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When Negation and Epistemic Modality Combine: The Role of Information Strength in Child Language

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Negative sentences with epistemic modals (e.g., John might not come/John can not come) contain two logical operators, negation and the modal, which yields a potential semantic ambiguity depending on scope assignment. The two possible readings are in a subset/superset relation, such that the strong reading (can not) asymmetrically entails the weak reading (might not). In this situation, a potential learnability issue arises. Based on the Semantic Subset Principle, we anticipated that children’s initial interpretations would sometimes differ from those of adults because children are expected to initially prefer strong (can not) readings for sentences that convey weak (might not) readings for adults. This proposal is investigated in two experiments using Standard Italian, which is an ideal testing ground for child language, in view of its simple modal paradigm. The results of these experiments confirm the predictions of the Semantic Subset Principle. Five-year-old Italian-speaking children were found to strongly favor the scope assignment that generates strong (can not) readings, even in cases where adults strongly favor the weak (might not) scope assignment. This result is discussed in relation to some recent alternative proposals (Musolino, 2006; Gualmini & Schwarz, 2009) that do not assume any initial bias toward the strong readings.

INTRODUCTION

Human languages permit inferences about how the world might be, as well as descriptions of the way things are, or were. Modal expressions (e.g., can, might, must) are one means by which human languages refer to circumstances that extend beyond the here and now. Modals are linguistic vehicles for describing events that we believe to be likely, or at least possible, as well as events that we think will happen of necessity. Given that modal expressions refer to events that are not directly observable, it is important for our understanding of the nature of cognitive development to document how and when children master the meanings of modal expressions.

The current picture of the acquisition of modality in child language is incomplete. One unresolved issue concerns the stages at which different aspects of the meanings of modal expressions are acquired. Even the acquisition of the basic distinction between epistemic and deontic modality is poorly understood, probably because the distinction between these modalities turns on intricate differences in semantic representations which prove to be difficult to tease apart experimentally.

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Briefly, epistemic modals express the speaker’s beliefs about current states of affairs, whereas deontic modals are generally associated with rules of conduct (Lyons, 1977; Palmer, 1986; Portner, 2009). Some researchers have suggested that deontic modality is more basic and is acquired before epistemic modality (Piéraut-Le Bonniec, 1980; Wells, 1979; Perkins, 1983), whereas other researchers have reported results that are seen to support the opposite view (Hirst & Weil, 1982; Byrne & Duff, 1989).

As important as it is for language learners to understand the basic meanings (deontic vs. epistemic) of modal expressions, this is only one factor in modal development. It is likely that some of the apparent inconsistencies in the findings reported in the literature are due to experimental factors that may have been overlooked or at least were not controlled for in previous experimental studies. There are other factors that could help us gain an understanding of the acquisition of modality but which have not been investigated. One of these factors is how modals combine with other logic operators, including negation. The present study demonstrates the relevance of the interaction between modality and negation in investigating children’s early comprehension of modal expressions. To see why the interaction between modality and negation is relevant to studies of modal development, we would note first that negative statements are known to impose processing demands beyond those that are incurred with the corresponding positive sentences (e.g., Wason, 1965; Wason & Johnson-Laird, 1972). Moreover, the processing costs associated with negation in general are further exacerbated when negation is combined with modal expressions, depending on the meanings that are generated. In many languages, the interaction between modal expressions and sentential negation is governed by specific lexical restrictions on the modal paradigm. Consider, for example the English negative statements in (1) and (2), which introduce the basic opposition that will be the focus of the present article:

(1) John might not come (possible not)
(2) John can not come (not possible)

In addition to negation, both of these sentences contain a modal expression denoting possibility, might in (1) and can in (2). Although these modal expressions both precede negation in the examples, the sentences yield different interpretations. In (1), might takes scope over negation, so the meaning that is associated with (1) can be represented as possible > not. In (2), by contrast, negation takes scope over can, so the associated meaning is not > possible. Since the difference in meaning between (1) and (2) cannot be explained by differences in word order, it is generally assumed that English, and many other languages, encode certain polarity restrictions in its modal paradigm.

Polarity restrictions dictate the scope relations that must obtain between certain logical expressions and negation. They can be illustrated by a familiar restriction on how the existential quantifier some is interpreted when it appears within the scope of negation in the surface syntax. This expression is traditionally denoted as a positive polarity item, because it must be interpreted outside the scope of negation, regardless of its position in surface syntax. To illustrate, consider the sentence John did not order some dessert. The meaning of this sentence can be paraphrased as There is some dessert that John did not order. However, its meaning cannot be paraphrased

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1In some varieties of English, the indicative forms may not and can not can both express impossibility. To avoid confusion, we have chosen to use the subjunctive form might.
as *John did not order any dessert.* The semantic relationship between *some* and negation is such that if *some* appears in the scope of negation in the surface syntax, not...some, it must be ‘raised’ so as to have scope over negation (*some > not*) at the level of semantic interpretation, as indicated in (3).

(3) some dessert John did **not** order **some** dessert  

We propose a related account of the interpretation of negative sentences with modal expressions such as *might* and *can*. In particular, we propose that the modal expression *can* is associated with a polarity restriction, and that this restriction is encoded by a lexical parameter. We will call the lexical parameter R. Parameter R applies to both *can* and *might*. According to parameter R, the modal expression *might* is interpreted in its surface syntactic position with respect to negation, as illustrated in (4). So there is no polarity restriction on the modal expression *might*; its scope relationship with respect to negation is determined by the surface word order. The lack of movement is indicated by assigning the “negative” value, [-R], to *might*.

(4) John **might** not come  

By contrast, the modal expression *can* exhibits a polarity restriction, so it receives the alternative value, [+R]. In deriving negative sentences with *can*, such as *John can not come*, *can* is forced to lower to a position below negation, as illustrated in (5). This lowering of a logical expression is often referred to as **reconstruction**. As example (6) shows, the German modal expression *darf* is also [+R], so it must also be lowered (reconstructed) to be assigned scope under negation.

(5) John **can** not come  

(6) Sie **darf** das Land **nicht** darf verlassen  

‘She cannot leave the country’

The question we take up in the present article is how children converge on the adult interpretation of negative sentences, such as (1) and (2), that is, how children learn to assign the correct (adult) values of the lexical parameters associated with modal expressions such as *can* and *might*. To answer to this question, it is important to consider the truth-conditions that correspond to these sentences. The two sentences are clearly not truth-conditionally equivalent. Example (1) asserts that John’s coming is not certain, whereas (2) makes a stronger assertion that John is certain not to come. Based on the different information that is conveyed by (1) versus (2), we can ascertain that the truth-conditions of (1) and (2) are in a subset/superset relation, with (2) being informationally

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2In the vast majority of linguistic contexts, the logical expressions *any* and *some* are in complementary distribution, such that *any* must be interpreted inside the scope of negation, whereas *some* must be interpreted outside the scope of negation. See Crain (2012) for examples of linguistic contexts in which *some* and *any* are assigned the same meaning.
stronger, i.e., example (2) yields the subset reading. More formally, the truth of (2) entails the truth of (1), but not vice versa. In terms of lexical parameters, a subset/superset relation obtains when one value of a lexical parameter makes sentences true in a subset of the circumstances that correspond to the other value. Going back to our original contrast between \textit{can}$_{[-R]}$ and \textit{might}$_{[-R]}$, the value \([-R]\) is the one associated with the informationally weaker, superset meaning \textit{possible} \(>\) \textit{not}, while the value \([+R]\) is associated with the informationally stronger, subset meaning \textit{not} \(>\) \textit{possible}.

Whenever parameter values result in an asymmetric entailment, this raises a potential learnability problem. Suppose that language learners start off by assigning all modal expressions the value \([-R]\). On this scenario, there would be no polarity restrictions on either \textit{might} or \textit{can}. Therefore, the interpretations that are assigned to these expressions, with respect to negation, are entirely determined by surface word order. Since the modal expressions precede negation in both examples, the [-R] setting would lead language learners to assign the same meaning to examples (1) and (2); they would both mean that it is possible for John not to come, \textit{possible} \(>\) \textit{not}. This results in the correct interpretation for example (1), that is, \textit{John might not come}. However, it yields the wrong result for sentence (2). That is, because adults assign the \([+R]\) value of the parameter to \textit{can}, for them this sentence would be verified only in circumstances in which John does not come. For children, by contrast, sentence (2) would be verified both in circumstances in which John does not come (as for adults), and also in circumstance in which John does come. This means that adults would consistently produce sentence (2), in one of the sets of circumstances that verify the meaning assigned by children. So, if children assign value \([-R]\), whereas adults assign value \([+R]\), it is difficult to see how children can discover that they have selected the wrong parameter value.

This learnability dilemma does not arise, however, if children initially assign all modal expressions the value \([+R]\). On this scenario, children and adults both assign the same meaning to sentences like (2), \textit{John can not come}. However, children and adults assign different meanings to (1), \textit{John might not come}. Adults assign the \textit{possible} \(>\) \textit{not} reading, whereas children assign the \textit{not} \(>\) \textit{possible} reading. Consequently, only the adult (\textit{possible} \(>\) \textit{not}) reading is verified in circumstances in which John does come, so these circumstances would represent positive evidence for children that the parameter value that they assign to the same sentence, \([+R]\), is not the value assigned by adult speakers of the local language for the modal expression \textit{might}.

The upshot is that potential learnability dilemmas can be avoided if children initially adopt the subset value of lexical parameters, \([+R]\). The proposal that children initially adopt the subset value of such parameters is called the Semantic Subset Principle (SSP), which is a variant of the Subset Principle introduced by Berwick (1985). The SSP makes a number of interesting predictions for language acquisition. In the case at hand, the SSP predicts that children will assign the value \([+R]\) to epistemic modals. It is then expected that children will obligatorily reconstruct a modal expressing possibility within the scope of negation. In this article, we extend the SSP to explain differences we have observed in how Italian-speaking children and Italian-speaking adults interpret negative sentences with modals. Before we describe the experiments that yielded these differences, it will be useful to say a bit more about modality in Italian.

