**Abstract**  Across languages, plural marking on count nouns typically gives rise to *multiplicity inferences*, indicating that there is more than one entity in the denotation of the noun. Plural marking has also been observed to occur on mass nouns in Greek, giving rise to a parallel *abundance inference*, indicating that there is more than a little of the relevant substance. It has been observed in the literature that both of these inferences disappear in downward-entailing environments, such as when a plural appears in the scope of negation (Tsoulas 2009; Kane et al. 2015). There are two main competing approaches in the literature that aim to account for the described pattern with respect to multiplicity inferences: the ambiguity approach (Farkas & de Swart 2010) and the implicature approach (Sauerland 2003; Spector 2007; Mayr 2015, among others). As discussed in Tieu et al. (2017a), while both approaches can account for the upward- versus downward-entailing pattern of multiplicity inferences, they differ in what they predict with respect to the acquisition of these inferences and their relationship with implicatures. Tieu et al. (2014; 2017a) tested the predictions of the two approaches for multiplicity inferences in English, and reported evidence for the implicature approach. In this paper, we first show how the ambiguity approach and the implicature approach to the multiplicity inference can be extended to account for the abundance inference. We then report on an experiment.

*Acknowledgements to be added.*
that tests the predictions of the two approaches for multiplicity and abundance inferences in preschool-aged children and adult native speakers of Greek. Our results replicate the patterns reported in Tieu et al. (2014; 2017a) for multiplicity inferences, and crucially reveal an analogous pattern for abundance inferences. Adults computed both inferences more in upward-entailing environments than in downward-entailing ones. Moreover, children computed fewer inferences overall than adults did. The results reflect an overall pattern of implicature calculation, supporting a unified implicature analysis across the three kinds of inferences. The children’s results in particular, however, pose a challenge for the ambiguity approach.

Keywords:
count nouns, mass nouns, multiplicity inference, abundance inference, scalar implicatures, Greek language

1 Introduction

1.1 Plural marking on mass nouns

In English and various other languages, while the plural combines freely with count nouns, it can appear on mass nouns only in restricted ways. To illustrate, a sentence like (1a), containing the plural mass noun *waters*, is ungrammatical, unlike the corresponding sentence in (1b), containing the singular counterpart of the noun.

\[(1)\]
\[
a. \text{*Waters are dripping from the ceiling.} \\
b. \text{Water is dripping from the ceiling.} 
\]

A sentence like (1a) can only be rescued when the mass term is coerced or reinterpreted as types of or standardized quantities of the relevant substance, such as in (2) or (3) (Allan 1980; Link 1983; Chierchia 1998; 2010a; Deal 2017, among many others).\(^1\)

\[(2)\]
\[
\text{In this restaurant we offer three waters: sparkling, still, and tap water.}
\]

\(^1\)In addition, plural marking on mass nouns is allowed in idiomatic contexts like in (i) or other restricted cases like (ii) (see Acquaviva 2008 and Tsoulas 2009 for discussion).

\[(i)\]
\[
\text{Matilde’s waters broke.}
\]

\[(ii)\]
\[
\text{The waters of the pacific.}
\]
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(3) We ordered three waters one hour ago!

The incompatibility of plural marking and mass terms is such a widely observed generalisation that it has become criterial in deciding whether a noun is mass or count. Recently, however, it has been observed that pluralised mass nouns are attested in a variety of unrelated languages, e.g., Kuikuro (Franchetto, Santos & Lima 2013), Innu-aimun (Gillon 2015), Ojibwe (Rhodes 1990; Mathieu 2012), Blackfoot (Wiltschko 2012), and Greek (Tsoulas 2009). In Greek, in particular, the equivalent of (1a) in (4) is as acceptable as its singular counterpart in (5), and crucially is not interpreted as giving rise to a coerced meaning where waters refers to types of or standardised units of water (Tsoulas 2009; Alexiadou 2011; Harbour 2009; Kane et al. 2015).

(4) Trehun ner-a apo to tavani.
   drip.3PL water-PL from the.NEUT.SG.ACC ceiling
   ‘Water is dripping from the ceiling.’

(5) Trehi ner-o apo to tavani.
   drip.3SG water-SG from the.NEUT.SG.ACC ceiling
   ‘Water is dripping from the ceiling.’

In addition, as discussed in Tsoulas (2009), although mass nouns in Greek can be pluralised, they appear to retain their mass properties; for example, they cannot directly combine with numerals, as shown in (6) (unlike the examples of coercion in English above in (2) and (3)).

(6) Tsoulas (2009: p.135)
   *Dio ner-a trehun apo to tavani.
   two water-PL drip.3PL from the.NEUT.SG.ACC ceiling
   ‘Two waters are dripping from the ceiling.’

---

2 See also Lima (2014) and Deal (2017) for related discussion on number marking and the mass-count distinction in Yudja and Nez Perce. In these languages, while there appear to be combinations of plural marking with substance-referring nouns, it is unclear whether these nouns are mass at all or whether coercion of the type shown above in (1a) and (1b) happens in a much more generalised way than in English. Either way, they differ from the case of Greek in that crucially these plural substance nouns do combine with numerals.

3 The following glosses are used in this paper: DET = determiner; SG = singular; PL = plural; 1 = First person; 2 = Second person; 3 = Third person; FEM = feminine, MASC = masculine, NEUT = neutrum, NOM = Nominative, ACC = Accusative, DAT = Dative; CL = clitics; SBJ = subjunctive, POSS = possessive. An example marked with ‘*’ or ‘#’ means that the example is unacceptable for grammatical or semantic/pragmatic reasons, respectively.

4 These coerced examples are also possible in Greek. Importantly, however, in Greek, like in English, cases involving coercion can directly combine with numerals and for that reason appear different from cases like (4), which cannot.
Most relevantly for us, pluralised mass nouns are typically associated with an intensifying abundance inference that there is more than a little of the substance denoted by the mass noun. For example, (4) generally conveys that not just a little water dripped from the ceiling (Tsoulas 2009).

Kane et al. (2015) argue that the abundance inference is a scalar implicature arising in the same way as the ‘more than one’ or multiplicity inference of plural count nouns. In particular, (7), containing the pluralised count noun leaves, gives rise to the inference that more than one leaf fell from the tree.

(7) Leaves fell from the tree.

Kane et al. show that the abundance inference of pluralised mass nouns can be seen as the context-dependent counterpart of the multiplicity inference of pluralised count nouns. In the next subsection, we turn to the similarities between these two inferences.

1.2 The inferences of plurals

1.2.1 The multiplicity inference

The multiplicity inference of plural morphology on count nouns is the source of a long-standing puzzle. We illustrate the pattern below using examples from Greek.

Consider the sentence in (8a), containing the pluralised count noun pigs. This sentence sounds equivalent in meaning to one in which the plural marker is replaced by ‘more than one,’ as in (8b).

(8) a. I tighri taise ghurunia.  
   the.FEM.SG.NOM tiger fed pig.PL
   ‘The tiger fed pigs.’

b. I tighri taise parapano apo ena ghuruni.  
   the.FEM.SG.NOM tiger fed more than one pig.SG
   ‘The tiger fed more than one pig.’

---

5 It should be noted though that it is not only mere quantity playing a role in this reported intuition. In particular, the spreadness of the relevant substance appears to be important as well (Tsoulas 2009; Alexiadou 2011). In the study we report below we focus on the aspect of the inference related to quantity and leave to future investigation the potential role of spreadness.

6 For relevant discussion, see Krifka (1989); Sauerland (2003); Sauerland, Andersen & Yatsushiro (2005); Spector (2007); Zweig (2009); Farkas & de Swart (2010), and Magri (2014).

7 The same pattern is reported in the literature for English (see references in footnote 6). The intuitions about Greek reported below are based on the intuitions of two of the present authors, who are native speakers of Greek.
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This fact suggests that plural morphology should be associated with an exclusive ‘more than one’ meaning; in other words, the literal meaning of (8a) could be paraphrased as (8b) (Lasersohn 1995; Chierchia 1998; Link 1983). The problem with this hypothesis arises when we consider the negative counterpart of (8a), provided in (9a). Given the hypothesis above, we would expect (9a) to have a meaning that corresponds to the negation of (8b), as in (9b). Instead, the sentence’s meaning is the negation of the corresponding sentence with the singular noun in (9c).

(9) a. I tighri dhen taise ghurunia.
   the.FEM.SG.NOM tiger NEG fed pig.PL
   ‘The tiger didn’t feed pigs.’

b. I tighri dhen taise parapano apo ena ghuruni.
   the.FEM.SG.NOM tiger NEG fed more than one pig.SG
   ‘The tiger didn’t feed more than one pig.’

c. I tighri dhen taise kanena ghuruni.
   the.FEM.SG.NOM tiger NEG fed any pig.SG.
   ‘The tiger didn’t feed any pig.’

