations.

Theory of Mind and the Grammar Tasks

Previous research has repeatedly found a link between performance on measures of tensed complement understanding and performance on False-Belief tasks. To see if this experiment replicated those results, partial correlations (controlling for age) compared children's performance on the Unseen Displacement task, to their performance on the two different measures of grammatical competency: Imitation and Truth-Value Judgment.

Table 1: Partial Correlations Between False Belief Performance and Imitation of Sentences.

	Imitation of Sentences		
	Infinitival Compl.	Tensed Compl.	Relative Clause
Pass False Belief	-0.24	**-.38***	-.07

*$p < .05$

As may be seen in Table 1, passing the False-Belief task does correlate with imitation of sentences that contain tensed complements, and does not correlate with imitation of other complex types of sentences. However, this correlation is in the opposite direction to the one predicted. In other words, children who can imitate tensed complements well are less likely to be the ones passing the false belief test. There is no theoretical reason for this reverse relationship, and it goes strongly against a large body of previous research, therefore this paper offers no explanation for its existence.

Table 2: Partial Correlations Between False-Belief Performance and Truth-Value Judgments (TVJ) of Sentences.

	TVJ sentence/scenario combination			
	Scenario 1		Scenario 2	
	Inf. Compl.	Tensed Compl.	Tensed Compl.	Rel. Clause
Pass False Belief	-.26	-.06	-.11	.18

From Table 2, we see that False Belief performance does not correlate significantly with any of the Truth-Value Judgment (TVJ) measures, even those using tensed complements. In fact, when we check for the relationship between the Imitation and Truth-Value Judgment measures themselves, there are almost no significant relationships, even between similar items. The only significant relationship found in Table 3 is between imitation of tensed complement sentences and performance on one type of tensed complement sentence in the Truth-Value Judgment task.

Table 3: Partial Correlations Between Imitation and Truth-Value Judgment Items.

	TVJ sentence/scenario combination			
	Scenario 1		Scenario 2	
Imitation	Inf. Compl.	Tensed Compl.	Tensed Compl.	Rel. Clause
Inf. Compl.	.31	-.02	.16	-.11
Tensed Compl.	.25	.02	**.35***	-.08
Rel. Clause	.33	.02	.25	-.12

*$p < .05$

Comparisons with the Fast Mapping Task

For all of the following comparisons involving the Fast Mapping task, age was again partialed out. In Table 4 the comparison of children's performance on the False Belief task and their responses on the Fast mapping task may be seen.

Table 4: Partial Correlations Between Fast Mapping Conditions and False Belief Performance.

	Infinitival Complement	Tensed Complement
Pass False Belief	.24	.04

There are no significant relationships in either condition. Contrary to predictions, the ability to pass the False Belief does not seem to help children discern the meaning of a novel verb in a sentence containing a tensed complement.

Table 5: Partial Correlations Between Fast Mapping and Imitation of Sentences.

	Imitation of Sentences		
Fast Mapping	Infinitival Compl.	Tensed Compl.	Relative Clause
Inf. Compl.	-.19	.29	.47
Tensed Compl.	**.53***	.26	.41

*$p < .05$

Table 5 shows the comparison of Imitation and Fast mapping performance. The only significant relationship is extremely puzzling: Even partialing out the effects of age, imitation of sentences with infinitival complements is related to performance in the tensed complement condition. There are no theoretical reasons for this correlation, but it may reflect mediation of some general linguistic ability of the child. Since children in general did well on the imitation of infinitival complements, the few who did poorly had the worst general linguistic ability, making the Fast Mapping task extremely hard. However, the same relationship doesn't hold for the infinitival complement condition in the Fast Mapping task.

Table 6: Partial Correlations Between Fast Mapping and Truth-Value Judgment Performance.

	TVJ sentence/scenario combination			
	Scenario 1		Scenario 2	
Fast Mapping	Inf. Compl.	Tensed Compl.	Tensed Compl.	Rel. Clause
Inf. Compl.	**.70*** **	.25	.29	-.09
Tensed Compl.	.10	-.12	.06	-.26

***$p < .005$

Finally, Table 6 shows the partial correlations between Fast Mapping and TVJ tasks. Here the only significant correlation is between performance in the infinitival complement portions of both tasks, which would be expected. However, the expected parallel relationship between tensed complement performance on the Truth-Value Judgment tasks and Fast Mapping tasks was not found.

Predicting Performance on the Fast Mapping task

Two stepwise regressions were undertaken to see if performance on certain portions of all measures could predict performance on the Fast Mapping task. For the infinitival complement condition, it was hypothesized that four factors might predict performance: age, imitation of infinitival complement sentences, truth-value judgments of infinitival complement sentences, and judgments of tensed complement sentences in scenarios which also contained events that could be described with infinitival complements. Age was entered into the regression alone, and was found to be a significant predictor of fast mapping performance in this condition, $F(1,16) = 18.819$, $p = .001$. The other three factors were entered step-wise after age. Only truth-value judgments of infinitival complement sentences significantly added to the prediction, over and above the effect of age $F(2,15) = 14.745$, $p < .001$.

A similar regression was performed for the tensed complement condition. The five factors considered here were: age, imitation of tensed complement sentences, truth-value judgments of tensed complements in each type of scenario, and performance on the False Belief task. When age was entered first, as in the first regression, it was not found to be a significant effect $F(1,16) = 1.069$. $p = .317$. If all factors were added to the model in a step-wise fashion, none of the factors were found to be significant. In other words, nothing about children's performance on the theory of mind or syntactic ability measures could predict if children would perform the tensed complement condition of the fast mapping task successfully.

Another regression was performed to try and explain the children's choices of "enticer" in the Fast Mapping task. If children are doing extremely well at infinitival complements, as seen in the imitation data, and are simply treating the tensed complements in the Fast Mapping task as sentences with infinitival complements, then the choice of the "enticer" should be predicted by their performance on measures of infinitival complements. A regression was therefore performed, where the dependent variable was number of "enticer" choices in the tensed complement condition of the Fast Mapping task. Age was first entered into the regression, and was found to be a significant predictor of "enticer" choices in this condition, $F(1,16) = 7.246$, $p = .016$. Various other measures of infinitival complements were then entered into the regression stepwise: performance on TVJ infinitival complements, performance on TVJ tensed complements that were contrasted with infinitivals, imitation of sentences containing infinitival complements, and finally imitation of tensed complements. These two tensed complement measures were chosen, since they were the ones where children seemed to mistake tensed complements for infinitival complements, as shown in previous analyses. However, none of the other measures could significantly predict children's number of "enticer" choices in the Fast Mapping task, beyond what was predicted by age. As stated above, children's "enticer" choices in the infinitival complement condition were predicted by infinitival performance on the TVJ, but infinitival performance on the TVJ doesn't predict "enticer" choices in the tensed complement condition. While children do seem to treat tensed complements in some kind of tenseless way, they aren't just mentally substituting infinitival complement structure when they come across tensed complements.

A final pair of regressions was run to see if errors in understanding the "enticer's" role in the story, as measured by their performance on the memory question about the "enticer's" actions, made a difference in children's performance on the Fast Mapping tasks in each conditions. If the reason younger children are unable to pass the infinitival complement condition has to do with their comprehension of the role of the "enticer," then performance on that memory question should predict how they perform. For infinitival complements, performance on the "enticer" memory question predicted performance on the Fast Mapping task, over and above the effects of age, $t(17) = 3.561$, $p < .001$. If performance on the "enticer" memory question predicted performance, the interpretation of this prediction would lie in the direction of the effect. If performance on the memory question positively predicted performance in the Fast Mapping task, it might be due to some general skill the children have with complement-taking actions. If performance on the memory question negatively predicted performance in the Fast Mapping task, it would be nearly the same as if performance on the TVJ infinitival complements predicted performance on the Fast Mapping task. It would show that infinitival competencies, whether syntactic or in their related cognitive domains, had a negative effect on whether or not children chose the *discovered* meaning of the verb "dax". Neither of these possibilities were born out by the data. Performance on the "enticer" memory question did not predict performance in the Fast Mapping task either alone, or factoring out age.

Experiment 1 - Discussion

Very few of the original predictions for Experiment 1 held true. First, the Truth-Value Judgment task and the Imitation task did not seem to represent similar measures of children's understanding of complement structures. Only when children were presented tensed complement sentences in contrast with events that relative clauses could describe, was their TVJ performance correlated with their ability to imitate tensed complement sentences. The most striking example of the mismatch in performance between the two tasks was 3- and 4-year olds' ease of imitating infinitival complement sentences, and their inability to judge these sentences correctly.

The predictions regarding False Belief fared better, at least in the Unseen Displacement Task. Results here replicated a multitude of studies that found largest increase in performance on this task occuring between three and four years of age.

However, there was no replication of the positive relationship between False Belief with performance on the tensed complement sentences in either the TVJ or Imitation tasks.

The Fast Mapping results deviated the most from the original predictions. It was predicted that 5 year old children might be able to pass in the infinitival complement condition, but it was predicted that children would perform better in the tensed complement condition. In actuality the children in the infinitival complement condition performed perfectly; all of them choose the "enticer" in all of the stories. Performance in this condition was not related to children's ability to imitate infinitival complement sentences, as seen in the correlations and step-wise regression. However, performance on the infinitival complement sentences of the TVJ was a significant predictor of performance on the Fast Mapping task. This points out again that the Imitation and TVJ tasks seem to be unequal measures. It may be that the imitation of sentences measures children's basic understanding of these sentences, but only TVJ performance shows the deeper level of understanding which is necessary to use a sentence in a Fast Mapping scenario.

It was not predicted that very few children would pass the tensed complement condition in the Fast Mapping task. The original predictions were that children should, at least by age 5 and in the three story version, be able to easily fast map the meaning of abstract verbs in tensed complement sentences. In fact, 5 year olds seem to do worse than the three and four year olds. It was also unexpected that performance on any of the syntactic or cognitive measures would prove not to be related to or predictive of performance in the tensed complement condition.

Finally, an analysis of the types of errors children made in the tensed complement condition of the Fast Mapping task led to a cluster of unpredicted results. First, children reliably chose the "discoverer" or the "enticer" in the Fast Mapping task, indicating two distinct but differing interpretations for the verb. Secondly, children often repeated tensed complement sentences by including some type of infinitival marker. Finally, TVJ performance indicated that children allowed an interpretation of the tensed complement sentence as an infinitival complement, since they accepted the tensed complement sentence when its subject matched the one more appropriate to the infinitival complement. While this could mean that children are simply mistaking tensed complements for infinitival ones, it is unlikely given the regression results. Children's performance on the infinitival complements in any of the syntactic measures did not predict when they chose the "enticer" in the tensed complement condition, as it did in the infinitival complement condition.

While this full set of results does not map onto the predictions, five-year old children were able to bootstrap abstract verbs in infinitival complement sentences. This is a significant result, and shows competency at an earlier age than found by Johnson (2001). Also, the results suggest that there is more than one stage in understanding complements: a superficial understanding shown in imitation of sentences and correct productions by children, and a later, deeper understanding required to make fine discriminations. Finally, the cluster of results surrounding children's seeming confusion with regard to the tense in the tensed complement clauses offers a potential explanation for their failure on the Fast Mapping task, which will be elaborated in the general discussion.

Experiment 2- Results

In Experiment 2, a single story version of the Fast Mapping task from Experiment 1 was utilized, but only with a tensed complement sentence to describe the story. The results[11] of this abbreviated task may be seen in Figure 20.

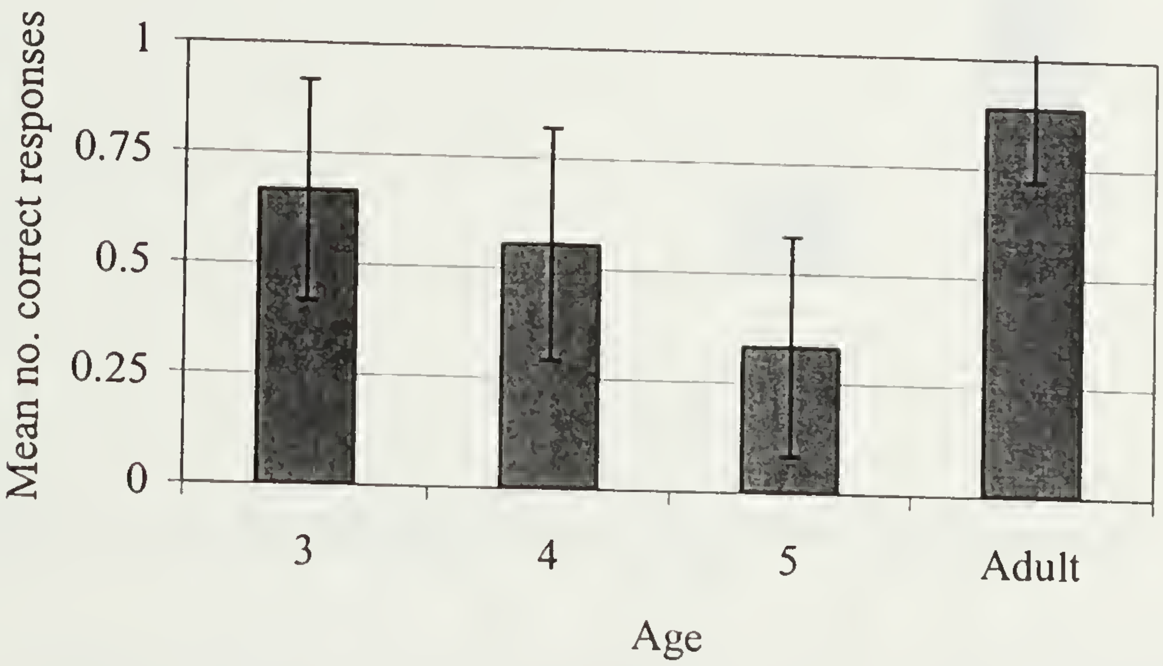

Figure 20: Performance on Fast Mapping Task (Experiment 2).

