Romanian 5-year-olds derive global but not local implicatures with quantifiers embedded under epistemic adverbs: Evidence from a shadow play paradigm[1]

Adina Camelia BLEOTU — *ZAS Berlin, University of Bucharest*
Anton BENZ — *ZAS Berlin*
Nicole GOTZNER — *University of Potsdam*

Abstract. Our paper investigates the rates with which Romanian 5-years-olds and adults derive local and global implicatures. We test a novel combination of multiple scalar terms, where quantifiers are embedded under epistemic adverbs such as *Poate că unii câini sunt albaştri* 'It is possible that some dogs are blue.' In our study, we employ a shadow play paradigm, where participants reward a baby dragon for his guesses about various silhouettes of animals hiding behind a curtain. Such a paradigm creates a situation of indirect access, which makes epistemics adequate in the context. Both Romanian adults and children derived few local implicatures but a considerable number of global implicatures, especially *not-certain-some* global implicatures, where *possible* is strengthened to *not certain*. We observed an interaction of group and implicature type with children deriving fewer global implicatures than adults. Our findings are more compatible with a pragmatic account of implicatures than a grammatical one. Moreover, they are in contrast with previous work by Bill (2017) and Bill et al. (2021), who found that children derived more local implicatures than adults (~50%), but few global ones. We take our results to suggest that local implicature rates may decrease when the embedded scalar terms do not belong to the same scale as the non-embedded ones, but rather to different scales (<*certain, possible*>, <*all, some*>). We also explore other possible explanations for the low local implicatures rates in terms of the role of uncertainty and the role of the *possible/certain* contrast as a question under discussion.

Keywords: global implicatures, local implicatures, epistemic adverbs, quantifiers, language acquisition, Romanian

1. Introduction

Previous research on local implicatures has mostly looked at quantifiers embedded under other quantifiers, such as <*all, some*> (Geurts & Pouscoulous, 2009), <*every, some*> (Bill, 2017; Bill et al., 2021; Chemla & Spector, 2011) or <*each, some*> (Gotzner & Benz, 2018). However, quantifiers embedded under modals have only scarcely been investigated from a pragmatic perspective (see Geurts & Pouscoulous, 2009 for an exception). Moreover, previous research has mostly focused on adults, and only a few studies have investigated whether children derive local implicatures (Bill, 2017; Bill et al. 2021), and even then only for quantifiers embedded under quantifiers (<*every, some*>). In the current paper, we address these gaps in the literature,

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investigating how quantifiers embedded under epistemic adverbs are interpreted by Romanian children and adults. In particular, we are interested in whether children and adults derive (global/local) implicatures to an equal extent. As we show in the following, our novel test cases provide insights into theoretical accounts of implicature and the question of why children often struggle to derive implicatures.

2. Background on implicatures with multiple scalar terms

2.1. Implicatures with one or multiple scalar terms and how to derive them

Scalar implicatures have been defined as inferences that we draw in conversation by adhering to or violating conversational maxims (Grice, 1989). Such inferences can arise for simple utterances involving only one scalar term, or for more complex utterances involving multiple scalar terms.

An utterance containing a single scalar term such as (1) can receive either a logical/semantic reading, where *some* is understood as meaning 'some, possibly all' or a pragmatic/implicature reading, where *some* is strengthened to 'not all'.

(1) The pig carried some of his rocks.

Two main accounts have been proposed for implicature derivation: a Gricean account and a grammatical account. According to the ***Gricean account*** (Grice, 1989; Horn, 1972), the fact that the speaker did not choose a more informative utterance leads the hearer to infer that he thinks the more informative sentence is false. Thus, the stronger utterance *The pig carried all of his rocks* is considered false by the speaker. According to the ***grammatical account*** (Chierchia, 2004; Chierchia, Fox & Spector, 2012), scalar inferences are derived through a covert exhaustivity operator *exh* (equivalent to silent *only*) which affirms a proposition and excludes its stronger alternatives, see (2).

(2) exh (the pig carried some of his rocks) = the pig carried some of his rocks &
¬ (the pig carried all of his rocks)
Alt = {*the pig carried **some** of his rocks, the pig carried **all** of his rocks*}

The picture becomes more complicated for utterances containing multiple scalar items such as (3), which can receive a semantic interpretation where *some* is read logically as 'some, possibly all' (3a), a global implicature reading, which negates the alternative utterance as a whole (3b), and a local implicature reading, which strengthens *some* to 'some, not all' (3c):

(3) Every pig carried some of his rocks.
   a. **Semantic**: Every pig carried some and possibly all of his rocks.
   b. **Global implicature**: Not every pig carried all of his rocks.
   c. **Local implicature**: Every pig carried some, not all of his rocks.