This pattern is not restricted to negation. The absence of the expected ‘more than one’ meaning of the plural is also observed in other downward-entailing environments. Again, in these environments, the plural nouns do not receive the corresponding ‘more than one’ interpretation. While one can deduce from (10a) that we should thank the tiger even if she fed only one pig, one cannot make such an inference from (10b). Similarly, if the tiger fed only one pig, the interlocutor can respond affirmatively to the question in (11a) but not to the question in (11b).\(^8\)

(10) a. Ean i tighri taise ghurunia, prepi na tin
   if the.FEM.SG.NOM tiger fed pig.PL should SBJ CL.FEM.SG.ACC
   efharistisume
   thank
   ‘If the tiger fed pigs, we should thank her.’

b. Ean i tighri taise parapano apo ena ghuruni, prepi
   if the.FEM.SG.NOM tiger fed more than one pig, should
   na tin efharistisume.
   SBJ CL.FEM.SG.ACC thank
   ‘If the tiger fed more than one pig, we should thank her.’

\(^8\) The downward-entailing status of the antecedent of conditionals and of questions is controversial. Nonetheless, what is relevant for us here is that these contexts generally pattern with downward-entailing environments with respect to the behaviour of multiplicity inferences.
(11) a. Taise i **tighri ghurunia?**
   fed the.FEM.SG.NOM tiger pig.PL
   ‘Did the tiger feed pigs?’

   b. Taise i **tighri parapano apo ena ghuruni?**
   fed the.FEM.SG.NOM tiger more than one pig.SG
   ‘Did the tiger feed more than one pig?’

The pattern above can be summarised as follows: the interpretation of positive sentences with plural morphology includes a ‘more than one’ inference, but this multiplicity inference disappears under negation, in the antecedent of conditionals, and in questions. This pattern is clearly problematic for a simple semantic account of multiplicity inferences, which simply encodes the inference in the literal meaning of plural morphology; such an approach would wrongly predict weaker meanings than are observed for cases like (9a), (10a), and (11a).

1.2.2 The abundance inference

The same pattern arises in the case of the abundance inference of pluralised mass nouns in Greek. To illustrate, consider the sentences in (12) and (13), containing the pluralised mass noun *zahares* ‘sugars.’ (12) gives rise to the abundance inference that the Zebra dropped much sugar. And similarly, (13) does not suggest that the Zebra didn’t drop much sugar, but rather that she didn’t drop any sugar.

(12) Tis zebras tis epesan zahar-es.
    the.FEM.SG.NOM zebra CL.FEM.SG.DAT fell.3PL sugar-PL
    ‘The zebra dropped sugar.’

(13) Tis zebras dhen tis epesan zahar-es.
    the.FEM.SG.DAT zebra NEG CL.FEM.SG.DAT fell.3PL sugar-PL
    ‘The zebra didn’t drop sugar.’

As discussed in Kane et al. (2015), the same holds for conditionals and questions: if the zebra dropped only a little sugar, we should tell her mother in the case of (14a) but not in the case of (14b). Analogously, if the zebra dropped only a little sugar we should respond affirmatively to (15a) but not to (15b).

(14) a. Ean tis zebras tis epesan zahares, prepi
    if the.FEM.SG.DAT zebra CL.FEM.SG.DAT fell.3PL sugar.PL should
    na to pume sti mama tis.
    SBJ CL.NEUT.SG.ACC tell to-the.FEM.SG.ACC mom POSS.FEM
    ‘If the zebra dropped sugar, we should tell her mom.’
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(15) a. Tis  

\begin{verbatim}
CL.FEM.SG.DAT fell.3PL sugar.PL the.FEM.SG.DAT zebra
\end{verbatim}

‘Did the zebra drop sugar?’

b. Tis  

\begin{verbatim}
CL.FEM.SG.DAT fell.3SG much sugar.SG the.FEM.SG.DAT zebra
\end{verbatim}

‘Did the zebra drop much sugar?’

As in the case of the multiplicity inference, the presence of the abundance inference in upward-entailing contexts and its disappearance in downward-entailing ones is problematic for an analysis of the abundance inference as simply part of the lexical meaning of plural morphology on mass nouns (as proposed for instance in Alexiadou 2011). Rather, it suggests that a unified account explaining the pattern of the multiplicity and abundance inferences in upward- and downward-entailing contexts is possible.

There are two main competing approaches in the literature that aim to account for the described pattern with respect to multiplicity inferences: the ambiguity approach (Farkas & de Swart 2010, see also Marti 2017 and Grimm 2013) and the implicature approach (Sauerland 2003; Spector 2007; Mayr 2015, among others). As discussed in Tieu, Bill, Romoli & Crain (2017a), while both approaches can account for the upward- versus downward-entailing pattern of multiplicity inferences, they differ in what they predict with respect to the acquisition of these inferences and their relationship with scalar implicatures. Tieu et al. (2014; 2017a) tested the predictions of the two approaches for multiplicity inferences in English, and report evidence for the implicature approach to multiplicity inferences.

In the following sections, we first show how the ambiguity approach and the implicature approach to the multiplicity inference of pluralised count nouns can be extended to account for the abundance inference of pluralised mass nouns. We then test the predictions of the two approaches for multiplicity and abundance inferences in Greek, extending the previous experimental studies by Tieu et al. (2014; 2017a). In particular, we compare adults’ and preschool-aged children’s performance on abundance inferences, multiplicity inferences, and the ‘not all’ implicature of ‘merika’ (some) illustrated in (16), which suggests that Lion didn’t carry all of the apples.
As we will see, our results replicate the patterns reported in Tieu et al. (2014; 2017a) for multiplicity inferences, and crucially reveal an analogous pattern for abundance inferences. The findings provide further support for an implicature approach to the multiplicity inference and an extension of the approach to abundance inferences. In addition, we show how investigating a language like Greek, which allows the pluralisation of mass nouns, provides an empirical basis for a unified analysis of plural marking across the mass-count divide.

The rest of the paper is organised as follows. In the next section, we sketch the ambiguity and the implicature approach to multiplicity inferences and we show how they can be extended to account for abundance inferences. We also discuss the predictions of the two approaches in relation to adults’ and children’s behaviour. In Section 3, we summarise the previous studies by Tieu et al. (2014; 2017a), which tested the predictions of the two accounts for the multiplicity inference; we show how their paradigm can be extended to a novel investigation of the abundance inference. In Section 4, we present our experiment comparing the two inferences in children and adults, and in Section 5 we discuss the results in the context of the predictions of the two approaches. We conclude the paper in Section 6.

2 Theoretical background

2.1 The ambiguity approach

2.1.1 The multiplicity inference

In order to account for the observation that multiplicity inferences appear in upward-entailing contexts but disappear in downward-entailing contexts, Farkas & de Swart (2010) (see also Marti 2017; Grimm 2013) propose a more enriched semantic account than the one mentioned above. Simplifying somewhat, their approach is based on two main ingredients: a polysemous meaning for plural morphology and a principle for choosing between these meanings in different contexts. \(^9\) In other words, they argue that a sentence like (8a), repeated below in (17), is ambiguous between two meanings, which can be paraphrased as in (17a) and (17b). Corre-

\(^{9}\) The proposal in Farkas & de Swart (2010) also includes a bi-directional optimisation over form-meaning pairs, captured within an Optimality Theory framework. As it is not relevant for our purposes, we will set aside this part of their proposal.
The abundance inference of pluralised mass nouns is an implicature. (9a), repeated in (18), is associated with the two meanings paraphrased in (18a) and (18b).

(17)   I tighri taise ghurunia.
       the.FEM.SG.NOM tiger fed pig.PL
       ‘The tiger fed pigs.’
       a. The tiger fed one or more pigs. INCLUSIVE (WEAK)
       b. The tiger fed more than one pig. EXCLUSIVE (STRONG)

(18)   I tighri dhen taise ghurunia.
       the.FEM.SG.NOM tiger NEG fed pig.PL
       ‘The tiger didn’t feed pigs.’
       a. The tiger didn’t feed one or more pigs. INCLUSIVE (STRONG)
       b. The tiger didn’t feed more than one pig. EXCLUSIVE (WEAK)

However, the proposed ambiguity alone will not account for the fact that in upward-entailing contexts, the plural tends to be interpreted exclusively as in (17b), while in downward-entailing contexts it tends to be interpreted inclusively as in (18a). In order to account for this pattern, Farkas & de Swart (2010) assume a version of the Strongest Meaning Hypothesis, formulated as in (19), which essentially regulates the choice between the two possible meanings in favour of the strongest of the two (see Dalrymple, Kanazawa, Kim, Mchombo & Peters 1998; Winter 2001, among others).

(19)   The Strongest Meaning Hypothesis for Plurals: for a sentence involving a plural nominal, prefer that interpretation of plural which leads to the stronger overall interpretation for the sentence as a whole, unless this interpretation conflicts with the context of utterance.