An ANOVA conducted on the number of correct responses in the one-story version of the Fast Mapping task found that there was a significant age effect on this task $F(2,27) = 6.889$, $p = .004$. This age effect is entirely due to the difference in performance between the five year olds and the adults, $t(16) = -2.774$, $p = .014$. None of the other groups differed significantly from each other. Since there were three actor roles in the story, chance may be considered to be .33. Only the adults performed above this chance level, $t(8) = 5.030$, $p = .001$. It is remarkable, however, that one adult did make an error, and chose the boy/enticer as the daxer. While performance was relatively poor, several participants who chose the correct daxer also gave an appropriate definition for the word

[11] In this experiment, age and gender were confounded. All adult subjects were women, and only one of the three year old participants was female. Therefore, no analysis was performed to look for gender effects.

"dax" (i.e. discovering or seeing). Figure 21 shows the mean correct definitions as a function of age. Here the age effect is also significant, $F(3,36) = 8.593$, $p < .001$.

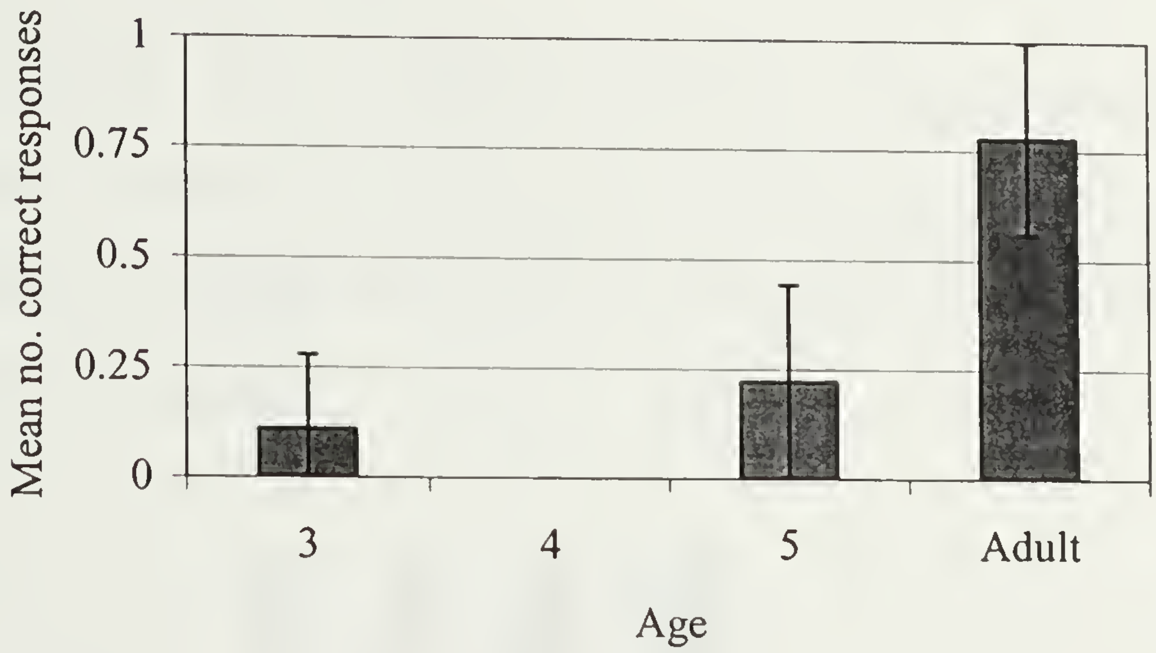

Figure 21: Correct Definitions for the Novel Word (Experiment 2).

Performance on the memory questions by the participants was again analyzed for Experiment 2, and the results can be seen in Figure 22.

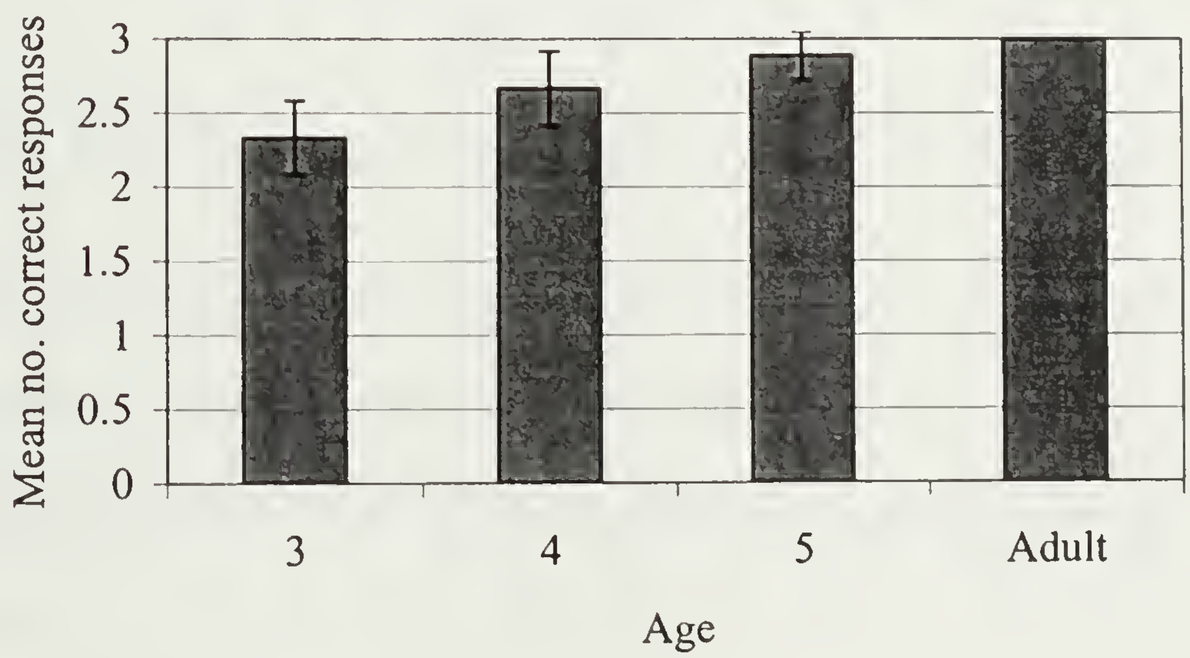

Figure 22: Performance on the Memory Items (Experiment 2).

Performance by all ages is very high, just as in Experiment 1, and increases with age. An ANOVA run on the total number of correct answers found a significant age effect, $F(3,36) = 5.091$, $p = .005$.

Figure 23 shows the analysis of performance on memory items by type. Remember that in Experiment 1, the memory question that referred to the action of the enticer had a much poorer performance by younger children than the question that referred to the discoverer's actions.

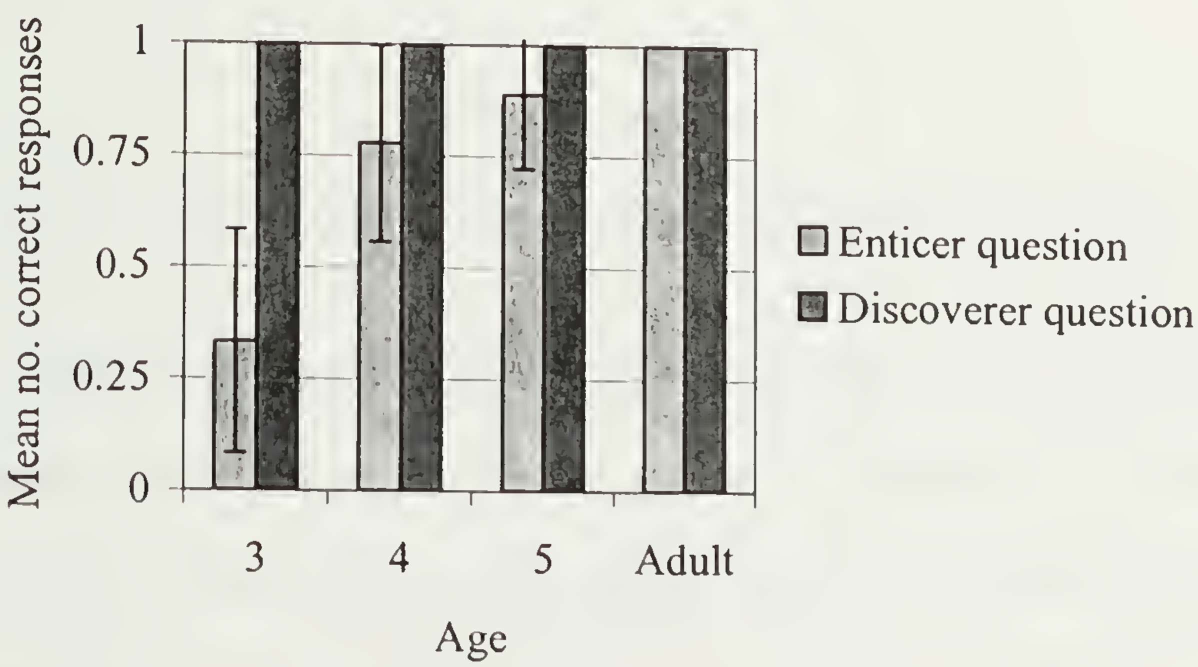

Figure 23: Performance on Memory Items by Type (Experiment 2).

In the second experiment, the enticer question was again difficult for the younger children. A repeated measures ANOVA found that the effect of question type was significant, $F(1,32) = 16.2$, $p < .001$, and that type interacted with age, $F(3,32) = 5.583$, $P = .004$.

Comparison with Experiment 1

<u>Comparison of Identical Stories</u>

To compare performance in the two experiments, only the child subjects can be used; there were no adult participants in Experiment 1. There are two ways to compare the performance of participants on the two Fast Mapping tasks. Since both experiments contained the "raccoon" story, the first comparison will be of the answers to that story.

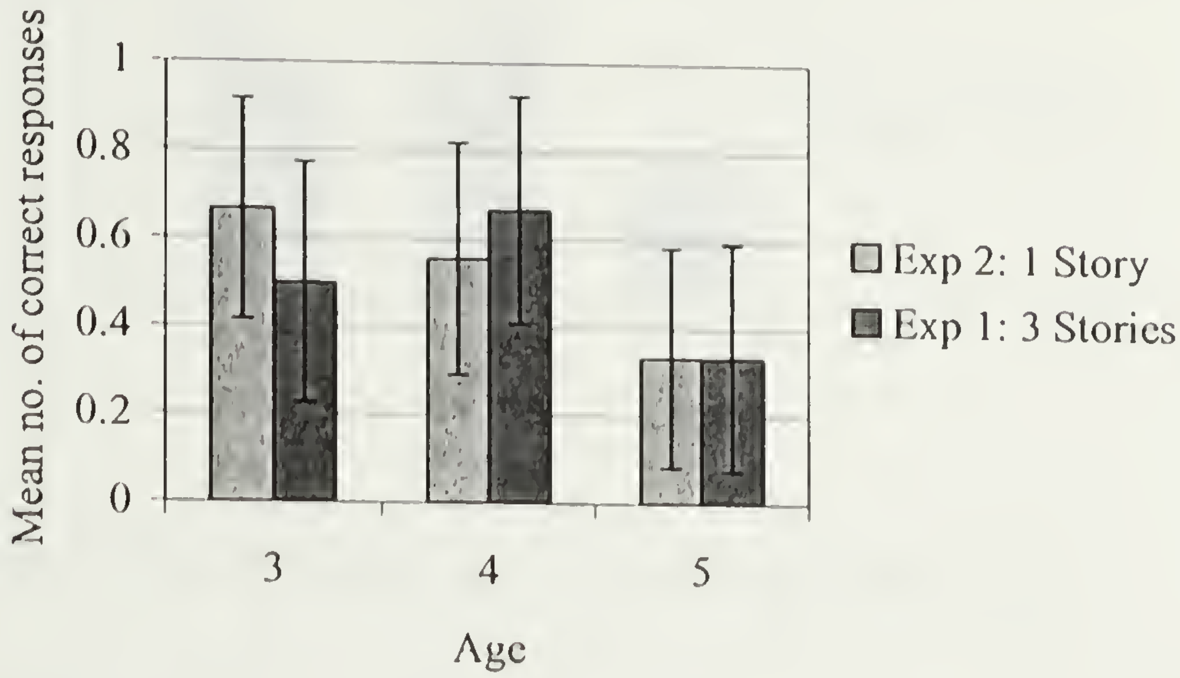

Figure 24: Fast Mapping in Identical Stories (Experiments 1 and 2).