The Gricean account derives global implicatures in a similar fashion to simple scalar implicatures. The grammatical account, on the other hand, derives them by applying the exhaustivity operator *exh* to the whole sentence:

(4) exh (every pig carried some of his rocks) = every pig carried some of his rocks & ¬ (every pig carried all of his rocks)
Alt = {***every*** *pig carried* ***some*** *of his rocks,* ***every*** *pig carried* ***all*** *of his rocks}*

Since Gricean reasoning applies to whole utterances, global implicatures are easily derived in the ***Gricean account***. However, local implicatures are more problematic, as it is not clear how Gricean reasoning affects embedded sentences, and there is no general mechanism for deriving both local and global implicatures in the Gricean framework. Various explanations have been proposed in the literature. According to one such explanation, local implicatures are the result of prosodic cues such as stress on *some,* i.e., *SOME* in *Every dog carried SOME of his bones* (Geurts & van Tiel, 2013). According to another explanation, local implicatures are not implicatures but readings which arise if certain plausible pragmatic assumptions are met (Geurts & Pouscolous, 2009). A Gricean account would thus capture global and local implicatures by resorting to two different mechanisms. In contrast, in the ***grammatical account*** local implicatures can be derived via the same mechanism of exhaustification as global implicatures. The sites for exhaustification differ for the two implicature types. Whereas global implicatures are derived by applying the exhaustivity operator *exh* to the whole utterance, local implicatures are derived by applying *exh* below the first scalar item:

(5) every pig exh (carried some of his rocks) = every pig did not carry all of his rocks
=> None of the pigs carried all of their rocks.

While both types of implicatures are derivable theoretically, empirically, adults generally seem to derive global implicatures more than local implicatures. The local implicature rates are rather low, especially in truth value judgment tasks and with quantifiers like *each* and *some*. Geurts & Pouscoulous (2009) conclude that participants produce very few local implicatures, using various experimental methods (inference task, verification tasks) in both upward entailing and downward entailing contexts. On this basis, they argue that, since exhaustification does not seem to apply in embedded contexts, it must be the case that implicatures should not be accounted for through exhaustification at all. Instead, according to Geurts & Pouscoulous (2009), the results are more in line with a pragmatic account, which predicts global implicatures for utterances with multiple scalar items, but no local implicatures. However, local implicatures have been found to be obtained at higher rates in other tasks. Using a picture selection task, Clifton & Dube (2010) show that participants most commonly pick both pictures corresponding to local implicatures and global implicatures. Moreover, using a rating task, Chemla & Spector (2011) show that adults derive local implicatures for *Every letter is connected to some of its circles.* Gotzner & Benz (2018) also show high rates of local implicatures in an interactive game-theoretic reward task which satisfies Grice's conversational requirements for implicature generation (i.e., a talk exchange with a specific purpose/direction). Based on these findings, we would thus expect Romanian adults to derive (at least some) local implicatures in embedded contexts in a shadow play reward task.

2.2.Scalar items embedded under modals and local implicatures

While most of the literature on global and local implicatures focuses on quantifiers embedded under quantifiers, utterances containing quantifiers embedded under modal items have received little attention from a pragmatic perspective. Nevertheless, embedding scalar items under

modal items rather than under quantifiers may affect the rates of local implicatures. Given that it is generally important for the speaker to be certain of what he/she is saying, a speaker's uncertainty about an utterance may cancel all local implicatures in a Gricean framework involving knowledgeability. However, no experimental study has been conducted for scalar items embedded under uncertainty adverbs. Previous studies only look at scalar items embedded under belief verbs and certainty adverbs and argue that these give rise to local implicatures. In an experimental investigation of simple and local implicatures, Geurts & Pouscoulous (2009) find that French-speaking adults derive more local implicatures with *some* when embedded under *think* (65%) than under *want* (32%) or *all* (0%) or *has to* (0%). The high rate of local implicatures for *think* compared to the other items is explained by Geurts & Pouscoulous (2009) within a non-grammatical account by embracing the background assumption that the subject is opinionated regarding the strong alternative to the embedded clause (Russell, 2006). Given the neg-raising nature of *think*, enabling the inference from *Betty does not think p* to *Betty thinks (not p)*, it is possible to go from *Either Betty thinks p or Betty does not think p* to the additional assumption *Either Betty thinks p or Betty thinks (not p)* (6):

(6) Betty thinks Fred heard some of the Verdi operas.
Additional assumption: Either Betty thinks that Fred heard all of the Verdi operas or she thinks that he didn't hear them.
Inference: Betty thinks Fred didn't hear all of the Verdi operas.

However, a similar assumption cannot be made for structures with disjunction embedded under *certain* (see (7)), according to Sharvit & Gajewski (2008) and Gajewski & Sharvit (2012). Given that *certain* does not license the inference from *John is not certain that p* to *John is certain that (not p)*, one cannot go from *Either John is certain that p or John is not certain that p* to *Either John is certain that p or John is certain that (not p)* (as John may be uncertain about p):

(7) John is certain that the boss or her assistant disappeared.
   a. **Local implicature**: John is certain that the boss or her assistant, but not both, disappeared.
   b. **Global implicature:** John is not certain that the boss and her assistant both disappeared.
   c. **Additional assumption**: Either John is certain that both the boss and her assistant disappeared, or he is not certain.

Thus, they reject the non-grammatical account provided by Russell (2006) for *certain*, arguing instead for a grammatical account relying on exhaustification.

It is important to bear in mind that Geurts & Pouscoulous (2009) and Sharvit & Gajewski (2008) and Gajewski & Sharvit (2012) focus on adults: Geurts & Pouscoulous (2009) present experimental results from French adults, while Sharvit & Gajewski (2008) and Gajewski & Sharvit (2012) rely on their own adult intuitions. However, it is not clear whether these conclusions carry over to children, whose pragmatic mindset differs from adults.