The Strongest Meaning Hypothesis favours the exclusive interpretation of plurals in upward-entailing contexts; that is, it favours the stronger (17b) over the weaker (17a). Conversely, the inclusive interpretation is preferred in downward-entailing contexts, as in these contexts it gives rise to the stronger reading; that is, the stronger (18a) is preferred over the weaker (18b). The combination of the proposed ambiguity with the Strongest Meaning Hypothesis therefore allows Farkas & de Swart’s (2010) approach to account for the sensitivity to monotonicity exhibited by the multiplicity inference.

In addition, note that the Strongest Meaning Hypothesis as formulated in (19) does allow for the possibility of weak interpretations, in cases where the strong meanings are in conflict with the context of utterance. We therefore expect to be
able to force a weak interpretation through a continuation that is in conflict with the strong interpretation. This is indeed the case, as illustrated in (20):

(20) I tighri dhen taise ghurunia jati taise mono ena!
the.FEM.SG.NOM tiger NEG fed pig.PL because fed.3SG only one.NEUT.SG.ACC
The tiger didn’t feed pigs, because she fed only one!

2.1.2 Extension to the abundance inference

The ambiguity account can be readily extended to the abundance inference. In the domain of pluralised mass nouns, a sentence like (21), repeated from above, would then be associated with the two meanings in (21a) and (21b). In the same way, the negative counterpart in (13), repeated below in (22), would be associated with the two meanings in (22a) and (22b).

(21) Tis zebras tis epesan zahar-es.
the.FEM.SG.DAT zebra CL.FEM.SG.DAT fell.3SG sugar-PL
‘The zebra dropped sugar.’

a. The zebra dropped a little or more than a little sugar.
INCLUSIVE (WEAK)
b. The zebra dropped more than a little sugar.
EXCLUSIVE (STRONG)

(22) Tis zebras dhen tis epesan zahar-es.
the.FEM.SG.DAT zebra NEG CL.FEM.SG.DAT fell.3PL sugar-PL
‘The zebra didn’t drop sugar.’

a. The zebra didn’t drop a little or more than a little sugar.
INCLUSIVE (STRONG)
b. The zebra dropped more than a little sugar.
EXCLUSIVE (WEAK)

In the same way as above, the Strongest Meaning Hypothesis in (19) would regulate the choice between the two possible meanings, favouring the strongest between the two, namely the exclusive interpretation (21b) in upward-entailing contexts and the inclusive interpretation (22a) in downward-entailing contexts. In addition, as in the case of count nouns, the strong interpretation of the plural should be blocked if it is in conflict with the continuation of the sentence, as illustrated in (23):
The abundance inference of pluralised mass nouns is an implicature (23)

Tis zebras dhen tis epesan zahares jati the.FEM.SG.DAT zebra NEG CL.FEM.SG.DAT fell.3PL sugar.PL because tis epese mono lighi! CL.FEM.SG.DAT fell.3SG only little
‘The zebra didn’t drop more than a little sugar, because she dropped only a little!’

In sum, the ambiguity approach can explain the different readings of the plural and their distribution across the mass and count domains in both upward- and downward-entailing contexts. In the next subsection, we turn to a different take on the puzzle, which involves treating multiplicity and abundance inferences as implicatures.

2.2 The implicature approach

2.2.1 The multiplicity inference

A different response to the pattern associated with the multiplicity inference is to treat it as a type of implicature (Sauerland 2003; Sauerland, Andersen & Yatsushiro 2005; Spector 2007; Zweig 2009; Iwildieva 2013; Mayr 2015). This approach is driven by the observation that (scalar) implicatures, just like multiplicity inferences, arise in upward-entailing contexts but typically disappear in downward-entailing contexts. To illustrate, a familiar example of a scalar implicature is given in (24). In response to a positive sentence containing a disjunction phrase ‘A or B,’ we typically infer exclusivity, such that the disjunction phrase ‘A or B’ is taken to mean ‘A or B, but not both.’ Illustrating again with Greek examples, (24a) implies (24b).

(24) a. O Dhimitris efaghe to milo i to the.MASC.SG.NOM Dimitri ate the.NEUT.SG.ACC apple or the.NEUT.SG.ACC portokali. orange.
‘Dimitri ate the apple or the orange.’

b. ⊳ Dimitri did not eat both the apple and the orange.

However, when disjunction is embedded under negation, it is typically interpreted inclusively, rather than exclusively: (25a) is typically interpreted as (25b) and not as (25c); the latter corresponds to the negation of the exclusive meaning of disjunction and is compatible with Dimitri eating both the apple and the orange. But (25a) is not generally interpreted as being compatible with such a situation.
Dhimitris dhen efaghe to milo the.MASC.SG.NOM Dimitri NEG ate the.NEUT.SG.ACC apple or the.NEUT.SG.ACC orange.
‘Dimitri didn’t eat the apple or the orange.’

b. ¬Dimitri didn’t eat the apple and Dimitri didn’t eat the orange.
c. ¬Dimitri either ate both the apple and the orange or he ate neither.

Thus we see that multiplicity inferences and classical scalar implicatures share the property of arising in upward-entailing environments and disappearing in downward-entailing environments.

The standard approach to deriving scalar implicatures like (24b) is to treat them as arising from a hearer’s reasoning about why a cooperative speaker would say what she did and not something else (see Grice 1975 and much subsequent work).
Schematically, the implicature above would arise from the comparison of the original assertion with alternative assertions that could have been uttered but were not.
In particular, a sentence with a weak scalar term like ‘or’ is compared to the stronger alternative sentence containing ‘and.

(26)  a. Dimitri ate the apple or the orange.
    b. Dimitri ate the apple and the orange.

Assuming the speaker is being cooperative and as informative as he or she can be, the fact that he or she uttered the assertion containing ‘or’, rather than the more informative alternative sentence containing ‘and’, invites the listener to conclude that the speaker was not in a position to assert the stronger alternative. The listener further infers that the stronger alternative must therefore be false, deriving the inference in (24b).

This reasoning also naturally explains why (25a) doesn’t give rise to an implicature and, as we observed, is instead interpreted as the negation of an inclusive disjunction. In this case, the listener will reason that the alternative sentence is (27), but (27) is not more informative than (25a); in fact it is weaker, and therefore the listener will draw no implicature from (25a).

(27) Dimitri didn’t eat the apple and the orange.

The implicature approach to multiplicity inferences extends the reasoning above to sentences like (8a) and (9a), repeated below in (28) and (29):

(28) I tighri taise ghrunia.
    the.FEM.SG.NOM tiger fed pig.PL
    ‘The tiger fed pigs.’
The abundance inference of pluralised mass nouns is an implicature

(29) I tighri dhen taise ghurunia.
    the.FEM.SG.NOM tiger NEG fed pig.PL
    ‘The tiger didn’t feed pigs.’

Roughly, the idea is that upon hearing a sentence like (28), which is assumed to unambiguously mean that the tiger fed one or more pigs, the listener will ask herself why the speaker didn’t say (something to the effect of) (30) instead.\(^{10}\)

(30) The tiger fed exactly one pig.

Given that (30) would have been more informative than (28), the listener will conclude that the speaker must believe that (30) is false. If (28) is true and (30) is false, the result is then precisely the multiplicity inference that arises as part of the meaning of the plural, as illustrated in (31):

(31) The tiger fed one or more pigs and it’s not true that he fed exactly one pig =The tiger fed more than one pig.

In addition, in the same way as with the disjunction case above, this approach can explain why the negated sentence in (29) is not associated with a multiplicity inference. The listener will compare (29) to its alternative in (32). (32), however, is weaker than (29) and therefore the listener will not draw any implicature from (29).

(32) The tiger didn’t feed exactly one pig.

Moreover, the scalar implicature approach can also account for the additional reading of the negated plural in (20) above, repeated below in (33).

(33) I tighri dhen taise ghurunia jati taise mono ena!
    the.FEM.SG.NOM tiger NEG feed pig.PL because fed.3SG only one
    The tiger didn’t feed pigs, because he fed only one!

This kind of reading also arises with standard scalar items like disjunction; for instance, (34), when pronounced with stress on ‘or’, also has a marked reading compatible with Dimitri eating both the apple and the orange. The implicature approach simply resorts to whatever mechanism accounts for (34) and extends it to (33). The general way of generating these marked readings involves postulating a ‘local’ scalar implicature under the scope of negation. Scalar implicatures tend not to arise under negation so such readings are correctly predicted to be marked.

\(^{10}\) Notice that (30) is simply a paraphrase of the required alternative. Variants of the implicature approach differ in how they derive the alternative over which the multiplicity inference is computed; see Mayr (2015) and Tieu et al. (2017a) for discussion.
(34) Dimitri didn’t eat the apple or the orange, he ate both!

2.2.2 Extension to the abundance inference

As with the ambiguity account, the implicature approach can also be extended to the mass domain, as recently proposed by Kane et al. (2015). The gist of Kane et al.’s (2015) proposal is that a sentence like (12), repeated below in (35), is associated with the weak literal meaning in (36a) only. In addition, however, (36a) is assumed to be in competition with an alternative that can be paraphrased as in (36b).