Figure 24 shows the responses to the "Who daxed..." question across the two experiments when using the raccoon story as the comparison. An ANOVA carried out as a function of age(3,4,5) and experiment(1,2) found no significant effects in the selection of the "daxer." Since there were no correct responses to the definition question in the 3-story version of the Fast Mapping task, and very few from children in the 1-story version, no comparison was undertaken.

Comparison of First Stories

Since there were two orders of presentation in Experiment 1, half of the participants heard the raccoon story first, half heard the cookie story first. A more equitable comparison might be, therefore, to compare the results from Experiment 2 with the first story heard in Experiment 1.

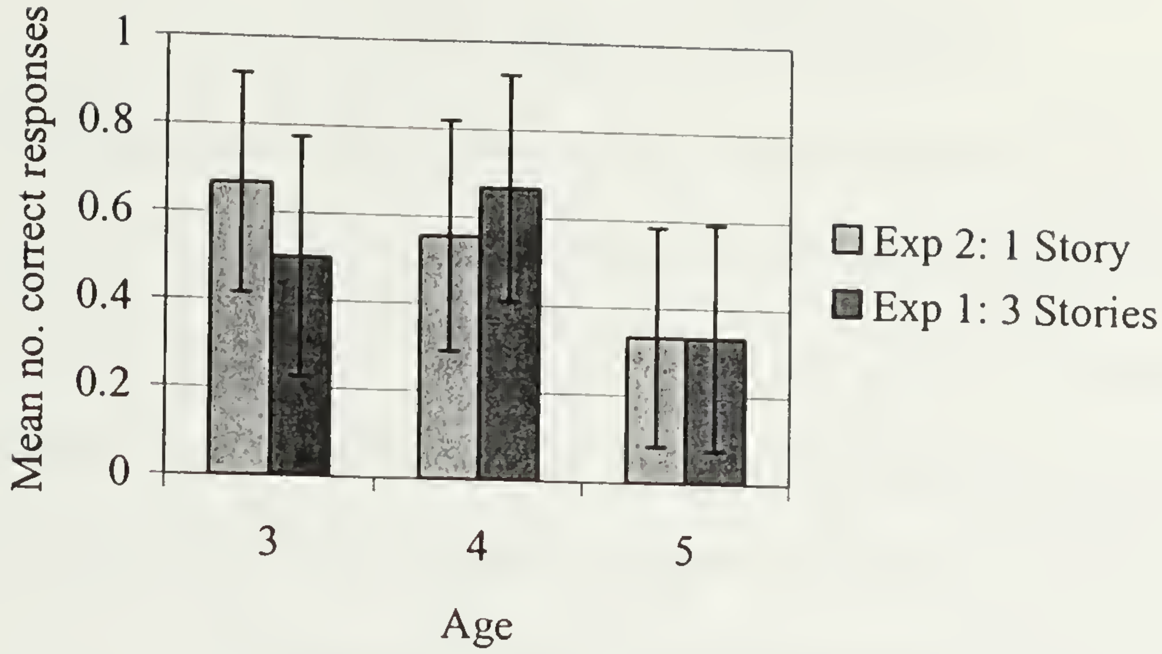

Figure 25: Fast Mapping in First Stories (Experiments 1 and 2).

As seen in Figure 25, however, the results found when comparing the two experiments by using story positioning were extremely similar to those found in the comparison using the story type. Between-subjects ANOVAs found no effects of age or experiment for the selection of the "daxer."

Experiment 2 - Discussion

The results of Experiment 2 replicated those found in Experiment 1, and were contrary to predictions that the Fast Mapping task in Experiment 1 should be easier. Most of the children in the Fast Mapping task in both experiments were unable to correctly choose the "discoverer" as the "daxer." In both experiments, three and four year old children seem do marginally better than the five year olds. Also, in both experiments, three and four year olds have difficulty with the memory question that discusses the action of the "enticer." While these results are not in line with predictions, they do replicate children's performance in the three story version of the task, indicating that the failure in Experiment 2 is not due to the comparative lack of scene information.

CHAPTER 4

GENERAL DISCUSSION

The general goal of this experiment was to see if children could bootstrap the meaning of abstract verbs from sentences containing complements. While the results did not confirm all predictions, as a whole they may say more about what exactly is necessary for bootstrapping to occur than was previously known. Most importantly, we may now be able to see the subtle steps in the acquisition of complement sentences.

Bootstrapping with Infinitival Sentential Complements

This study originally suggested a similar time line for the acquisition of tensed and infinitival complements, and a corresponding similar acquisition of the ability to bootstrap from these sentences. However, the results from the preceding experiments present a different picture for tensed and infinitival complement acquisition, and so will be discussed separately.

Experiment 1 has shown that five year-old children can bootstrap the meaning of a novel abstract verb from infinitival complement syntax, given only a few exposures. Remember that success at this task required that a number of abilities come together, as is shown in Figure 3 (reproduced here as Figure 26).

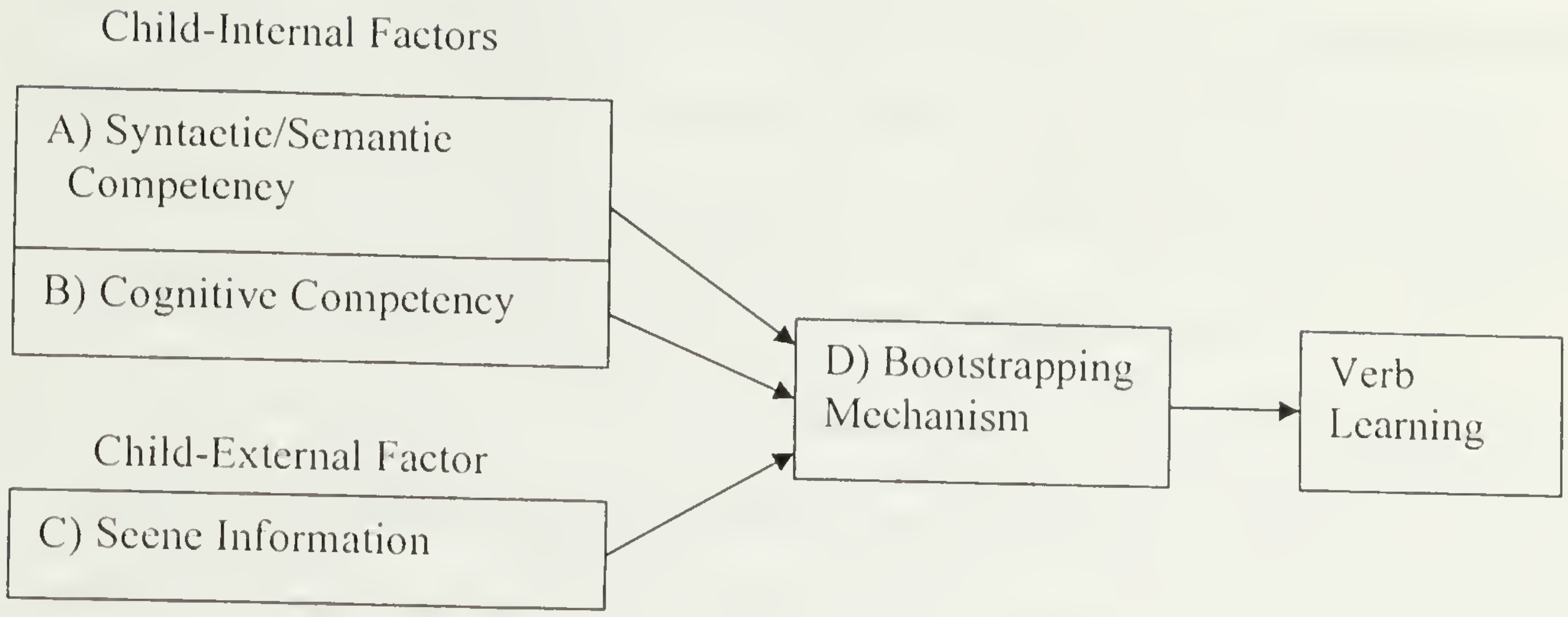

Figure 26: Prerequisites to Learning Verb Meanings Through Syntactic Bootstrapping.

Children needed to understand the syntax of the sentence with the infinitival complement and how it relates to the meaning of the main verb (prerequisite A), they needed to cognitively analyze what the "enticer" was doing in the story (prerequisite B), and needed to have enough information from the stories to make a clear and reliable judgment (prerequisite C). All of this information was analyzed by a bootstrapping mechanism (D) and the children were then able to reliably choose the "enticer" as the subject of the sentence.

Sufficient Scene Information

This experiment found that 5 year-old children were able to fast map the meaning of verbs presented in infinitival complements sentences, where Johnson (2001) did not. This is especially puzzling, since Johnson explicitly labeled the subject when she presented the pictures and complement sentences to the children. None of the syntactic reasons for Johnson's failure that were mentioned earlier (e.g. need time to analyze the structure before passing the task, or use in different structures) are the cause here, since the ages and structures used were the same between the two experiments. There remain, however, several possible reasons for the age difference in success between the two experiments which relate to the amount of information available to the child in this difficult task. These were elaborated previously, and have to do with the design of the two experiments and the amount of information available to the children (prerequisite C).

First, the pictures used in Johnson's experiment not only contained communication events that were linked to the infinitival complement sentences, but they also contained novel instruments to be described by transfer sentence structures (e.g. the woman sugged the ball to the girl.) These instruments may have been especially salient, and caused a bias of interpreting the verb as a transfer verb (e.g. sent), or instrument verb (e.g. poled, meaning "moved it with a long pole").[12]

Secondly, children in Johnson's experiment were given no story context, just a single picture and a sentence describing that picture. A full story context may help children understand the relationship between the actors and the objects in the scene more fully, and allow the children to make a better judgment. Finally, only one story was used in Johnson's experiment, whereas the current experiment used three. In Experiment 2, conducted to evaluate the difference between one and three stories, only tensed complement sentences were utilized. In comparing the results between Johnson's experiment and the current one, it is still possible that the three stories helped the children fast map the meaning of the novel verb, and correctly answer questions relating to the subject of the sentence at an earlier age.

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[12] Remember that the replication of Johnson's results in the DELV, mentioned earlier, did find a number of instrument choices for the "sugger."

Cognitive Factors

While five-year-olds could solve the bootstrapping problem with regards to infinitival complements, three- and four-year olds could not. An identical age effect was found in the infinitival portion of the TVJ task . This is despite the fact that Bloom, Tackeff, & Lahey (1984) stated that children are capable of reliably producing these complements at age four, and the Imitation task replicated this finding. It seems remarkable that children are producing sentences they might not fully understand: the standard assumption is that children understand more utterances than they can reliably produce.

There are three possible reasons why children have difficulties in the infinitival complements portions of the Fast Mapping and TVJ tasks a full year after they are reliably producing them. First, there may be some cognitive requirement in the current tasks that is related to infinitival complements which the children might not have mastered yet; a previously unknown prerequisite B. This is a distinct possibility, since children of these ages had difficulty answering the "enticer" memory question, and their performance on that question predicted how well they did in the Fast Mapping task's infinitival complements.

Why are younger children unable to answer "What did the boy do?" when the boy's actions were explicitly stated in the script? Unlike the acquisition of tensed complements, which correlate with false belief understanding (de Villiers, 2001), no cognitive abilities have been experimentally linked to infinitival complement acquisition. Obviously, children's understanding of desires may play a key role, most of children's infinitival complements use the verb "want" as in "I want to X." Bloom's stages of acquisition of infinitival complements, elaborated above (Bloom, Tackeff, & Lahey, 1984), state that children first use verbs of desire with an NP or a bare "to" as in "I want apple" or "I want to". Later, children add a verb "I want to open it" and finally add a subject in the lower clause " I want this doll to stay here." However, none of these stages, and their corresponding level of understanding, occur after the age of four.

