On the Acquisition of Modality

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1 Introduction

This paper is concerned with the acquisition of the semantics and pragmatics of epistemic modal verbs. The sentences in (1) are examples of epistemic modality:

(1) a. It has to rain in the afternoon.
b. It may rain in the afternoon.

Epistemic modality concerns what is possible or necessary given what is known and what the available evidence is (von Fintel 2005). Semantically epistemic modal operators encode modal force (necessity or possibility) and get interpreted against a conversational background which includes the speaker's beliefs or the available evidence. Necessity in a given world encodes truth in all alternative possible worlds, whereas possibility encodes truth in at least one alternative possible world (Hintikka 1969).

Along similar lines, Kratzer (1981:43) states that "a proposition is a simple necessity in a world w with respect to the conversational background f if, and only if, it follows from f(w)." However, "a proposition is a simple possibility in a world w with respect to the conversational background f if, and only if, it is compatible with f(w)." For instance, sentence (1a) is a necessary proposition in a world where the speaker has definitive evidence that it will rain. Hence, the embedded proposition in (1a) follows from her previous knowledge. On the other hand, (1b), is only compatible with the speaker's previous knowledge or the evidence.

Pragmatically, epistemic modal verbs typically give rise to conversational implicatures of the following sort:

(2) It does not have to rain in the afternoon.

Logically, (1b) is compatible with (1a). However, in conversation, (1b) excludes (1a)—hence it implicates (2). Let us examine how the implicature above arises. According to the standard analysis, modal terms are ordered in terms of informational strength so that they form a scale (Grice 1989, Horn 1972). A statement with a relatively stronger term entails a statement with a relatively weaker term: (1a) entails (1b) but not vice versa. Why did the

speaker use a weaker modal when a stronger modal was available (and presumably relevant)? Recall that according to Grice (1989), "our talk exchanges do not normally consist of a succession of disconnected remarks, and would not be rational if they did. They are characteristically, to some degree at least, cooperative efforts..." According to Grice's Quantity Maxim, participants in a conversational exchange should make their contribution as informative as is required (for the current purposes of the exchange).

If we follow Grice's general pattern for working out a conversational implicature we can list the following steps the listener has to follow in order to work out the implicature:

1. The speaker chose a relatively weaker term (1b) from an ordered scale *<have to/must,..., may>*
2. The statement containing the stronger term would have been more informative and relevant.
3. The speaker is trying to be a cooperative conversational partner.
4. The reason why he/she chose a weaker term must be that he/she is not in a position to offer a stronger statement.
5. The stronger statement (1a) does not hold.
6. Hence, the implicature given in (2) arises.

In order for the child to acquire epistemic modality, he/she needs to acquire both the semantic aspects of modal meaning (including the notions of possibility and necessity) and the pragmatic inferences associated with modal expressions.

The acquisition of epistemic modality may prove to be difficult for learners for several reasons. First, it has been claimed that children have problems with the notions of necessity and possibility, i.e. they may not always identify alternative outcomes of a situation or handle these outcomes even if they are aware of them (Piaget and Inhelder 1975, Green 1979, Le Bonniec 1980, Byrnes and Overton 1986).

Second, even if they have acquired the conceptual basis of possibility and necessity, children may find it hard to map them onto modal vocabulary. Modal verbs do not have actual referents in the real world. For instance, the word "tree" refers to an actual tree in the real world. A child who is learning the word "tree" is able to see the actual tree and establish a link between the word and the actual object in the real world. Similarly, the referents of words which are associated with or depict actions are more readily observable than the modal verbs. For example, in many—if not every—occurrences of the word "kick" in a conversational exchange the action of kicking accompanies

the word. Hence, the child will be able to associate the word with the action. However, a child learning an epistemic modal verb is not able to observe something concrete in the real world. The notions of necessity and possibility are abstract and hence the acquisition of modal verbs may be more demanding than the acquisition of concrete vocabulary (see Gleitman 1990).

