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From Evidence to Belief: Developmental Precursors for False Belief Ascriptions

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From Evidence to Belief. Developmental Precursors for False Belief Ascriptions.
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1. In search of prerequisites for false belief ascriptions

Recently, a fruitful line of inquiry has linked children's acquisition of the language of the mind to their developing understanding of other minds. In particular, a cascade of linguistic effects regarding sentences embedded under mental verbs has been shown to occur around the age of four years for the average child, roughly the age when children start passing standard false belief tests. This set of linguistic effects is summarized briefly below. In the proposed study, we will turn our attention to possible precursors for the ability to ascribe a false belief to another person. These precursors include knowledge about how people form beliefs from the evidence of their senses and by what evidence they judge the existence of such belief states in others. To explore such questions, we will examine how children acquire some selected constructions relating to the path leading from evidence to belief: epistemic uses of modals such as "must" and "might" and direct and indirect perception reports using verbs like "see".

Background

When children are able to ascribe a false belief to another person - as shown through various linguistic and non-linguistic tests of Theory of Mind - they have been found in earlier work by de Villiers and Roeper to have the following linguistic abilities, all related to mastery of the syntax and semantics of finite sentential complementation:

They spontaneously produce tensed complements of the following kind in their conversation:

- (1) My Mom thinks that was my class making that music.

They answer correctly when given the following kind of task with a pair of pictures:

- (2) Bill thought there was a butterfly in his drink, but it was just a piece of lemon.

Point back at first: What did Bill think? Child now says (that)(there was) a butterfly in his drink. Younger children say (that) (there was) a lemon.

They answer correctly when asked the following kind of question after a short story:

- (3) When did the boy say what he ate? The next morning.

Younger children would answer: "a cookie", thus answering the medial wh-word "what", possibly treating (3) as parallel to (4), a 'scope marking' construction of the kind that can be found in their spontaneous speech:

- (4) What did the boy say what he ate?

They produce indirect questions in spontaneous speech. Younger children do not produce full indirect questions, but might use constructions with implied ones:

(5) Ask Mom.

Furthermore, in the longitudinal data in CHILDES, there is a coincident emergence of
a) embedded questions e.g.

(6) I asked where she was going

and b) auxiliary inversion in the corresponding matrix question i.e.

(7) Where is she going? Instead of where she is going?

If there is a connection between auxiliary inversion and the presence of a complementizer position, as assumed in much syntactic work, failure to invert might be due to a missing complementizer projection. This in turn suggests that children acquire sentential complements incrementally. Before they produce finite sentential complements themselves in their spontaneous speech, they may perceive the ones they hear as syntactically simpler structures, and this might affect their interpretation in predictable ways. One way of testing such a hypothesis is to look at verbs that do in fact embed syntactically simpler types of complements, like bare infinitives, and investigate whether (a) such embedding structures are acquired earlier than the more complex ones, and (b), whether the semantic interpretations associated with the simpler types of complements are transferred to the more complex complements before children master those completely. One of the subgoals of the proposed work is to find answers to those questions generated by our earlier work.

De Villiers & de Villiers (in press) make the following claim based on data from normally developing children and from language-delayed oral deaf children: Developmentally, the mastery of sentential complementation is a prerequisite for the ability to ascribe a false belief to another person. That is, developmentally, children must be able to project a certain amount of syntactic structure before they are able to ascribe a false belief to somebody else. The precise nature of this requirement is under active investigation by considering its manifestation in other languages (such as ASL and Japanese), and many questions are still open.

In our previous work on false belief and the language of the mind, some crucial precursor properties have been taken entirely for granted, as they are in much of the existing research in this area. We assumed the necessary building blocks were present without testing how they get established. For example, in work on the development of referential opacity, we wanted to see if children would tolerate changing the name of an object when that object was not known to the protagonist under that description. So, for instance, we told them a little girl sees a silver box on top of a shelf which contained candy, a fact known to the child, but assumed not to be known to the little girl. Then we asked: “Did the little girl know a silver box was on the shelf?” (control), and “Did the little girl know candy was on the shelf?” (opaque context). Surprisingly to us, a fair number of young children (3-4 years) reply “no” even to the first question, making it difficult to use it as the baseline of comparison. The link between what others see and what they know or believe has been explored quite extensively in the theory of mind literature, but there are other important precursors that are only beginning to receive some attention. Take just three examples.

a) Papafragou (1998) reported a coincident development between epistemic uses of the modals “could”, “might”, “can” and the typical age of acquisition of a mature theory of mind. However, the connection must be less direct, as the successful use of epistemic modals does not necessarily require that the child assume another person’s point of view, for example (see discussion below).