One possible difference between the production of sentences found by Bloom et. al., and the task children were required to do here, is the agent of the desires is different. Bloom and colleagues found that children either talked about their own desires, placing themselves at the subject of the main clause (e.g. "I want this doll to stay here"), or the relationship of other's desires to their own actions, placing themselves as the subject of the lower clause (e.g. "want me to do it?"). In fact, they found the most frequent form of meaning was "the child's wish or intention towards performing the action named by the complement verb." The current experiment asked children to understand the desire of the "enticer," which might be especially difficult, since it requires a perspective outside the child. However, Bartsch & Wellman (1995) found that children referred to the desires of others soon (within three months) after their first references to their own desires. So, the fact that the "enticer" is not the child shouldn't be causing problems up to age four, sufficient to cause difficulties in the Fast Mapping task.

A final cognitive factor might make the actions of the "enticer" even more difficult for the children to understand, beyond the fact that the child had to interpret the desires of others. The "enticer" (e.g. boy) was receiving nothing in return for having instigated the actions of the principal actor (e.g. raccoon) in any of the three stories. In fact, the final story about a grandmother baking cookies for her grandson is a prototypical example of selfless behavior. In these cases, the motivation for the "enticer's" actions was not as transparent as a simple desire, and may have been more difficult for the children to understand. The actions of the "discoverer," on the other hand, were much better understood by the three and four year olds. They answered the memory question relating to the "discoverer" quite well, and frequently mentioned the consequences of the actor's actions (e.g. "The farmer is gonna get mad!" or "He's gonna get in trouble.")

Recent research by Witt & J. G. de Villiers (2002, Submitted) confirms children's task difficulties when it comes to infinitival complements, but supports the idea that it is not merely children's cognitive skill that is lagging. They compared children's ability to state the desired object or outcome of a story about desires across ages three to six. Importantly in these stories, all the characters are children other than the participant. If children were just having difficulties with understanding the desires of others, they may not be able to perform well here. In the object stories in this experiment, children were shown a picture series where one girl is reaching for an apple on top of a refrigerator, and another girl is standing beneath, but facing away from, a lime, also on the fridge. The children were then shown the girl who was reaching for the apple and asked "what does this girl want?" Children did very well here, performing at near ceiling across all age groups, by answering with the noun phrase (NP) "an apple". In a similar condition, children were shown a picture series where a girl is drawing a picture, then hands it and a hammer to a boy, while pointing to an empty wall. When asked to describe the desired outcome, i.e. "What does this girl want?," children did very poorly, in answering "she wants the boy to hang the picture".

The same conditions were repeated in a pointing task. In this case, children did not need to respond verbally, they only needed to point to the correct object or outcome.

Compared to the performance on the outcome condition, children did better. Overall, performance on the non-verbal measures was better than the verbal ones, especially when considering that the object results in the verbal condition were nearly perfect. Importantly, when the results are averaged across the verbal and non-verbal items there was a big increase in performance from the three and four year olds to the five year olds, similar to the Truth-Value Judgment task and Fast Mapping task results in the current experiment.

What we can take away from Witt and de Villiers is that children are not just failing to understand the desires of others. They do well in verbally stating the object of a desire, and in pointing out a desired outcome, even if they cannot verbally describe a desired event outcome.[13] It is still possible that the fact that the "enticers" in the Fast Mapping task had nothing to gain from their actions might have posed difficulties for the children. However, the difference in the verbal and non-verbal performance found by Witt & de Villiers is unexplained by this hypothesis, since they presented children with no unmotivated desires in their experiment. It seems more likely that some deeper analysis of the syntax, probably through semantic bootstrapping, is necessary before children can understand infinitival complements sufficiently to pass the Fast Mapping task.

Multiple Possible Interpretations for Novel Verbs in Infinitival Complement Sentences

Another possibility for three- and four-year old children's inability to perform well on the infinitival portions of the Fast Mapping and TVJ tasks may be that they lack an

[13] It is still possible that the non-verbal desire task can be solved by some other means, without needing to understand the desires of others. Perhaps the subjects guess "what happens next" on the basis of purely behavioral past experiences. It is hard to distinguish these in the case of ordinary, fulfilled, desires. See Witt & de Villiers (2002, Submitted) for a discussion.

understanding of the relationship between the syntax of the structure and the semantics of the verbs. Upon close inspection, and with a healthy dose of hindsight, there are a number of alternative ways that children could interpret the novel verb in the infinitival complement sentences. When Fisher, Gleitman, & Gleitman (1991) tested mental and perceptual verbs in complement sentences, they did not include infinitival complement sentences, even though they did include a number of complements, not just tensed ones with a "that" complementizer (21a). The other complements included tensed complements with "if" (21b) and "whether" (21c) as complementizers, and no overt complementizer (21d). Also, two forms similar to infinitival complements, but lacking the infinitival marker "to," were used (21e-f).

21a) Susan heard that the party was boring.

21b) Did you sense if the lock had been forced?

21c) Did you see whether the window was broken?

21d) Susan sensed the clouds were gathering.

21e) The hiker saw the sun rise over the hill.

21f) The spy glimpsed him delivering the note.

This means that Fisher and colleagues did not test whether or not infinitival complement sentences were predictive of any cluster of verb meaning. Since they did find strong results that linked tensed complements to mental and communication verbs, the current experiment was originally predicted to show bootstrapping in the tensed cases before the infinitival ones. This prediction was not borne out, but the reason the children's performance in Fast Mapping was a year behind their production may be due to a weaker link between desire/enticing verbs and infinitival complement sentences, than the link found between tensed complements and belief verbs.

One possible interpretation of infinitival complement sentences was elaborated by Felser (1999). She noted that some causative verbs are grammatical in infinitival complement sentences. For example, relying on syntax alone, "dax" could mean something similar to *forced* or *helped* as in (22).

22) Who forced/helped the raccoon to eat the corn?

However, this alone cannot be the reason for young children's failure in the Fast Mapping task. A causative interpretation would probably lead to a choice of the boy in the raccoon story, since the boy is the only actor that interacted with the raccoon directly.

Another possibility arises from a potential misunderstanding of the "to" in the infinitival complement. In English, "to" directly preceding a verb can occur in (at least) two distinct circumstances, shown in (23a) & (23b).

23a) The boy enticed the raccoon to eat the corn.

23b) The boy bought the ticket to go to Florida.

The "to" in (23b) has a meaning of "in order to," and is not just an infinitival marker or NP modifier. Children understand sentences like (23b) early.[14], but it is unknown when children differentiate between the two meanings. In the Fast Mapping task, if the children misunderstand the "to" in the target sentence, they might come up with an interpretation as in (24).

24) The boy daxed the raccoon in order to eat the corn.

---

[14] In a separate portion of the DELV discussed above, extremely few (23 out of nearly 1200) children allowed wh- extraction from the adjunct in sentences like (23b), and most of those (14) children were four years old. This shows strong competency with these adjunct phrases at an early age (de Villiers, personal communication, June 2002).

Since the boy did not eat the corn, this sentence is not a possible description of events. If this is the only option for the children, they may have great difficulty assigning any meaningful interpretation to "dax."

Results from the final two questions (5c and 5d, reproduced here) in Johnson's (2001) experiment show that children may indeed be interpreting "to" as "in order to".

5c) Which one did the girl sug the woman to send? (the ball)

5d) Which one did the girl sug to send the ball? (the woman).

These questions require children to correctly label the subject of the embedded complement (5d), and the object of the complement (5c). In a sentence like (24), the agent of the "eating" is the boy, where as in the tensed complement, the "eater" is the raccoon. If younger children are having difficulty with the role of "to" in the syntax of the sentence, they should have more difficulty answering questions about the subject of the complement, than the object. This is indeed the case, for both the sentences containing real verbs (Figure 27) and containing novel verbs (Figure 28). In fact, for the four year olds, their performance on the subject of the complement question is only around 50% in both the real and novel verb sentences.

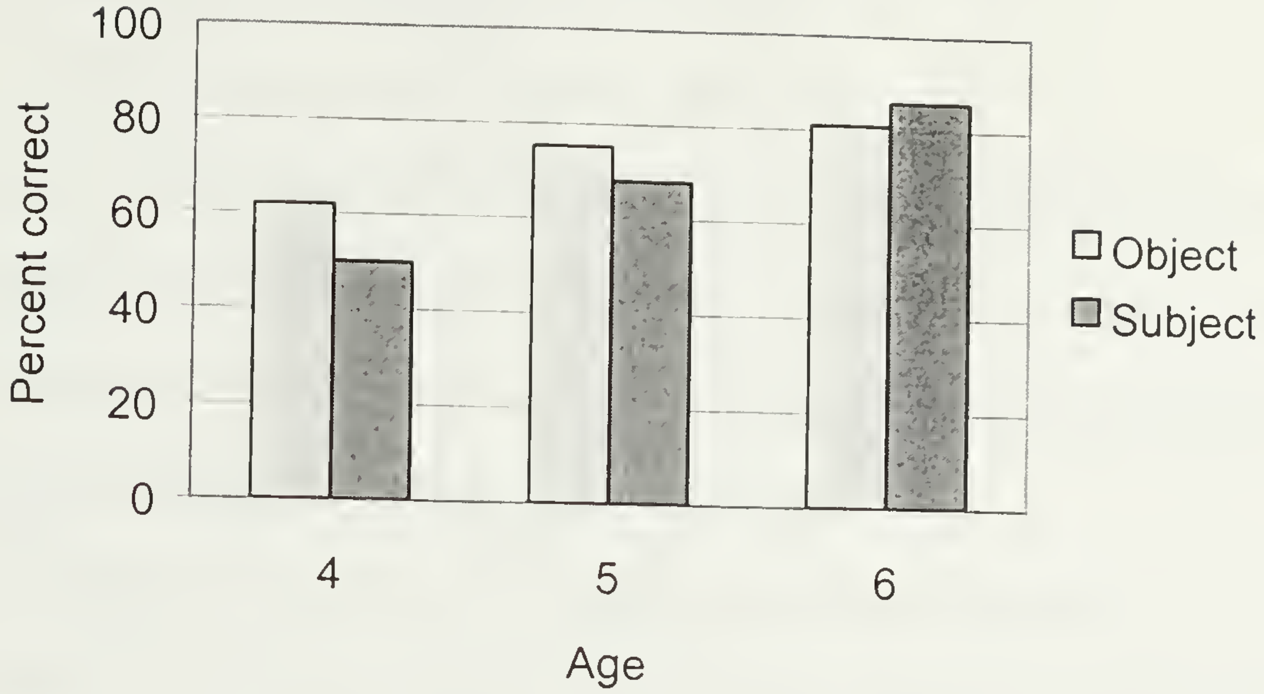

Figure 27: Children's Correct Choices of Subject and Object of Infinitival Complement Clauses, Real Verb Condition (adapted by permission from Johnson, 2001b).

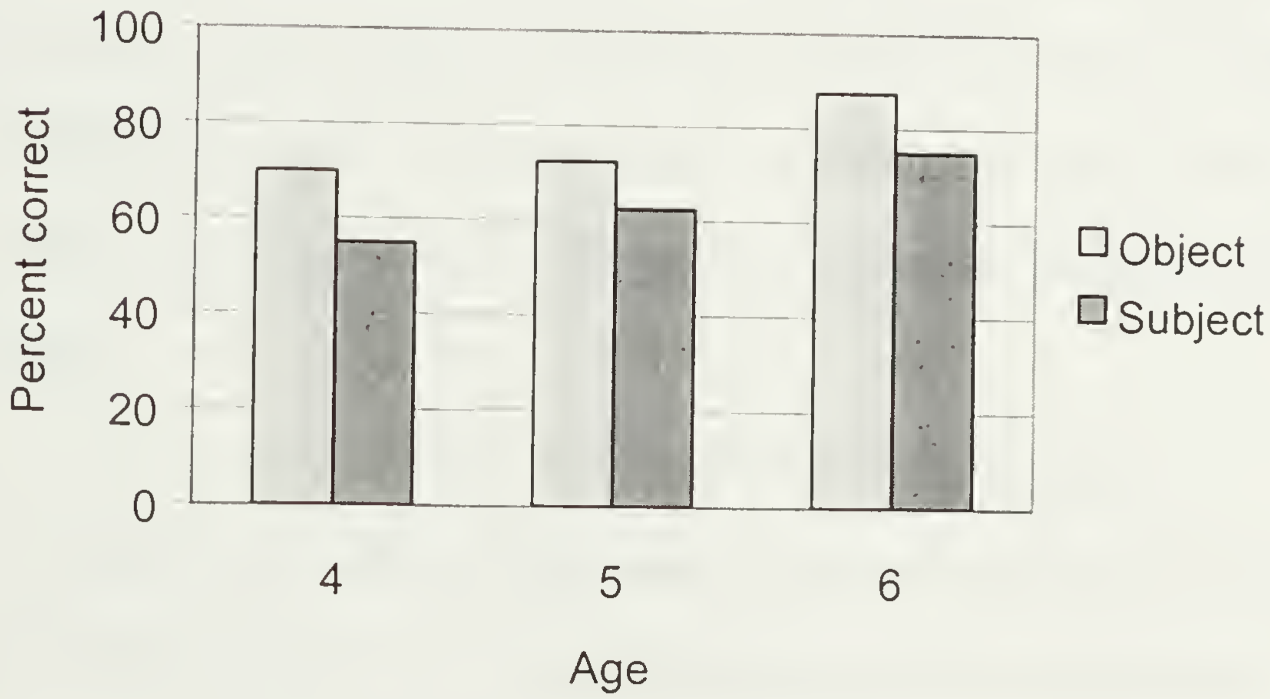

Figure 28: Children's Correct Choices of Subject and Object of Infinitival Complement Clauses, Novel Verb Condition (adapted by permission from Johnson, 2001b).