2.3.Implicatures in child language

2.3.1. Implicatures with quantifiers in child language

Most of the research on implicatures with quantifiers in child language focuses on simple scalar implicatures, i.e., implicatures that obtain in utterances with one single scalar item. Experimental studies in language acquisition show that children accept underinformative simple scalar sentences to a higher degree than adults (Guasti et al., 2005; Noveck, 2001; Papafragou & Musolino, 2003; a.o.). Despite this general consensus, children's behaviour seems to vary with the scalar items in the sentence, as well as with the type of task used. Scale-wise, children derive implicatures the most with cardinal numbers (Papafragou & Musolino, 2003; Bleotu, 2021b). From the point of view of task sensitivity, children have difficulties with binary judgment tasks. However, they are more adult-like in act-out tasks, where they have to perform an activity to make a statement true (Pouscoulous et al., 2007) or reward a character in various ways (Katsos & Bishop, 2011). According to Katsos & Bishop (2011), binary tasks fail to capture children's performance: children's acceptance of underinformative sentences does not necessarily mean that they fail to derive implicatures, but rather that they are tolerant of underinformativity. A ternary reward task where children must give rewards (strawberries of various sizes) for underinformative, fully informative or false statements shows that children are sensitive to underinformativity. Experiments on existential quantifiers in Romanian also suggest that children generally accept underinformative scalar sentences more than adults. Using a felicity judgment task, Stoicescu, Sevcenco & Avram (2013, 2015) found that preschoolers were logical in 90% of the cases. No difference was noticed between *unii* "some$_1$" and *câţiva* "some$_2$". Bleotu (2021a) investigated implicatures with existential quantifiers for Romanian 7- and 9-year-olds and found that children become less accepting of underinformative sentences as they grow older: while 7-year-olds reject underinformative sentences with a rate of 38.5%, 9-year-olds reject them with a rate of 60.5%, close to adults (74.5%). Importantly, however, there is variability in performance depending on the task. Bleotu (to appear) found that Romanian 5-year-olds had a high (adult-like) rate of implicatures in coloring and erasing tasks, as opposed to truth value judgment tasks or picture selection tasks. These results support the general findings about implicatures and task sensitivity.

While most of the literature on implicatures in child language focuses on simple scalar implicatures, recent work by Bill (2017) and Bill et al. (2021) investigates implicatures for utterances containing multiple scalar items, showing that children prefer local implicatures, while adults prefer global implicatures. Bill (2017) tested monolingual English-speaking children and adults, using different stories. In one such story involving three pigs, each pig had in front of him a set of four rocks, and they could decide how many they would carry (Figure 1). After all the pigs had made their decision, the experimenter asked the puppet what happened, and the children judged the puppet's answer (8) as right/wrong and explain their judgment.

(8) Every pig carried some of his rocks.

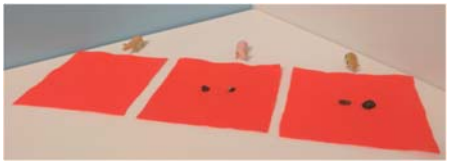

Figure 1. Example of a set-up in Bill (2017)

Bill's (2017) experiment shows that, for both children and adults, 50% of their answers were literal/semantic readings. The remainder of the answers given by children and adults were implicatures, but while adults derived global implicatures children derived local implicatures. The results are taken to suggest a grammatical account of implicature derivation, with exhaustification as the first stage in acquisition. In addition, Bill (2017) argues that the reason for children deriving local implicatures may be the fact that they can lexically access both scale mates (<*every, some*>) in the same utterance (e.g., Barner et al., 2011; Tieu et al., 2016; Gotzner et al., 2020). Children's ease with local implicatures may thus be explained within an **alternative-based account**. However, this explanation is dismissed by Bill et al. (2021), who conducted another experiment where they tested children's derivation of simple scalar implicatures and showed that children did not derive significantly more implicatures in <*every, some*> sentences than in sentences containing only one quantifier. This led Bill et al. (2021) to reject the alternative-based account and argue that children and adults are guided by different principles. Adults abide by the *Principle of Charity* (Grice, 1975), a principle which leads them to prefer interpretations that make sentences true in context (global implicatures). In contrast, children observe the *Subset Principle* (Crain et al.,1994; Crain & Thornton, 1998), a principle which leads them to prefer stronger (subset) interpretations over weaker (set) ones, i.e., local implicatures over global ones.

2.3.2. Implicatures with epistemics in child language

As far as epistemics are concerned, children seem to be sensitive to their relative strength from early on, being aware of the existence of a modal scale and deriving implicatures where they strengthen epistemic *may* to epistemic *must/has to* (Hirst & Weil, 1982; Noveck, Ho & Sera, 1996; Noveck, 2001; Ozturk & Papafragou, 2015; a.o.). From a methodological point of view, most of the experiments on epistemic modality rely on some version of the *hidden-object paradigm*, and, more specifically, *the hidden-box paradigm* developed initially by Noveck, Ho & Sera (1996) and Noveck (2001), either in its more complex form, or in a simplified/adapted version (Moscati, Zhan & Zhou, 2017; Ozturk & Papafragou, 2015). Participants must infer whether a certain object/animal is in a certain box or not, based on evidence. While children generally handle epistemic modals adult-like (both semantically and pragmatically), the modal system is not fully in place: 5-year-olds sometimes accept overly strong statements with *must/has to* over pragmatically adequate ones with *may*. This can be explained through *premature closure* (Acredolo & Horobin, 1987), a tendency to 'reduce' uncertainty to certainty.