Third, children may face pragmatic problems when acquiring epistemic modals. We know that young children have difficulty computing conversational implicatures, especially of the scalar type (Noveck 2001, Chierchia et al. 2001); in particular, they seem to treat statements with epistemic modal terms logically and not pragmatically. So even after the acquisition of modal semantics, children may have trouble understanding conversational inferences associated with the use of modality.

Our goal in this paper is to shed light on the processes underlying the acquisition of the semantics and pragmatics of epistemic modality. This is how we propose to proceed: in the next section, we will discuss some findings from the developmental literature on how children interpret the vocabulary of epistemic necessity and possibility. In section 3 we will report our experimental findings on the acquisition of epistemic modality. Section 4 offers a conclusion.

2 Background: The Acquisition of Logical vs. Pragmatic Aspects of Epistemic Modality

In a study most closely related to our own experimental efforts, Noveck (2001) examined 5-, 7-, 9-year-olds' and adults' comprehension of modality in a reasoning task. Specifically, subjects were presented with two opened boxes and one closed box. Participants were told that the closed box had the same contents as one of the two open boxes. For instance, one open box contained a parrot and another contained a parrot and a bear. Next, participants heard eight modal statements about the content of the closed box (e.g. "There has to be a parrot in the box") and they were asked to say whether they agreed or disagreed with each of these statements.

The findings show that 7- and 9-year-olds but not 5 year-olds show mastery of epistemic modal semantics. Moreover, 5-, 7- and 9-year-olds accept true but under-informative statements (e.g. "There might be a parrot") instead of a more informative one (e.g. "There has to be a parrot") which shows that they still lack epistemic modal pragmatics (i.e. they cannot compute scalar implicatures). Moreover, the majority of adults are shown to treat a weaker modal term (e.g. *might*) as incompatible with a stronger term (e.g.

has to) whereas the majority of 7- and 9-year-olds generally treat a weaker modal term (e.g. *might*) as compatible with a stronger term (e.g. *has to*).

Although Noveck (2001) provides us with valuable insight about the acquisition of modal verbs, his study raises a number of questions. First, each participant in his study was presented with 8 statements, 4 of which included negation. The negative items might have been more difficult to comprehend than simple affirmative ones for reasons unrelated to modality.

Moreover, the experimental design was too complex. It not only required the participant to assess the content of the two boxes but also to keep these in mind while trying to comprehend and judge the statements about the third box. Hence, this design introduced a memory load component.

Additionally, Noveck's findings show that not all of his adult subjects treated the experimental task as a pragmatic one. In 35% of the adult responses, the statement "There might be a parrot" was accepted even though pragmatically this statement should have been excluded in a scenario where there has to be a parrot in the third box. In a real pragmatic task, the use of a weaker modal term, in this case *might,* should have been treated as incompatible with a stronger one, in this case *have to.* Hence, the fact that 69% of children's responses accepted the pragmatically infelicitous use of the modal verb *might* may not be due to the fact that children are unable to calculate scalar implicatures (and hence, they are "more logical than adults", as Noveck concludes); rather it may be due to the task's semantic—and not pragmatic—nature.

Relatedly, other investigators have claimed that children's inability to compute scalar implicatures is not due to lack of relevant semantic/pragmatic knowledge but rather stems from the fact that children cannot implement that knowledge in an experimental setting. For instance, Papafragou and Tantalou (2004) showed that, in contexts which are similar to naturalistic conversations, five-year-olds are able to assess the informativeness expectations of a conversational exchange and derive scalar implicatures when these expectations are not met. The question remains whether these recent developmental findings (which have mostly been based on scalar quantifiers such as *some* and *all)* generalize to modal scales.

In sum, all of these findings offer a useful starting point for further systematic tests of children's comprehension of epistemic modals and their pragmatic interpretations, ideally with simpler tasks. In what follows we present an experiment designed to do this. Our experiment is a simpler version of Noveck (2001) and it tests competence with epistemic modality in 5-year-old children. It is designed to examine, first, whether an easier task would reveal earlier competence with epistemic modality, and second,

whether five-year-olds truly treat a relatively weak modal term logically and not pragmatically.