Another problem that children must solve when learning infinitival complements, is how the verb in the upper clause interacts with the reference of the subject in the lower clause. Take the following sentences:

25a) The boy promised the raccoon to eat the corn.

25b) The boy asked the raccoon to eat the corn.

In (25a & 25b) we again have a problem with the subject of the verb "eat." Verbs such as promise as exceptional in their control properties, in that the implicit subject is controlled by the matrix subject, not the object. The verb "promise" in the infinitival complement sentence changes the subject of "eat" to the boy.

Children may then have two separate stages in the acquisition of infinitival complements. First, they have an initial understanding of the meaning and structure of these sentences, especially when used with verbs of desire (e.g. want). However, complexities in the structure, and the relationship between that structure and the verbs that appear in them, require a refinement and reanalysis of infinitival complements before children fully understand these sentences. In particular, they must fix the control properties of particular verbs to determine the referent for the subject of the embedded clause.

Relationship Between Syntax and Semantics

The goal of elaborating the different interpretations for novel verbs in infinitival complements sentences was to show what an incredible task children have in learning the relationship between the syntactic structures and the meaning of the verbs that can occur in them. These possible interpretations of the verb may not lead to an alternate choice for the subject of the sentence (i.e. the "enticer"), but do lead to different meanings of the verb "dax." The relationship between the sentences and the words they appear in may not be a simple 1:1 relationship. In fact the structures or syntax of these complex sentences may not have a clear meaning apart from the words that appear in them. A particular syntactic structure may have different "meanings" when paired with different verbs. This concept is central to Construction Grammar (Goldberg, 1995). According to this approach, in previous attempts to find a consistent, independent meaning for a particular structure, any variation has been delegated to the individual lexical items (e.g. the individual verbs). In Construction Grammar, however, the frames or sentences that a verb can appear in may be uniquely determined by the individual verb; there need not be a distinct class of verbs that appear in a particular frame, and vice versa. One form of evidence supporting this approach comes from sentence processing experiments. When a reader hears a sentence that contains a verb with two distinct meanings, they can show a garden path effect (an increase in processing time, and/or a re-reading of the sentence) when the sentence continues with a sense that supports the less common meaning. However, when a reader hears a sentence that contains a verb with two distinct possible sentence structures, there is no garden path effect. In other words, Carlson & Tanenhaus (1988) found that sentences like (25a) and (25b), which show differing meanings of a verb will produce a re-analysis of the sentence, but sentences like (26a) and (26b), which show different possible structures, do not.

25a) Bill set the alarm clock on the shelf.

25b) Bill set the alarm clock for six.

26a) Bill loaded the truck onto the ship.

26b) Bill loaded the truck with bricks.

In her book, Goldberg addresses the issue of syntactic bootstrapping directly. She recognized that evaluating each sentence as an interaction of verb and structure seems to allow for no bootstrapping; if there are no independent structures/frames and no independent meanings, how can frames be used to learn verb meanings? Her answer:

> "What the child hypothesizes, upon hearing a verb in a particular previously acquired construction, is not that the verb itself has the component of meaning associated with the construction, but rather that the verb falls into one of the verb clusters conventionally associated with the construction." (p. 20)

This leads to an interesting consequence for bootstrapping, which was not elaborated by Goldberg. If a particular construction is complex, and can support several different meanings (e.g. both causative and desire), children may require time to learn which meanings are "conventionally associated" with the construction, and when those meanings are more likely to appear than others. To learn these associations, they may need to have heard a large set of meaning/structure pairings. This leads to specific predictions about bootstrapping the meaning of novel verbs in infinitival complement sentences. First, it may require some time, once children are producing these sentences, for them to collect information about the verbs that appear in infinitival complement sentences. Also, children may be initially unable to amass the specific information about the relationship between the verbs of desire/enticing and the infinitival complement syntax if they don't fully understand the seemingly unmotivated intentions of others. To summarize, it may take a combination of learning the syntax of the infinitival complements (which occurs by age four), and learning the cognitive skills required to understand the intentions of our "enticer" (as shown in the memory question errors before age 5), to be able to learn the relationship between verbs of desire or intention and infinitival complement syntax. Only then could children bootstrap the meanings of verbs in these sentences.

However, construction grammar is probably not the entire solution. If children were required to keep track of all the sentence-meaning pairs and start analyzing them for similarities, the memory load and learning problems would be acute. It seems more likely that construction grammar starts to operate on top of a limited set of universal meaning-structure links that may be innate. Children start with some basic links, such as two arguments are likely associated with a causative verb, or maybe that sentential complements are found with abstract and mental verbs. These links have been the cornerstone of previous bootstrapping theories, which examine the earliest cases of verb and sentence structure learning. Children can use their knowledge of these links to break into the system, pointing them to the meaning of a few simple verbs, and showing them simple grammatical properties, such as the placement of the subject of the sentence in their language.

However, based on the current research, and on other ambiguities in the languages of the world with regards to complements, this cannot be the entire story. The entire structure of complements, and their links to verb meanings, cannot be predetermined for the child. As stated above, tensed and infinitival complements usually select different verbs (say vs. tell), but this is not always the case. Both "forget" and "remember" appear in tensed and infinitival complements, creating enormous confusion for the child, and creating late understanding of the difference between the structure-meaning pairs (e.g. "forget to" and "forget that")

Two separate studies have looked at the acquisition of the distinction between "forget to" and "forget that." The first, done by Roeper & de Villiers (1994), presented four- and five-year-old children with stories like the following: a main character (Big Bird) forgot to invite one person to a party, and forgot that he invited another. When then asked either (27a) or (27b), the children were very poor at selecting the correct answer.

27a) Who did Big Bird forget that he invited?

27b) Who did Big Bird forget to invite?

Similar versions were tested with the verbs "not remember," "tell," and "promise," and all showed poor discrimination between the two complement types with four- and five-year-olds. This is very similar to the results from the current experiment, where children are having difficulties differentiating between the meanings of complement sentence types that they already correctly produce.

A second study had very different results. Schulz (1999) used a Truth-Value Judgment task to assess children's understanding of complements. In her experiment, she compared children's acceptance of sentences containing "forget" and the two types of complements, in different scenarios. The scenarios differed in whether or not the action in the complement (the embedded clause) had actually occurred. As an example, Kermit either did, or did not buy eggs when he went to the store. Children were then asked one of the following two questions (28a) & (28b):

28a) Did Kermit forget to buy eggs?

28b) Did Kermit forget that he bought eggs?

The four possibilities outcomes are as follows: If Kermit did buy the eggs, then the answer to (28a) should be no, and (28b) should be yes (the story that accompanies the questions made this possible). If Kermit did not buy the eggs, then the answer to (28a) will be no, and the answer to (28b) should be a full rejection of the sentence, as in "no, he didn't buy any eggs." Schulz found that children, ages 3 to 6, did very well on all of these questions, except for the case where Kermit didn't buy any eggs, and the children were asked (28b).

Why did the children in Schulz's experiment do so well understanding the distinction between these two complements, when those in this dissertation, and in Roeper & de Villiers did not? The answer lies in the number of abstract or mental actions in the scenarios. In Roeper & de Villiers, and in the Fast Mapping and TVJ tasks in the current experiment, children were presented with stories that had two actions, where each were compatible with a different complement sentence (i.e. a tensed and an infinitival complement sentence). Schulz only had one action in her scenarios that was compatible with a complement interpretation. Children did not have to choose between complement types within one story, they only had to verify that the story was compatible with a complement interpretation or not. Children at ages four and five were able to do so well at Schulz's task since they have a basic understanding of complements and the abstract verbs that appear in them, but cannot yet discriminate between complement types. The same can be said for the tensed complements in second scenario in the TVJ task in the current experiment, where they were paired with actions that had a relative clause interpretation. Children did much better on these tensed complements than the tensed complements which were paired with actions that had a infinitival complement interpretation.

Based on the body of experimental data, and the preceding discussion, we can now reevaluate Figure 26, based on what we now know of the possible additional prerequisites for bootstrapping with infinitival complement sentences.

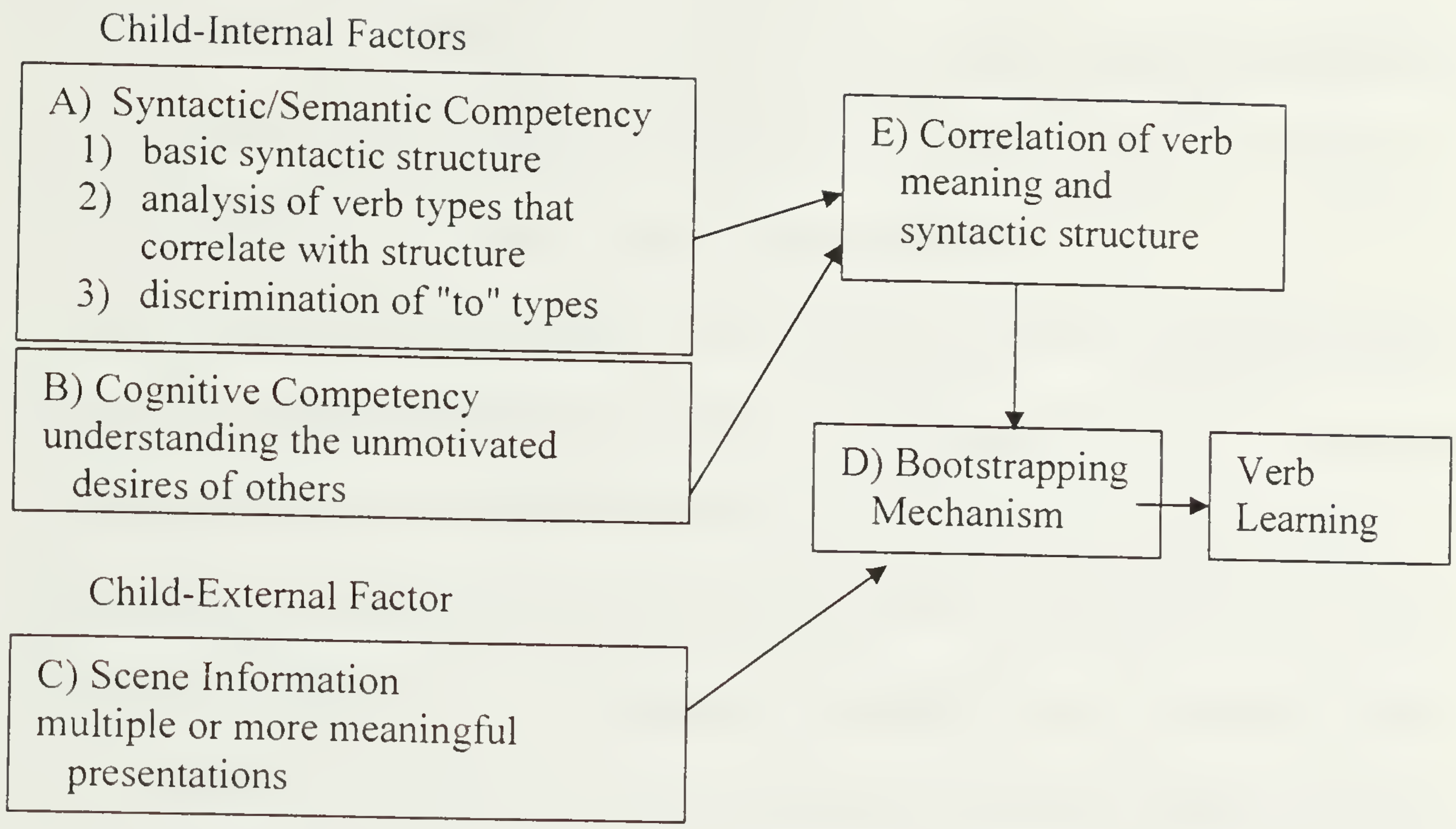

Figure 29: Revised Prerequisites to Learning Verb Meanings in Infinitival Complements Through Syntactic Bootstrapping.