(35) Tis zebras tis epesan zahar-es.
    the.FEM.SG.DAT zebra CL.FEM.SG.DAT fell.3PL sugar-PL
    ‘The zebra dropped sugar.’

(36) a. The zebra dropped a little or more than a little sugar.
    b. The zebra dropped just a little sugar.

Given that (36b) would have been more informative than (36a), the listener will conclude that the speaker must think that (36b) is false. But, again, if (36a) is true and (36b) is false, the result is the abundance inference that arises as part of the meaning of the pluralised mass noun, as illustrated in (37):

(37) The zebra dropped a little or more than a little sugar and it’s not true that she dropped just a little sugar.
    =The zebra dropped more than a little sugar.

In addition, in the same way as above, we can explain why (13), repeated below in (38), is not associated with any inference.

(38) Tis zebras dhen tis epesan zahar-es.
    the.FEM.SG.DAT zebra NEG CL.FEM.SG.DAT fell.3PL sugar-PL
    ‘The zebra didn’t drop sugar.’

This is because the listener will compare (38) to its alternative in (39), which is in fact weaker than (38) and therefore the listener will not draw any implicature from (38).

(39) The zebra didn’t drop just a little sugar.

As was the case for the multiplicity inference, the scalar implicature approach will also account for the marked reading of (38) in (40), repeated from above.
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(40) Tis zebras dhen tis epesan zahares jati the.FEM.SG.DAT zebra NEG CL.FEM.SG.DAT fell.3PL sugar.PL because tis epese mono lighi zahari CL.FEM.SG.DAT fell.SG only little sugar.SG ‘The zebra didn’t drop more than a little sugar, because she dropped just a little!’

In sum, both the ambiguity and the implicature approaches can account for the different readings associated with plural morphology across the mass and count divide, and in particular for the pattern of sensitivity to monotonicity that they exhibit. In the next subsection, we turn to the different predictions they make for acquisition. These predictions motivated the previous experiments reported in Tieu et al. (2014; 2017a), which investigated multiplicity inferences, and they also motivate the present study, which extends the investigation of the predictions of both approaches to abundance inferences.

2.3 Predictions

2.3.1 Sensitivity to monotonicity

As discussed, both the ambiguity and the scalar implicature approaches predict the pattern above regarding upward- and downward-entailing contexts, with multiplicity and abundance inferences arising in the former but less so in the latter. Under both approaches, we therefore expect to observe this pattern experimentally when we look at adults’ interpretations of the plural in such contexts. Things are more complex, however, when we consider the comparison between adults and children, an issue to which we turn next.

2.3.2 Children vs. adults

As discussed in Tieu et al. (2017a), the ambiguity and the scalar implicature approaches make different predictions for how children and adults should interpret the plural. In this respect, a comparison between 4–6-year-old children and adults is particularly useful, as much work has already been conducted on how the two groups differ in the computation of scalar implicatures. Amidst considerable variation in the reported rates at which children and adults compute implicatures, a fairly robust finding has been that children typically compute fewer implicatures than adults do (Noveck 2001; Gualmini et al. 2001; Chierchia et al. 2001; Foppolo et al. 2012; Papafragou & Musolino 2003, among many others). For example, children typically accept sentences such as (41) in situations where the stronger al-
ternative (41a) is also true. This observation has usually been taken to indicate that children fail to compute the implicature in (41b).

\[(41)\quad \text{To liontaraki kuvalise merika apo ta mila!} \quad \text{‘The lion carried some of the apples.’} \]
\[\begin{align*}
a. & \quad \text{The lion carried all of the apples.} \\
\text{b.} & \quad \leadsto \text{The lion didn’t carry all of the apples.} \\
\end{align*}\]

Certain factors have been shown to impact children’s performance on scalar implicatures, such as, for example, making the scalar alternatives more salient in the context (for discussion of potentially relevant factors, see Papafragou & Tantalou 2004; Barner et al. 2011; Katsos & Bishop 2011; Stiller et al. 2015; Tieu et al. 2016a; Singh et al. 2016; Hochstein et al. 2016; Tieu et al. 2016b; Skordos & Papafragou 2016, among others). What matters for our purposes is that if multiplicity and abundance inferences are scalar implicatures, then we might also expect children not to compute such inferences from sentences like (42) and (43) below, or at least to do so less often than adults do.\footnote{We focus on the some and not all implicature because it has been the most extensively studied in the developmental literature. What is important for us is that children have consistently been shown to compute fewer some and not all implicatures than adults; moreover, among the numerous scales tested by van Tiel et al. (2014), adults generated the some and not all inference more often than most other implicatures, so we take it to be a good test case for children’s ability to compute implicatures.}

\[(42)\quad \text{I tighri taise ghurunia.} \quad \text{‘The tiger fed pigs.’} \]
\[\begin{align*}
a. & \quad \text{The tiger fed one or more pigs.} \\
\text{b.} & \quad \leadsto \text{The tiger fed more than one pig.} \\
\end{align*}\]

\[(43)\quad \text{Tis zebres tis epesan zahar-es.} \quad \text{‘The zebra dropped sugar.’} \]
\[\begin{align*}
a. & \quad \text{The zebra dropped a little or more than a little sugar.} \\
\text{b.} & \quad \leadsto \text{The zebra dropped more than a little sugar.} \\
\end{align*}\]

While the implicature approach makes a fairly clear prediction about how children should perform on multiplicity and abundance inferences compared to adults, what the ambiguity approach predicts instead depends on whether the children being tested have already acquired the two proposed meanings of the plural, and whether they are able to comply with the Strongest Meaning Hypothesis in an adult-
like fashion. In particular, under the ambiguity approach, there could be three reasons for children to display non-adult-like performance on plural sentences like the above (see discussion in Tieu et al. 2017a; Tieu & Romoli To appear):

(a) Children have only acquired the strong exclusive meaning of plurals;
(b) Children have only acquired the weak inclusive meaning of plurals;
(c) Children have acquired both meanings of the plural but have not yet mastered adult-like application of the Strongest Meaning principle.

These three potential developmental scenarios would lead to distinct patterns of behaviour from children, compared to adults. Recall that for adults, the plural is typically interpreted exclusively in upward-entailing contexts but inclusively in downward-entailing contexts. With this in mind, we can formulate the predicted patterns of behaviour arising from scenarios (a)–(c) as follows:

• (a) predicts that children will behave like adults in their interpretation of the plural in upward-entailing contexts but not in downward-entailing contexts.
• (b) makes the opposite prediction: children will behave like adults in their interpretation of the plural in downward-entailing contexts but not in upward-entailing contexts.
• (c) predicts that children may not be guided by the relative strength of the two meanings in their selection of the different readings across upward- and downward-entailing contexts.\textsuperscript{12,13}

2.3.3 Multiplicity vs. abundance inferences vs. scalar implicatures

The implicature and ambiguity approaches also differ when we look at the comparison between scalar implicatures on the one hand and multiplicity/abundance inferences on the other. This is because if multiplicity and abundance inferences are derived as a kind of scalar implicature, the implicature approach predicts that the behavioural pattern associated with these inferences should mirror that of other scalar implicatures. The exact nature of this uniformity prediction is actually complicated by the fact that adults’ rates of implicature computation have been reported to vary quite widely across different lexical scales (van Tiel, van Miltenburg, Ze-
vakhina & Geurts 2014). For example, the ‘not all’ implicature of some was found to be computed much more by adults than the ‘not love’ implicature of like. Importantly, however, following Tieu et al. (2017a), if we look at the comparison between these three inferences across different populations, there remains an expectation of a uniform pattern across populations, regardless of whether the three inferences differ within populations. Tieu et al. (2017a) formulate the uniformity prediction of the implicature approach as follows:

(44) Uniformity prediction of the implicature approach: If multiplicity inferences, abundance inferences, and scalar implicatures are of the same nature, we expect to observe the same pattern of between-group differences (or between-group similarities) when we investigate the three kinds of inferences.

In other words, while the implicature approach is compatible with within-population differences, it predicts a similar pattern across populations with respect to the three inferences.

The ambiguity approach, on the other hand, makes no particular predictions with respect to the relationship between standard implicatures on the one hand, and multiplicity/abundance inferences on the other.

In sum, while both the ambiguity and implicature approaches make the same prediction with respect to the pattern of multiplicity and abundance inferences in upward- vs. downward-entailing contexts, they differ in the predictions they make regarding children’s and adults’ interpretations of the plural, as well as how the plural inferences should compare with standard implicatures. In the next section, we briefly describe Tieu et al.’s (2014; 2017a) studies, which tested the predictions of these approaches for the multiplicity inference in English. We then discuss how their paradigm can be adapted to multiplicity and abundance inferences of pluralised mass nouns in Greek.

3 Previous studies

We will focus here on the experiments reported in Tieu et al. (2014; 2017a), as they are the most relevant for our purposes. For an overview of experimental work on semantic approaches to plurality, see Tieu & Romoli (To appear).