Interestingly, most of the experiments on epistemic modality focus on modal verbs. However, as shown by Cournane (2015, 2021), looking at modal verbs might give a deceptive picture about children's epistemic abilities given that modal verbs might be more challenging for children for other reasons than cognitive ones (the ambiguity between root and epistemic readings, as well as their interaction with tense and aspect, see also Hacquard 2006, 2009). In contrast, epistemic adverbs are semantically unambiguous (always epistemic), and they occur in children's speech even prior to the first uses of modal verbs. In Romanian, epistemic modal verbs are also much less frequent than epistemic adverbs (Avram & Gaidargi, 2021). In particular, epistemic *trebuie* 'must' is hardly ever used by adults or children. For these reasons, the experiments previously conducted in Romanian, as well as the current experiments look at utterances which employ epistemic adverbs rather than verbs. Using a coloring task, Bleotu (2019) shows that Romanian 5-year-olds master the meaning of *poate* 'possibly' and *sigur*

'certainly': children vary in their coloring responses for *Poate că pantalonii sunt roşii*, 'It is possible that the trousers are red', using either the color mentioned or another color, while always using the color mentioned for *sigur* 'certainly'. Similar results indicating children's sensitivity to modal strength are obtained by Gaidargi (2019). However, in a modified version of Noveck (2001), Bleotu (2019) finds that children do not derive implicatures at this stage. Moreover, they often reject sentences with *sigur* 'certainly' even when appropriate, similarly to adults, who show caution, saying they cannot trust what they cannot see. So as to prevent overly cautious answers because of lack to access the object of inquiry, Bleotu, Benz & Gotzner (2021b) investigate implicatures with *poate* 'possibly' for Romanian 5-year-olds through a *shadow play paradigm*, which takes inspiration from Heizmann (2006). In the shadow play paradigm, the object is no longer fully inaccessible: participants can see the silhouette of the animal (see Figure 2) and hear its specific sounds. Such (visual and auditory) evidence serves as additional support for epistemic inferences, preventing caution. Taking Katsos & Bishop (2011)'s ternary reward task as a starting point, the experiment was implemented in PCIbex (Zehr & Schwarz, 2018) as a binary reward task where a wizard asks two baby dragons to say who they think the silhouette belongs to, and participants must reward them with a big apple if their statements (see (9)) are the best description of the situation, and a small apple otherwise. The best description was used as a reward criterion, based on previous findings in Bleotu, Benz & Gotzner (2021a), where participants derived more implicatures when they rewarded *the best description* rather than *the right/wrong description.*

(9) Poate că câinele este albastru.
possibly that dog-the is blue.
'It is possible that the dog is blue.'

Figure 2. Example picture for the shadow play paradigm

In Bleotu, Benz & Gotzner (2021b), Romanian 5-year-old children derived scalar implicatures with a rate of 49.28%, while Romanian adults derived them with a rate of 66.18%. In addition, children rewarded overly strong statements with big apples more than adults. This can be explained by premature closure (Acredolo & Horobin, 1987): given their minimal representations of possibility, children commit to only one possibility, unlike adults, who have modal representations of possibility. These results are in line with previous findings and proposals from Noveck et al. (1996), Ozturk & Papafragou (2015), Robinson et al. (2006), Moscati, Zan & Zhou (2017) and Leahy & Carey (2020).

3. Current experiment

3.1. Aim

In the current experiment, we investigate Romanian children's and adults' ability to derive local and global implicatures in utterances that embed the quantifiers *unii* 'some' and *toţi* 'all' under the epistemic adverbs *sigur* 'certainly', *poate* 'possibly'.

3.2.General expectations

We test the hypothesis that quantifiers embedded under epistemic adverbs behave identically to quantifiers embedded under other quantifiers. If they pattern alike we expect Romanian children to show a preference for local implicatures, while failing to derive global implicatures, as in Bill (2017) and Bill et al. (2021). The results would then favor a grammatical account of implicature derivation, with exhaustification as the first stage in acquisition. However, quantifiers embedded under epistemics may lead to a different response pattern than quantifiers embedded under other quantifiers. Several factors may affect (local) implicature rates. On the one hand, if the alternative-based account is correct and children derive more local implicatures when they have lexical access to both scale mates in the same sentence (according to Bill 2017 but not Bill et al. 2021), then children should have difficulties with local implicatures in our experiment. On the other hand, uncertainty may play an important part: if epistemics trigger uncertainty, children may find it hard to derive (any) implicatures at all.

3.3.Participants

32 Romanian monolingual adults and 30 Romanian monolingual 5-year-olds (14 male & 16 female; age range: 5-5;11, mean: 5;8) took part in the experiment.

3.4.Procedure and materials

Following Bleotu, Benz & Gotzner (2021a, b), we employed a shadow play paradigm, where participants see silhouettes of animals hiding behind a curtain and hear their specific sounds, and they have to reward a baby dragon with a big apple if his statements about the shadows are the best description of the situation, and a small apple otherwise. The paradigm makes the use of epistemic adverbs legitimate by providing indirect visual cues.

The materials involved three (true and false) trial sentences about bunnies, where participants got accustomed to the shadow play paradigm, and a randomized list of seventeen critical sentences per group of animals (dogs, frogs, cats, cows), where the quantifiers *unii* ‘some’ and *toţi* ‘all’ were embedded under the epistemic adverbs *poate* ‘possibly’ or *sigur* ‘certainly’, see (10). The sentences were organized in four scenarios testing participants’ ability to reason that a situation has multiple alternatives or only one. Regarding the adverb (possibility/certainty adverb), nine sentences contained *sigur* ‘certainly’ and eight contained *poate* ‘possibly’. Regarding informativeness, there were five fully informative sentences, six underinformative sentences, six non-informative sentences, out of which four were overly strong, using a stronger scalar item than needed. The scenario-sentence pairings distinguished among semantic answers/local/global implicatures: participants were expected to reward a certain kind of interpretation differently from the other two. For instance, one reading would lead to a big apple reward, while the other two would lead to small apple rewards. The four scenarios were presented two at a time (Scenarios 1 and 2, and Scenarios 3 and 4).