Unfortunately, since the original focus of this experiment was on tensed complements, these additional factors are mostly speculative. The individual factors, such as understanding the unmotivated desires of others, misunderstanding of the meaning of "to" as "in order to" and presentation in one vs. three stories were not tested. A much more complete story can be told for the tensed complements.

Tensed Sentential Complements

Experiment 2 has shown that adults (but not children up to age 5 in Experiments 1 or 2) can bootstrap the meaning of a novel abstract verb from tensed complement syntax, just as in the infinitival complement case. These adults also needed to understand the syntax of the tensed complement (prerequisite A), to cognitively analyze what the discoverer was doing and thinking in the story (prerequisite B), and to have enough information from the single story to make a clear and reliable judgment (prerequisite C). However, even with the sophisticated linguistic and cognitive mechanisms available to adults, one adult did fail to make a correct interpretation of the verb.

The children in both Experiment 1 and 2 did not, on the whole, interpret the verb in the tensed complement sentence as one akin to the meaning of *discovered*. The number of repetitions of the sentence structure, and the number of stories had no effect. This suggests that the principal limiting factor on the children's performance lay not in the amount of contextual and scene information (prerequisite C), but in some other factor. Also interesting is the fact that none of the syntactic and cognitive measures related to tensed complements that were used in this experiment could predict performance for the few children who did well on this task. At this point, we cannot say which prerequisite(s) are responsible for children's failure on this task.

The key to understanding why children failed at the tensed complement portion of the Fast Mapping task, when they were predicted to succeed overwhelmingly, lies in their actual choices for the one who "daxed." As stated earlier, children very reliably picked either the "enticer" or the "discoverer" in all three stories. This seems to indicate that they had two clear options for interpreting the verb and its corresponding sentence. The "enticer" option was less prevalent for the three and four year olds, probably for the same reasons that created failures in the infinitival complement condition for these age groups. Namely, children may not have fully understood the actions of the "enticer" in the stories.

But why was the "boy/enticer" a choice for the five year olds in the tensed complement condition? The clues we have come from children's treatment of the tense in the Imitation and Truth-Value Judgment tasks. When imitating tensed complement sentences, children often erred by creating some kind of infinitival complement. Also, when tensed and infinitival complements were directly contrasted in the TVJ task, children allowed the subject of the infinitival sentence to be the subject of the tensed sentence. It seems that children are mistaking tensed complement sentences for infinitival ones.

The story can't be this simple, however. Since performance on the infinitival complements in the TVJ task predicted the choice of "enticer" as the subject of the infinitival complement in the Fast Mapping task, the same should be true in the tensed complement condition. This was not the case: TVJ infinitival performance did not predict the choice of "enticer" when fast mapping using tensed complement sentences. Children aren't just treating tensed complement sentences as infinitival ones, with which they are more adept. Children seem to be permitting some reading of the tensed clause that is not available to us..

Development of Tense Understanding in Complement Sentences

Hollebrandse's (1998) theory about children's acquisition of tense in embedded clauses can help explain these results. He has found that children allow the tense in the lower clause to have a larger range of interpretation than adults usually allow.

A tensed complement sentence like (29) has four possible interpretations as to when the events in the sentence occurred: real past, simultaneous, forward shifted but before utterance time (UT), and forward shifted after UT.

29) Cookie Monster said that he was at the store.

These four possibilities are outlined in Figure 30, and described below.

Matrix event: say UT

Time line: --------------|-------|-------|-------|-------|-------|-------|----------|-------|-------|

Embedded event:	E1	E2	E3	E4
Interpretation	real past	simul-taneous	forward before UT	forward after UT
Japanese Speaking Adults	ok			
English and Dutch Speaking Adults	ok	ok		
English and Dutch Speaking Children	ok	ok	**ok**	

Utterance time (UT) is the time the complement sentence was uttered.
Event times (E1-E4) are the time of the embedded event (e.g. going to the store).

Figure 30: Sequence of Tense Acquisition in Tensed Complement Sentences (adapted from (Hollebrandse, 1998).

If Cookie Monster (CM) was at the store before he said "I was at the store," then the embedded event occurs at time E1. This is called the real past interpretation of the sentence. This reading is allowed for all known languages, and is found acceptable by both adults and children. If CM said "I am at the store." while he was at the store (E2), and all of this occurred before (29) was uttered, this is the simultaneous reading of the sentence. In other words, the time of the "saying" and the "being at the store" are simultaneous. In this case, English and Dutch adults and children still allow (29) to describe this scenario, but the grammar used by Japanese adults correctly does not, as illustrated in Figure 30.

If CM said "I am going to the store," went to the store, and then sentence (29) was uttered, English- and Dutch speaking children still find (29) grammatical. That is, they allow "said that he was at the store" to describe an event where the "saying" occurred before the "being at the store," which was at time E3. Adults from these two languages do not find this "forward shifted, but before UT reading" grammatical. Finally, (29) is found to be ungrammatical by children and adults of all ages when CM has not yet gone to the store when the sentence is uttered. This is the "forward shifted and after UT reading."

In Hollebrandse (1998), English- and Dutch-speaking children's rejection of the forward shifted (E3) reading as a grammatical option for sentences like (29) was more likely if they had also passed a false belief test. In other words, when they had more adult-like comprehension of the complement clauses, they also had passed false-belief. However, looking at Hollebrandse (2000), we find that children are still making errors (allowing E3 as a possibility) as much as 83 % of the time at age six.[15]

So it seems that the tense in the lower clause can have a forward shifted reading for these children well past the time they are producing tensed complement sentences and are passing false belief tasks. This is relevant to the current Experiment. As stated before, children seem to be treating the tensed complements as if the tense in the lower clause was future-directed, but are not just wholly interpreting them as infinitival complements. If children allow an E3 reading of our test sentences, they may be interpreting (30a) as (30b), where the eating only need occur before the time the test sentence was uttered.

30a) Who daxed that the raccoon ate the corn?

30b) Who daxed that the raccoon [eat] the corn?

However, (30b) is not grammatical when "dax" means something like *entice*. So what might children be taking "dax" to mean?

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[15] Interestingly, even adults in this study of Dutch-speakers allow this possibility 5% of the time.

Alternate Verb Meanings in the Tensed Complement Condition

Another recent paper suggests a possible interpretation for "dax" that would fit with an interpretation like (30b). Perner, Sprung, Zauner, & Haider (2002) argue that German-speaking children and adults allow verbs of desire (e.g. wollen) to appear in tensed complement sentences (31).

31) Er wollte dass Linnea ins Bett geht.
He want-Past that Linnea in bed go-Present
"He wanted that Linnea go to bed."

In these cases, we again have a forward shifted reading, where the embedded event (going to bed) has not yet occurred when the main event (wanting) happened. However, here the embedded verb is in the present tense, not the past. When the embedded verb is placed in the past tense, as in (32a), or in the present perfect (which is used as a form of past tense in southern Germany), as in (32b) the sentence with a forward shifted reading is ungrammatical to adults (A. Kratzer, personal communication to J. G. de Villiers, April, 2002).

32a) *Er wollte dass Linnea ins Bett ging

32b) *Er wollte dass Linnea ins Bett gegangen ist.

Children learning a language start out with all grammatically possible interpretations for constructions like tensed complements that exist in the world's languages. These children cannot know they are learning a language that doesn't allow sentences like (31) until they discover otherwise. They may initially allow a desire verb, or other verb whose meaning entails a description of events not currently true, to take a tensed complement.

Another possible interpretation for the verb "dax" as it appears in tensed complement sentences is available in English. The verb "expect" carries an element of future in its meaning. So (30a) could be understood by the children as (33).

33) *Who expected that the raccoon ate the corn?

While both the German "wollen" and the English "expect" are ungrammatical for adults with a past tense verb in the embedded clause (see 32a and 33), children of this age are having difficulty fixing the tense in these sentences, as seen in Hollebrandse's sequence of tense experiments. These two facts together, allow for an interpretation of (30a) as something similar to (34).

34) Who expected that the raccoon [eat] the corn?

This would allow children to choose the boy, which we had previously labeled the enticer. So now we can see how children can have two different interpretations for "dax" in the tensed complement condition. They seem to either think "dax" means something like *discover*, or that it means something like *expect* or *want*, and at the same time, they do not interpret the past tense in the embedded clause as adults do. It is very important to reiterate that individual five-year-old children reliably chose one interpretation or another in the tensed complement condition, indicating a single interpretation for the verb, not just a random guess.

Thus, to pass the tensed complement portion of the Fast Mapping task, a very specific syntactic/semantic skill is needed: namely, the acquisition of the sequence of tense. When older children no longer allow the forward-shifted reading for tensed complement sentences, our test sentence is no longer ambiguous. Without a forward shifted reading, interpreting "dax" as *want* or *expect*, creates the ungrammatical sentence in (35), leaving *discoverer* as the most viable option.

35) *The boy wanted/expected that the raccoon ate the corn.

We can now amend our prerequisites for bootstrapping the meaning of novel verbs from tensed complement syntax to the following (Figure 31):

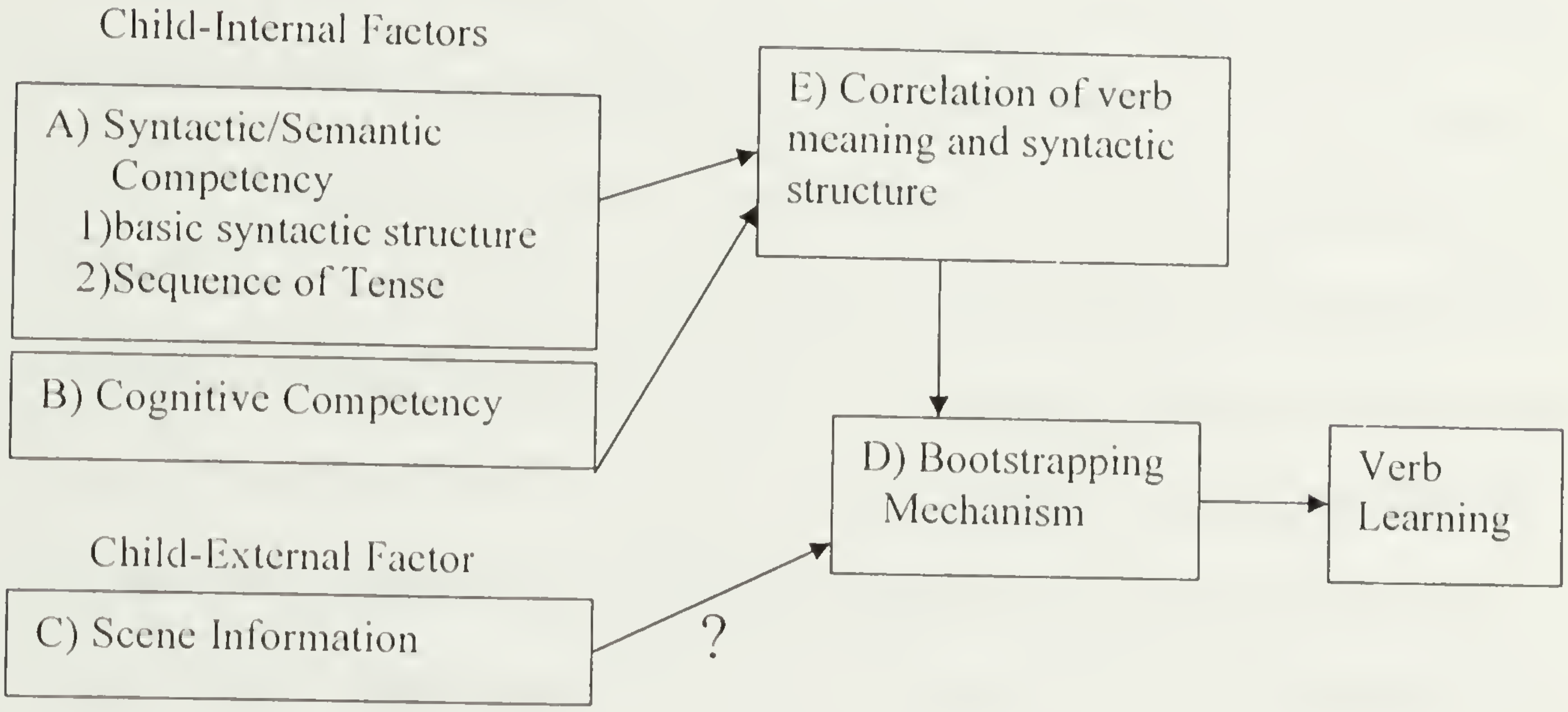

Figure 31: Revised Prerequisites to Learning Verb Meanings in Tensed Complements Through Syntactic Bootstrapping.