Italian has a modal paradigm that is far simpler than that of English. For adult speakers of Italian, there are no polarity restrictions. The meanings of negative modal sentences are determined by other grammatical factors, mainly word order. More specifically, there is no opposition in Italian between \textit{might not} and \textit{can not}. Italian-speaking adults use different word orders to
derive different scope relations. Consider the Italian examples (7) and (8), which are translations of the English examples (1) and (2).

(7) Gianni può non venire (possible > not)
     Gianni mod neg come
     ‘Gianni might not come’

(8) Gianni non può venire (not > possible)
     Gianni neg mod come
     ‘Gianni can not come’

As example (7) shows, in Italian, the possible not (English: might not) meaning is generated when the modal può precedes the negative marker non. To derive the impossibility reading (English: can not), the order of the negation marker non and the modal expression può is reversed, as in (8). In short, surface word order dictates the difference in interpretation for adult speakers of Italian.

Although modal expressions do not exhibit polarity restrictions for adult speakers of Italian, the SSP predicts that Italian-speaking children nevertheless initially assign polarity restrictions to modal expressions. In particular, the prediction is that children assign the value [+R] to the modal expression potere. Specifically, children are expected to initially interpret potere under negation, generating the not > possible reading, a reading that is completely unacceptable for adults. We tested this prediction in two experiments, reported in sections 3 and 4.

Here is the structure of the article. The next section introduces the basic notions of modal semantics, focusing on the complex interaction between negation and modals. In particular, we indicate how the strong and weak readings of modal expressions are derived in negative sentences. In section 3, we present results coming from previous studies on the development of epistemic modality in child language. Against this background, the details and findings of two new experiments with Italian-speaking children are reported in sections 4 and 5. The findings of these experimental studies are largely in line with the predictions, based on the Semantic Subset Principle. In section 6 we discuss the empirical results of the two experiments and we conclude by addressing some of the criticisms that have been levied against the Semantic Subset Principle in two recent papers.

MODALITY AND NEGATION

Modality has been traditionally analyzed using what is called possible world semantics (e.g., Hintikka, 1969; Kripke, 1959; see Portner, 2009, for a survey). In this framework, modal expressions quantify over sets of possible worlds (perhaps more intuitively one may think of modal expressions as quantifying over possible states of the actual world) and most of the differences in meaning can be captured through the notions accessibility relation and quantificational force. In addition, we will also discuss logical scope and information strength, two notions that are relevant for the semantics of negative sentences and the understanding of our experimental hypothesis.
Accessibility Relation

When we evaluate epistemic modal propositions, we draw conclusions on the basis of the evidence that is available to us. We use the evidence to draw inferences about the likelihood or certainty of the proposition turning out to be true in the actual world. In formal semantics, the likelihood or certainty of a proposition being true in some world W (e.g., the actual world) depends on the truth of the proposition in worlds that are accessible to W. Thus the accessibility relation determines the set of worlds taken into considerations. In the case of epistemic modality, the set of possible worlds is determined by the knowledge available to the speaker: a proposition must/can be true in the set of worlds built on the basis of what the speaker knows. Since the topic of the present study is epistemic modality, all the examples in the remainder of this section involve modals that are associated with an epistemic accessibility relation.

Quantificational Force

In ordinary declarative statements, alternations such as the one between might and must are used to encode force distinctions. To illustrate, consider the epistemic modality statement John might have sneezed. This statement is true if John sneezed in some accessible world (or, equivalently, in some possible state of the actual world). Intuitively, must is stronger than might. The stronger epistemic modal statement, John must have sneezed is true if John sneezed is true in every state of affairs that the speaker can imagine (i.e., in every accessible world). The difference between statements with might and statements with must is one of quantificational force. Statements with must take every possible world into account (every possible state of affairs in the actual world), whereas statements with might take into account only some possible worlds (some possible states of affairs in the actual world).

The force of a modal is either existential or universal (Lyons, 1977). If the proposition at issue is true if there exists one possible world, then the modal has existential force. If the proposition must be true in every possible world, the modal has universal force. When we consider modals of the same kind, such as epistemic modals, attention is paid to the force of the modal expression, whether it has universal or existential force.

Information Strength

In addition to accessibility and force, a third notion is operative when pairs of modal expressions are under consideration: information strength. This can be traced back to the neo-Gricean tradition (Gadzar, 1979; Horn, 1989). Based on information strength, modal expressions can be aligned on a scale. To illustrate, consider sentence (9) and its variant in (10).

(9) John might be the culprit
(10) John must be the culprit

Example (10) is stronger than example (9), in the sense that if (10) is true, than (9) is also true. However, the inverse does not hold. Example (9) can be true and (10) can be false at the same time; the fact that John might be the culprit does not force us to conclude that he must be the culprit. This is an example of asymmetric entailment and information strength can be defined in these terms, whereby stronger expressions asymmetrically entail weaker ones. Information
strength can be used to order modals on a scale. One such scale is given in (11), where an expression on the left-hand side of the symbol ‘>’ is stronger than an expression on the right-hand side.

(11) necessity > possibility

This asymmetric relationship between modal expressions has figured centrally in studies of modal development (Hirst & Weil, 1982; Byrnes & Duff, 1989; Bascelli & Barbieri, 2002). However, none of the previous studies considered the fact that this relationship is not absolute. Once certain logical operators combine with a modal expression, the information strength of the modal expression may be reversed. This happens in general with downward entailing expressions. Negation is a case in point. When negation is combined with a modal expression, the result may be a reversal in information strength of that modal expression as compared with other modal expressions on a scale. This can be illustrated by comparing examples (9) and (10) with their negated counterparts in (12) and (13). The statement in (9), with *might*, was weaker than the statement in (10), with *must*. When negation precedes the modal expressions, as in (12) and (13), the statement with *might* (12) becomes stronger than the negative statement with *must*, as in (13).

(12) It is not the case that John might be the culprit
(13) It is not the case that John must be the culprit

This reversal in information strength is effected by a reversal in entailment relations that is initiated by negation. This reversal in information strength when modal expressions appear in the scope of negation is fully general. So, for example, as indicated in (14), *not possible* is stronger than *not necessary*, so these expressions form the following scale.

(14) not possible > not necessary

Logical Scope

To fully capture the interaction between negation and modality, one final distinction is needed, that of logical scope. Negation may combine with a modal in two ways: negation may either take wide or narrow scope over the modal expression (for Italian, see Moscati, 2010). When negation is assigned wide scope, the readings *not possible* and *not necessary* are generated. When negation is assigned narrow scope, the interpretations *possible not* and *necessary not* are generated. In (15), we summarize the four logical interpretations that can be derived using different combinations of quantificational force and logical scope.

(15) A. STRONG B. WEAK
not possible > possible not
necessary not > not necessary

With the distinction between strong and weak readings in mind, we turn our attention to children’s understanding of epistemic modal sentences.
The main hypothesis in the present article is that children initially access only a subset of the scope assignments that are available to adults, namely those scope assignments illustrated in (15)a, ones that generate strong readings. This possibility has been extensively explored in the literature on child language, using a variety of quantificational expressions. However, few studies to date have explicitly investigated children’s understanding of negative sentences with modal expressions.

A number of studies have assessed children’s scope preference for sentences in which negation interacts with other scope bearing elements, including the quantifiers every and some (Musolino et al., 2000; Musolino & Lidz, 2006; Gualmini, 2005; Gualmini et al., 2008) and the logical connectives or and and (Crain et al., 2002; Goro & Akiba, 2004; Gualmini & Crain, 2005; Crain et al., in press). Several of these studies have found that children disfavor scope interpretations that are preferred by adults. Different explanations have been advanced, including pragmatic factors (Gualmini et al., 2008) and parsing strategies, such as a preference to assign interpretation based on surface scope relations (isomorphic) between logical expressions, rather than assigning interpretations based on inverse scope relations (nonisomorphic) (e.g., O’Grady, 2012; Lidz & Musolino, 2002).

Another factor that has been invoked to explain children’s initial scope assignment is the Semantic Subset Principle (Crain, Ni, & Conway, 1994). As discussed in the introduction, the Semantic Subset Principle is based on considerations of language learnability. This explanation of children’s initial scope assignments is of special interest because the initial scope assignments that are assigned by children are attributed to information strength. Essentially, the proposal is that children are initially restricted to settings of lexical parameters that generate strong readings, even in cases where adults instead favor weak readings (e.g., Notley et al., 2011; Moscati, 2008).

The present study was designed to evaluate the prediction that children’s initial scope assignments correspond to the strong readings of negative sentences with epistemic modals, following a related study by Moscati (2008) using deontic modals. As far as we know, the possibility that children’s interpretation of epistemic modals in negative sentences is determined by information strength has not been investigated previously. Before addressing the particular research questions under consideration in the present study, it will be useful to review the previous literature on children’s acquisition of the various semantic notions introduced earlier: accessibility, quantificational force, and information strength.