b) Slobin & Aksu (1982) and Fitneva (1999) have worked on the verb markers in Turkish and Bulgarian respectively that are referred to loosely as “evidential” markers, because they differentiate whether the event was witnessed or not by the speaker. Again, there is evidence from Slobin & Aksu that the age of proper use of the evidential in Turkish is age four years or so. Fitneva explored a more complex picture suggesting the type of evidence - seeing versus hearsay - made a difference in the child’s interpretation of certainty. Again, the use of evidentials by the speaker does not in itself presuppose anything about other minds, but it does raise interesting questions about the assessment of evidence for the formation of beliefs.

c) Johnson & Maratsos (1977), Moore, Byant, & Furrow (1979), Moore, Pure, & Furrow (1990), and Tager-Flusberg et al. (in press), have all done interesting experimental work on the child’s ability to distinguish degrees of belief certainty in the mental verbs “think”, “guess” and “know”. Surprisingly, these distinctions seem to emerge relatively late, after the classic “false belief” breakthrough, a finding supported also in work we have done on the semantic differences among mental verbs.

Cognitive and linguistic precursors for false belief ascriptions

The ability to ascribe a false belief to another person has cognitive and linguistic prerequisites. On the cognitive side, the end point at which children can handle false belief ascriptions seems to rest on at least the following three developments:

- the ability to assess evidence with respect to where it came from and who has access to it.
- awareness of how we reason, and thereby acquire beliefs, from the evidence available to us.
- the appreciation that others may reason, and thereby acquire beliefs, from evidence that is potentially distinct from our own.

We suspect that the ability to assess evidence with respect to where it came from and who has access to it and the gradual appreciation of how we acquire beliefs from the evidence available to us is at least part of the path that leads to awareness that others could have different, and potentially false, beliefs about a particular matter of fact. As for linguistic precursors for false belief ascriptions, we will look at a selection of constructions whose mastery requires the cognitive abilities we have just mentioned. Roughly, the cognitive abilities and the linguistic constructions are matched as follows:

- Epistemic possibility modals: Entertaining various possible hypotheses with respect to a given piece of reality. “This might be Dad coming up the stairs, but it might also be our neighbor.”
- Epistemic necessity modals: Distinguishing direct and indirect evidence. “Look at those gnawed off trees. There must be beavers living around here.”
- Perception verbs + bare infinitives: Describing the events that another person perceives in an epistemically neutral way. “Ann saw Sally hide the candy.”
- Perception verbs+ finite complements: Describing what another person perceives or is bound to conclude from what (s)he perceives in an epistemically non-neutral way. “Dad saw that Mom had eggs for breakfast.”

The following section 2 describes the relevant linguistic properties of epistemic modals and perception reports, explains in more detail why we selected those particular constructions, and prepares the ground for the presentation of experimental ideas in section 3.

2. Relevant properties of the constructions to be investigated

Epistemic modals

Epistemic modality has played an important role in the development of modal logic and natural language semantics. In fact, some recent formal analyses of modality, e.g. the data semantics of Landman 1986 or the update semantics of Veltman 1996, are primarily concerned with epistemic modality. One of the basic insights modeled by data semantics and update semantics is that the truth-value of a sentence with epistemic “might” can change from true to false when new information becomes available. This is illustrated by the following example, which is a variation of one discussed in Veltman 1996: Suppose we hear a knock at the door, and the evidence we have at that point in time is compatible with either John or Mry being the knocker at the door. In such a situation, we can truly utter the following two “might” – sentences:

- (1) a. The knocker at the door might be John.
- b. The knocker at the door might be Mary.

Once the door opens and, say, Mary appears, the possibility that John was the knocker at the door has to be discarded. Even though John never was in fact the knocker at the door, he might have been, given the information we had until a little while ago. Consider next the following two sentences:

- (2) a. The knocker at the door was Mary.
- b. The knocker at the door must have been Mary.

Assuming that Mary was indeed the knocker at the door, 2(a) and 2(b) would both be true if uttered after the door has opened and Mary has appeared. There are subtle differences between the two sentences, however. Uttering 2(a) commits us to the truth of Mary being the knocker at the door. Uttering 2(b) yields a weaker claim. At least since Karttunen 1972, scholars have wondered why. One possible answer, suggested in Kratzer 1981 among others, is that an utterance of 2(b) indicates that Mary’s being the knocker at the door follows not just from facts, but from facts plus possibly violable generalizations. In our particular example, a relevant generalization would be that when there is a knock at the door that is followed directly by an opening of the door and the appearance of a person x, then that person x was the knocker. Without knowing it, we might happen to be in a situation where that generalization is violated. An utterance of 2(b), then, does not commit us to the truth of 2(a). Uttering 2(b) commits us only to the claim that Mary’s having been the knocker at the door can be inferred from the evidence we had in the utterance situation with the help of plausible, but possibly violable, generalizations.

