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RESEARCH

The abundance inference of pluralised mass nouns is an implicature: Evidence from Greek

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Across languages, plural marking on count nouns typically gives rise to a *multiplicity inference*, indicating that the noun ranges over sums with a cardinality of 2 or more. Plural marking has also been observed to occur on mass nouns in Greek and a few other languages, giving rise to a parallel *abundance inference*, indicating that there is a lot 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. (2018), 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; 2018) investigated 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 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; 2018) for multiplicity inferences, and crucially reveal an analogous pattern for abundance inferences. Adults computed both kinds of inferences more in upward-entailing environments than in downward-entailing ones, and children computed fewer inferences overall than adults did. These results reflect an overall pattern of implicature calculation in line with a unified implicature analysis across the three kinds of inferences. By contrast, we discuss how they 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. ***Waters** are dripping from the ceiling.
b. **Water** is dripping from the ceiling.

A sentence where a pluralised mass noun, like *waters* in (1a), occurs, 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; 2010; Deal 2017, among many others).[1]

(2) In this restaurant we offer three **waters**: sparkling, still, and tap water.

(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 that otherwise do make a grammatical mass/count distinction, e.g., Kuikuro (Franchetto et al. 2013), Innu-aimun (Gillon 2015), Ojibwe (Rhodes 1990; Mathieu 2012), Blackfoot (Wiltschko 2012), and Greek (Tsoulas 2009).[2] In Greek, in particular, the equivalent of (1a) in (4) is acceptable, and it is not interpreted as giving rise to a coerced meaning where *waters* refers to types of or standardised units of water (Harbour 2009; Tsoulas 2009; Alexiadou 2011; Kane et al. 2015).

(4)

Trehun	**ner-a**	apo	to	tavani.
drip.3PL	water-PL	from	DEF.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 (5) (unlike the examples of coercion in English above in (2) and (3)). To be clear, 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.

(5) Tsoulas (2009: 135)

*Dio	**ner-a**	trehun	apo	to	tavani.
two	water-PL	drip.3PL	from	DET.NEUT.SG.ACC	ceiling

‘Two waters are dripping from the ceiling.’

The equivalent of (1b) in (6) is acceptable as well. However, (4) and (6) give rise to different inferences. In particular, pluralised mass nouns are typically associated with an abundance inference that there is a significant amount of the substance denoted by the mass noun. For example, (4) generally conveys that *a lot of water* dripped from the ceiling (Tsoulas 2009).

(6)

Trehi	**ner-o**	apo	to	tavani.
drip.3SG	water-SG	from	DEF.NEUT.SG.ACC	ceiling

‘Water is dripping from the ceiling.’

[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) Matilde’s waters broke.
(ii) the waters of the Pacific

[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.

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.

Before we move on, it should be noted that it is not merely quantity that plays a role in the reported intuition about the abundance inference. In particular, the extent to which the substance is spread out in space appears to be important as well. Taking this aspect of the inference into account might require an analysis that treats the abundance contribution of the plural in a more abstract way, for example, along the lines of 'abundance along some dimension' (Tsoulas 2009; Alexiadou 2011).[3]

Alexiadou (2011) also observes that there are distributional restrictions on pluralised mass nouns in Greek. First, she reports that some pluralised mass nouns in Greek are more acceptable than others. For example, *nero* 'water', *ladhi* 'oil', *laspi* 'mud', *amos* 'sand', *rizi* 'rice', and *hioni* 'snow' are easier to pluralise than *meli* 'honey', *himos* 'juice', and *kinisi* 'traffic'.[4] Second, pluralised mass nouns in Greek tend to occur with predicates such as *pefto* 'fall', *treho* 'run/drip', and *mazevome* 'gather' — predicates that easily allow for the abundance interpretation (Alexiadou 2011). They can, however, also be found with existential, perception, and other predicates. In the experimental study we report below, we ensured that the combination of mass nouns and predicates were judged to be entirely acceptable (Appendix B provides a list of the experimental sentences). We also focus on the aspect of the inference related to quantity and leave to future investigation the potential role of spreadedness.