Modal expressions are attested early in children’s spontaneous speech. They appear before children begin their second year of life (Kuczaj & Maratsos, 1975; Shepherd, 1982; Bliss, 1988; Stromswold, 1990; Wells, 1979; Perkins, 1983). At the initial stage, however, not all modal expressions are produced with the same frequency. As noted earlier, several studies point to the prominent use of deontic modal expressions at the earliest stages. A noteworthy delay in children’s spontaneous production of epistemic modals has been attributed to children’s difficulty in dealing with the specific kinds of accessibility relations that govern the use of epistemic modals. As discussed, the use of epistemic modal expressions involves assessing the likelihood or certainty that a proposition is true based on the available evidence, and it has been suggested that the observed delay in children’s use of epistemic modals may be related to other difficulties observed in cognitive development (Papafragou et al., 2007).
Epistemic modals become productive in children’s spontaneous speech by the time they reach the age of five. By age five, moreover, children are able to distinguish between modal expressions on the basis of their quantificational force. Evidence for this conclusion comes from a groundbreaking series of studies by Hirst and Weil (1982). These researchers developed a forced choice paradigm to assess children’s sensitivity to the quantificational force of modal expressions. In an experimental paradigm called the Hidden Object Task, an object was placed under one of two containers, a cup or a box. As the experiment proceeds, an object (e.g., a peanut) is hidden under the box or under the cup. The child’s task is to decide where the peanut has been hidden, on the basis of statements produced by two characters, who we will simply refer to as A and B. The statements differ in information strength. One of the characters uses the modal expression *must*, and the other character uses *may*. Children are then asked to indicate which container the hidden peanut is under. The experimental set-up is represented in Figure 1.

The critical assumption is that modals are ranked on a scale according to quantificational force, with *must* being stronger than *may*, and that the force of a modal expression indicates the degree of confidence in the location of the hidden object. Since Character A uses *must*, A is highly confident about the location of the hidden peanut, as compared to Character B, who uses *may*. Children knowledge of the relative force of the modals can therefore be evaluated by observing which container they decide to look under, based on the statements by the two characters.

The main finding by Hirst and Weil (1982) was that 5-year-olds consistently looked under the container mentioned in the sentence with *must*, that is, the modal expression with universal force, as compared with the container corresponding to the (weaker) modal *may*, which has existential force. Similar findings using different modal alternatives have been reported in Byrnes and Duff (1989), Noveck et al. (1996), and Bascelli and Barbieri (2002) for Italian-speaking children. Taken together, the previous findings indicate that, by five, children are sensitive to the quantificational force conveyed by epistemic modals, at least in positive statements.

As mentioned earlier, the *information strength* of modal expressions is reversed under negation. Information strength also critically depends on the scope relations that are assigned to negative sentences with modal expressions. In view of these complicating factors, it is not surprising that our understanding of 5-year-old children’s knowledge of the information strength of epistemic modals in negative statements is less clear-cut than it is for positive statements. For example, the Byrnes & Duff (1989) study also used the Hidden Object Task to assess children’s understanding of the quantificational force of modals in negative statements such as (16) and (17).

(16) Character A: The peanut *can’t* be under the cup
(17) Character B: The peanut *might not* be under the box

FIGURE 1 The hidden object task.
In English, negation takes scope over *can* in (16), whereas *might* takes scope over negation in (17). Consequently, the compound *can not* is stronger than *might not*, although *can* and *might* are similar in information strength in positive sentences. Consider example (16), where Character A makes the strong assertion, *The peanut can’t be under the cup*. If children have the same scope assignments as adults, then they should look for the hidden peanut under the box in response to the statement in (16). However, Byrnes and Duff (1989) reported that 5-year-old children found it difficult to distinguish between (16) and (17). This finding raises the possibility that 5-year-old English-speaking children fail to make the same scope assignments as adults. For children, both *can* and *might* could take scope over negation, and this could be due simply to children’s failure to distinguish between these modal expressions.

A different version of the Hidden Object Task was introduced in Noveck (2001). In this version of the task, children were provided with a background against which to evaluate the truth conditions of modal statements. Children were presented with three boxes, not just two. Two of the boxes were open, so the contents could be seen. In one box, there was a parrot, and in the other there was both a parrot and a bear. The third box was closed, however, so its content was not known. Children were told, however, that the content of the closed box was the same as the content of one of the other two boxes. Children were then asked to evaluate the truth or falsity of a number of test sentences containing epistemic modals, including both positive and negative statements.

In positive sentences, the two modal forms *might* and *has to* appeared, as indicated in (18)-(20) alongside the (correct) truth values.

(18) There *has to/might* be a parrot True
(19) There *might* be a bear True
(20) There *has to* be a bear False

In the negative statements, *can* replaced *might*. The negative statements included both strong and weak sentences. The strong sentences were always false, as in (21).

(21) There *cannot* be a parrot/bear in the closed box False

The weak sentences were sometimes true and sometimes false, as illustrated in (22) and (23).

(22) There does *not have* to be a bear in the closed box True
(23) There does *not have* to be a parrot in the closed box False

Five-year-old children found this task difficult. They succeeded at above-chance levels in assigning the correct truth-values to sentences in just three out of eight conditions. In two of these conditions, children responded to true, positive sentences such as (18). Children performed above chance in only one condition with negative modal statements; in the context represented in Figure 2, where parrots were visible in both of the open boxes, children correctly rejected negative statements such as (23) – *there does not have to be a parrot in the closed box*. It is worth

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3Although children’s justifications of their rejections were not reported, it is worth commenting on the counter-intuitive finding that children correctly rejected false negative statements like (23) more often than they correctly accepted true negative statements like (22). This makes sense if, unlike adults, 5-year-old children generate scope assignments that make sentences true in the narrowest range of circumstances, i.e., the strong reading. If so, then both (22) and (23) mean that there cannot be a parrot/bear in the closed box. This makes (23) clearly false, and it also makes (22) false (but perhaps
noting that this sentence would be false regardless of the scope relations between negation and the modal. That is, (23) is false both on the weaker possibly not reading, and on the stronger not possible reading.

Two previous studies, reported in Moscati (2008) and Gualmini and Moscati (2009), examined the scope interactions between modality and negation. Children’s comprehension of Italian sentences such as (24) was investigated using a Truth-Value Judgment Task (Crain & Thornton, 1998).

(24) Il contadino può non dare le carote all’elefante
the farmer can not give the carrots to-the elephant
a. *It is not possible that the farmer gives carrots to the elephant strong
b. It is possible that the farmer does not give carrots to the elephant weak

This sentence was a true description of what had taken place in a short story, if it is interpreted in accordance with its weak interpretation in (24)b, the only one allowed in the adult grammar. In the story corresponding to (24), a farmer was charged with feeding the animals at the local zoo. There were two elephants and one tiger. In the first part of the story, the farmer was compelled to feed carrots to the tiger. This created the expectation that all the animals would eat carrots. However, this expectation was not fulfilled as the story unfolded. It turned out that the farmer was free to give to the elephants any vegetables of his choosing. At the end of the story, the farmer had given carrots to one of the elephants and turnips to the other one. Against this outcome, sentence (24) was true under its weak interpretation. A control group of Italian-speaking adults consistently accepted (24) as an accurate description of the story, but the majority of the child participants rejected it.

Gualmini and Moscati interpreted children’s rejections as evidence that they did not generate the weak interpretation, and accessed the strong reading in (24)a, which made the sentence false for children, as it was not an accurate description of the events that had taken place in the story. The findings of the Moscati (2008) and Gualmini and Moscati (2009) studies are clearly compatible with the predictions of the Semantic Subset Principle. However, it is also possible that children rejected the test sentences for a different reason. The alternative reason for children’s rejections was due to the form of the test sentences, which all contained a definite determiner. Definite determiners were used to avoid many of the complications associated with the use of indefinite expressions, such as “an elephant”. However, the use of the definite expression “the elephant” introduced a potential confound. If the definite noun phrase “the elephant” was...
interpreted as referring to the elephant who had received the carrots, then the sentence is false. On this analysis of the findings, children’s rejections could be explained without recourse to the strong-weak distinction and, hence, could not be attributed to the Semantic Subset Principle. In order to control for definiteness, and to explicitly address the interpretation of epistemic modals in negative sentences, two experiments were designed to investigate children’s interpretation of modals in circumstances in which information strength is the determining factor.

**EXPERIMENT 1. CHILDREN’S COMPREHENSION OF WEAK EPISTEMIC SENTENCES**

At the beginning of the paper, we discussed the cross-linguistic variability of modal paradigms. Some languages, including English, have a rich lexical array of modal forms. These languages can therefore distinguish narrow and wide scope readings in negative sentences by selecting different lexical items, while maintaining the same word order. A possible concern here is that, in languages like English, children may take some time to fully master the usage of the different modal forms. This additional factor of complexity can be avoided, however, by looking at other languages, including Italian, that have a more modest lexicon of modal expressions.

Italian has only two modals, *dovere* and *potere* and, in negative sentences, differences in scope assignment can be captured by differences in word order. In particular, when combined with negation, the logical scope of the modal expression *potere* is determined solely by its position with respect to negation, at least for adult speakers. Consider the sentences in (25):

(25) a. Ci può non essere una mucca nella scatola
   there possible not be a cow in-the box
   ‘There might not be a cow in the box’
   (weak: possibly not)

b. Non ci può essere una mucca nella scatola
   not there possible be a cow in-the box
   ‘There cannot be a cow in the box’
   (strong: not possible)

The modal expression *potere* is inflected for person and number. In (25)a, *potere* precedes the negation marker *non*. The only licit adult interpretation of (25)a is the surface scope reading, where *può* takes scope over *non*—what you see is what you get. The resulting interpretation is the possibly not (weak) reading. When the modal *può* follows the negation marker *non*, as in (25)b, adults also derive a surface scope reading. This time, however, surface scope yields the stronger statement, not possible. In view of its simple modal lexicon and the absence of polarity restrictions, Italian is a profitable testing ground for assessing children’s understanding of negative modal sentences such as (25)a and (25)b.

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4 Another quasi-modal is “bisogna”, with a meaning similar to need. This form has idiosyncratic properties which distinguish it from the other two modals *potere* and *dovere*. For example, in Standard Italian, it cannot have a referential subject.

5 In the case of *dovere*, an ambiguity remains when the modal follows negation: *non dovere* could be either translated in English as “need not” or “must not.”