Children who master the use of epistemic modals have the ability of historians or detectives. Given the available evidence, they can infer what had to be the case or might have been the case, using plausible generalizations. Note that, as long as the epistemic modal is in the matrix clause, the evidence relied on is always evidence available to the speaker, unless indicated otherwise. Often, but not always, that evidence is also shared with the hearer(s). When the evidence relied on is

shared, epistemic modals can be used and understood successfully without having to consider the possibility that somebody else may be reasoning with respect to a different piece of evidence or might draw different inferences from the same piece of evidence. In those cases, then, there is no point of view involved, but only awareness of how we acquire beliefs by drawing inferences from available clues in the world. This property of epistemic modals warrants the hypothesis that their mastery might be a precursor for the fully developed ability of ascribing a false belief to another person. If the evidence relied on by a particular use of an epistemic modal construction is not shared by speaker and hearer, grasping the full impact of the information conveyed by the use of such a construction might require appreciation of another person's different point of view, hence is a more complicated cognitive task. Our Suzy experiments described in section 4.2 below are constructed in such a way that the simpler ones don't, but the more complicated ones do confront the child subjects with utterances of epistemic modals that rely on evidence that is not shared.

As has often been observed, epistemic modals occupy a higher position in their syntactic tree than root modals (deontic or 'ability' modals). This can be seen most clearly in languages like German, where root modals can, but epistemic modals cannot be embedded under aspectual "haben" ('have'):

- (3) Das Rotkäppchen hat ihre Oma besuchen müssen.
 The Red Ridinghood has her Grandma visit must
 Red Ridinghood had to visit her Grandma (deontic interpretation only).
- (4) Das Rotkäppchen muss den Wolf besucht haben.
 The Red Ridinghood must the wolf visited have
 Red Ridinghood must have visited the wolf.
 (Epistemic interpretation. A deontic interpretation is possible in principle, but marginal out of context.)

The fact that epistemic modals occupy a higher syntactic position than root modals means that they embed complements with 'more' structure than root modals. If clauses are seen as hierarchical structures consisting of successive layers that obey a fixed order and are each projected from a head in a uniform way, the notion of 'more' syntactic structure can be given a precise interpretation in modern syntactic theory, as emphasized in Rizzi 1992. A finite sentential complement, for example, would be the projection of a complementizer C, and a bare infinitival complement might just be a projection of V. Intermediate layers will include projections of Tense or Aspect heads. Children who master epistemic modals, then, must be able to project complements that are Aspect Phrases, hence more complex than the complements of root modals, which can be mere VPs. If the ability to project at least an Aspect Phrase complement is a prerequisite for the mastery of epistemic modals, we expect epistemic interpretations of modals to appear later in a child's language than root interpretations. Following up on the findings of our earlier work, we moreover expect that when children are at a stage when they do not yet project Aspect Phrase complements in their spontaneous speech, but are confronted with sentences like (4), they should interpret the modal as deontic, rather than epistemic. To test this, we can place sentences like (3) and (4) in the context of a story where Red Ridinghood was supposed to visit Grandma and was not allowed to visit the wolf, but was caught in a blizzard, and ended up at the wolf's house. The child subject is then presented with a scene that has tracks in the snow leading to the wolf's house, but there are no tracks leading to Grandma's house. Given this scenario, (3) and (4) are both true, but a deontic interpretation for (4) would make that sentence outright false.

Perception reports

Mastery of the simplest kinds of perception reports requires the recognition that another person might have a different visual field from one's own. In a direct perception report, we describe an event or an object that a person perceives. If the report is epistemically neutral, our description does not have to be faithful to the perceiver's own conceptualization. Consider the following case, which is a variation of an example from Barwise 1981, 1989 (see also Gee 1977 for related examples):

(5) Ralph saw Ortcutt hide the letter under a rock, but thought he was just tying his shoe.

The truth of an utterance of the first conjunct of (5) requires Ralph to have seen an actual event of Ortcutt hiding the letter under a rock. However, he does not have to have interpreted what he saw correctly. He might have thought Ortcutt was just tying his shoe. As observed by Gee and Barwise, epistemically neutral perception reports contrast with epistemically non-neutral perception reports like the following:

(6) # Ralph saw that Ortcutt hid the letter under a rock, but thought he was just tying his shoe.