3 Experiment

3.1 Method

3.1.1 Participants

A total of 40 native English-speaking-children (20 female and 20 male, mean age: 5;8, ranging from 4;2 to 5;9) and 40 native English-speaking adults participated in this study. The children were recruited from two preschools in Newark, DE. Adults were undergraduates at the University of Delaware who participated as part of course requirements. All participants completed the experiment.

3.1.2 Stimuli and Procedure

Participants were presented with eight short animated stories on a computer screen. At the beginning of the experiment the experimenter told participants that they would play a game together with two puppets (Minnie and Daisy) which were seated across from the computer. The game would involve several animals which were part of the computer-animated stories. All of the animals were introduced to the participants and named in an introductory slide.

All stories involved a stage on the screen whose curtains could be lowered and two containers (identical in shape and size but different in color). The experimenter told participants that each of the animals introduced in the first phase would hide in one of the boxes on the screen while the stage curtains were lowered. After the curtains went up again, Minnie and Daisy would take turns in guessing which box the animal had hidden. Participants had to say whether they agreed with each puppet or not.

At the beginning of the experiment participants were randomly assigned to either the Possibility or the Necessity condition. Stories and statements were identical in both conditions except for the modal verb used in the puppets' guesses (*may* in the Possibility and *have to* in the Necessity condition). For instance, in one of the stories a mouse hid in one of the two boxes (a yellow or a pink one) while the curtains were lowered. Each story gave the puppets two opportunities to guess. In the first guessing phase (closed boxes phase) the puppets made the following guesses right after the animal was hidden but before any of the boxes were opened (see Fig. 1):

Possibility Condition

(3) Minnie: "The mouse may be in the yellow box." (True)
(4) Daisy: "The mouse may be in the pink box." (True)

Necessity Condition

(5) Minnie: "The mouse has to be in the yellow box." (False)
(6) Daisy: "The mouse has to be in the pink box." (False)

After each statement the experimenter asked the participants whether or not the puppet was right. Because of the design of the task, both puppets were correct in the Possibility condition and incorrect in the Necessity condition during this first phase of each story.

In the next guessing phase, one of the boxes was opened. In four of the stories, it revealed the animal (Animal-Found Stories). For instance, in our earlier story, the yellow box was opened to reveal the animal (Fig. 2). The experimenter again asked each of the puppets where the animal was hidden. Depending on the condition the child was assigned to, the puppets offered the answers given below. Again, the experimenter asked the participant whether or not the puppet was right:

Possibility Condition

(7) Minnie: "The mouse may be in the yellow box." (True but underinformative)
(8) Daisy: "The mouse may be in the pink box." (False)

Necessity Condition

(9) Minnie: "The mouse has to be in the yellow box." (True but underinformative)
(10) Daisy: "The mouse has to be in the pink box." (False)

In the remaining four stories, there was no animal hidden in the opened box (No Animal-Found Stories). For instance, a cow hid in one of the two boxes (an orange and a blue one). After the first guessing round, the blue box was opened and was found empty. The puppets offered the answers given below:

Possibility Condition

(11) Minnie: "The cow may be in the orange box." (False)
(12) Daisy: "The cow may be in the blue box." (True but underinformative)

Necessity Condition

(13) Minnie: "The cow has to be in the orange box." (False)

(14) Daisy: "The cow has to be in the blue box." (True but under-informative)

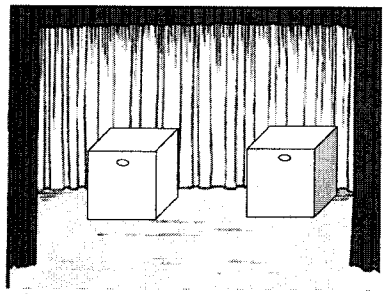

Figure 1. The first guessing phase.