Tieu et al. (2014; 2017a) conducted a pair of experiments aimed at detecting multiplicity inferences in preschool-aged children. The experiments were aimed at testing the developmental uniformity prediction that arises from the scalar implicature approach to multiplicity inferences, namely that children’s performance
The abundance inference of pluralised mass nouns is an implicature on multiplicity inferences should mirror their performance on standard scalar implicatures. Tieu et al. (2014) tested the interpretation of the plural in affirmative and negative declarative sentences, with the expectation that multiplicity inferences would appear in the former but not the latter. The authors used a Truth Value Judgment Task (Crain & Thornton 1998); participants watched a series of short stories and then had to judge a puppet’s descriptions of the stories. For example, in one of the stories, a girl named Emily visited a pig farm and wanted to feed the pigs. However, she only had enough food to feed one pig. At the end of the story, the puppet uttered either the test sentence in (45a) or (45b).

(45)  

a. PUPPET: Emily fed pigs!  

b. PUPPET: Emily didn’t feed pigs!  

Participants were expected to accept the positive (45a) if they accessed the weak inclusive meaning of the plural, but to reject the sentence if they computed the multiplicity inference. On the other hand, participants were expected to reject the negative (46b) if they accessed the literal meaning of the test sentence, but to accept the sentence if they computed the multiplicity inference locally under negation.

In their first experiment, Tieu et al. (2014; 2017a) tested 28 English-speaking 4- and 5-year-olds and 43 adult native speakers of English. The adult participants rejected positive targets like (45a) 92% of the time, but accepted negative targets like (45b) 42% of the time, suggesting they computed more multiplicity inferences in upward-entailing than in downward-entailing environments. Children, on the other hand, computed multiplicity inferences only 40% of the time in response to the positive targets, and 19% of the time in response to the negative targets.

In a second experiment, Tieu et al. (2017a) conducted a more direct comparison of the plurality inference and classical scalar implicatures by including a some implicature condition. The plural targets and scalar implicature targets were made to be maximally similar in structure. On one of the plural targets, for example, Zebra picked a single banana at the orchard, and the puppet uttered the test sentence in (46a); on one of the scalar implicature targets, Lion carried four out of four apples in his basket at the orchard, and the puppet uttered the sentence in (47a). In both cases, participants were expected to accept the test sentence if they accessed the literal meaning, and to reject the sentence if they computed the relevant inferences, e.g., (46b) and (47b).

(46)  

a. The zebra picked bananas.  
b. ⇛ The zebra picked more than one banana

(47)  

a. The lion carried some of the apples.  
b. ⇛ The lion carried some but not all of the apples
The results of the second experiment were similar to the results of the first. Adults again computed more multiplicity inferences in upward-entailing than in downward-entailing contexts (75% vs. 19%), and children (17 4- and 5-year-olds) computed fewer multiplicity inferences than adults (16% in the upward-entailing condition vs. 4% in the downward-entailing condition). A similar pattern was observed for the scalar implicature of some, with children computing fewer implicatures than adults (adults 81% vs. children 28%). Children’s responses to the two kinds of inference targets were also significantly correlated.

Overall, Tieu et al.’s (2017a) results provide evidence in support of the scalar implicature approach to multiplicity inferences, at least in English. We turn now to our experiment, which adapts the approach of Tieu et al. (2017a) and extends it to multiplicity and abundance inferences in Greek.

4 Experiment

In order to test the uniformity prediction for both abundance and multiplicity inferences, as compared to standard scalar implicatures, we extended Tieu et al.’s (2017a) paradigm, using a modified version of Katsos & Bishop’s (2011) ternary judgment task, which was originally used to test children on implicatures.

4.1 Methods

4.1.1 Participants

We tested 69 Greek-speaking children and 63 adult native speakers of Greek. 41 children (4-7 years, mean age 4;05) and 35 adults completed the count noun condition, and 28 children (4-6 years, mean age 4;06) and 28 adults participated in the mass noun condition. All children were tested in Rhodes, Greece. Due to practical constraints, adults in the count noun condition were tested in Belfast, UK, while adults in the mass noun condition were tested in Rhodes. We excluded from analysis any participants who answered fewer than 5/8 control trials correctly, leaving a total of 33 adults and 34 children in the count noun condition, and 21 adults and 21 children in the mass noun condition.

4.1.2 Procedure

Participants were presented with short animations on a laptop, prepared in a PowerPoint presentation. To begin, participants were familiarized with a puppet with whom they would interact throughout the experiment. In reality, the puppet and her utterances were prerecorded. Subsequently, an experimenter read a series of
short stories that were accompanied by the animations. After each story, the experimenter asked a question to the puppet, and the puppet responded with the test sentence. Participants were instructed to judge the puppet’s utterances by rewarding the puppet with one, two, or three strawberries, depending on her performance. The participants were given clear instructions on the different choices of reward: If they thought the puppet didn’t answer well, they were instructed to give her only one strawberry; if they thought she answered well, they were instructed to give her three strawberries; finally, if they thought the puppet’s answer was not perfect but somewhat okay, they were instructed to give her two strawberries. Previous experimental studies have employed this type of ternary task with children and have shown that they can make use of the middle reward appropriately. In particular, similar to adults, children appear to distinguish between clearly false controls, to which they give the minimal reward, and target items, for which they tend to use the middle value (see Katsos & Bishop 2011 and Tieu, Križ & Chemla 2017b).

In order to reward the puppet, children moved cutouts of the strawberries to a basket in which the puppet was collecting her strawberries, and the experimenter recorded the participants’ answers. Adult participants, on the other hand, received a response sheet with the rewards indicated next to each experimental trial (one, two, and three strawberries), and were asked to circle the appropriate number of strawberries depending on the puppet’s performance. The response sheets also contained space for participants to give brief explanations for their responses. The task took about 20 minutes to complete for adults, and 30 minutes for children.

4.1.3 Materials

There were four factors manipulated in the experiment: group (child vs. adult), condition (plural vs. scalar implicature, within subjects), polarity within the plural condition (positive vs. negative, within subjects), and noun type (mass vs. count, between subjects). The plural and scalar implicature conditions were presented in blocks, with order counterbalanced across participants.

In the scalar implicature condition (adapted from Tieu et al. 2014; 2017a), participants were presented with stories in which the protagonist acted in some way on a whole set of objects introduced in the story. When asked by the experimenter to describe what had happened in the story, the puppet answered using the scalar term merika ‘some’, as exemplified in (48) (see Figure 1 for the final slide of the story):

(48) Context: The lion carried all of the apples.
PUPPET: To lointaraki kuvalise merika apo ta mila! the.NEUT.SG.NOM lion carried SOME of the.NEUT.PL.ACC apples ‘The lion carried some of the apples.’
If participants accessed the scalar implicature of some, interpreting the sentence as the lion is carrying some but not all of the apples, then they were expected to find the puppet’s utterance infelicitous in the context, and therefore were expected to give the puppet one or two strawberries. If they instead interpreted the sentence on its literal meaning, which is true in the context, they were expected to give the puppet the maximal reward of three strawberries.

Consider next the plural condition. Here it was made clear in the stories that the multiplicity inferences and abundance inferences triggered by the plural did not hold; see (49) and (50) for examples of the multiplicity and abundance targets, respectively; Figure 2 provides the corresponding pictures.

(49)  **MULTIPLICITY INFERENCE** target: The tiger is visiting the farm today. Look at these cows and pigs! The tiger wants to feed the animals, but he only has a little bit of food. The tiger feeds this pig over here. Now he has no more food, so he doesn’t feed the rest of the animals. So remember, the tiger only fed this pig here! Now let’s see if Ellie’s paying attention.

E: Okay, Ellie, so the tiger didn’t feed any cows. What about pigs?

P: I tighri taise ghurunia!
   the.FEM.SG.NOM tiger fed pig.PL
   ‘The tiger fed pigs.’

(50)  **ABUNDANCE INFERENCE** target: The zebra is helping her mother to bake today. Look at the sugar and eggs! The zebra wants to add flour to the cake. He is very careful not to drop anything on the table. The zebra is very careful and he drops only a small amount of sugar on the table. The zebra did not drop any eggs. So remember, the zebra only dropped this small amount of sugar! Now let’s see if Ellie’s paying attention.

E: Okay, Ellie, so the zebra didn’t drop any eggs. What about sugars?
The abundance inference of pluralised mass nouns is an implicature of a mass noun to refer to a specific quantity of the mass noun. Consider the following example:

**Positive Example:**

The tiger fed more than one pig.

**Negative Example:**

The tiger did not feed any pig.

Both inferences were presented in the positive, as in (49) and (50), and in the negative, as in (51) and (52) (the respective stories were the same as in (49) and (50)).

(49) The tiger dropped sugar.

(50) The zebra only dropped sugar.

(51) The tiger did not feed pigs.

(52) The zebra didn’t drop sugar.