6 The position of the clitic ‘ci’ can vary, so an alternative to sentence (25) is “può non esserci una mucca nella scatola”, with the clitic following the copular verb. The absence of ‘clitic climbing’ here is possibly related to the absence of ‘restructuring’ effects (see Rizzi, 1982). This difference, however, has no consequences for scope assignment.
To assess children’s knowledge of modality, Experiment 1 used sentences like those in (25) in a task that combines some of the features of the Hidden Object task (Hirst & Weil, 1982) with truth-value judgments.

In Experiment 1, we used an experimental setup similar to the one described in Noveck (2001), where children were asked to judge the truth or falsity of one sentence at a time. The task was to assess the truth of the target sentences against simple scenarios, as illustrated in Figure 3. The target sentence was always about the content of the closed box, that is, Box C in Figure 3. Children were told that this box contained exactly the same contents as either Box A or Box B. So, children could infer the possible contents of the closed box, based on the contents of the two open boxes.

Children’s interpretation of modality was investigated in three types of sentences: positive, negative strong and negative weak. All of these sentences were associated with both a true answer and a false answer on different trials, for a total of six experimental conditions. All of them incorporated the modal expression potere.

In the positive sentences, the modal appeared without negation, as in the examples in (26).

(26) **POSITIVE**
- a. Ci può essere una mucca nella scatola True
  ‘There might be a cow in the box’
- b. Ci può essere una fragola nella scatola False
  ‘There might be a strawberry in the box’

---

7A difference is the presence of an extra object (e.g., a strawberry). The extra object was added outside the boxes to counterbalance true and negative answers. In this way, we have a false positive sentence *There might be a strawberry in the box* and a true negative strong sentence *There cannot be a strawberry in the box*. These were not among the conditions tested in Noveck (2001).
Based on the contents of the open boxes, A and B, it can be inferred that the content of Box C is either a horse or a cow + a horse. An ‘extra’ object (e.g., a strawberry) was positioned outside of the open boxes, so it could not be in Box C. In these circumstances, sentence (26)a is true for adults \((\text{there might be a cow})\). However, sentence (26)b is false \((\text{there might be a strawberry})\).

The negative strong sentences contained the negation marker non followed by the modal potere, as in (27). For adults, the only interpretation is the strong reading, not possible. Example (27)a is true \((\text{there cannot be a strawberry})\) but example (27)b is false \((\text{there cannot be a cow})\).

\[
\text{(27) Negative Strong} \\
\begin{align*}
a. & \text{Non ci può essere una fragola nella scatola True} \\
& \text{‘There cannot be a strawberry in the box’} \\
b. & \text{Non ci può essere una mucca nella scatola False} \\
& \text{‘There cannot be a cow in the box’}
\end{align*}
\]

According to the experimental hypothesis, sentences like (27)b should be unproblematic for children, since children are expected to initially assign strong readings to negative statements with epistemic modals.

A third set of sentences were negative weak sentences, where the order of the negative marker non and the modal può was reversed as compared to the negative strong condition:

\[
\text{(28) Negative Weak} \\
\begin{align*}
a. & \text{Ci può non essere una mucca nella scatola True} \\
& \text{‘There might not be a cow in the box’} \\
b. & \text{Ci può non essere un cavallo nella scatola False} \\
& \text{‘There might not be a horse in the box’}
\end{align*}
\]

For adults, only the weak interpretation is permitted for the sentences in (28). This is the possible not reading. The scenario under consideration makes (28)a true for adults, since there might not be a cow in the closed box, Box C. By contrast, sentence (28)b is false since a horse could be in Box C, either alone (as in Box A) or there could be both a horse and a cow (as in Box B).

The sentences in (28) are similar in word order to those investigated in Moscati (2008) and Gualmini and Moscati (2009). However, two changes were introduced in the present study. First, an indefinite determiner was used and, second, the sentences could not be evaluated against the actual circumstances, given that the content of the closed box was unknown. This allowed us to control for the potential confound previously mentioned. For sentences such as (28), the experimental hypothesis is that 5-year-old children differ from adults in their scope assignments. We expect children to systematically judge sentences such as (28)a to be false descriptions by virtue of assigning a nonadult reading \((\text{not possible})\) to such sentences. Thus, we are led to predict that children should reject sentences like (28)a, for the same reasons they reject (27)b.

Participants

Twenty-five monolingual Italian-speaking children took part in the experiment. The children were recruited from kindergartens in Siena and Florence. The children ranged in age from 5;2 to 5;11 \((M=5;4, \sigma=0.3)\). Twenty adults between the age of 20 and 30 served as the control group. The adult participants were undergraduate students at Siena University.
Materials

The experimental materials included eighteen white cardboard boxes, divided into six sets that were positioned on a table in front of the child participants. Different objects were placed inside the boxes (animals, fruit, small toys). A hand puppet was used to present the test sentences to children. The first two sets of boxes were used in the familiarization procedure, while the remaining four sets (Appendix A) served to test the interpretation of the six target sentences in (26)-(28).

Method

Children’s interpretations of the test sentences were assessed using a game scenario, as exemplified in Figure 3. The target statements were uttered by the puppet, and the child’s task was to determine, based on the items placed in the boxes, whether the puppet’s statements were “right” or “wrong.” Children were instructed to reward the puppet with a special prize every time it said something right (e.g., a cake), and to give the puppet a lesser prize (e.g. some fruit) when it said something wrong.

The test phase was preceded by two familiarization procedures. The first part was a naming task where the experimenter pointed at the objects in the open boxes and asked the puppet to name the objects. The puppet produced simple declarative sentences of the form “This is an X” and the child participants judged whether the puppet was right or wrong. When the puppet was wrong, the child was instructed to tell the puppet the correct name of the object. This served to familiarize children with the task, and to verify that the children knew the names of the objects that were used later in the main testing session. In the second part of the training procedure, children were asked to judge the puppet’s assertions about the content of Box C. The puppet produced positive and negative sentences of the form “There is/isn’t an X in the box.” The child’s task was to judge whether or not the puppet’s statements were true. However, in this part of the task, children were allowed to peek into the closed box before making their decisions. Each child made judgments about three sentences for each of the first two sets of boxes.

Following the familiarization procedures, the modal statements were introduced in the main session. This session consisted of six sentences for each set of boxes (Appendix A), one for each experimental condition, as illustrated by the examples in (26)–(28). Six different lists of sentences were prepared, in order to vary the presentation order across participants; the child subjects were randomly assigned one of the lists. In total, each child subject heard 4 sentences per condition for a total of 24 sentences. Every time a sentence was judged “wrong,” the child was asked to indicate to the puppet why it was wrong.

Results

The responses by children and by adults were counted as correct answers, according to the adult truth conditions represented in examples (26)–(28), that is, when participants accepted true sentences and rejected false ones. Whenever children rejected a sentence, they were asked to indicate why the puppet was wrong. When children produced “irrelevant” justifications of their rejections, these were excluded from the analysis (e.g., “Wrong, because cows don’t like boxes”). A total of six answers were excluded, coming from three children (one from child A, two from child B, and
three from child C). Table 1 summarizes the overall results for the six conditions, and for both groups of participants.

As Table 1 shows, adults made relatively few incorrect responses overall, and the errors made by adults were limited to the negative sentences. There was no clear pattern to the incorrect responses by adults. In particular, the weak sentences did not introduce greater difficulty for adult speakers of Italian, over and above that of the strong sentences.

Children did not have problems with the task per se, although children’s performance was lower than that of adults overall, and children’s responses were strikingly different from those of adults in two conditions—the Positive True condition and the Negative Weak True condition. A series of t-tests revealed that children’s performance differed significantly from chance performance. It was above chance in four out of the six conditions: Positive False: t(24) = 20.189, p < .001, Negative Strong True: t(24) = 6.859, p < .001, Negative Strong False: t(24) = 4.106, p < .001, and Negative Weak False: t(24) = 4.226, p < .0001). In the Negative Weak True condition, instead, performance was below chance t(24) = -2.366, p < .001. Only in the Positive True condition did children exhibit chance-level performance: t(24) = 0.140, p > 0.5.

Data were analyzed using a 2 (Age) × 6 (Condition) ANOVA, with Subjects and Items as random factors. The proportion of correct responses was transformed using the arcsin function. The analysis revealed a significant main effect of Condition (F1(5, 215) = 12.463, p < .001; F2(5, 18) = 15.060, p < .001) and Age (F1(1, 43) = 113.368, p < .001; F2(1, 18) = 215.497, p < .001). The interaction between Age × Condition was also significant (F1(5, 215) = 7.927, p < .001; F2(5, 18) = 9.681, p < .001). Planned post-hoc contrasts revealed a significant difference between the Negative Strong True condition and the Negative Weak True condition (p < .01), while no significant difference was found between Negative Strong False and Negative Weak False (p > .05), a result predicted by our experimental hypothesis. The post-hoc analyses also revealed a significant contrast between the Positive True and the Positive False conditions (p < .05), which we will discuss momentarily.

Let us look in greater detail at the between-group differences in response to the negative and positive sentences. As Figure 4 shows, a between-group difference was observed for the Negative Weak True sentences; children consistently rejected these sentences, whereas adults consistently accepted them. Remember that, when children judged a sentence to be wrong, they were asked to justify their decision. The majority of children answered that the puppet was wrong to assert
"There might not be a cow in the box" because children said, "A cow **might** be in the box!" We take this as evidence that children were assigning the inverse scope (strong) interpretation to the Negative Weak sentences (which were True for adults), according to which the sentence "There might not be a cow in the box" can be paraphrased as "It is impossible for the cow to be in the box."

We turn now to Positive sentences. The findings are summarized in Figure 5. As the figure indicates, children produced a much lower proportion of correct answers than adults for the Positive True sentences 51.5%.