(10) Poate / Sigur că unii / toţi câini sunt albaştri / galbeni.
possibly / certainly that some / all dogs are blue yellow
‘It is possible that some dogs are blue/yellow.’

In all scenarios, participants see the silhouettes of two pairs of animals (i.e., four animals) in the spotlight behind the curtain, and they have to infer their identity. The scenarios differ in the situations they create. **Scenarios 1** and **3** are indeterminate scenarios, allowing multiple possibilities for the identity of the silhouettes, while **Scenarios 2** and **4** are determinate scenarios, where the silhouettes can only belong to certain pairs of animals. For example, in the dog version of the experiment, participants are introduced to four pairs of dogs (two pairs of yellow dogs, i.e., four yellow dogs, and two pairs of blue dogs, i.e., four blue dogs). The four pairs of dogs (i.e., the eight dogs) go behind the curtain. In **Scenario 1 (*Two in front*)**, two yellow dogs come in front of the curtain. There are six more dogs behind the curtain, but participants see the silhouettes of only four of them. Scenario 1 tests participants' understanding of alternatives, their ability to reason that the situation has two possible outcomes: (i) either the silhouettes belong to four blue dogs, or (ii) they belong to two blue dogs and two yellow dogs. The sentences in Scenario 1 are schematically depicted in Table 1. Each sentence-scenario pair represents one experimental item.

Table 1. Sentences tested in Scenario 1. *Legend: S = sentence, CERT = certain, INFO = informative, UNDER-INFO = underinformative, NON-INFO = non-informative, referring to a different set, OVERLY STRONG = non-informative, using a stronger scalar term instead of the pragmatically adequate weak term*

SCENARIO 1 *(Two in front)*							
SCERT.SOME (YELLOW DOGS)	SPOSSIBLE.SOME (YELLOW DOGS)	SPOSSIBLE.SOME (RED DOGS)	SPOSSIBLE.ALL (YELLOW DOGS)	SCERT.SOME (BLUE DOGS)	SPOSSIBLE.SOME (BLUE DOGS)	SCERT.ALL (BLUE DOGS)	SPOSSIBLE.ALL (BLUE DOGS)
OVERLY STRONG NON-INFO	INFO	NON-INFO	OVERLY STRONG NON-INFO	INFO	UNDER-INFO	OVERLY STRONG NON-INFO	INFO

Figure 3. Example picture for Scenario 1

Figure 4. Example picture for Scenario 2

In **Scenario 2 (*Four in front – same color*)**, two more yellow dogs come in front of the curtain in addition to those in Scenario 1, leading to four yellow dogs (Figure 4). Scenario 2 (Table 2) tests whether participants can reason that the four silhouettes can only belong to four blue dogs.

Table 2. Sentences tested in Scenario 2

SCENARIO 2 (*Four in front – same color*)				
SPOSSIBLE.SOME (BLUE DOGS)	SCERT.ALL (BLUE DOGS)	SCERT.SOME (YELLOW DOGS)	SPOSSIBLE.ALL (BLUE DOGS)	SCERT.SOME (BLUE DOGS)
UNDER-INFO	INFO	NON-INFO	UNDER-INFO	UNDER-INFO

In **Scenario 3 (*None in front*)**, there are no dogs in front of the curtain (Figure 5). The four dog silhouettes in the spotlight could belong to any of the eight dogs in the game. Thus, Scenario 3 (Table 3) tests whether participants understand that several alternatives are possible: either (i) the silhouettes belong to four blue dogs, (ii) four yellow dogs, or (iii) two blue dogs and two yellow dogs. In **Scenario 4 (*Four in front – mixed colors*)**, four dogs come in front of the curtain: two blue dogs and two yellow dogs (Figure 6). Scenario 4 (Table 4) tests whether participants can infer that the four silhouettes can only belong to two blue dogs and two yellow dogs.

Figure 5. Example picture for Scenario 3

Figure 6. Example picture for Scenario 4

Table 3. Sentences tested in Scenario 3

SCENARIO 3 *(None in front)*	
SPOSSIBLESOME (BLUE DOGS)	SCERTALL (YELLOW DOGS)
UNDER-INFO	OVERLY STRONG NON-INFO

Table 4. Sentences tested in Scenario 4

SCENARIO 4 (***Four in front – mixed colors***)	
SPOSSIBLESOME (BLUE DOGS)	SCERTSOME (BLUE DOGS)
UNDER-INFO	INFO

By rewarding one interpretation differently from the others, **Scenarios 1 and 2** tease apart semantic readings, local implicatures and global implicatures, while **Scenarios 3 and 4** tease apart different types of global implicatures. For instance, we were able to differentiate between the semantic reading and the local and global implicature readings for the pairing of the utterance in (11) and the picture associated with **Scenario 2** (***Four in front – same color***; Figure 4). In this context, if participants interpret the utterance semantically, they reward the baby dragon with a big apple, if they interpret it pragmatically, deriving either a global or a local implicature, they reward him with a small apple.