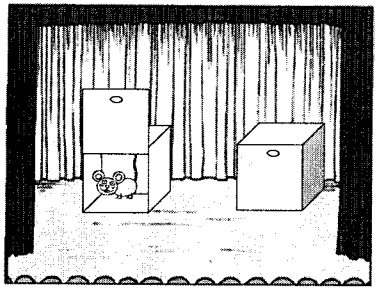

Figure 2. The second guessing phase (Animal-found).

The stories were administered in a fixed order where No Animal-Found stories preceded the Animal-Found stories. This was done to prevent children from getting impatient with stories in which no animal is found in case Animal-Found stories were administered first or in intermixed order. The side from which an animal entered the stage, the position of the box (left-right) where the animal hid, and the order in which the two statements were offered within each trial were counterbalanced.

We also administered eight control trials, one in the beginning of each story. Immediately after each animal entered the stage, and before it hid in one of the boxes, the animal did something: for instance, a giraffe jumped into the air and then laughed. Next, Minnie and Daisy would utter one statement each about what the animal had done (e.g. "The giraffe jumped into the air"). The participant's task was to say whether they agreed with the puppets' statements or not. The two statements were either both true or one of

them was true while the other one was false. The purpose of these trials was to ensure that children would treat each of the two statements independently in deciding whether they agreed with it or not (i.e. they could reject one and accept the other, or accept both) when no modal operators were involved. Half of the Animal-Found stories included a true-true and the other half a true-false combination of control statements; similarly, half of the No Animal-Found stories included a true-true and the other half a true-false combination of control statements. The order of the statements within each trial was counterbalanced.

Adults were tested individually in the same way as the children, except that the initial slides where the animals were introduced and the control trials were omitted.

We expected adults to accept the true statements and reject the false statements in both the Possibility and the Necessity conditions; we also expected them to accept the under-informative statements in both conditions on semantic grounds, even though pragmatic responses were also acceptable. We were interested in examining whether five-year-old children have difficulties with the semantics and pragmatics of epistemic modals, as previous work has suggested (Noveck 2001)—hence, whether their responses would be different from adults'.

3.2 Results

For purposes of analysis, unless otherwise indicated, we coded under-informative statements as true. A 2 (Age: children vs. adults) x 2 (Condition: Necessity vs. Possibility) x 2 (Story Type: Animal found vs. No-Animal found) ANOVA with the proportion of correct responses as the dependent variable and Story Type as a within subjects factor revealed a significant main effect of Age ($F(1, 72) = 37.171$, $p<.005$): overall, adults performed better than children in this task ($M_{adults}= 98.44\%$ vs. $M_{children}= 71.72\%$). The analysis revealed no significant main effect of Condition: participants gave correct responses 88.75% of the time in the Possibility condition and 81.41% of the time in the Necessity condition. The analysis also revealed a significant main effect of Story Type ($F(1, 72) = 764.34$, $p< .001$): Animal Found stories elicited a higher proportion of correct responses than the No Animal Found stories ($M= 83.44\%$ vs. $M= 79.38\%$, respectively). This advantage is probably due to the fact that this outcome offers stable knowledge of the animal's location while in the No Animal found cases, the animal's location still needs to be inferred. There were no significant interaction effects.

We next looked at performance on each of the two modal Conditions in more detail. We conducted two separate ANOVAs on the proportion of cor-

rect responses in the Necessity and the Possibility Conditions with Age as a between-subjects factor and Story Type as a within-subjects factor. For the Necessity condition, the analysis revealed a main effect of Age, $F(1, 38) = 26.95$, $p < .001$. Specifically, adults gave higher proportions of correct responses (M=97.62%) than children (M= 63.49%). Moreover, there was a main effect of Story Type, $F(1, 38) = 720.79$, $p < .001$. Specifically, performance on Animal Found Stories was significantly better than in No animal Found stories ($M_{\text{Animal Found}} = 82.63\%$, $M_{\text{No Animal Found}} = 78.48\%$). Our analysis revealed no significant interaction of Age x Story Type. Independent samples t-tests revealed that children's performance was significantly different from chance for the Animal-found type of stories (M=66.45%, $t(19) = 2.563$, $p<.05$) but not for the No Animal-found type of stories (M=60.53%, $t(19) = 1.323$, $p=.202$).