This finding deserves closer examination. Consider again the true positive sentence (26)a repeated below as (29):

(29) Ci può essere una mucca nella scatola

'There might be a cow in the box'

At first look, the high rate of rejections of sentences such as (29) is compatible with the hypothesis that children confused potere (**might**) with dovere (**must**). On this view, children incorrectly reject sentences like (29) because they experience difficulties with modals even in positive sentences. However, this explanation is not consistent with the justifications children produced for their rejections of sentences like (29). Children gave an explanation for their rejections in 40% of the cases and all of them (19/48) appealed to the fact that there was also a horse in the box. Such comments are mysterious if children misinterpret (29) as meaning *There must be a cow in the box*, as the infelicitous exchange in (30) shows:

---

8 Children made comments along these lines about 34% of the time (on 22 of their 63 rejections). In the remaining cases, they gave no explanation or said "I don’t know."
This encourages us to explore a second alternative of children’s not-adult behavior in response to sentences like (29). First, it is noteworthy that children often used the particle *also* in justifying their rejections. The particle *also* is related to focus (Krifka, 2007). In particular, it is appropriate to use *also* in response to sentences that contain the focus operator *only* (Horn, 1969). So, in contrast to the infelicitous exchange in (30), the following exchange is felicitous.

(31) Puppet: There might be only a cow in the box  
Children: Wrong. There is also a horse in the box

To see why (31) is felicitous, it will be helpful to discuss the semantic contribution of the focus operator *only* in more detail. The focus operator *only* is associated with some linguistic expression in the sentence that contains it; this is called the focus element. In addition, *only* carries a presupposition and it is used to make an assertion. The presupposition is that alternatives to the focus element have been introduced into the domain of discourse. The assertion is that the property being attributed to the element in focus does not extend to any of the alternatives. The assertion for the statement in (31), *There might be only a cow in the box*, is represented in (32).

(32) For every other toy x, such that x is not a cow, it is not possible that x is in the box

The assertion in (32) is clearly false in the context of Figure 3 because there must be a horse in the closed box, since there is a horse in both of the open boxes. Under the proposed account, children know the meaning of *potere* (*might*), but they are led to reject the test sentences because they
assign them a focus interpretation. The conclusion that Italian-speaking children are introducing a covert focus operator is not without precedence. Consider sentence (33). Although there is no overt focus operator, it seems clear that sentence (33) contains an implicit/covert ONLY, at least in certain circumstances. Suppose that (33) is uttered in a context in which there are three individuals, Mary, Fred and Bill. Although (33) does not contain an overt focus operator, it is interpreted as if it contained one, in the sense that we immediately exclude Mary from consideration as someone who might have taken the iPhone 5.

(33) Bill or Fred stole my iPhone 5.

Meaning: ONLY Bill or Fred stole my iPhone 5.

We made the tentative proposal that children introduced a covert ONLY when they interpreted the true positive sentences.

Discussion

When the results of Experiment 1 are compared with those reported in Noveck (2001), the first observation to be made is that Italian-speaking children performed better than their English-speaking age-matched counterparts. Italian-speaking children’s proportion of correct responses differed from chance in five out of six conditions, whereas English-speaking children were at chance in the majority of the experimental conditions in the Noveck study. This cross-linguistic difference could be due to at least two reasons. First, Experiment 1 contained fewer statements (six instead of eight) for each set of boxes, making each trial shorter and easier for children than in the Noveck study. A second possibility is that Italian-speaking children are advantaged by the reduced size of the lexicon of modal expressions. Whereas English-speaking children have to make distinctions between may, can, must, need and has to, Italian-speaking children need only to distinguish potere and dovere.

To sum up, there are two main findings from Experiment 1. First, children differed from adults in responding to Positive True sentences and, second, children differed from adults in responding to sentences in which combining an epistemic modal and negation yields a weak interpretation. We have offered two different accounts of these between-group differences. In response to the Negative Weak sentences, we contend that children assign scope relations that yield a strong interpretation. In response to the Positive True sentences, children’s explanation of their rejections suggests that another factor, related to focus, was at play. So we are claiming that Italian-speaking children correctly interpret the modal expression might in sentences such as (29) There might be a cow in the box. However, children introduce a covert focus operator only into their interpretation, so children’s interpretation of (29) can be paraphrased as There might only be a cow in the box. For children, this assertion is clearly false in the context of Figure 3. Since there was a horse in both of the open boxes, there must be a horse in the closed box. The prediction is that if the assertion in (29) were a true description of the context (for example, if there was a horse in one of the open boxes, but not in both), then children would be expected to accept the same positive modal sentences, as least to a much higher extent. Experiment 2 is designed to investigate this proposal.
EXPERIMENT 2. EXCLUSIVITY AND COVERT ONLY

In discussing the findings of Experiment 1, we claimed that children’s low rate of correct answers is due to two different factors: the generation of a covert focus operator in positive sentences and a nonadult scope assignment in Negative Weak sentences. If this is correct, we should be able to disentangle these two different factors. This is the aim of Experiment 2. In this experiment, the experimental set up will be manipulated so as to make irrelevant the introduction of a covert only into the positive true sentences. If the contextual manipulation is effective, we expect to observe an increase in children’s acceptances of Positive True sentences, bringing children’s responses more in line with those of adults. However, the contextual manipulation we implement in Experiment 2 should not result in any observable change in children’s non-adult behavior to sentences in the Negative Weak True condition. If children continue to manifest non-adult-like behavior in the Negative Weak True condition, then this would confirm our hypothesis that another factor was instrumental in evoking children’s non-adult behavior in positive sentences. The experimental manipulation is simple. In Experiment 2, a single toy was placed in each of the open boxes, as indicated in Figure 6.

Keeping in mind the experimental set-up represented in Figure 6, consider how the true positive sentence (34) will be interpreted by children and by adults. The critical point is that the insertion of the focus operator only should have no impact on participants’ judgments about the

![Figure 6](https://example.com/figure6.png)

FIGURE 6 Typical scenario in Experiment 2. (Color figure available online.)
truth of sentences such as (34), as a description of the situation depicted in Figure 6. Sentence (34) is true regardless of the presence or absence of the focus operator only.

(34) There might be (only) a cow in the box  True

If the introduction of a covert only was responsible for children’s rejections of sentences such as (34) in Experiment 1, children should produce a much higher rate of acceptance in Experiment 2, since the closed box could contain just a cow or just a horse. This same contextual manipulation is not expected to alter the truth of true negative weak sentences. For example, sentence (35) remains true for adults even if a covert only is introduced.

(35) There might not be (only) a cow in the box  True

In the context depicted in Figure 6, the closed box might contain a horse, since a horse is contained in one of the open boxes. It is possible therefore to be neither a cow alone, nor a cow and another object in the closed box. If children’s rejections of sentences such as (35) depend on logical scope, the contextual manipulation introduced in Experiment 2 is not expected to have an effect on the interpretation children or adults assign to these sentences. Experiment 2 tested the effect of this contextual manipulation using stimuli similar to those of Experiment 1. Again, test sentences were divided into Positive, Negative Strong and Negative Weak. Examples are provided in (36)–(38).

(36) POSITIVE
   Ci può essere una mucca nella scatola
   ‘There might be a cow in the box’  True

(37) NEGATIVE STRONG
   Non ci può essere un’oca nella scatola
   ‘There cannot be a duck in the box’  True

(38) NEGATIVE WEAK
   Ci può non essere un cavallo nella scatola
   ‘There might not be a horse in the box’  True

Recall that, for adults, scope relations between the modal potere and the negative marker non in (36)–(38) is constrained by linear order, such that sentences (36)–(38) are completely unambiguous for adults.

As controls, we also presented three positive sentences such as (39) on each trial. These sentences referred to objects that were in proximity to the boxes, but not contained in the boxes.

(39) Ci può essere un gallo nella scatola
   ‘There might be a rooster in the box’  False

Given that Box C may contain solely things that are within the other two boxes, sentence (39) is false. In summary, for each set of boxes, children encountered six sentences, three true sentences and three false sentences.
Participants

Eighteen monolingual Italian-speaking children participated in the experiment. The children were recruited from the same childcare centers as in Experiment 1. Children ranged in age from 5;2 to 6;0 (M=5;4, σ=0.4). Ten adults served as a control group. The adults were undergraduate students at Siena University.

Materials

The experimental materials included 21 white cardboard boxes grouped into seven sets. As in Experiment 1, the boxes were positioned on a table in front of the participants. Different kinds of toy animals were placed inside the boxes, and other toy animals were placed outside the boxes, as illustrated by the example in Figure 6. Two changes from Experiment 1 were made in Experiment 2. As noted earlier, the main change was that a unique (and different) object was placed in each of the open boxes. The second change was the addition of other toys which were placed outside of the boxes; not just a single toy, as in Experiment 1. This enabled us to balance the number of true and false sentences that were presented to the participants on each trial.

Method

The experimental procedure was the same as in Experiment 1, and the same two-stage familiarization procedure was implemented. In the main session, six sentences were presented for five sets of boxes: one sentence for each experimental condition plus three false control statements about the objects outside the boxes (see Appendix B). As in Experiment 1, six different presentation lists were prepared and children were randomly assigned to one of them. In the test phase, children and adult heard 30 sentences in total.

Results

Both children and adults produced a high proportion of correct answers to the control sentences, where correct responses were associated with judgments that the puppet’s statements were “wrong.” Children committed only 3 mistakes out of 270 sentences, for a total of 0.2% errors.

Turning to the target sentences, the contextual changes implemented in Experiment 2 had effects both on the children, and on the adult controls. Adult judgments were much sharper in Experiment 2, as compared to Experiment 1 in that all true test sentences were accepted by adults. Turning to the child subjects, the contextual modifications resulted in a more selective effect. Most notably, children accepted the true sentences in the positive condition 95.5% of the time, as compared to the 51.5% acceptance rate in Experiment 1. In fact, the performance by children and adults was almost the same. Children’s acceptance of Negative Strong sentences also increased, albeit slightly more modestly, from the 76.5% in Experiment 1, to 86.6% in Experiment 2.