(11) **Semantic reading** versus **global implicature & local implicature**
Poate că unii câini sunt albaştri.
possibly that some dogs are blue
'It is possible that some dogs are blue.'

Semantic: It is possible, maybe certain that some, possibly all dogs are blue. (big apple)
Global: Semantic + It is not certain that all dogs are blue. (small apple)
Local: Semantic + It is possible that some, not all dogs are blue. (small apple)

We distinguished the local implicature reading from the global implicature reading and the semantic reading for the pairing of the utterance in (12) and **Scenario 1** (***Two in front***; Figure 3): unlike other readings, local implicatures are rewarded with a small apple.

(12) **Local Implicature** versus **Global Implicature & Local Implicature**
Sigur că unii câini sunt albaştri.
certainly that some dogs are blue
'It is certain that some dogs are blue.'

Semantic: It is certain that some, possibly all dogs are blue. (big apple)
Global: Semantic + It is not certain that all dogs are blue. (big apple)
Local: Semantic + It is certain that some, not all dogs are blue. (small apple)

We also distinguished the global implicature reading from the semantic reading and the local implicature reading for the pairing of the utterance in (13) and **Scenario 2** (***Four in front – same color****;* Figure 4): unlike other readings, global implicatures receive a small apple.

(13) **Global Implicature** versus **Semantic reading (& Local Implicature)**
Poate că toţi câini sunt albaştri.
possibly that all dogs are blue
'It is possible that all dogs are blue.'

Semantic: It is possible, maybe certain that all dogs are blue. (big apple)
Global: Semantic + It is not certain that all dogs are blue. (small apple)
Local: None

Scenario 3 (*None in front*) and **Scenario 4 (*Four in front – same color*)** allowed us to further distinguish between two types of global implicatures for an utterance of the type 'It is possible that some Xs are Y': global implicatures of the type 'It is not certain that some Xs are Y' (*not-certain-some* GIs) and global implicatures of the type 'It is not possible that all Xs are Y' (*not-possible-all* GIs). Thus, in Scenario 3 (see Figure 5), *not-possible-all* GIs receive a different reward than all other interpretations for (14) (Table 5). In Scenario 4 (see Figure 6), *not-certain-some* GIs are also distinguished by reward for (14) (Table 5).

(14) ***Not-possible-all* GI** versus ***Not-certain-some* GI & Local Implicature & Semantic**
Poate că unii câini sunt albaştri.
maybe that some dogs are blue
'It is possible that some dogs are blue.'

Semantic: It is possible, maybe certain that some, possibly all dogs are blue.
Global: Semantic + It is not certain that some dogs are blue.
Semantic + It is not possible that all dogs are blue.
Local: Semantic + It is possible that some, not all dogs are blue.

Table 5. Rewards per interpretations distinguishing different types of GI

Interpretations	**Semantic**	***Not-certain-some* GI**	***Not-possible-all* GI**	**Local Implicature**
Not-possible-all GI vs. *Not-certain-some* GI & Local Implicature & Semantic	big apple	big apple	small apple	big apple
Not-certain-some GI vs. *Not-possible-all* GI & Local & Semantic	big apple	small apple	big apple	big apple

4. Results

Looking at the data from Scenarios 1 and 2, where we contrast semantic interpretations, global implicatures and local implicatures (see Figure 7), we find that 5-year-olds derive fewer global implicatures (43.18%) than adults (49.35%). In terms of local implicature rates, children overall are rather adult-like: local implicatures are equally infrequent in both groups (18.6% for children, 19.5% for adults). Statistically, we computed a logit mixed-effects model with the factors Group (Adults, Children), Interpretation (Semantic, Global Implicature, Local Implicature) and their interaction as fixed effects, and random by-item and by-participant slopes, taking as reference the Children Group and the Semantic Interpretation. The results reveal a significant effect of Group ($\beta = -0.846$, $SE = 0.183$, $z = -4.628$, $p < .01$), Local Implicature Interpretation ($\beta = -1.615$, $SE = 0.315$, $z = -5.13$, $p < .01$), Global Implicature Interpretation ($\beta = 1.025$, $SE = 0.1973$, $z = -4.738$, $p < .01$) and the interaction between Group and Global Implicature interpretation ($\beta = 0.337$, $SE = 0.122$, $z = 2.762$, $p < .01$), but no significant interaction between Group and Local Implicature interpretation.

Looking at the data for different types of global implicatures (GIs) from Scenarios 3 and 4 (see Figure 8), we find that both children and adults derive more *not-certain-some* GIs (40.17% for adults, 44.17% for children) than *not-possible-all* GIs (18.3% for adults, 13.82% for children).These results are confirmed statistically by computing a logit mixed-effects model with the factors Group (Adults, Children), Interpretation (*not-certain-some* GI, *not-possible-all* GIs), as well as their interaction as fixed effects. Thus, we find significant effects for Group ($\beta = -2.283$, $SE = 0.7123$, $z = -3.205$, $p < .01$), Interpretation ($\beta = 1.461$, $SE = 0.712$, $z = -3.205$, $p < .05$), but no significant interaction between the two.