Unlike the first conjuncts of (5), the first conjunct of (6) implies that Ralph knows that Ortcutt hid the letter under a rock, and consequently, (6), but not (5) is a contradiction. Not only are perception verb+finite-complement-constructions epistemically non-neutral. They also permit inferences from direct visual evidence, hence are often labeled 'indirect perception reports'. Some typical examples are given in (7):

(7) a. The radiologist saw that Mary hadn't eaten, since her stomach was empty.
b. They heard that John was asleep, since he was snoring.

The fully competent use of constructions with perception verbs embedding finite complements, then, is a complex task, requiring the epistemically non-neutral characterization of what a person infers from what (s)he perceives. Unlike belief reports, however, constructions like (7) are necessarily factive. No possibly false belief ascriptions are involved.

When used in an epistemically neutral direct perception report, the verb "see" simply expresses a relation between a perceiver and a part of the actual world, an object or an event. If bare infinitives express properties of events, they can saturate the direct object position of such a verb "see" in pretty much the same way as a bare plural noun like "dogs" can, ultimately yielding an existentially quantified statement (see e.g. Higginbotham 1983). "That"-clauses do not express properties of events, and this means that they cannot be used to saturate an event argument position. Consequently, their presence triggers a slight change in the meaning of "see", affecting the type of its direct argument position. Work in lexical semantics has addressed the connection between the meaning of verbs and the type of complements they tolerate (see in particular Gleitman 1990 and Levin 1993). Work in formal semantics, like Zucchi 1988,1993 and Portner 1992, building on Vendler 1967, has identified plausible types of denotations for a large class of different types of embedded complements. Knowing the types of denotations for different types of embedded complements, we have at least the beginnings of an explanation for why particular kinds of syntactic complements force particular types of changes in the lexical meanings of the verbs that embed them.

The examples reviewed above illustrate the often reported observation that the embedded complements of indirect perception reports seem to require ‘more’ syntactic structure than the complements in direct perception reports. Assuming that more complex structures are acquired after simple ones, we expect direct perception report interpretations to become available before indirect ones. As in the case of modals, we expect moreover that children that do not yet produce finite complements in their own spontaneous speech will interpret them as non-finite constructions, possibly like bare infinitives. An indirect epistemically non-neutral perception report might then be interpreted as one that is direct and epistemically neutral. The earlier work on finite complements by the de Villiers suggests that this is exactly how young children interpret finite clauses embedded under mental verbs.

While we will start out with an investigation of the dramatic contrast between direct epistemically neutral and indirect epistemically non-neutral perception reports, we are aware that there are more complementation possibilities for a verb like “see” and its counterparts in other languages which have been studied extensively in the literature. As expected, these different complementation possibilities come with different interpretations. Boivin 1998 points out, for example, that in French, the verb “voir”, like its English counterpart “see”, has a true perception, hence a veridical interpretation, as well as an ‘imagine’ reading. Interestingly, she presents evidence that when “voir” has the ‘imagine’ interpretation, it requires complements with ‘more’ syntactic structure. Boivin presents the following contrasts, for example:

- (8) a. Je vois Jean jouer de la guitare.
I see Jean play of the guitar
I see John play(ing) the guitar.
- b. Je vois Jean posséder une maison.
I see Jean own a house
I imagine John owning a house.

8(a) is ambiguous. It can mean that I saw an actual event of Jean playing the guitar or that I imagine Jean as someone who plays the guitar, that is, as a guitar player. 8(b) can only mean that I imagine Jean as a house owner. The crucial difference between 8(a) and (b) is the embedded predicate. 8(a) has a stage-level predicate that can optionally have an individual-level interpretation, and 8(b) has an individual-level predicate. The two types of predicates differ in their behavior in a number of ways, and there is a considerable literature dedicated to this topic. Kratzer 1995 has argued that individual level predicates do not have an available event argument. One way for this to come about would be through an incorporated aspectual operator binding off the event argument. A proposal along these lines is made in Chierchia 1995. A predicate without an available event argument cannot saturate an event argument position, hence cannot be a complement for veridical “see” or “voir”. The complement projected by an individual-level predicate has to be at least an Aspect Phrase (Boivin actually argues that it is a Tense Phrase). The difference in the type of the complement, then, forces a different interpretation of the verb. Similar cases have been discussed for English (see e.g. Safir 1993). Here are some relevant examples:

- (9) I can’t see John owning a house.

- (10) From the perspective of those who house the homeless, the building was seen to have collapsed, but in view of the Housing Authority, the building was merely classified as substandard.
(Higginbotham 1983, Safir 1993)

In (9) “see” has the ‘imagine’ reading discussed by Boivin. (10) is a clear case of an epistemically non-neutral perception report. Again, the change in interpretation is triggered by the type of complement, a “to”-infinitive in this case. Because of the diversity of their complements, with each type triggering a subtle difference in meaning, the family of perception verbs is an ideal testing ground for our hypothesis that children who do not yet fully master finite sentential complements may interpret those complements like the less complex complements they master already. Note that nothing we have said or assumed implies that we shouldn’t find, say, direct epistemically neutral perception reports using finite sentential complements. Those constructions do in fact exist in Russian or German, for example (Bayer 1982, Rizzi 1992):

- (11) Sie hat gesehen, wie du ganz schnell um die Ecke gebogen bist.
She has seen how you really fast around the corner turned are
She saw you turn the corner really fast.