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 longstanding puzzle.[5] We illustrate the pattern below using examples from Greek.[6] Consider the sentence in (8), containing the pluralised count noun *ghurunia* 'pigs'.

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[3] An anonymous reviewer points out that Greek also allows a use of the plural on count nouns that are typically unique, as in (i) or (ii). Such cases often involve body parts, giving rise to a hyperbolic effect related to the notion of abundance.

(i) Ponane i plates mu.
hurt.3PL DEF.FEM.PL.NOM backs mine
'My back hurts.'

(ii) Kano dhieta na rikso tis kiljes.
do.1SG diet SBJ drop DEF.FEM.PL.ACC bellies
'I am on a diet to lose my belly.'

Ultimately, such uses should be unified with the cases of the pluralised mass nouns. We leave this for future work.

[4] There seems to be some variation among speakers. While for most speakers both *meli* 'honey' and *himos* 'juice' are easily pluralisable in appropriate contexts, *kinisi* 'traffic' does not appear to be pluralisable.

[5] For relevant discussion, see Krifka (1989), Sauerland (2003), Sauerland et al. (2005), Spector (2007), Zweig (2009), Farkas & de Swart (2010), and Magri (2014).

[6] The same pattern is reported in the literature for English (see references in footnote 5).

(8) I tighri taise ghurunia.
DEF.FEM.SG.NOM tiger fed pig.PL
'The tiger fed pigs.'

The sentence in (8) sounds roughly equivalent in meaning to one in which the plural marker is replaced by 'more than one', as in (9).

(9) I tighri taise parapano apo ena ghuruni.
DEF.FEM.SG.NOM tiger fed more than one pig.SG
'The tiger fed more than one pig.'

This fact suggests that plural morphology should be associated with an exclusive 'more than one' meaning; in other words, the literal meaning of (8) could be paraphrased as (9) (Link 1983; Lasersohn 1995; Chierchia 1998). The problem with this hypothesis arises when we consider the negative counterpart of (8), provided in (10a). Given the hypothesis above, we would expect (10a) to have a meaning that corresponds to the negation of (8), as in (10b). Instead, the sentence's meaning is the negation of the corresponding sentence with the singular noun in (10c).

(10) a. I tighri dhen taise ghurunia.
DEF.FEM.SG.NOM tiger NEG fed pig.PL
'The tiger didn't feed pigs.'

b. I tighri dhen taise parapano apo ena ghuruni.
DEF.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.
DEF.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 noun is also observed in other downward-entailing environments. For example, while one can deduce from (11) that we should thank the tiger even if she fed only one pig, one cannot make such an inference from (12). Similarly, if the tiger fed only one pig, the interlocutor can respond affirmatively to the question in (13) but not to the question in (14).[7]

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

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

[7] 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.

(13) Taise i tighri ghurunia?
fed DEF.FEM.SG.NOM tiger pig.PL
'Did the tiger feed pigs?'

(14) Taise i tighri parapano apo ena ghuruni?
fed DEF.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 encodes the inference in the literal meaning of plural morphology; such an approach would wrongly predict weaker meanings than are observed for cases like (10a), (11), and (13).

1.2.2 The abundance inference

Interestingly the same pattern arises in the case of the abundance inference of pluralised mass nouns in Greek. To illustrate, consider the sentences in (15) and (16), containing the pluralised mass noun *zahares* 'sugars'. Analogously to the case of plural count nouns, the observation is that (15) seems equivalent to (16), suggesting that the plural morphology on mass nouns should be associated with an exclusive 'a lot of' meaning.

(15) Tis zebras tis epesan zahar-es.
DEF.FEM.SG.DAT zebra CL.FEM.SG.DAT fell.3PL sugar-PL
'The zebra dropped sugar.'