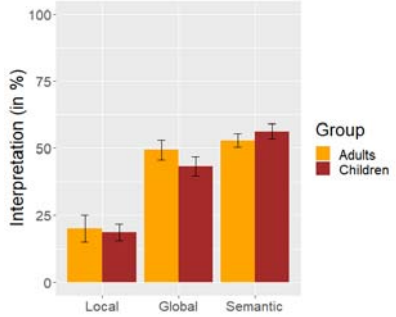

Figure 7. Interpretation by Group in Scenarios 1 and 2 (in %)

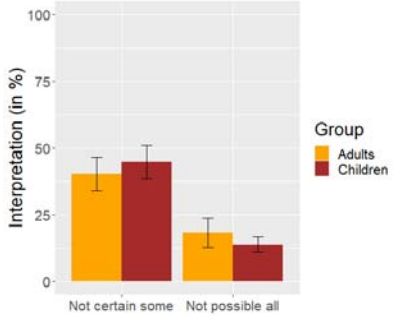

Figure 8. Global implicatures by Group in Scenarios 3 and 4 (in %)

With regard to control statements, both children and adults have generally high accuracy rates (77.72% in the case of adults, 86.88% in the case of children). Interestingly, however, accuracy is higher in non-informative statements (81.3% for adults, 90.6% for children) than in informative ones (70.57% for adults, 79.44% for children). This could be explained through participants' sensitivity to the task requirement: if the task asks participants to reward the dragon with big/small apples based on whether the sentence is *the best description* of the picture, we expect participants to sometimes consider a sentence as not the best for a variety of reasons (typicality, reference to the color). Among non-informative statements, there were purely non-informative ones, as well as overly strong sentences, where a strong scale term was used instead of a weak one (i.e., *sigur* 'certain' is used instead of the pragmatically adequate *poate* 'possible'). Interestingly, children tend to accept overly strong sentences as *the best description* to a larger extent (17.5%) than purely non-informative sentences (1.285%). This tendency can be explained by premature closure, i.e., children's tendency to prefer certainty over uncertainty (Acredolo & Horobin, 1987; Moscati, Zhan & Zhou, 2017). It can also be explained through a tendency to place a bet on a stronger alternative than the present one. The results for overly strong statements are in line with Bleotu, Benz & Gotzner (2021b), who obtained similar findings for utterances containing only epistemic adverbs.

5. Account

5.1. Why do Romanian children and adults derive global but almost no local implicatures?

Our first finding is that Romanian children and adults derive few local implicatures for utterances where quantifiers are embedded under epistemic adverbs, contrary to the proposals for adults in Sharvit & Gajewski (2008) and Gajewski & Sharvit (2012). Moreover, both children and adults seem to derive quite high rates of global implicatures. Interestingly, our results differ from Bill (2017) and Bill et al. (2021), who found that, while both adults and children gave semantic interpretations 50% of the time, they differed in the kind of implicatures they derived for the remaining 50% of the interpretations. More specifically, in their experiment, while adults derived global implicatures but no local implicatures, children derived local implicatures but no global implicatures. The contrast between our results and Bill's (2017) and Bill et al.'s (2021) results is striking. Under an account that assumes speakers should derive implicatures in a similar fashion for all types of utterances with multiple scalar items, it is indeed expected that adults should behave similarly for both utterances embedding quantifiers under quantifiers and utterances embedding quantifiers under epistemic adverbs. However, it is inexplicable why children should prefer to derive global implicatures for utterances containing quantifiers embedded under epistemics, but they should derive local implicatures for utterances containing quantifiers embedded under quantifiers. One reason for the difference in results could simply be that the children in Bill's (2017) and Bill et al.'s (2021) experiments were 4-year-olds, whereas the children in our experiments were 5-year-olds. Since ability with implicatures usually observes a gradual developmental path (interpretive preferences do not change dramatically in a single year, see Noveck 2001), we discuss other potential explanations.

5.1.1. Same sentence scale mates account

One possible explanation for the results and how they differ from Bill's (2017) and Bill et al.'s (2021) could relate to the fact that, while in Bill (2017)'s and Bill et al. (2021)'s experiments, both scale mates are present in the same asserted sentence (<*every, some*>), in our experiments, the sentences contained scalar items belonging to different Horn scales (<*certain, possible*>, <*all, some*>). Interestingly, scalar items have been shown to prime when belonging to the same scale but not across scales (Husband & Patson, 2021). This difficulty may carry over to language acquisition. According to the alternatives-based account (Barner & Bachrach, 2010; Barner et al., 2011; Tieu et al., 2016), children have difficulties accessing scalar alternatives. However, children might more readily derive inferences when they are assisted in accessing the alternatives through contexts making them relevant (Skordos & Papafragou, 2016), or easier to retrieve (e.g., when relevant alternatives are presented in the context, see Barner et al., 2011 and Gotzner et al., 2020). Nevertheless, in our experiment, the alternative relevant to the local implicature was presented in the discourse / over the course of the experiment, and yet the rates of local implicatures in children and adults were low. This suggests that mere accessibility of alternatives is not enough. It might be that a more specific same-sentence requirement is at work, leading participants to generate more implicatures for utterances which contain scale mates (<*all, some*>, <*every, some*>). This would explain the high rates of local implicatures for children in Bill's (2017) and Bill et al.'s (2021) experiments. In contrast, if the utterance contains scalar items belonging to different scales, as in our experiments (<*certain, possible*>, <*all, some*>), derivation of local implicature derivation becomes more challenging. Further support for the alternatives-based account in terms of a same-sentence requirement comes from children's performance with simple scalar implicatures with *poate* 'possibly'. If children are indeed sensitive to the same-sentence requirement for scalar items, then it should make no difference for implicature derivation whether children have access to utterances with epistemics and quantifiers or only to utterances with epistemics. Indeed, a comparison with our previous shadow play paradigm experiment testing implicatures with *poate* 'possibly' reveals similar implicature rates for children (~50%) whether exposed only to epistemic adverbs or to both epistemic adverbs and quantifiers.