Direct perception reports like (11) require the special complementizer “wie”, whose function seems to be to map a proposition back into a set of events (see Portner 1992 for other instantiations of such mappings). What we would not expect to find, for example, are mere VP complements used in indirect, epistemically non-neutral perception reports.

4. Description of tasks

In what follows, we present the main ideas for the kind of experiments we will be developing, providing at least one example of a set of materials. The scenarios can easily be reproduced.

1) Deduction task: Evidence for own belief

The first experiment tests whether children can make appropriate deductions based on evidence from visible "signs" - this is a fundamental cognitive prerequisite for epistemic language. In the past summer, we explored in some pilot work how children aged 3-5 reason on the basis of clues in a scene, based on simple associative rules. Not all children grasped the concept easily, and several mis-steps were evident. For example, we told the child that only the mother ate eggs for breakfast, and we intended the evidence of broken eggshells and a dirty plate to constitute the evidence that she had breakfasted. But the sight of a full box of unbroken eggs in the fridge triggered some children to draw this conclusion. We intend to explore the connections between evidence, seeing and reasoning to belief in a series of experiments that gradually elaborate the complexity of the conditions. One such example is spelled out below.

Task: Look at these characters:

Girl wears scarf all the time, never takes it off!

Boy always wears boots outside - but is not allowed to wear them in the house, always leaves them outside when he goes in.

Dad has bike, parks it next to door – he’s the only one that rides the special blue bike.

Mom’s the only one that drives the car – always parks it outside.

See this Puppy? He always chews slippers if he gets inside.

See this cat? Cat always knocks over plants if he gets inside.

Memory Check questions: Now, do you remember

- | | |
|----------------------------------|---------------------------------|
| (a) who always wears the scarf? | (b) Who drives the car? |
| (c) Who chews the slippers? | (d) Who knocks over the plants? |
| (e) Who wears the boots outside? | (f) Who rides the bike? |

Spontaneous deduction: Let's see what you can figure out from this scene.

Scene A:	or	Scene B:
Scarf from under table		Scarf from bed covers
Boots outside		No boots
No bike		Bike outside
Car outside		No car
Slippers chewed		Slippers fine
Plant upright		Plant knocked over

Elicited deduction. Ask for spontaneous inference, then if not mentioned:

Where is the girl? How did you know?
Is the boy home? Is the Dad home? Is the Mom home? How did you know?
Is the Dog inside? Is the Cat inside? How did you know?

2) Epistemic possibility: the modal "could"

Task: Suzy is watching TV and her mother notices that it is late and says loudly. "Go to bed". Suzy is startled, cries and runs into her sister's room and gets in bed with her sister who is sleeping and gets under the cover with her. Her mother goes in and wants to give Suzy a goodnight kiss, and sees two girls under the covers. She does not want to wake Suzy's sister. She looks at one of the completely covered girls and says: "Could this one be Suzy?" "What do you think?" And then she looks at the other completely covered girl and says: "Could this one be Suzy?"

The interesting point here is that either one of the two covered children could/might be Suzy, and at the same time, could/might also be the sister. Each of those girls is either Suzy or her sister, but not both. On the other hand, either one might be Suzy, but also might be her sister, hence might be either one. This kind of scenario seems to capture an important property of epistemic reasoning: One and the same piece of evidence allows several hypotheses about the complete truth regarding the actual identity of the persons. Note that the possibilities considered here are objective possibilities, not subjective possibilities as in attitude ascriptions. A certain piece of limited evidence is compatible with several different ways the actual world might be.

3) Understanding the contrast of epistemic "must" and "is":

Before pursuing the meaning of epistemic "must" in detail, it is necessary to test if the child can distinguish the use of "must" from simple "is". This is one task that will test this.

Task: Grandma arrived for a holiday with two suitcases. "I have three presents for my grandchildren". She opens one suitcase and empties it. "Here is one, but where are the others?" [Holds one wrapped present. A second one is visible near clothes from the emptied suitcase.] One of her grandchildren looks around and says "one must be....." Can you say it? (to experiment child)...[expected: "in the other suitcase"] or: "one is....." [expected: right there " or "right near that shirt"]

Since Grandma arrives from elsewhere, the relevant search space must be with what she brought with her. The other suitcase is pretty much the only place the present could be for the "must". If one present is a little bit visible, then it is reasonable to point it out but it is not appropriate to use "must" in that case.