Reconciling the Sequence of Tense Hypothesis with the Results from the Imitation and TVJ Tasks

At this point, we must reexamine what children are doing in the Imitation and TVJ tasks. Why are children adding infinitival markers when they imitate tensed complement sentences if they aren't just mistaking one form for another? If the children don't fix the tense in the embedded clause, they may not be processing the past tense marker. When they reconstruct the sentence in an attempt to repeat it, they may be unclear as to the actual tense the verb carried. This fits well with the results that show inconsistent use of the infinitival markers. Some children changed the verb, some added the "to," and some did both. Remember that all children were good at imitating infinitival complement sentences. If they were simple replacing one form with another, we might expect their choice of tense markers in the embedded clause to be more consistent.

In the TVJ task, children hearing the tensed complement sentences did not hear infinitival complement sentences in the same scenario, even though events occurred that could be described by one. So children were not choosing between one type of sentence and another. They merely allowed an interpretation of the tensed complement to have a forward shifted reading (e.g. the one who told the cow to ring the bell was allowed to be the subject of the tensed complement sentence.) If the target sentence was "The dog said that the cow rang the bell," it is a real past scenario, where cow rang the bell before the dog reported it. In the case where "The bird said that the cow rang the bell," it is a forward shifted reading, since the bird didn't report the cow's action, but told the cow to perform the action. The "saying" occurred before the action, which is ungrammatical for adults, but still remains an option for children of this age. Another way of stating this is that children found the tensed complement sentence acceptable in any case where the speech act and the action are completed before the target sentence was uttered.

It's important to restate here that performance on infinitival complement items in the Imitation and TVJ tasks, did not predict performance in the tensed complements in the Fast Mapping task. Children are not forced into one interpretation or another by their competency in infinitival complements.

Alternative Explanation -
Are Tensed Complements Treated as Relative Clauses?

Another possibility for why children chose the "enticer" in the tensed complement condition comes from the comparison with sentences containing relative clauses. Children might be treating the target sentence (34a) as a transitive verb with a relative clause (36b)

36a) Who daxed that the raccoon ate the corn?

36b) Who daxed the raccoon that ate the corn?

If this were true, children might also pick the boy/enticer as the subject of the sentence, since the boy is the only character that directly interacted with the raccoon. This possibility is very similar to the one that stated that children were treating the tensed complements as infinitival complements.

However, the results do not favor that interpretation of the data. There is no corroborating evidence for a relative clause substitution from the Imitation and TVJ tasks, as was found for the Sequence of Tense interpretation. Children do not repeat the tensed complement sentences as relative clause sentences, even though they would only need to move the word "that." Also, remember that if children are allowing a transitive (plus relative clause) subject to stand in for the complement subject, they should have a high false positive rate in the TVJ task. The only time there was a significant difference between performance on the true and false items was for the tensed complements in the infinitive scenarios. Children were not allowing the subject of transitive plus relative clause sentence to be the subject of the tensed complement as well.

Steps in the Acquisition of Complements

The most important finding from this experiment is that children who are able to produce certain sentence types correctly, don't necessarily understand all of the subtleties of the syntax. Three- and four-year-old children understand and produce infinitival complements, but in difficult scenarios where they have to use their syntactic information to make a subtle judgment, or to learn the meaning of a new word, they aren't proficient until the age of five. A similar story can be told for children using tensed complements. They are able to produce them at around age four, and can use them in unambiguous false-belief scenarios. However, in an ambiguous case where the tense in the embedded clause matters, children may not be fully proficient until age seven or later.

In all of these cases, bootstrapping was not possible until all the pieces were in place. An initial understanding of the complement, and it's relationship to "abstract" verb meanings was acquired at one stage, but smaller, neighboring competencies weren't there. Children first understand the basics of a complex sentence type, (i.e. they learn the basic structure of a tensed complement) and then they can use semantic bootstrapping to further analyze the syntax. At the same time, they are collecting vast amounts of information about the types of verb meanings that can fit in a certain sentence type. At a later stage, after they have examined the structure of the sentence, and the meanings of the words that appear in them, they can make more fine grained syntactic distinctions. They will then be able to use the structures to make a complete judgment on a new verb's meaning. If the verb learning situation only requires the child to discriminate between an abstract verb meaning (e.g. a mental state), and a more concrete one (a causative action), children have success at an earlier age, as shown by Schulz (1999), and the second scenario in the TVJ task in the current experiment.

The results from this experiment suggest a step-wise acquisition of complement syntax. First children are able to reliably produce sentences, but the complexities of the grammar in each case require semantic bootstrapping analysis. In the case of infinitival complements, children need to work out the control mechanisms for determining the referent of the implicit subject of the embedded clause. In the case of the tensed complements, they must understand the complex effect the tense in the upper clause can have on the tense in the embedded clause. Once the syntactic structure is more completely understood, and a sufficient number of cases have been heard for the children to make generalizations about the relationship between the syntax and the semantics of the verbs involved, children can indeed bootstrap the meaning of abstract verbs from complement syntax.

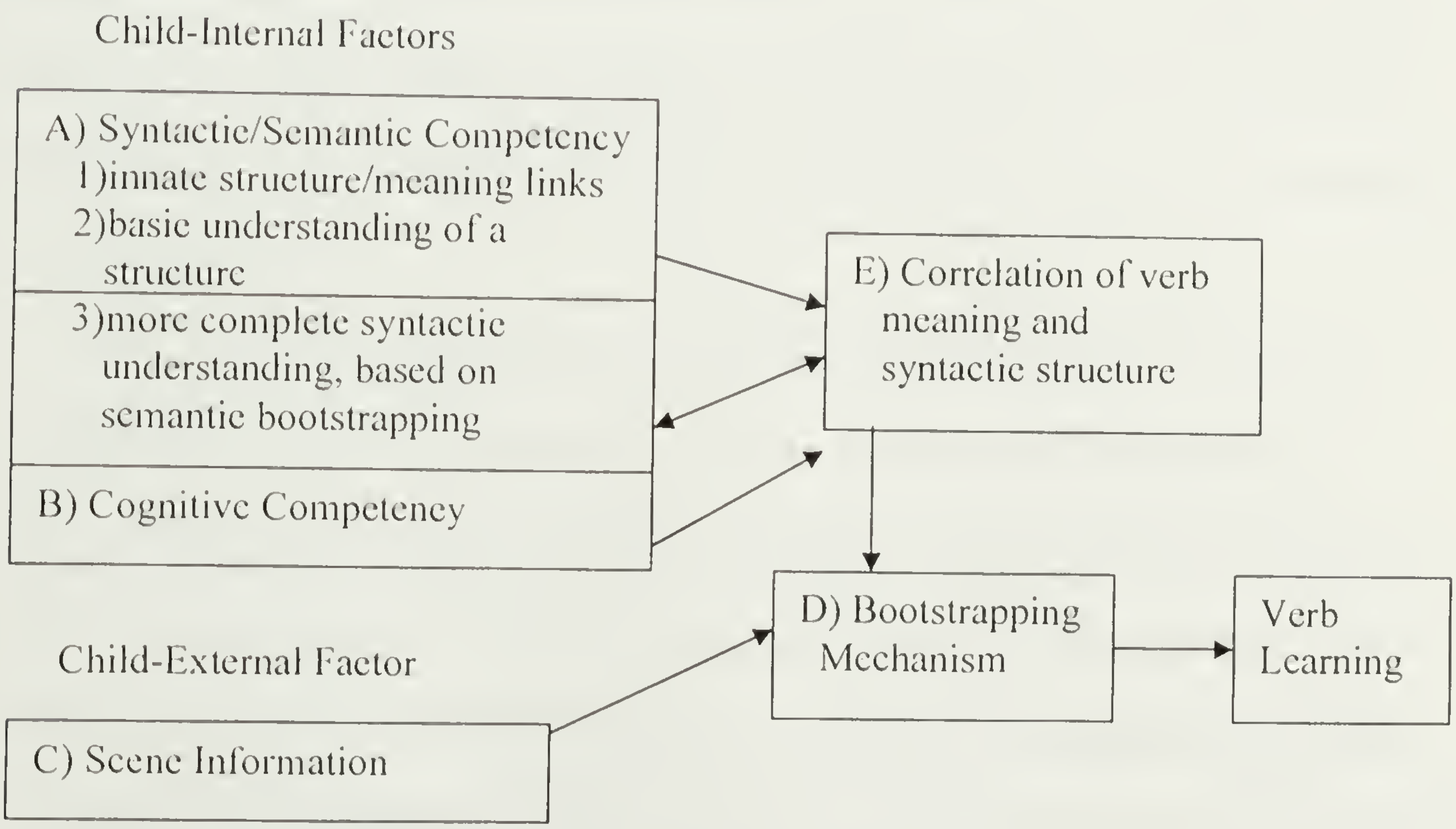

Figure 32: Revised Prerequisites to Learning Verb Meanings in Complement Sentences Through Syntactic Bootstrapping.

Remaining Questions

This experiment found children, up to age five, could not consistently bootstrap the meaning of novel verbs placed in tensed complements. The proposed reason for this failure is that children need to understand that a past tense in the embedded verb doesn't allow for a future-shifted (but before utterance time) reading of the sentence. If this were true, then children around seven or eight years old, who have mastered the embedded tense properties, should map (non-optionally) the meaning of "dax" to be something like *discover*. A future experiment needs to test older children on the Fast Mapping task, and see if the choice of subject for the sentence correlates with acquisition of sequence of tense.

While the comparison of Experiments 1 and 2 failed to find any differences in performance between the one and three story versions of the Fast Mapping task, the performance on the tensed complement version of this task was poor overall. If more scene information is helpful to the children, it might not help until they are closer to mastering the task. In other words, children on the cusp might perform better with more information than less.

Also, while the current experiments controlled for the amount of time between presentation of the story, and presentation of the target question, the number of presentations of target sentences differed. Therefore, a better comparison would be to have one story presented three times to compare with the presentation of three different stories. This will show if the differing types of stories and target sentences are helpful, over and above multiple presentation of one story and target sentence. This was originally discussed as an option for the current experiment, but was rejected for the following reason: children and adults find it pragmatically odd to hear the same short story three times. Children may, in fact, be offended by or inattentive to the third presentation of the story, defeating the purpose of three presentations of the same story. However, TVJ tasks (Crain, 1991; Gordon, 1996), and research on children's television (e.g. Crawley, 2002) show that children are willing to listen to seemingly inane questions if they are being helpful to someone more ignorant than themselves.

So the proposed study would have a dumb puppet, just as in the TVJ task, whose job it is to answer the questions. After the first repetition of the story, the puppet would say "Wait, I don't get it, can you say that story again?" After three presentations of the story, the experimenter would ask the puppet the target question (i.e. "Who daxed that the raccoon ate the corn?") and the puppet could say to the child "I don't know, can you help me?"

Another method for helping children learn the meaning of verbs in these complement sentences is suggested by the work of Naigles and her colleagues (Hoff & Naigles, 2001). Following the suggestion of Gleitman (1990), Naigles is exploring the effect of frame diversity in the learning of verbs. In other words, children are more adept at learning verbs, when they hear them in a variety of syntactic frames. It is this variety of frames that allows the children to continually narrow their hypotheses for the meaning of the verb. In elaborating above the steps children take to learning complement syntax, a way of distinguishing the two complement types becomes apparent. Infinitival complements are frequently the object of desire verbs. Desire verbs also can take an irrealis noun phrase (NP). In other words, verbs of desire become more apparent when children hear them paired with an unseen or unattainable object. On the other hand, tensed complements are frequently paired with belief or communication verbs, but these verbs cannot take an NP object, as in (37).

37) *The boy thought/believed/said the corn.

Therefore placing a novel verb in an infinitival complement frame and a simple NP object frame should more fully distinguish it from a verb that could take a tensed complement.

The special property of belief and communication verbs that has been repeatedly examined is the fact that they can take false complements. So, to show children that a verb is one of these two types, they can be paired with both tensed complements and a situation where a belief or statement is false, similar to a false belief scenario.

Implications for Bootstrapping Theories

The theories of bootstrapping, both semantic and syntactic, rely on a set of innate linking rules between sentence structures and verb meanings. In syntactic bootstrapping, children can take the sentence structure, once they know it, and use it as a "zoom-lens" to narrow the possible meanings of a verb. In semantic bootstrapping, children use the meanings of the words they know to analyze the structures they appear in. Evidence of both of these types of learning is clear in children (and adults) learning language. However, it is too soon to claim that the rules linking structures are completely specified in advance of learning. Most of the previous research has focused on simple structures, such as transitive and intransitive sentences. It seems logical that a transitive action should have two arguments and an intransitive only one, and that this information could be innately available to the child. However, the story for mental verbs and complements is not so clear. It seems unlikely that an innate rule that links complement structure and mental verbs would be able to capture the enormous complexity of the learning problem here. Children not only need to learn which verbs take which types of complements, they also need to establish what the complement structures are in their particular language. Furthermore, the variation in sequence of tense reveals that they also need to know related information, such as the types of tense interpretations allowed for these structures in their language. It is plausible that there is a general link between mental verbs and sentential complements. But the subtypes of mental verbs and the complements they take are not so easily given in advance. There cannot be an innate rule linking desire verbs with infinitival complements and another linking belief verbs with tensed complements, since German allows desire verbs to appear with tensed complements, and English does not. Children do indeed use syntactic information from sentential complements when learning new, abstract verbs. However, children are not able to bootstrap the meaning of novel verbs from complement sentences as soon as they are able to produce them correctly. Younger children's inability to bootstrap verb meaning from complements tells us much about the cognitive and linguistic complexities of complement structures.