On the implicature approach, participants were expected to interpret the positive targets with their respective multiplicity/abundance inferences (i.e., Tiger fed more than one pig/Zebra dropped a lot of sugar); given these inferences were incompatible with the context, participants were expected to reward the puppet with either one or two strawberries. For the negative targets, participants were expected to interpret these without their respective multiplicity/abundance inferences (i.e., Tiger did not feed any pig/Zebra did not drop any sugar); they were therefore expected to give the puppet a non-maximal reward. Similar predictions are made by the ambiguity approach: in upward-entailing contexts, the Strongest Meaning Hypothesis would lead participants to interpret the positive sentences on their strong interpretation (i.e., Tiger fed more than one pig/Zebra dropped a lot of sugar) and would there-
fore give a non-maximal reward to the puppet in contexts like (49) and (50). In downward-entailing contexts, the Strongest Meaning Hypothesis would also favour the strong interpretation of the sentence (i.e. *Tiger did not feed any pig/Zebra did not drop any sugar*), which would predict non-maximal rewards to the puppet for the negative targets in the same contexts above.

In addition to the target trials, participants also received eight control trials that allowed us to ensure that they could give minimal and maximal rewards where appropriate. Four of the control trials corresponded to clearly true plural sentences that were expected to elicit the maximal reward of three strawberries, as in (53) and (54). In the positive example in (53), the multiplicity inference is satisfied; in the negative example in (54), the sentence refers to the other mentioned set of objects.

(53) **Positive Control:** The chicken loves to visit the petting zoo. Look at these cats and dogs! The chicken wants to feed the animals, but she only has a little bit of food. The chicken feeds these four cats over here. Now she has no more food, so she doesn’t feed the rest of the animals. So remember, the chicken only fed these four cats here! Now let’s see if Ellie’s paying attention.

E: Okay, Ellie, so the chicken didn’t feed any dogs. What about cats?

P: *I* kota taise ghates.

   the.FEM.SG.NOM chicken fed cats

   ‘The chicken fed cats.’

(54) **Negative Control:** The tiger loves to visit the petting zoo. Look at these turtles and mice! The tiger wants to feed the animals, but he only has a little bit of food. The tiger feeds these four turtles over here. Now he has no more food, so he doesn’t feed the rest of the animals. So remember, The tiger only fed these four turtles here! Now let’s see if Ellie’s paying attention.

E: Okay, Ellie, so the tiger didn’t feed any turtles. What about mice?

P: *I* tighri dhen taise pontikia.

   the.FEM.SG.NOM tiger NEG fed mouse.PL

   ‘The tiger didn’t feed mice.’

In addition, four control trials corresponded to negation controls. They involved negative sentences that contained a definite noun phrase instead of a bare plural. These trials could be associated with either a minimal reward target or a maximal reward target; the experimenter selected the appropriate version of the trial depending on how participants were responding to the critical target trials. These controls allowed us to ensure that participants could properly interpret negation indepen-
The abundance inference of pluralised mass nouns is an implicature independently of the plural, and also allowed us to balance the overall number of minimal and maximal rewards given across the experiment.

(55) **NEGATION CONTROL:** The frog loves to color shapes with her paint. Look at these stars and hearts! The frog wants to paint the shapes, but she only has a little bit of her favourite yellow paint. The frog paints these four stars over here. Now she has no more paint, so she leaves the hearts colorless. So remember, the frog only painted these four stars here! Now let’s see if Eliie’s paying attention.

E: Okay, Ellie, can you tell us something about the story?

P': O vatrahos dhen evapse tis kardies.

the.MASC.SG.NOM frog NEG painted the.FEM.PL.ACC heart.PL TRUE‘The frog didn’t paint the hearts.’

P'': O vatrahos dhen evapse ta asteria.

the.MASC.SG.NOM frog NEG painted the.NEUT.PL.ACC star.PL FALSE‘The frog didn’t paint the stars.’

To sum up, each participant received 2 training items, followed by 18 test trials: 6 critical plural targets (3 positive, 3 negative), 4 scalar implicature targets, 4 clearly true positive/negative plural controls, and 4 clearly true or clearly false negation controls. The plural and scalar implicature targets were presented in blocks, with order counterbalanced across participants. Within the plural block, the test and control trials were pseudorandomized.

### 4.2 Results

#### 4.2.1 Count noun condition

Figure 3 displays the proportion of 1-, 2-, and 3-strawberry responses to the scalar implicature, plural positive, and plural negative targets. At this stage we interpret the non-maximal 1- and 2-strawberry responses alike, in contrast to the 3-strawberry responses, mapping the reward types to different readings of the target sentences in the following way (we will return in the General discussion section to the potential significance of the 1- versus 2-strawberry responses): for the scalar implicature targets and the positive plural targets, 1- and 2-strawberry responses were interpreted as a measure of the target inference having been computed, while 3-strawberry responses corresponded to a no-inference reading. For the negative plural targets, the opposite would hold: 3-strawberry rewards were interpreted as
consistent with the multiplicity inference having been computed (under negation), while 1- and 2-strawberry responses corresponded to a no-inference reading.

As we can see, adults gave non-maximal rewards in response to the *merika* ‘some’ sentences in contexts where the scalar implicature was falsified. By contrast, children were much more willing to give maximal rewards for these sentences in the same contexts, suggesting that they either ignored or did not compute the implicature.

Figure 3 reveals a similar pattern for the plural positive targets (plural sentences in contexts that falsified the multiplicity inference): adults mostly gave the puppet intermediate 2-strawberry rewards, suggesting that they computed the multiplicity inference, while the children were happy to give maximal rewards for the plural positive targets, suggesting they were either ignoring or not computing the multiplicity inference. As for the plural negative targets, adults and children alike tended to give minimal rewards (1 strawberry), suggesting that they interpreted the negative sentences along the lines of negated existential statements, that is, without the multiplicity inference.

**Figure 3: Count nouns**: Proportion of 1-, 2-, and 3-strawberries responses to positive, negative, and scalar implicature targets.

Figure 4 displays the results for the positive and negative plural targets, with the ternary responses recoded in binary terms (1 for inference reading, 0 for no-inference reading). Logistic regression models fitted to these recoded plural data revealed significant effects of Polarity ($X^2(1) = 13.2 \ p < .001$) and Group ($X^2(1) = 7.30 \ p < .01$), and a significant interaction between Group and Polarity ($X^2(1) =$...
17.1 $p < .001$): adults gave more multiplicity inference-consistent responses than children, and also differentiated the positive and negative targets more than children (giving more multiplicity inference-consistent responses to the positive than to the negative targets).

Figure 4: Multiplicity inference computation in positive and negative contexts, after recoding the ternary responses in binary terms (1 for inference reading, 0 for no inference reading). Each dot represents an individual participant’s mean inference rate for the given condition (a horizontal jitter of .1 and vertical jitter of .025 were applied for easier visualization).

4.2.2 Mass noun condition

Figure 5 displays the proportion of 1-, 2-, and 3-strawberry rewards to the positive and negative plural targets and the scalar implicature targets. As in the count noun condition, adults mostly gave minimal or intermediate rewards for the underinformative merika ‘some’ sentences. By contrast, children appeared more willing to give maximal rewards, suggesting they computed fewer implicatures than adults did.

Consider next the plural positive targets, corresponding to pluralised mass nouns in contexts in which the abundance inference was made false. Here, adults were split between intermediate and maximal rewards for the positive plural targets, while children generally preferred to give the maximal reward, suggesting children computed fewer abundance inferences than adults. For the negative targets,
both adults and children tended to give minimal rewards, suggesting neither group computed abundance inferences under negation.

![Figure 5: Mass nouns](image)

Figure 5: **Mass nouns**: Proportion of 1-, 2-, and 3-strawberries responses to positive, negative, and scalar implicature targets.

Figure 6 displays the results for the positive and negative abundance inference targets, with the ternary responses recoded in binary terms (1 for inference-consistent, 0 for inference-inconsistent). While adults computed more abundance inferences than children in the positive condition, neither group gave any inference-consistent responses in the negative condition. Logistic regression models fitted to the positive targets revealed a significant effect of Group ($X^2(1) = 18.1, p < .001$), with more abundance inference-consistent responses from adults than children.

### 4.2.3 Multiplicity vs. abundance inferences vs. scalar implicatures

We now consider the results across all the positive conditions, namely the positive multiplicity inference targets, the positive abundance inference targets, and the scalar implicature targets. Figure 7 displays the proportions of reward types given in response to these targets, across the two groups. In general, adults tended to give more intermediate rewards in response to statements that were uttered in contexts that falsified their respective inferences, while children generally gave more maximal rewards than adults did.