4) Epistemic modals: producing and understanding "must"

This series of experiments, illustrated here with one case, tests an increasingly sophisticated appreciation of the epistemic modal "must". (Note that this particular case may demand an appreciation of "right" and "left: as designators of one glove or the other, but never requires the child to understand which is which. Our other scenarios do not depend on this.)

Task: Suzy has two winter coats, a green one and a purple one. She only has one pair of mittens, and she keeps the mittens in the pockets of one of her coats, one mitten in the left pocket, and the other mitten in the right pocket. Suzy doesn't always remember which coat she has left her mittens in, but both mittens are always in the same coat.

(a) Eliciting epistemics

Now Suzy wants to go outside, and has to find her mittens. She doesn't remember which coat they're in, but she starts to look in the pockets. First she checks one of the pockets of her green coat – there's her left mitten! She says: "The right mitten must be..."

Complete the sentence. (in the other pocket of the green coat)

What if Suzy doesn't find anything in the first pocket of the green coat? This time she says: "The right mitten must be..."

Complete the sentence. (in one of the pockets of the purple coat)

(b) Understanding epistemic use

What if Suzy checks in one of the pockets of her green coat, and finds her right mitten. She says: "The left mitten must be in the other pocket of this green coat!" Why does Suzy say that?

Children who fail test (a) or (b) may fail it because they might lack any one of the following abilities.

- Understanding epistemic modals: When Suzy says "The right mitten must be...", she draws an inference from a piece of reality (a clue) that is accessible to her.
- Knowing that plausible, but violable generalization like 'both mittens are always in the same coat' will be used in such an inference.
- Knowing that Suzy knows about this generalization and will use it when drawing the inference.
- Being aware that since Suzy has found the left mitten in one of the pockets of the green coat, she knows that that's where the left mitten was.
- Reasoning that if the mittens are always in the pockets of the same coat, the fact that one of them was found in a pocket of the green coat means that the other mitten is in the other pocket of the green coat.
- Assuming that Suzy, too, goes through the piece of reasoning in the previous step.

(c) Trickery and false evidence

Before Suzy decides to go outside, Mom goes into the room where Suzy's coats are hanging. Suzy's left mitten has fallen out of her purple coat! Mom doesn't know that the mitten was in the purple coat, so she puts it back in one of the pocket of her *green* coat. Now Suzy comes into the room and starts to look for her mittens. She checks the pocket of her purple coat, and finds her right mitten. She says:

"The left mitten must be in the other pocket of this purple coat!"

Why does Suzy say that?

This case is complicated by the fact that the generalization used in Suzy's modal inference has been violated in reality. The child has to appreciate that Suzy doesn't know this, hence will still use that generalization. Point of view is essential here.

(d) Knowing what someone does or doesn't know

This time, both of Suzy's mittens are in the same coat, one in the left pocket and one in the right pocket. Suzy checks one of the pockets of her purple coat, but you can't see what she's found there. Suzy says:

"The right mitten must be in one of the pockets of my green coat"

What did Suzy find in the pocket?(nothing, neither the left mitten nor the right mitten)

What if she says:"The right mitten must be in my purple coat"

What did Suzy find in the pocket? (the left mitten, not the right one)

What if she says:"The right mitten is in my purple coat"

What did Suzy find in the pocket?

(possibly the left mitten, more probably the right one)

The reasoning that is required to pass this test is again rather complicated. Here are some of the steps:

- Understanding Suzy's utterance: She says (roughly) that she has evidence implying that the right mitten is in her purple coat.
- Assuming that Suzy is speaking truly.
- Reconstructing the evidence that Suzy was relying on when she drew her inference. This is the really difficult part.

5) "Must" as epistemic versus deontic:

This experiment allows us to tell by eliciting the child's justification whether the child interprets the "must" as an epistemic or as a deontic modal. A child who lacks the epistemic reading can provide a justification for the statement as a deontic modal. This study was also piloted successfully last summer, but with older children aged 4-5 years, and at that time we required the child to point to one of two alternative speakers. The results suggested a possible bias towards deontic interpretations. We have thus streamlined the task requirements.

Props: stories with pictures illustrating the scenes.

a) The painter has just painted this room. He didn't want anyone to go in the room and mess up the paint, so he put a little alarm in each of the rooms so that a light would go red if someone went in. See? It's white right now, but if anyone goes in---RED!

This painter's going to sell the house he was painting. He is showing this woman around who wants to buy the house. Then they come to the hall outside the room he was painting. The painter says to the woman:

"Nobody must be in there" WHY?