For the Possibility condition, an ANOVA on the proportion of correct responses with Age as a between-subjects factor and Story Type as a within-subjects factor revealed a main effect of Age, $F(1, 38) = 11.271$, $p<.01$ (for adults: M=99.34%; for children, M=79.17%). There was no main effect of Story Type, or interaction of Age x Story Type. Children's performance was significantly different from chance for both the Animal-found (M= 78.57%, $t(20) = 4.77$, $p < .001$) and the No Animal-found type of story (M= 79.76%, $t(20) = 4.96$, $p < .001$).

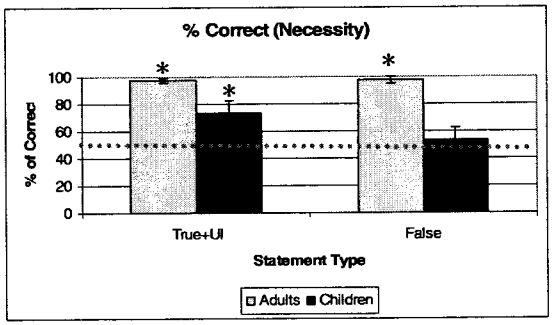

Figure 4. Percentage of correct responses of adults and children for the True (including Under-informative) and False statements in the Necessity condition.

We next analyzed participants' performance on each of the two modal Conditions looking at the kind of statement participants had to judge (true, including under-informative, or false). Results are presented graphically in Fig. 4 and 5. Beginning with the Necessity condition, a 2 (Age: adult, child)

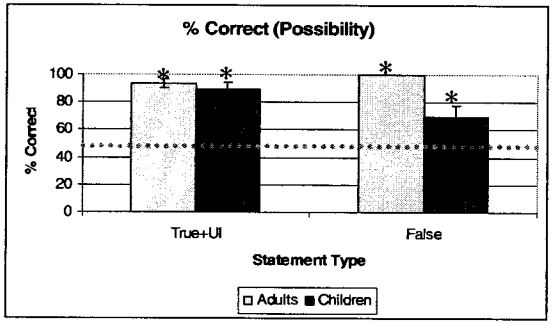

Figure 5. Percentage of correct responses of adults and children for the True including Under-informative) and False statements in the Possibility condition.

x 2 (Statement type: true, false) ANOVA with the last factor as a within-subjects factor revealed a significant Age effect, $F(1, 38) = 25.504$, $p<.001$: adults offered correct responses 98.44% of the time, while children did so 71.72% of the time. The analysis also revealed an effect of Statement Type ($F(1, 39) = 187.353$, $p<.001$: true statements elicited correct responses 86.25% of the time, while false ones did so 76.56% of the time. The analysis did not reveal a significant interaction between Age and Statement Type.

Children's success in accepting true (including under-informative) Necessity statements was significantly different from chance ($t(18) = 2.738$, $p< .05$, 2-tailed). However, their success in rejecting the false Necessity statements were not significantly different from chance ($t(18) = .371$, $p >.05$, 2-tailed). We went on to examine children's responses to false Necessity statements more closely. We split those statements in terms of availability of evidence for or against the statement in question. Specifically, the false Necessity statements which were offered before any of the boxes were opened were considered *non-critical* as there is no observable evidence against the statement in this case. Hence, the child may evaluate these statements as guesses[1]. However, the false Necessity statements which were offered after one of the boxes was opened were considered *critical* as there is evidence in

[1]For instance, before any of the boxes were opened, one of the characters would say: "The animal has to be in the yellow box". This statement is false. However, there is no observable evidence against it. The child has to conclude that in this case one cannot tell where the animal is and it is inappropriate to use the modal *have to*. Alternatively, she can conclude that the character is only offering a guess.

this case against the statement[2]. Children's performance on Critical vs. Non-critical false Necessity statements was found to be significantly different ($M_{critical}$ = 79.6%, $M_{not\text{-}critical}$ = 40.63%, t (18) = 19.288, p< .001, 2-tailed). Furthermore, children's performance on the critical false Necessity statements was found to be significantly different from chance level (t (18) = 8.353, p <.001), unlike performance on the non-critical statements (t (18) = -1.743, p >.05).