As anticipated, by contrast, the experimental manipulation introduced in Experiment 2 had no observable effect on children’s responses to sentences in the Negative Weak condition. Children
TABLE 2
Proportion of Correct Answers by Condition for the Two Groups. Experiment 2

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Groups</th>
<th>Positive</th>
<th>Negative Strong</th>
<th>Negative Weak</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Children</td>
<td>95.5%</td>
<td>86.6%</td>
<td>33.3%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(86/90)</td>
<td>(78/90)</td>
<td>(30/90)</td>
</tr>
<tr>
<td></td>
<td>Adults</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(50/50)</td>
<td>(50/50)</td>
<td>(50/50)</td>
</tr>
</tbody>
</table>

Error bars = S.E.

FIGURE 7 Proportion of correct answers by condition and by group.

accepted these sentences 33.3% of the time, as compared to the acceptance-rate of 38% in Experiment 1. A summary of the overall results are reported in Table 2, and Figure 7 graphically presents the similarities and differences in performance by children and adults.

The statistical analysis was the same as in Experiment 1, with the proportion of correct responses being transformed using the arcsin function and Subjects and Items set as random factors in a 2 (Age Group) × 3 (Condition) ANOVA. The analysis revealed a significant main effect of Condition (F1(2, 52) = 13.607, p < .001; F2 (2, 12) = 30.926, p < 0.001) and Age (F1(1, 26) = 112.207, p < .001; F2 (1,12) = 138.801, p < 0.001). The interaction between Age × Condition was also significant (F1(2, 52) = 13.607, p < 0.05; F2 (2, 12) = 30.926, p < 0.001). Post-hoc comparisons (with a Bonferroni correction) were conducted in order to assess the effect of each experimental condition on the proportion of correct responses by group. The only significant contrast was between the Negative Weak condition and the other two conditions (p < .001). This finding is in line with our experimental hypothesis.

Experiment 2 was designed to assess the hypothesis that children’s non-adult responses that were observed in Experiment 1 were due to two factors. Experiment 2 introduced a contextual manipulation to isolate one of these factors. As a result of the manipulation, the closed box contained a single item. The consequence was that the proportion of children’s “right” answers
dramatically increased in the Positive condition (86.6% acceptances). However, children’s proportion of acceptances in the other two conditions was not altered by the change in context. In particular, children continued to reject Negative Weak sentences (only 33.3% acceptances).

Discussion of the Experimental Findings

Experiment 1 was based on a study reported in Noveck (2001). The main finding was that Italian-speaking children correctly understood most sentences with modal expressions. The principal exceptions were two types of true sentences, the Positive sentences and the Negative Weak sentences. Children’s differed sharply from adults in making judgments in response to both types of sentences.

For the Negative Weak sentences, the SSP predicts that children initially assign scope interpretations that make sentences true in the narrowest range of circumstances. If so, children were expected to reject sentences such as (40) based on the assignment of an interpretation that is not even available to adults, as indicated in (40)b.

(40) Ci può non essere una mucca nella scatola
   a. ‘There might not be a cow in the box’ weak
   b. ‘There cannot be a cow in the box’ strong

Children’s nonadult interpretation made the test sentences false in both Experiments 1 and 2. This result is analogous to the one reported in Moscati (2008) and Gualmini and Moscati (2009), and it indicates that children’s difficulties with weak interpretations do not vary in function of the modal base. Moreover, once the potential confound associated with definiteness, as discussed in section 2, is eliminated, children’s acceptance of (40) is still low.

For true Positive sentences, Experiment 1 revealed a high rate of nonadult rejections. In this case, children’s comments helped us to shed some light on the reason why they considered sentence (41) as “wrong.” In particular, children often said that the sentence was wrong because “there could also be another animal” or because “the cow cannot be alone in the box.” On the basis of such comments, we proposed that children assign focus to the nominal constituent “the cow” and that the meaning of (41) is similar to the one in (41)b:

(41) Ci può essere una mucca nella scatola
   a. ‘There might be a cow in the box’ no focus (true in Exp.1-2)
   b. ‘?There might be only a cow in the box’ focus (false in Exp.1, true in Exp.2)

This reading is false in Experiment 1 and it could explain why children were rejecting (41). In our view, rejections of (40) and (41) resulted from different factors: strength in (40) and focus in (41). Experiment 2 was designed to disentangle these factors, by a seemingly subtle change in the context. The result was that children almost always accepted the Positive true sentences in (41) but continued to reject sentences such as (40). This showed that, if nothing in the truth-conditions hinges on focus assignment, children do not find it difficult to correctly judge positive sentences with an epistemic modal. Experiment 2 clearly singled out the Negative Weak sentences from all the other experimental conditions, confirming that information strength is relevant in initially guiding children’s interpretations of sentences with scope ambiguities.
The results of Experiments 1 and 2 show that Italian children do not have problems with modal sentences in general but only with certain interpretations. This could explain some of the results reported in previous studies using modal comprehension. For example, the sentences (42)–(43) are considered to be among the most difficult for children to process.

(42) It might not be under the blue cup  (Byrnes and Duff, 1989)
(43) There might not be a bear       (Noveck, 2001)

To the extent that the present results from our study of Italian-speaking children is an indication, the complexity posed by these sentences can be understood, given that these are sentences that are interpreted by adults as having weak readings generated by the value [-R] on the modal might, the value that excludes reconstruction under negation. This data can be accounted for by an interpretive bias by children toward strong readings, the one associated with the lexical value [+R], as predicted by the SSP.

An alternative hypothesis is that sentences with a weak interpretation, such as “può non” / “might not” appear less frequently in the input. In absence of an accurate corpora analysis, we can address this concern by assuming that weak sentences are indeed less frequent when compared with their strong alternatives. It is not clear, however, that a frequency-based account explains why children generate interpretations that are not acceptable for adults. Children do not simply express confusion when they encounter sentences that have weak readings for adults; rather, children interpret them by assigning a strong meaning.

A further issue remains. We observed that in certain cases, even without a specific intonation, children enriched sentence meanings with a covert only. What determines the distribution of this covert focus operator? Tentatively, we propose that in this case, too, information strength plays a role. In particular, our tentative proposal is that children associate a focus operator only with a constituent when a stronger statement is generated (then would be otherwise, without the focus operator). To illustrate, consider a positive modal statement with or without only, as in (44) and (45), and the corresponding situations that would satisfy their truth-conditions:

Box content

(44) It is possible that a cow is in the box (horse) OR (cow + horse)
(45) It is possible that only a cow is in the box (cow)

As the contents associated with (44) and (45) indicate, the sentence in (45) is stronger than (44), in the sense that it is true in a narrower set of circumstances. If information strength plays a role in determining children’s insertion of a covert focus operator, we would expect that an implicature of exclusivity would be generated. Now consider negative sentences and the corresponding situations which made them true:

Box content

(46) It is not possible that a cow is in the box (horse)
(47) It is not possible that only a cow is in the box (horse) OR (cow + horse)
(48) It is not possible that there is a cow is in the box (horse)
(49) It is not possible that only a cow is in the box (horse) OR (cow + horse)
In strong negative sentences, the presence of only makes the sentence true in two situations (47), whereas the corresponding sentence without only (46) is true in one situation. The same holds for Negative Weak sentences, where the introduction of only simply verifies the sentence in one more situation (49), as compared to sentences without only (48). In contrast to positive sentences, the insertion of only in negative sentences generates weaker statements.10

IN DEFENSE OF THE SEMANTIC SUBSET PRINCIPLE

As noted in the introduction, the SSP has been invoked in a series of recent papers to explain the children’s acquisition of scope ambiguities (Crain, 2012; Huang & Crain, in press; Notely et al., 2012a; Zhou & Crain, 2012). In particular, the SSP has been invoked to explain children’s preferences for readings that are not generated, or are highly disfavored, by adult speakers. In the formulation of the SSP we have adopted in the present paper, the SSP is viewed as a learning mechanism that dictates how children initially set certain lexical parameters. For these parameters, the alternative values generate readings that stand in a subset/superset relation. In such cases the SSP entreats children to initially adopt the parameter value that is associated with the stronger, subset reading, even if this requires the child to enforce polarity restrictions that are not enforced by adults. The polarity restrictions that are established by these lexical parameter enable the SSP to dictate the initial scope preferences of language learners, by instructing them to execute covert operations that raise or lower (reconstruct) lexical items with respect to negation. By these covert operations, the SSP ensures that language learners avoid adopting the superset value of lexical parameters where these values would lead to a subset problem.

In two recent papers, the rationale behind the Semantic Subset Principle and its empirical adequacy have both been questioned (Gualmini & Schwarz, 2009; Musolino, 2006). We will briefly comment on these critiques in order to make the case that there remain compelling reasons to maintain the Semantic Subset Principle if the goal is to explain children’s initial preferences for interpreting scopally ambiguous sentences.

Empirical Adequacy of Semantic Subset Principle

One of the two critques we will discuss appeared in Musolino (2006). In the paper, Musolino cites two empirical findings as counterexamples to the SSP. One of the two putative counterexamples concerns negative sentences with the existential quantifiers some in subject position, as illustrated in (50). The problem here, according to Musolino, is that both children and adults assign the weak reading (some > not) to sentences like (50), according to which some takes scope over negation, just as it does in surface syntax. The SSP, according to Musolino, predicts that children, unlike adults, should assign the strong (not > some) subset reading to sentences such as (50).