OR:

"There must be nobody in there" WHY?

b) There is an apple tree orchard and these kids are picking apples. Their Mom notices an apple that is high up – really dangerous to try to get that one! She says:

"There must be nobody who can climb up that high". WHY?

OR

"Nobody must climb up that high" WHY?

6) German epistemic modals

Our colleagues in Potsdam will be testing children's understanding of the German deontic/epistemic contrasts (Red Ridinghood sentences) mentioned in section 2 above. German has a whole series of such contrasts with epistemic modals classifying evidence in ways known from typical evidentials (see Palmer 1986, Westmoreland 1998):

- (1) a. Das Rotkäppchen hat ihre Oma besuchen dürfen.
The Red Ridinghood has her Grandma visit may
Red Ridinghood was allowed to visit her Grandma.
- b. Das Rotkäppchen dürfte den Wolf besucht haben.
The Red Ridinghood might the wolf visited have
Red Ridinghood probably visited the wolf.
- (2) a. Das Rotkäppchen hat ihre Oma besuchen sollen.
The Red Ridinghood has her Grandma visit shall
Red Ridinghood was supposed to visit her Grandma.
- b. Das Rotkäppchen soll den Wolf besucht haben.
The Red Ridinghood shall the wolf visited have
Red Ridinghood is said to have visited the wolf.

Here, too, we expect young children to understand the epistemic modals in the (b) sentences as root modals. In addition to providing intriguing root/epistemic contrasts, the lexical differences between different epistemic modals in German can be used in tasks testing children's ability to classify evidence as more or less reliable, mere hearsay, etc.

7) Perception verbs: "see"/"see that"

Our earlier work has been extensively concerned with complementation under mental verbs, and we have a rich background set of experimental results on the stages of development between 3 and 8. We intend to use tasks derived from those studies (see introduction) as part of the battery of tasks in this study. As mentioned above, with the verb "see", the type of complement has different entailments: "She saw Fred swim" is a direct, epistemically neutral perception report that entails that she saw an event of Fred's swimming without entailing that she knew that that's what she saw. She might have thought it was just a log floating in the water. In contrast, for "She saw that Fred swam" to be true, it's sufficient that she saw his wet bathing trunks in the bathroom, for example. Moreover, "she saw that Fred swam" entails that she knew that Fred swam. Obviously, testing these differences rests on all the kinds of skills we have just encountered, including awareness of how knowledge is acquired by drawing inferences from direct evidence (in this case perceptual evidence), appreciation of the fact that different people might have different pieces of evidence available to them, and ultimately awareness that different people might come up with different interpretations of the evidence they have. Before embarking on more complicated tasks, we have to ensure that the child has the prerequisite abilities for judging line of sight of characters, so we include that as a control condition.

Control 1: Check first: the child can appreciate *privileged access*: one doll looks in box, one does not. Who can see what is in the box? Who can't see what is in the box?

Control 2: More sophisticated: line of sight appreciation

Girl outside, looking at house. Daddy is in window, other objects not in line of sight. (cardboard models)

Can the girl see the daddy? Can the girl see the cat? (cat is below window level)

Can the girl see the table? (below window level)

"See" : Direct/indirect perception contrast

Establish facts e.g. who lives in house etc.

Here they are in the morning. The girl passed by on her way to school. She waved at Bill.

Did the girl see Bill eating breakfast? Did the girl see Bill eat breakfast?

Did the girl see that Bill ate breakfast?

Now Bill has left for work and left his dishes on the table. His wife Sally comes in from the store and sees them. Did Sally see Bill eating breakfast

Did Sally see Bill eat breakfast? Did Sally see that Bill ate breakfast?

“See” : Transparency / Opacity contrast

Our previous work on how children understand referential opacity finds it to be late-acquired, but the only intensional contexts explored have been those that involved a point-of-view difference between characters. Children do not begin to understand referential opacity until they pass false belief tasks and appreciate differences in the contents-of-other-minds (for belief states, see deVilliers, Pyers and Broderick, 1997; de Villiers and Fitneva, 1996; for desire states, see de Villiers, Segal, Feldman and Broderick, 1999). But might they appreciate referential opacity of epistemics, without the point-of-view requirement, at an earlier stage? To this end we will pursue an experiment modeled on this previous work that compares substitution under the verb “see” as either a direct or indirect perception verb.

Imagine a character who is Joe's doctor, but he is also Sally's father.