APPENDIX A

FAST MAPPING TASK

Script

Story 1: Raccoon

[Present picture 1] Look at the boy. He has corn. He waves the corn in front of the raccoon. The raccoon sees the corn.

[Present picture 2] Here's the raccoon. It's eating the corn. YMMMM

[Present picture 3] The farmer sees the empty corn cobs. He sees raccoon tracks.

[Memory questions- all conditions]

1) What did the boy do?

2) What did the farmer see?

3) What did the raccoon do?

Now, I'm going to use a word you've never heard before. The word is dax.

Listen closely and try and remember this sentence for later.

[Test sentence]

[infinitival complement condition] Someone daxed the raccoon to eat the corn.

[tensed complement condition] Someone daxed that the raccoon ate the corn

Story 2: Mother's Day

[Present picture 1] Josh sees the calendar. It's May. Mother's day is tomorrow. Josh is going to the store to buy his mother a present. Martha should get a present, too, but she doesn't have any money. Josh says "You should make something for mother"

[Present picture 2] So Martha stays home. She paints a card for her mother and makes a mess.

[Present picture 3} Later dad comes by. He sees the mess.

[Memory questions- all conditions]

1) What did Josh say to his sister, Martha?

2) What did Martha do?

3) What did the father see?

Now, listen closely to this sentence, and try and remember this for later.

[infinitival complement condition] Someone daxed the girl to paint the card.

[tensed complement condition] Someone daxed that the girl painted the card.

Story 3: Cookies

[Present picture 1] Grandma just made cookies. They are very hot. She is leaving. She tells Billy "You can have two cookies when they are cool."

[Present picture 2] Billy doesn't eat two cookies. Billy eats many cookies. Look at the crumbs. He has chocolate on his face.

[Present picture 3] There are no more cookies. Mom sees the mess. She sees the crumbs. She sees crumbs by the door to Billy's room.

[Memory questions- all conditions]

1) What did the grandmother say?

2) What did the mother see?

Now, listen closely and try and remember this sentence.

[infinitival complement condition] Someone daxed the boy to eat cookies.

[tensed complement condition] Someone daxed that the boy ate cookies.

Second Presentation of Stories with Test Questions

Story 1

Do you remember this story? [Present picture 1] The boy with the corn? [Present picture 2] The raccoon eating the corn? [Present picture 3] The farmer seeing the raccoon tracks?

Can you tell me ?

[infinitival complement condition] Who daxed the raccoon to eat the corn?

[tensed complement condition] Who daxed that the raccoon ate the corn?

Story 2

And do you remember this one? [Present picture 1] Martha and her brother Josh? [Present picture 2] Martha painting a card? [Present picture 3] Martha's dad seeing the mess?

Can you tell me ?

[infinitival complement condition] Who daxed the girl to paint the card?

[tensed complement condition] Who daxed that the girl painted the card?

Story 3

And this last one? [Present picture 1] The grandma and the cookies? [Present picture 2] Billy eating many cookies? [Present picture 3] Mom seeing crumbs by the door to Billy's room?

Can you tell me ?

[infinitival complement condition] Who daxed the boy to eat cookies?

[tensed complement condition] Who daxed that the boy ate the cookies?

Definition Question

[all conditions]

Now, what do you think dax means?

Picture sets

Story 1: Raccoon

Picture 1

Picture 2

Picture 3

Story 2: Mother's Day

Picture 1

Picture 2

Picture 3

Story 3: Cookies

Picture 1

Picture 2

Picture 3

APPENDIX B

IMITATION TASK

Training script

I will tell you a little story. It will have pictures, to help you remember the stuff in the story. Can you tell me the story back exactly the way I say it? Let's try it.

- The horse hopped.

Ok, let's try another one.

- The cow ate the grass.

One more practice one, then we'll start the game.

- The dog pushed the bird over to the cow.

Test Script

Now here we go. These will be a little harder than the practice ones.

Remember to say each story back to me, exactly the way I say it. OK?

1. The cow told the dog to push the pumpkin.
2. The bird said that the cow stood on the fence.
3. The horse hugged the pig that touched the barn.
4. The dog saw that the pig kicked the shovel.
5. The horse lifted the bird that ate the bug.
6. The pig asked the horse to wear the hat.
7. The bird poked the dog that chased the tractor.
8. The cow said that the horse rolled the ball.
9. The pig told the cow to eat the apple.

APPENDIX C

UNSEEN DISPLACEMENT TASK

Items needed: kitchen, cake, man, boy, cupboard, fridge.

Bold indicates experimenter performed action that was also uttered out loud.

This is a story about a boy named Bobby and his Dad. This is Bobby, and this is his Dad, and this is the kitchen of their house. Dad and Bobby have just made a delicious cake for after dinner and they are getting ready to put it away.

So, Bobby put the cake away in the cupboard.

"OK" says Bobby, "I am going to go out and play now, I'll be back by dinner time, so I can eat the cake."

So, Bobby goes outside to play.

Then, Dad says to himself, "Hmmmm.... I better put the cake in the refrigerator so the frosting doesn't melt."

So, Dad puts the cake in the refrigerator.

Then Dad goes to the store.

Control 1: Where did Bobby put the cake before Bobby went out to play?

Control 2: Where is the cake now?

Bobby comes back to have dinner. He's real hungry now. But he hasn't gone inside yet.

Test 1: Where will Bobby first look for the cake?

Test 2: And why will Bobby look there?

APPENDIX D

TRUTH-VALUE JUDGMENT TASK

Warm-up and Training

Now ____(Child's name), we're going to play a game with my friend here. His name is Imidaka. He's an animal that comes all the way from the moon. It's really far away, and they don't speak English there, they speak Moonspeak.

Say hello and good day to _____, Imidaka.

"Bleck, ee dorg leda."

See, that's how they say hello in Moonspeak. Now Imidaka is trying to learn English, isn't that right.

"Yes, I am learning English."

Now was what he just said right? It was, wasn't it? Well, Imidaka really likes playing ball, so when he gets something right, you can give him the ball. That will help him learn when he says something right, and when he doesn't. You can help him learn English.

So give him the ball (Imidaka is really happy)

Thank you.

Imidaka, tell me something about ______'s shirt.

"_____ has a _____ (false color) shirt."

Now was that right? It isn't, because you have a _____ (true color) shirt on. Well, to let Imidaka know he didn't get it right, you can give him the foot. He doesn't like feet, he thinks they are stinky. If you give him the foot, he'll know that he said something wrong.

So, give him the foot. (Imidaka is really unhappy)

Good. Imidaka, can you try again?

"______ has a ______ (true color) shirt."

Was that right? Yes. So we can give him the Ball. (Imidaka is really happy)

Ok. So this is the game we'll play with Imidaka. When he says something right, you give him the ball, when it's wrong, you give him the foot, ok?

Practice Trials

Now I'm going to say a little story and show it to you with my toys. Then Imidaka is going to say something and you give him the ball or the foot, ok?

(Objects in brackets are the props needed, capitalized sentence is the experimenter's actions and utterances, and bold statements are uttered by the puppet)

1) [horse, tractor] PUT HORSE ON TRACTOR **"The horse is under the tractor."**
2) [bird, hairbrush, cow] BIRD BRUSHES COW **"The bird brushed the cow."**
3) [dog, pig, horse, hat] DOG WATCHES WHILE PIG PUTS HAT ON HORSE. **"The dog put the hat on the horse."**

Test Trials

1) [bird, dog, cow, bell] BIRD SAYS TO COW "RING THE BELL, COW." COW RINGS BELL. DOG SAYS "THE COW RANG THE BELL" **"The dog told the cow to ring the bell."**
2) [table, pudding (play-doh in a small bowl), bird, pig, cow] TABLE AND PUDDING ARE OUT. BIRD AND PIG COME IN. PIG SAYS "LOOK AT THE PUDDING. THAT MAKES ME HUNGRY. GOTTA GO HOME FOR LUNCH." PIG LEAVES BIRD EATS PUDDING AND SAYS "YUMMMMM". BIRD LEAVES. COW COMES BY, SAYS "LOOK AT THE PUDDING!!! IT HAS BIRD BEAK MARKS IN IT!" **"The cow saw that the bird ate the pudding."**

3) [carrot, bird, pig, horse] BIRD SAYS TO HORSE "HEY HORSE, EAT THE CARROT" HORSE EATS CARROT PIG SAYS "THE HORSE ATE THE CARROT." **"The pig said that the horse ate the carrot"**

4) [cement (play-doh in the shape of a sidewalk), cow, dog, bird] COW AND DOG COME IN. COW SAYS "THAT LOOKS LIKE WET CEMENT." COW LEAVES. DOG SAYS "THIS LOOKS LIKE FUN!" DOG RUNS THROUGH CEMENT THEN LEAVES. BIRD COMES BY "LOOK AT MY SIDEWALK!!! IT'S GOT DOG PRINTS IN IT!" **"The bird saw the dog that messed up the sidewalk."**

5) [horse, bird, pig, ring] PIG SAYS TO BIRD "PLEASE STAND IN THE RING." BIRD STANDS IN RING, PAUSES THEN GOES OUT. HORSE SAYS "THE BIRD WENT IN THE RING" **"The pig told the bird to stand in the ring"**

6) [brown stamp pad, paper, dog, cow, pig] PIG AND COW COME IN. COW SAYS "WATCH OUT FOR THE MUD!!!" COW WALKS AROUND MUD AND LEAVES. PIG SAYS "I LIKE MUD PUDDLES" PIG WALKS THROUGH MUD, AND WALKS AWAY LEAVING HOOFPRINTS ON PAPER DOG COMES IN, SAYS "LOOK AT THE PAPER ! IT'S GOT PIG HOOF MARKS ALL OVER IT" **"The cow saw the pig that walked in the mud."**

7) [broom, dog, bird, cow] COW SAYS TO DOG "SWEEP UP THE FLOOR PLEASE, DOG" DOG SWEEPS THE FLOOR. BIRD SAYS "THE DOG SWEPT THE FLOOR." **"The cow said that the dog swept the floor."**

8) [paint, paper, horse, pig, dog] DOG AND HORSE COME IN. DOG SAYS "LOOK AT THE PAINT. I'D BETTER BE CAREFUL NOT TO SPILL IT." DOG CAREFULLY WALKS AROUND PAINT AND LEAVES HORSE SAYS "I LIKE TO PAINT" HORSE DIPS HIS TAIL IN PAINT AND PAINTS ON PAPER. HORSE LEAVES. PIG COMES IN "THERE ARE HORSE TAIL STREAKS ALL OVER MY PAPER!" **"The dog saw that the horse painted the paper"**

APPENDIX E

UNEXPECTED CONTENTS TASK

Well, look at what I have (bring out crayon box).

What do you think is in this box?

Crayons, huh? Let's see. (pull out turtle)

Look, it's a turtle. (put turtle back in box)

Control question: Now what is in this box?

Question 1: Before, when you first saw this box, what did you think was in it?

Question 2: If I asked XXX (a friend of the child) to come in here, what would he/she think was in the box?

APPENDIX F

FAST MAPPING TASK - ONE STORY (EXPERIMENT 2)

Script

[Present picture 1:] Look at the boy. He has corn. He waves the corn in front of the raccoon. The raccoon sees the corn.

[Present picture 2:] Here's the raccoon. It's eating the corn. YMMMM

[Present picture 3:] The farmer sees the empty corn cobs. He sees raccoon tracks.

[Memory questions] Do you remember the story?

1) What did the boy do?

2) What did the farmer see?

3) What did the raccoon do?

Now, I'm going to use a word you've never heard before. The word is dax. Listen closely and try and remember this sentence for later. Someone daxed that the raccoon ate the corn.

[Coloring of picture with participant, approx. 2.5 minutes]

Now remember this story? [Present picture 1] The boy with the corn?

[Present picture 2] The raccoon eating the corn?

[Present picture 3] The farmer seeing the raccoon tracks?

Can you tell me?

1) Who daxed that the raccoon ate the corn?

2) Now, what do you think dax means?

Pictures

Please see Appendix A, Story 1: Raccoon

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