However, an explanation in terms of the alternatives-based account is problematic for a variety of other reasons. One possible issue is that, although there is no <*certain, some*> Horn scale, modal items could be conceived as representing an <*all, some*> scale in the modal domain, if one adopts Kratzer's (1981) perspective upon modals as quantification over possible worlds, with *must/certain* introducing states/events true in *all* possible worlds and *may/possible* introducing states/events true in *some* possible worlds. In this case, both utterances with quantifiers embedded under quantifiers and utterances with quantifiers embedded under modals provide access to the same scale. Consequently, the differences between our results and Bill's (2017) would be in need of a different explanation. Moreover, as shown by Bill et al. (2021), a comparison between the results for utterances with the multiple scalar items <*every, some*> and the results for utterances with single scalar items reveals no significant difference between implicature rates. This casts doubt upon the same-sentence alternatives-based account as an explanation for the high local implicature rates even for utterances containing scalar items belonging to the same scale (Bill, 2017; Bill et al., 2021)[2]. It is also unclear why (same

[2] As mentioned in Section 2.3.1, Bill et al. (2021) account for the interpretive differences between children and adults in their experiment by arguing that adults abide by the *Principle of Charity* (Grice 1975), thus deriving

sentence) access to alternatives would affect local implicature rates but not global implicature rates. Taking these problematic issues into consideration, we explore other explanations.

5.1.2. Epistemics introduce uncertainty

A possible explanation for the low rates of local implicatures for both children and adults in our experiment could be the fact that epistemics introduce uncertainty, preventing local implicatures. In a Gricean framework, local implicatures may be more easily licensed in contexts where the speaker is assumed to have reliable knowledge about situations.

5.1.3. A Question Under Discussion (QUD) account

The effect of uncertainty upon interpretations could also be due to uncertainty being at issue in our experiment under a Question under Discussion (QUD) such as 'Is it certain or possible that there are blue dogs behind the curtain?'. Two aspects may contribute to this: (i) firstly, the shadow play paradigm makes the probability of certain animals being behind the curtain in the spotlight relevant in the context, (ii) secondly, the epistemic adverb is the first scalar item in all the utterances, which increases its salience. Such an explanation adds to the literature on the role of the QUD in implicatures (see Skordos & Papafragou, 2016; Zondervan, 2010).

5.2. Why do Romanian children and adults derive more global *not-certain-some* implicatures than global *not-possible-all* implicatures?

Our second important finding is that both Romanian children and adults derived more global *not-certain-some* implicatures than global *not-possible-all* implicatures. We propose that the preference to strengthen *possible* to *not certain* can also be explained within a QUD account. If we assume that the *possible/certain* contrast is more relevant/salient than the *some/all* contrast because of the experimental set-up (the shadow play paradigm) or the salience of *possible/certain* in the discourse (they occur first in all utterances), or even both, then Romanian children and adults are expected to derive more *not-certain-some* global implicatures, where the stronger alternative of *possible* is negated. We leave for future work a more in-depth investigation of sensitivity to QUD through experiments where the QUD is manipulated linguistically through questions activating the two scales (<*all, some*>, <*certain, possible*>).

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global implicatures, children observe the *Subset Principle* (Crain et al.,1994; Crain & Thornton, 1998), thus preferring stronger interpretations (local implicatures) over weaker ones (global implicatures). The Subset Principle is useful for learnability considerations, given that, if one assumes children initially prefer stronger interpretations, this means they can learn about weaker interpretations at a later stage through positive evidence. In our experiment, however, children and adults behaved similarly. Therefore, children's preference for global implicatures cannot be explained using the Subset Principle. While one could argue that, just like adults, they might observe the Principle of Charity, it is unclear why they would resort to one principle for utterances with quantifiers embedded under quantifiers but to another for utterances with quantifiers embedded under modals.

6. Conclusion

The current paper employed a novel shadow play paradigm in order to investigate how Romanian children and adults interpret quantifiers embedded under epistemic adverbs. The paradigm we used ensures indirect access to the hidden object through visual cues (silhouettes behind a curtain) and auditory cues (specific sounds), thereby creating an ideal situation for the use of epistemic adverbs. Our first finding is that, just as Romanian adults, Romanian children derive very few local implicatures. Moreover, both children and adults derive more global implicatures than local implicatures, but children seem to derive fewer global implicatures than adults. These results are in contrast with Bill (2017) and Bill et al. (2021), who found that both children and adults derive implicatures with a rate of around 50%, but that children prefer local implicatures, while adults prefer global implicatures. The data seem to suggest the need for a more careful look at utterances with multiple scalar items and the differences between them. One interesting direction is a more restricted version of the alternatives-based account, according to which children derive more local implicatures if they have access to both scale mates within the same utterance and no local implicatures otherwise. Another possible explanation is children's difficulty in handling the special nature of modality, in particular, uncertainty, which might prevent local implicatures in embedded contexts. Last but not least, the results could be explained within a QUD account that places the certain/possible contrast at issue through the experimental set-up and linguistic input. This latter account can also explain our second finding, namely, that both children and adults prefer to derive global implicatures where *possible* is strengthened to *not certain* over other global implicatures.

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