(50) Some girls won’t ride on the merry-go-round

10For some speakers, sentences (47) and (49) are false when a horse is in the box. Even under this more restrictive interpretation, (47) and (49) are not stronger than (46) and (48), since they do not asymmetrically entail those in (46) and (48).
However, this prediction, attributed to the SSP, does not follow from the formulation of the SSP presented in this article. Consider again the lexical parameter associated with Positive Polarity Items like English some. The value [+PPI] enforces a polarity restriction for adults when some appears in the scope of negation in the surface syntax, as in (51).

(51) The detective some guys didn’t find some [+PPI] guys

For adults, the polarity restriction is associated with the value [+PPI], which generates the weak, superset reading. To avoid subset problems, however, the SSP requires children to initially adopt the [–PPI] value of the lexical parameter, so the lexical item some is not raised but rather interpreted in its surface syntactic position. Because children assign the value [–PPI] to some, its interpretation with respect to negation is determined by surface word order. For children, then, when some appears in subject position, it is interpreted as taking scope over negation (some > not), whereas when some appears in object position, negation takes scope over some (not > some).

This brings us to the second potential counterexample raised in Musolino (2006). These are negative sentences with a universal quantifier appearing in object position, as illustrated by (52).

(52) The Smurf didn’t buy every orange (not > every)

Again, Musolino contends that the SSP predicts children to initially generate the strong, subset reading of (52), contrary to fact. Again, we disagree with this assessment of the situation since, in the case of universal quantifiers, there is no lexical parameter to be set. In fact, to our knowledge, there exist no polarity restrictions on universal quantifiers like every which would force the quantifier to raise over negation in order to generate the strong reading (every > not). In the absence of polarity restrictions on universal quantifiers in any human language, there are no lexical parameters for children to evaluate, so the SSP will never be invoked for sentences like (52).

There are findings from studies of children’s interpretations of negative sentences with quantificational expressions that are potentially troublesome for the SSP. In particular, several studies have found that children who exhibit a clear preference for the subset reading of certain sentences will also accept these sentences in circumstances in which only the weaker, superset reading is true (Musolino & Lidz, 2006; Gualmini et al., 2008). According to the version of the SSP we have adopted in the present paper, this can only happen if children have reset the lexical parameter to the superset value. In that case, children are expected to accept sentences in the full range of circumstances that are associated with the superset value, which includes circumstances that children should have previously rejected, according to the SSP.

The finding that children accept sentences in a range of circumstances, depending on the context, has also led to a reformulation of accounts based on surface-syntax, originally proposed to capture the initial “Observation of Isomorphism” (Musolino, 2006). These accounts, too, have

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11 When uttered with a neutral intonation, negative sentences like (52) are generally unambiguous. To capture this cross-linguistic generalization, a universal constraint has been proposed to ban the covert movement of universal quantifiers from object position (Mayr & Spector, 2010).
been reformulated as hypotheses about children’s default preferences for surface scope readings, but preferences that can be overridden by contextual factors (Musolino & Lidz, 2006).

Although the surface-syntax account and the SSP sometimes predict the same interpretative preferences by children, only the Semantic Subset Principle is able to explain children’s behavior when children’s initial analysis is the inverse scope reading, such that they accept a sentence on this reading but reject it on the surface scope reading. This can happen, first, when the strong (subset) reading requires a scope-bearing element to be ‘lowered’ to a position beneath negation. The present study of children’s interpretation of negative statements with modals is an example in point. As we saw in Experiments 1 and 2, children were found to generate the strong (subset) reading, rejecting the sentences in contexts that matched the weaker, superset reading. We explained this by invoking a lexical parameter whose initial subset value forces the modal to lower to a position beneath negation.

Consider, again, children’s interpretation of sentence (53). As we witnessed, children did not interpret potere/might in its surface position, as required by adults, as in (53a). Instead children derived the non-adult, inverse scope reading, as in (53)b.

(53) Ci puo’ non essere una mucca nella scatola
there can not be a cow in the box
a. “it is possible that a cow is not in the box” (ADULTS: possible > not)
b. *it is (possible) not possible that a cow is in the box” (CHILD: not > possible)

There is another kind of case in which the Semantic Subset Principle, but not an account based on surface-syntax, is able to explain children’s behavior. In cases of this kind, a lexical item is ‘raised’ by children in order to generate the strong, subset interpretation of a potential scope ambiguity, whereas the same lexical items are not raised by adult speakers of the local language. An example is children’s interpretation of negative statements with conjunction (English and). Consider sentence (54).

(54) John did not order (both) sushi and pasta.

English-speaking adults accept (54) in three circumstances: (i) if John ordered sushi but not pasta, (ii) if John ordered pasta but not sushi, and (iii) if John did not order either sushi or pasta. When this sentence is translated into Mandarin or Japanese, however, the sentence is true in only one of the three circumstances that make (54) true for English-speaking adults: (iii) if John did not order either sushi or pasta. So, in Mandarin Chinese and Japanese negative sentences with conjunction are true in a subset of the circumstances that are associated with the English sentence (54). The observed differences among languages can be attributed to different scope relations between negation and conjunction. In English, negation takes scope over conjunction, whereas conjunction takes scope over negation in Mandarin Chinese and Japanese. So, the interpretation assigned by Mandarin Chinese and Japanese speakers resembles a cleft structure in English, as in (55), where the order of conjunction and negation is inverted, as compared to (54).

(55) It is (both) sushi and pasta that John did not order sushi and pasta
One way to explain this cross-linguistic difference is to include logical connectives in the set of operators that are sensitive to polarity restrictions (Szabolczi, 2002; Goro, 2007). In this way, the more restrictive interpretations found in adult Japanese and Mandarin Chinese can be accounted for in terms of inverse scope, triggered by assigning the value [+PPI] to conjunction. On this analysis, the strong reading of negative sentences with conjunction is associated with a covert operation in which conjunction is compelled to ‘raise’ above negation at the level of semantic interpretation. In English, by contrast, sentence (54) receives a weak interpretation, so conjunction is [-PPI] and, hence, is interpreted in situ. English conjunction can only generate the strong reading found in Japanese and Mandarin Chinese when it is positioned above negation in the surface syntax, as in the cleft example in (55). Negative sentences with conjunction therefore comply with an isomorphic reading in adult English, but not in Japanese or in Mandarin Chinese.

Thus, to account for children’s interpretations of sentences like (54), the predictions of the Semantic Subset Principle are strongly favored over predictions generated by accounts based on surface syntax. The SSP predicts that English-speaking children will initially interpret conjunction as [+PPI], which generates the inverse scope reading, as in Mandarin Chinese and Japanese, but an interpretation that differs from that of adult English-speakers. This prediction can be tested in a situation in which sentence (54) is predicted to be true for adults but false for children; for example where John ordered sushi but not pasta. In fact, experiments with this design have been conducted, and English children rejected negative sentences with conjunction in situations where adults accepted them, as predicted by the Semantic Subset Principle (e.g., Crain, Goro, Notley, & Zhou, 2013). The findings represent a substantial challenge to any account based on surface syntax.

To summarize, a growing body of evidence shows that, even in typologically distinct languages, children initially prefer to assign strong readings to scope bearing elements when they combine with negation (and other Downward Entailing operators), even when this yields inverse scope interpretations, and even when these readings are strongly dispreferred by adults (Crain, Gardner, Gualmini, & Rabin, 2002; Goro & Akiba, 2004; Gualmini & Crain, 2002, 2005; Notley et al., 2012). Taken together, the findings of children’s interpretation of modals and logical connectives in sentences with negation both constitute direct counterevidence to an account based on surface syntactic relations, and as evidence supporting the SSP.

Conceptual Necessity of Semantic Subset Principle

In a recent paper, Gualmini and Schwarz (2009) criticize the Semantic Subset Principle on different grounds. They question the conceptual necessity of the SSP as a principle of language learnability. Implicit in Gualmini and Schwarz’s (2009) discussion, however, is a rejection of some of the fundamental assumptions about the nature of the linguistic data that children have access to in language learning.

The Semantic Subset Principle is grounded on the assumption that the primary linguistic data must be simple so as to be sufficiently abundant to guarantee that every child converges on a grammar that is equivalent to that of adult speakers of the local language (Lasnik & Crain, 1987; Lightfoot, 1989). In the literature on language learnability, there has been a concerted emphasis to reduce the degree of embedding in the input sentences that are required for language learning. Let us expand this point.
A sentence that contains no other sentences is said to be of degree 0. A sentence that has one sentence embedded in it is said to be of degree 1, and so on. The degree of a sentence is one measure of its complexity. Assuming that not every child encounters complex input (e.g., degree 1 or degree 2) in abundance, the fact that every child rapidly converges on a grammar that is equivalent to that of adults makes it evident that children do not require complex input for language learning. This observation calls into question the alternatives to the SSP that are proposed by Gualmini and Schwarz (2009).

To eliminate the SSP, Gualmini and Schwarz propose that the primary linguistic data available to children consists of evidence that is derived (a) by the computation of conversational implicatures and (b) from input that contains more than a single downward entailing operator, including sentences of degree 1, and ones with three logical expressions. Of course Gualmini and Schwarz may well be justified in relaxing the learnability constraints that have been imposed in the previous literature to ensure rapid convergence on the target grammar by all children. This is an empirical issue after all, but the consequences of expanding the primary linguistic data to include additional sources of input warrant careful scrutiny.

One proposal is that the input to language learners includes conversational implicatures. These implicatures are generally attributed to Grice's Maxim of Quantity. Assuming that speakers provide true and maximally informative statements, hearers assume that stronger meanings are excluded from consideration, even if their truth-conditions are satisfied in the domain of discourse. For example, when hearers encounter the sentence *It might not be in the box*, they infer the negation of the stronger meaning *It cannot be in the box*. The inference that the meaning associated with *It cannot be in the box* is no longer under consideration breaks the subset/superset relation which would otherwise obtain. In this way, according to Gualmini and Schwarz, children’s ability to compute conversational implicatures eliminates the need for the Semantic Subset Principle.