In Figure 8 we plot the results for the positive targets with the ternary responses recoded in binary terms (1 for inference-consistent responses, 0 for inference-inconsistent
The abundance inference of pluralised mass nouns is an implicature

responses). We fitted logistic regression models to compare the two kinds of plural inferences to the scalar implicature. The 2x3 analysis (Group: adults vs. children, Inference Type: multiplicity inference vs. abundance inference vs. scalar implicature) revealed significant effects of Group ($X^2(1) = 85, p < .001$) and Inference Type ($X^2(1) = 126, p < .001$), as well as a significant interaction between Group and Inference Type ($X^2(1) = 10.1, p < .01$). Subsequent post-hoc comparisons revealed that while children’s performance on the multiplicity and abundance inferences did not differ significantly from each other, adults performed distinctly on the two kinds of inferences ($X^2(1) = 8.31, p < .01$). For both groups, the multiplicity and abundance inference conditions differed significantly from the scalar implicature condition (multiplicity inference vs. scalar implicature: $X^2(1) = 20.7, p < .001$ for children, $X^2(1) = 56.8, p < .001$ for adults; abundance inference vs. scalar implicature: $X^2(1) = 27.1, p < .001$ for children, $X^2(1) = 72.1, p < .001$ for adults. All effects remained significant after application of a Bonferroni correction for multiple comparisons (yielding a new p-value threshold of .05/6=.0083).

Summarising, while the inferences were not all computed at the same rates within the two groups (a point to which we return below), the results overall are in line with the uniformity prediction we identified for the implicature approach:

Figure 6: Abundance inference computation in positive and negative contexts, after recoding the ternary responses in binary terms (1 for inference reading, 0 for no inference reading). Each dot represents an individual participant’s mean inference rate for the given target (a horizontal jitter of .1 and vertical jitter of .025 were applied for easier visualization).
adults computed more multiplicity and abundance inferences in positive than in negative contexts, and computed more of both than children, in parallel with the *merika* ‘some’ targets. The pattern of analogous differences between children and adults in all three inferences, in combination with the effect of polarity, support an implicature account of multiplicity and abundance inferences, and a unification of the effects of plural morphology across the mass and count divide.

5 General discussion

The results of the present experiment reveal that adult native speakers of Greek interpret plural sentences as giving rise to multiplicity and abundance inferences in positive but not in negative contexts, replicating in Greek the results reported for English in Tieu et al. (2014; 2017a). This finding is in line with both the ambiguity and the implicature approaches. The child participants in the present study, on the other hand, computed fewer of both kinds of inferences than adults, in both positive and negative environments. This finding is in line with the predictions of the implicature approach, but, as we will discuss further below, poses a challenge for the ambiguity approach. Moreover, the similar behaviour displayed by children in terms of their interpretation of the plural and their interpretation of the scalar term *merika* ‘some’ provides further suggestive evidence for an implicature approach to
The abundance inference of pluralised mass nouns is an implicature

5.1 Multiplicity, abundance, and monotonicity

One of the main findings of the present study is that both multiplicity and abundance inferences in Greek are sensitive to polarity. That is, adults gave significantly more inference-consistent responses in the positive condition than they did in the negative condition, ‘rejecting’ sentences like those in (56) and (57) in contexts in which the tiger fed exactly one pig and in which the zebra dropped a small amount of sugar, respectively.

(56) a. I tighri taise ghurunia.
    the.FEM.SG.NOM tiger fed pig.PL
    ‘The tiger fed pigs’
b. I tighri dhen taise ghurunia
   the.FEM.SG.NOM tiger NEG fed pig.PL
   ‘The tiger did not feed pigs.’

(57) a. Tis zebras tis epesan zahar-es.
    the.FEM.SG.DAT zebra her.CL.FEM.SG.DAT fell.3PL sugar-PL
    ‘The zebra dropped sugar.’

b. Tis zebras dhen tis epesan zahar-es.
   the.FEM.SG.DAT zebra NEG her fell.3PL sugar-PL
   ‘The zebra didn’t drop sugar.’

This observed sensitivity to monotonicity is in line with previous results reported for English in Tieu et al. (2014; 2017a), and is unsurprising on both the ambiguity and the implicature approaches.

Recall that the ‘rejection’ responses were obtained by collapsing the minimal 1-strawberry and intermediate 2-strawberry responses, and mapping them to the relevant inference versus no-inference readings of the target sentences. When we look at the actual reward types given in response to the positive and negative plural targets, however, we find more compelling evidence for the implicature approach. In particular, as seen in Figures 3 and 5, adults’ non-maximal responses to the positive targets corresponded primarily to intermediate 2-strawberry rewards, while their non-maximal responses to the negative targets corresponded primarily to minimal 1-strawberry rewards. This difference between the response patterns to the positive and negative plural targets is expected on the implicature approach, where ‘rejection’ in the positive condition is based on the relevant implicature being false in the context, while ‘rejection’ in the negative condition is based on the literal meaning being false. The ambiguity approach, on the other hand, does not predict such a difference: in both cases, a non-maximal response should be based on selecting one of the two readings of the sentence that is favoured by the Strongest Meaning Hypothesis. There is no difference in status between the source of rejection in the positive vs. negative cases. In other words, the ambiguity approach predicts the same type of answer in both conditions. This aspect of the responses from adults is therefore more in line with the implicature approach.15

5.2 Child vs. adult data

Let us turn next to a comparison of children’s and adults’ responses to the target conditions. While children’s behaviour on the positive and negative plural targets is in line with the predictions of the implicature approach, we believe it provides an important challenge for the ambiguity approach. Specifically, while children

15 Thanks to Alexandre Cremers (p.c.) for discussion of this point.
The abundance inference of pluralised mass nouns is an implicature

were non-adult-like in the positive condition, they were adult-like in the negative condition.

Recall that under the ambiguity approach, the plural is ambiguous between an inclusive and an exclusive interpretation, with the choice between two possible readings of a plural sentence being governed by the Strongest Meaning Hypothesis. Recall also that the exclusive interpretation of the plural leads to stronger readings in positive sentences, while in negative sentences it is the inclusive interpretation of the plural that leads to stronger readings. Adults are therefore expected to interpret plural morphology exclusively in sentences like (58a) and (59a), but to interpret it inclusively in sentences like (58b) and (59b).

Indeed in our experiment adults mostly rejected sentences like (58a) and (59a) as well as sentences like (58b) and (59b) in contexts in which the tiger fed only one pig or the zebra dropped only a small amount of sugar, in line with these predictions. The results from adults are therefore consistent with the ambiguity approach.

(58) Pluralised Count Nouns:

a. I tighri taise ghrunia.  
   the.FEM.SG.NOM tiger fed pig.PL  
   ‘The tiger fed pigs.’  
   (i) The tiger fed one or more pigs. INCLUSIVE (WEAK)  
   (ii) The tiger fed more than one pig. EXCLUSIVE (STRONG)

b. I tighri dhen taise ghrunia  
   the.FEM.SG.NOM tiger NEG fed pig.PL  
   ‘The tiger did not feed pigs.’  
   (i) The tiger didn’t feed one or more pigs. INCLUSIVE (STRONG)  
   (ii) The tiger didn’t feed more than one pig. EXCLUSIVE (WEAK)

(59) Pluralised Mass Nouns

a. Tis zebras tis epesan zahar-es.  
   the.FEM.SG.DAT zebra CL.FEM.SG.DAT fell.3PL sugar-PL  
   ‘The zebra dropped sugars.’  
   (i) The zebra dropped a little or more than a little sugar. INCLUSIVE (WEAK)  
   (ii) The zebra dropped more than a little sugar. EXCLUSIVE (STRONG)

b. Tis zebras dhen tis epesan zahar-es.  
   the.FEM.SG.DAT zebra NEG CL.FEM.SG.DAT fell.3PL sugar-PL  
   ‘The zebra didn’t drop sugars.’  
   (i) The zebra didn’t drop a little or more than a little sugar. INCLUSIVE (STRONG)
The zebra didn’t drop more than a little sugar.  

(ii) **The zebra didn’t drop more than a little sugar.**  

EXCLUSIVE

(WEAK)

The child participants, on the other hand, mostly accepted sentences like (58a) and (59a), and rejected sentences like (58b) and (59b) in the same contexts (in which the tiger fed only one pig and the zebra dropped only a small amount of sugar). This suggests that children interpreted plural morphology inclusively in both the positive and negative sentences, yielding weak readings in positive contexts but strong readings in negative contexts (in both the count and mass conditions). This pattern of results is not straightforwardly explained under the ambiguity approach.

In particular, as discussed in Subsection 2.3.2, the ambiguity approach gives rise to three main possibilities for why children might be observed to differ from adults:

(a) Children have only acquired the strong exclusive meaning of plurals;
(b) Children have only acquired the weak inclusive meaning of plurals;
(c) Children have acquired both meanings of the plural but have not yet mastered adult-like application of the Strongest Meaning principle.

Let us consider these possibilities in turn vis-a-vis our results. First, it is clear that (a) cannot be on the right track, as children consistently opted for the inclusive meaning of the plural. Option (c) is also somewhat difficult to reconcile with our results; if children had access to both meanings of the plural, one might reasonably expect them to charitably select the one that yields a true reading in the context. This would amount to responding in a manner consistent with the weak interpretation of the plural sentences, i.e. by selecting the inclusive meaning of the plural on the positive targets and the exclusive meaning of the plural on the negative targets. But this pattern of ‘charitability’ was not borne out by our experimental results, and it is unclear why, on this scenario, children should have varied systematically between the positive and negative conditions in the way that they did.