In the Possibility condition, a 2 (Age: adult, child) x 2 (Statement type: true, false) ANOVA with Statement type as a within-subjects factor revealed a significant main effect of Age, F (1, 38) = 11.271, p<.01), M_{adults}= 99.34% vs. $M_{children}$ = 79.17%. The analysis also revealed a significant effect of Statement Type (F (1, 19) = 1040.72, p< .001) and an interaction of Age and Statement Type (F (1, 19) = 272.73, p< .001). The interaction is due to the fact that adults rejected the false Possibility statements more often than the children (M= 100% and M=69.05% respectively, t (38) = -3.561, p<.005) but their acceptance of true Possibility statements did not differ significantly from children's (M= 98.68% and M= 89.29% respectively, t (38) = -1.613, p=.115).

Finally, we examined performance on true but under-informative statements in both conditions. In the Necessity condition, children accepted such statements 71.05% of the time and adults 90.48% of the time. This difference was not found to be statistically significant. In the Possibility condition, acceptance proportions for under-informative statements were 88.73% for children and 88.16% for adults (again statistically not significant). Children's acceptance proportions for under-informative statements differ significantly from chance (for all analyses, p<.05).

3.3 Discussion

Unlike previous studies, we have provided evidence that 5-year-olds have acquired the semantics of the modal of Possibility *may* and of the modal of Necessity *have to*, since they successfully accept true modal statements and reject false ones most of the time. As expected, we also found that adults' performance was better in both the Possibility and Necessity conditions. However, the question of whether 5-year-olds treat a relatively weaker term logically or pragmatically remains open as our adult participants treated these items semantically and not pragmatically.

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[2]For instance, the yellow box would be opened to reveal no animal inside and one of the characters would say: "The mouse has to be in the yellow box". This statement is false and the opened, empty, yellow box constitutes evidence against it.

Two aspects of our data require some further comment. First, children performed better on Animal-found type of stories than they did on No Animal-found type of stories in the Necessity condition, while in the Possibility condition, children performed equally well on both types of stories. We believe that this difference may be due to different task requirements in both types of stories. In the No Animal-found type of stories, before the participants judge the statement, they are required to infer that the animal is in the other box upon seeing the opened box empty. This additional requirement that the participants have to fulfill might have affected their performance. The fact that this difference proves to be significant only in the Necessity condition and not in the Possibility condition may point to some deeper difficulty with the comprehension of modals of necessity, a possibility we are currently exploring in ongoing experimental work.

Another interesting aspect of our data was children's treatment of false Necessity statements. We found a significant difference in children's performance in critical false Necessity statements (where there is evidence against the modal statement) vs. the non-critical ones (where there is no evidence against the statements present). One possibility is that children evaluated the non-critical false Necessity statements as guesses offered by the character, unlike the critical false Necessity statements; hence, the children were more inclined to accept non-critical statements than the critical ones.

4 Conclusion

Recall that, according to earlier studies, 5-year-olds do not show mastery of epistemic modal semantics during reasoning tasks (e.g. Noveck 2001). Moreover, children tend to treat a relatively weak modal statement semantically and not pragmatically. In this paper we investigated 5-year-old children's acquisition of the semantics and pragmatics of epistemic modality. Unlike these previous studies, our findings show that 5-year-olds have acquired the semantics for the modal of Possibility *may* and the modal of Necessity *have to*. However, both our adult sample and our child sample treated our task as a semantic one and hence, they accepted under-informative statements with modals when stronger statements would have been warranted. In future studies, we plan to explore further children's (and adults') inferences from the use of modality in more naturalistic conversational tasks in order to explore the scope and limitations of children's developing pragmatic abilities.

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