Computing implicatures is a complex process, however, and children’s ability to perform the necessary computations emerges relatively late in the course of language development, as Gualmini and Schwarz themselves acknowledge (Chierchia et al., 2001; Gualmini et al., 2001; Guasti et al., 2005; Noveck, 2001). Children’s rapid convergence on the target grammar therefore renders this source of input doubtful. The fact that implicatures are defeasible is also problematic for their account. When an implicated meaning is negated, what precludes children from cancelling the effects of implicatures, since they yield false outputs? But if children cancel the implicatures, then this reinstates the subset/superset relations that the computation of implicatures was designed to eliminate.

Gualmini & Schwarz also suggest that children avoid subset/superset learnability dilemmas by invoking constructions that contain Downward Entailing operators, which reverse entailment relations (Ladusaw, 1980). To see how this proposal obviates the need for the SSP, consider the subset/superset configuration in (56).

\[(56)\] The cow cannot be in the box
\[a. \quad \text{"the cow might not be in the box} \quad \text{(weak)}
\[b. \quad \text{the cow cannot be in the box} \quad \text{(strong)}
\]

In (56), where the sentences are not embedded under any other additional operator, there is no circumstance in which (56)a is false but (56)b is true. Thus, no simple positive evidence is available to children to jettison the nonadult, weak hypothesis (56)a, if it turns out that children initially
adopt this as their preferred interpretation of the example statement. However, entailment relations are reversed under Downward Entailing operators, including negation, so when the example statement in (56) is embedded under negation, as in (57), the meaning in (57)a becomes stronger than the meaning in (57)b. In this case, then the initial hypothesis of the meaning in (57)a is falsifiable. Simply observing a situation in which there is no cow in the box will suffice as evidence disconfirming the weak reading of sentences such as (57).

(57) it is not true that the cow cannot be in the box
   a. *it is not true that [the cow might not be in the box] (strong in DE)
   b. it is not true that [the cow cannot be in the box] (weak in DE)

The concern we wish to raise is whether it is prudent to consider sentences such as (57) to be readily available in the primary linguistic data. We advise caution in abandoning a principle of language learnability, such as the SSP, by invoking sentences of degree 1, with two negative markers, such as (57). To the extent that models of language learnability profit from input of low complexity (degree 0), they will need to invoke principles, such as the SSP, that operate on sentences of low complexity.

Finally, consider the empirical prediction of an early grammar biased toward strong readings, as envisioned by the SSP, and an early grammar without such a bias, as envisioned by Gualmini and Schwarz. Let us assume, for the purposes of argument, that children have no inherent bias toward strong readings, which seems consistent with the account offered by Gualmini and Schwarz. If so, nothing prevents some children from initially assigning an ungrammatical, strong reading to sentences such as (58), with *might* followed by *not*.

(58) The cow might not be in the box.
   a. it is possible that the cow is not in the box (weak)
   b. *it is not possible that the cow is in the box (strong)

On this scenario, children will encounter (58) in a context in which a salient cow is in a box. This will suffice for children to reject their initial hypothesis (b), and change their grammars to (58)a. This grammatical change is therefore expected to occur early in the course of language development.

Continuing to maintain the assumption that children’s grammars are initially unbiased, we are also led to expect some children to initially hypothesize that the ungrammatical weak reading is assigned to sentences such as (59), with *can* followed by *not*.

(59) The cow cannot be in the box
   a. *it is possible that the cow is not in the box (weak)
   b. it is not possible that the cow is in the box (strong)

We can see no reason why children are prevented from making this kind of non-adult meaning assignment, in the absence of the SSP. In this case, however, error detection by children would require degree 1 sentences in which degree 0 sentence such as (59) are embedded under negation or another Downward Entailing operator. On this scenario, the children under consideration

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12 The frequency of embedded sentences in child directed speech ranges between 6% and 11% of the overall input (Morgan, 1989). Arguably, very few of these are negative sentences like (57). More generally, sentences with two scope-bearing elements embedded under DE operators are rare.
would assign non-adult weak readings for an extended period of time, due to the complexity (and hence rarity) of the requisite input promoting grammar change. Thus, if children’s grammar is initially unbiased toward the strong reading, interpretive errors with (58) are expected to disappear earlier than errors with (59). Many of the aforementioned experimental findings (Moscati, 2008; Gualmini & Moscati, 2009) and the results of the present study, however, fail to support this scenario. While children correctly assign the strong reading to sentences such as (59), at the same stage they are still struggling with the correct meaning of (58). In short, children’s early non-adult interpretations of scopally ambiguous sentences with modals are difficult to explain, unless the explanation includes an inherent bias towards the strong readings, in accordance with the SSP.

CONCLUSION

The results reported in this article support the idea that informational strength is a relevant factor in determining logical scope in sentences with multiple logical operators. We addressed this issue in negative epistemic sentences, where we found that children prefer scope assignments that generate strong readings, even when these readings are ruled out by adult speakers of the local grammar. We observed that the process of strengthening and children’s initial preference for strong interpretations might not be an isolated case. The results of Experiment 1 showed that, in simple declarative sentences, children tend to assign more stringent truth conditions. We propose that this is due to the generation of an assertion of exclusivity, contributed by a covert only. The effect of the covert only is to restrict the set of circumstances that verify the sentence, resulting, again, in a more restrictive interpretation. The results suggest that children’s knowledge of epistemic modality cannot be considered in isolation. Different factors, such as scope and focus assignment, could also alter the interpretation of epistemic sentences. This observation has some important consequences for the study of epistemic development. In particular, some non-adult interpretations of epistemic sentences could be due to factors other than children’s early mastery of epistemic modals.

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APPENDIX A – MATERIALS. EXPERIMENT 1

Box Set #1 – Open Boxes: cow + horse, horse. Outside: strawberry.
(1) Ci può essere una mucca (there might be a cow) T
(2) Ci può essere una fragola (there might be a strawberry) F
(3) Non ci può essere una mucca (there can not be a cow) F
(4) Non ci può essere una fragola (there can not be a strawberry) T
(5) Ci può non essere un cavallo (there might not be a horse) F
(6) Ci può non essere una mucca (there might not be a cow) T

Box Set #2 – Open Boxes: pig + rooster, rooster. Outside: dog
(1) Ci può essere un maialino (there might be a pig) T
(2) Ci può essere un cane (there might be a dog) F
(3) Non ci può essere un maialino (there can not be a pig) F
(4) Non ci può essere un cane (there can not be a dog) T
(5) Ci può non essere un gallo (there might not be a rooster) F
(6) Ci può non essere un maialino (there might not be a pig) T

Box Set #3 – Open Boxes: roman soldier + car, car. Outside: ball
(1) Ci può essere un romano (there might be a Roman) T
(2) Ci può essere una pallina (there might be a ball) F
(3) Non ci può essere un romano (there can not be a Roman) F
(4) Non ci può essere una pallina (there can not be a ball) T
(5) Ci può non essere una macchinina (there might not be a car) F
(6) Ci può non essere un romano (there might not be a Roman) T

Box Set #4 – Open Boxes: duck + cat, duck. Outside: horse
(1) Ci può essere un gatto (there might be a cat) T
(2) Ci può essere un cavallo (there might be a horse) F
(3) Non ci può essere un gatto (there can not be a cat) F
(4) Non ci può essere un cavallo (there can not be a horse) T
(5) Ci può non essere una paperella (there might not be a duck) F
(6) Ci può non essere un gatto (there might not be a cat) T
APPENDIX B – MATERIALS. EXPERIMENT 2

Box Set #1 – Open Boxes: chicken, goat. Outside: horse, pig, rooster, duck
(1) Ci può essere una gallina (there might be a chicken) T
(2) Non ci può essere un cavallo (there can not be a horse) T
(3) Ci può non essere una capra (there might not be a goat) T
(4) Ci può essere un gallo (there might be a rooster) F
(5) Ci può essere un maialino (there might be a pig) F
(6) Ci può essere una papera (there might be a duck) F

Box Set #2 – Open Boxes: goat, horse. Outside: chicken, pig, rooster, duck
(1) Ci può essere una capra (there might be a goat) T
(2) Non ci può essere una papera (there can not be a duck) T
(3) Ci può non essere un cavallo (there might not be a horse) T
(4) Ci può essere un gallo (there might be a rooster) F
(5) Ci può essere un maialino (there might be a pig) F
(6) Ci può essere una papera (there might be a duck) F

Box Set #3 – Open Boxes: horse, pig. Outside: goat, rooster, chicken, duck
(1) Ci può essere un maialino (there might be a pig) T
(2) Non ci può essere una capra (there can not be a goat) T
(3) Ci può non essere un cavallo (there might not be a horse) T
(4) Ci può essere un gallo (there might be a rooster) F
(5) Ci può essere una gallina (there might be a chicken) F
(6) Ci può essere una papera (there might be a duck) F

Box Set #4 – Open Boxes: pig, rooster. Outside: goat, horse, chicken, duck
(1) Ci può essere un gallo (there might be a rooster) T
(2) Non ci può essere una papera (there can not be a duck) T
(3) Ci può non essere un maialino (there might not be a pig) T
(4) Ci può essere una capra (there might be a goat) F
(5) Ci può essere una gallina (there might be a chicken) F
(6) Ci può essere un cavallo (there might be a horse) F

Box Set #5 – Open Boxes: horse, chicken. Outside: goat, pig, rooster, duck
(1) Ci può essere un cavallo (there might be a horse) T
(2) Non ci può essere un maialino (there can not be a pig) T
(3) Ci può non essere una gallina (there might not be a chicken) T
(4) Ci può essere una capra (there might be a goat) F
(5) Ci può essere un gallo (there might be a rooster) F
(6) Ci può essere una papera (there might be a duck) F