The most promising of the three options appears to be option (b): if children only had access to the inclusive meaning of the plural, they would behave in exactly the fashion we observed – adult-like in the negative condition but non-adult-like in the positive condition. A major challenge for this explanation, however, comes from considerations of learnability (see Tieu et al. 2017a for similar conclusions). If children initially start out with the inclusive meaning of the plural, it is unclear how they might then proceed to add the exclusive meaning of the plural, given that any context that makes the strong meaning true will also make the weak meaning true. This lack of ‘negative evidence’ that would take the child from the inclusive to the exclusive meaning of the plural essentially gives rise to a subset problem, which
The abundance inference of pluralised mass nouns is an implicature has been much discussed in the context of other developmental phenomena (e.g., Berwick 1985; Crain et al. 1994; Gualmini & Schwarz 2009).

In sum, the behaviour of our child participants across the positive and negative mass and count noun conditions poses an important challenge for the ambiguity approach. The implicature approach, on the other hand, straightforwardly predicts the parallel patterns we observe when we compare children’s and adults’ responses to the plural targets versus the scalar implicature targets. Indeed what we observe in our study is very much in line with previous developmental findings regarding scalar implicatures. Children are non-adult-like in positive contexts, computing fewer implicatures than adults, but they are adult-like in negative contexts, which typically do not elicit implicatures from adults. Overall, then, our data from children and adults are consistent with the implicature approach but pose a challenge for the ambiguity approach.

5.3 Multiplicity vs. abundance inferences vs. implicatures

As discussed above, both multiplicity and abundance inferences exhibit the signature pattern of scalar implicatures: the adults in our experiment computed more multiplicity and abundance inferences in positive than in negative contexts, and computed more of both inferences than children did, in parallel with the merika ‘some’ targets. The pattern of analogous differences between children and adults across the three target inferences, in combination with the effect of polarity, supports a unification of the effects of plural morphology across the mass and count divide in terms of an implicature account.

There is, however, an additional finding from our experiment that merits further discussion. Specifically, the inference computation rate observed in the adult participants varied across the three target inferences: the scalar implicature of merika ‘some’ was computed the most, the abundance inference of the mass nouns was computed around half of the time, and the multiplicity inference of the count nouns was in between the two at around 75%. One might initially take this variation across inferences as problematic for an implicature approach; however, such diversity across ‘scales’ has already been observed in the literature. In particular, van Tiel et al. (2014) investigated a variety of scalar implicatures and found a wide range of variability in terms of how often they were computed by adults.

van Tiel et al. (2014) argue that there are two factors that may explain the observed variation among different scalar inferences. The first is the semantic distinctness of the alternatives on the scale, that is, how easy it is to perceive the distinction between the scalemates, e.g., the distinction between ‘some’ and ‘all’. van Tiel et al. (2014) operationalise this notion of distinctness by using two factors: semantic distance and boundedness. To investigate the role of semantic distance, the authors
conducted an experiment in which they asked participants to rate how distant two scalar terms were; for example, participants had to decide how distant on a scale from 1–7 they found sentences like *This is okay* vs. *This is fantastic*, compared to *This is fantastic* vs. *This is marvellous*. While van Tiel et al. did not test plural sentences, an explanation based on semantic distance could be extended to our study. In particular, our results could be explained by adults having perceived the scalemates ‘some’/‘all’ as more distant than the plural/singular scalemates (e.g., *gurumia* ‘pigs’ vs. *guruni* ‘pig’), which in turn would have been perceived as more distant than a similar pair involving mass nouns (e.g., *zahares* ‘sugars’ vs. *zahari* ‘sugar’).

The second factor is related to the nature of the scale, namely whether the scale is bound or unbounded. In their experiment, van Tiel et al. (2014) observed that the alternatives associated with bounded scales were more likely to give rise to implicatures than those associated with unbounded scales. Our results are, at least prima facie, in line with this as well. The scale formed by ‘some’ vs. ‘all’ is clearly upper-bounded by the term ‘all’. The scale formed by the plural ‘dogs’ vs. the singular ‘dog’ is not upper-bounded by the singular alternative, but it is at least lower-bounded by it, given the atomic elements forming the lower bound of the scale. On the other hand, the scale formed by the plural ‘waters’ vs. the singular ‘water’ is neither upper- nor lower-bounded by the singular alternative. In this sense, the fact that the abundance inference appears to be the weakest among the three would align with the idea that the boundedness of the scale plays a role in the observed variation.\(^{16}\)

Finally, in relation to the comparison between multiplicity and abundance inferences, one could also hypothesise that the varying context dependency of the scales plays a role. For example, one might propose that it is the distinction between what counts as small vs. not small in a context, as opposed to the distinction between what counts as a single vs. plural entity, that drives the observed differences between the mass and count results. In particular, this could explain why abundance inferences were observed to be weaker than multiplicity inferences.

In sum, while the differences among abundance inferences, multiplicity inferences, and scalar implicatures could prima facie be challenging for a unified implicature approach, they can be reconciled with such an approach on the basis of previous results regarding diversity of scalar terms (van Tiel et al. 2014).

\(^{16}\) This is true, we think, under any account of the denotation of mass nouns. For example, under an account that models the denotation of mass nouns as a whole semi-lattice structure without underlying atomic entities, the structure is not lower-bound (see Link 1983; Krifka 1989, among many others). Alternatively, under the assumption that the denotation of mass nouns is formed from vague atoms (e.g., Chierchia 1998; 2010b), it would be difficult to identify the lower bound of the scale precisely due to the vague nature of the elements forming the structure, and this might be sufficient to render the scale non-lower-bounded in some relevant sense.
This said, an interesting aspect of our results is that while children computed the inferences much less than adults, they also exhibited some amount of variation across them. This requires an extension of the account of the variability effects in adults and investigating whether the same factors play a role in children. In addition, recall that children’s inference rates varied between scalar implicatures, on the one hand, and multiplicity and abundance inferences on the other, but that their rates of the latter two did not differ from each other. This could simply be a floor effect, given children computed few of both plural inferences. Nevertheless, an analysis along the lines of what has been proposed to capture the variability observed in adults could conceivably be extended to explain the children’s response patterns.

Finally, as we have discussed, despite the within-group differences, the analogous between-group differences across the three kinds of inferences support a unified analysis and are in line with the uniformity prediction of the implicature approach.

6 Conclusion

In this study, we investigated the abundance inferences of pluralised mass nouns as compared to the multiplicity inferences of pluralised count nouns and the standard ‘not all’ scalar implicature of merika ‘some’ in Greek. Building on Tieu et al. (2014; 2017a), we tested the predictions of two approaches accounting for this abundance inference: an ambiguity approach based on Farkas & de Swart (2010) and an implicature approach, as defended in Tsoulas (2009) and Kane et al. (2015), among others. As we discussed, both approaches can account for the sensitivity to monotonicity exhibited by such inferences, with adults giving more inference-consistent responses in upward-entailing than in downward-entailing contexts. On the other hand, the results from children pose a challenge for the ambiguity approach but are readily accounted for by the implicature approach. In particular, children were adult-like in negative contexts but not in positive ones: they interpreted sentences containing pluralised mass nouns without the corresponding abundance inferences, in both positive and negative contexts. As we discussed, the implicature approach, but not the ambiguity approach, can straightforwardly account for this result. Previous developmental studies (as well as our own results regarding children’s interpretation of merika ‘some’) have revealed that without special facilitation, children in this age range tend to compute fewer implicatures than adults.

17 As we discussed, however, the fact that adults tended to use the intermediate rather than minimal reward in the positive condition compared to the negative condition is more in line with the implicature approach.
Therefore, if an abundance inference is a scalar implicature, we expect children to similarly compute fewer abundance inferences than adults.

In sum, our overall experimental findings replicate the pattern reported in Tieu et al. (2014; 2017a), suggesting a core commonality between the multiplicity inferences of pluralised count nouns and the abundance inferences of pluralised mass nouns. The findings provide further support for an implicature approach to multiplicity inferences and for an extension of the account to abundance inferences. In addition, investigating a language like Greek, which allows for the pluralisation of mass nouns, provides an empirical basis for a unified analysis of plural marking across the count-mass divide (Kane et al. 2015).

Finally, our results also revealed variation in the computation rates of the scalar inference of merika ‘some’, the multiplicity inference of count nouns, and the abundance inference of mass nouns, with the inference of merika being the strongest and the abundance inference being the weakest of the three. As we have discussed, such results are in line with previously reported results regarding diversity in strength across different scales (van Tiel et al. 2014). Future research could investigate how an account of such variation in adults could be extended to capture variation observed in children, and whether the source of variation is the same across the two populations.

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