The direct perception reports are fully amenable to substitution of extensionally equivalents, regardless of Joe's knowledge state:

- (3) Joe saw his doctor skate on the pond
- (4) Joe saw Sally's father skate on the pond

In indirect perception reports, extensionally equivalents can be less easily substituted without additional inferences; one can easily imagine scenarios where (5) is true, but (6) is false, for example:

- (5) Joe saw that his doctor skated on the pond
- (6) Joe saw that Sally's father skated on the pond

But the scenarios that most readily come to mind are those that involve Joe not knowing that his doctor is the same person as Sally's father, thus making this a case where unshared evidence, that is, a difference in point-of-view, is involved. How do we test the resistance to substitution of extensionally equivalents without introducing an ignorant character? One way is to ask for a justification of the claim, e.g. ask “How come?” after (5) and (6). The nature of the evidence presented should be different in the two cases e.g.

- (7)because Joe saw those fancy skates in the doctor's office.
- (8)because Joe saw his big skates next to Sally's.

The experiment will be extended to cover cases of substitution of extensionally equivalent event descriptions, a technique used successfully in Fitneva & de Villiers (1999). Imagine two acts: a boy waters the flowers and in doing so, knocks them over. Again, the evidence for (11) and (12) can be made distinct so that the justification can be distinguished.

- (9) Did the girl see the boy water the flowers?
- (10) Did the girl see the boy knock over the flowers?

- (11) The boy's mother sees that he watered the flowers.

(12) The boy's mother sees that he knocked the flowers over.

How come?

5. Plan for proposed study

We will study children between the ages of 2 and 1/2 to 5 years, with the major focus being on children between 3.5 and 4.5 years of age, the critical age bracket for the "false belief" change. In the first year, we will do individual studies as described above, with multiple examples, to allow us to identify the best age range for the tasks, and select the best examples among the materials. In this year we will also begin the collaborations on German and Spanish that allow exploration of contrasts in structure not presented in English. In the second year the main study will follow a small group of 10-12 children over the course of one year, testing each child at four time intervals. In those four testing periods, we will have the child complete a series of tasks designed to examine the interrelationships of cognitive and linguistic understanding of evidence, possibility, point of view, true and false beliefs. In addition to the materials above, children will receive as part of the battery the following tasks from our earlier work to allow us to map these new developments onto the developments involving Theory Of Mind, such as briefly outlined in the introduction.(see de Villiers and Pyers, 1997; de Villiers and de Villiers, in press).

- Memory for complements.
- Mental verb/complement elicitation.
- Standard False Belief tasks: Unseen Displacement and Unexpected Contents.

In this way we can trace the change in an individual child's understanding of belief states and check the consistency of those changes across the group. In each time interval the child will receive a series of tasks that are variations only in particular content from the other time intervals, and the contents will rotate across the subjects with three subjects receiving one set in any given time interval, in a Latin Square design. The third year will allow testing observations that result from these two years of empirical findings, and exploring their relation to the work in German and Spanish. We can begin to check the reliability of the findings from year 2) cross-linguistically.

Year 1:

- For experiments described above: Develop materials, make pictures and scenarios, pilot test on adults and 5 year olds.
- Conduct experiments described above with samples of 25-30 children in each study, most likely aged 3-5 years.
- Explore contrasts in German and Spanish with help of native speakers. Design materials and pilot test contrasts with graduate students in Potsdam, Konstanz (German) and Toronto (for access via Perez-Leroux, to Spanish speakers).

Year 2:

- After selecting materials from year 1, conduct longitudinal study on 12 children from Smith college Campus school, testing four times: October, January, May and September.
- Do selected related studies in German, Spanish.
- Write up/present initial studies.

Year 3:

- Conduct follow up studies in English based on results
- complete work in German, Spanish through collaborations.
- Write up results from year 2.

- Present results at major conferences.

6. Collaboration and impact

Jill de Villiers and Tom Roeper have been collaborating on common projects and papers for many years. Collaboration with Angelika Kratzer started through the NIH contract with Harry Seymour, Department of Communication Disorders at UMASS Amherst, where de Villiers and Roeper are Co-PIs and Kratzer is a consultant (see biographical sketches). Roeper, de Villiers and Kratzer, and a group of graduate students from UMASS have been meeting for about a year regularly at Smith College or UMASS to discuss the acquisition of embedded sentences. A mini-workshop on the same topic with about 15 graduate students was held last May at Smith College to mark the end of a UMASS graduate seminar about the semantics of embedding. Given the nature of the undergraduate and graduate programs at Smith College and at UMASS, students are typically directly involved with ongoing research. Apart from their relevance for ongoing Theory of Mind research, experimental results about how children understand sentential complements of increasing complexity are obviously relevant for educational purposes. They should also be relevant in the legal domain. In court proceedings of various kinds, crucial evidence often depends on reports made by children. A clear understanding of how children talk about evidence accessible to them and others should help with assessing the reliability of what they say.

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