(16) Tis zebras tis epese poli zahar-i.
DEF.FEM.SG.DAT zebra CL.FEM.SG.DAT fell.3SG much sugar-SG
'The zebra dropped a lot of sugar.'

Again, the problem with the hypothesis that the literal meaning of (15) can be paraphrased as in (16) arises in downward-entailing environments. Crucially, (17) does not suggest that the zebra didn't drop a lot of sugar, but rather that she didn't drop any sugar at all, which is unexpected if 'a lot of' is a part of the literal meaning of the plural noun.

(17) Tis zebras dhen tis epesan zahar-es.
DEF.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 (18) but not in the case of (19). Correspondingly, if the zebra dropped only a little sugar we should respond affirmatively to (20) but not to (21).

(18) Ean tis zebras tis epesan zahar-es, prepi na
if DEF.FEM.SG.DAT zebra CL.FEM.SG.DAT fell.3PL sugar-PL should SBJ
to pume sti mama tis.
CL.NEUT.SG.ACC tell to-DEF.FEM.SG.ACC mom POSS.FEM
'If the zebra dropped sugar, we should tell her mom.'

(19)

Ean	tis	zebras	tis	epese	poli	zahar-i,	prepi	na
if	DEF.FEM.SG.DAT	zebra	CL.FEM.SG.DAT	fell.3SG	much	sugar-SG	should	SBJ

to	pume	sti	mama	tis.
CL.NEUT.SG.ACC	tell	to-DEF.FEM.SG.ACC	mom	POSS.FEM

‘If the zebra dropped much sugar, we should tell her mom.’

(20)

Tis	epesan	zahar-es	tis	zebras?
CL.FEM.SG.DAT	fell.3PL	sugar-PL	DEF.FEM.SG.DAT	zebra

‘Did the zebra drop sugar?’

(21)

Tis	epese	poli	zahar-i	tis	zebras?
CL.FEM.SG.DAT	fell.3SG	much	sugar-SG	DEF.FEM.SG.DAT	zebra

‘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 we should seek a unified account that captures the pattern of the multiplicity and abundance inferences in upward- and downward-entailing contexts in a uniform fashion.

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 Grimm 2013 and Martí 2017) and the implicature approach (Sauerland 2003; Spector 2007; Mayr 2015, among others).[8] As discussed in Tieu et al. (2018), 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; 2018) 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 further test the predictions of the two approaches for multiplicity and abundance inferences in Greek, extending the previous experimental studies by Tieu et al. (2014; 2018). 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 (22), which suggests that the lion didn't carry all of the apples.[9]

(22)

To	liontaraki	kuvalise	merika	apo	ta	mila!
DEF.NEUT.SG.NOM	lion	carried	SOME	of	DEF.NEUT.PL.ACC	apples

‘The lion carried some of the apples!’

[8] There is also a third recent approach to the multiplicity inference that derives the heterogeneous behaviour of plural nouns in upward- and downward-entailing contexts based on homogeneity (Križ 2017). Under this approach, the sentence ‘The tiger fed pigs’ is true if and only if the tiger fed multiple pigs, false if and only if the tiger fed no pigs and undefined if and only if the tiger fed exactly one pig. By contrast, the sentence ‘The tiger didn't feed pigs’ is true if and only if the tiger fed no pigs, false if and only if the tiger fed multiple pigs, and undefined if and only if the tiger fed exactly one pig. We return to this briefly in footnotes 15 and 24.

[9] 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. Taken together these facts confirm that this is a good test case for children's ability to compute implicatures as well as a good baseline for implicature calculation in adults.

As we will discuss, our results replicate the patterns reported in Tieu et al. (2014; 2018) for multiplicity inferences, crucially revealing 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; 2018), 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 Grimm 2013; Mathieu 2014; Martí 2017) 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.[10] In other words, they argue that a sentence like (8), repeated below in (23), is ambiguous between two meanings, which can be paraphrased as in (23a) and (23b). Correspondingly, (10a), repeated in (24), is associated with the two meanings paraphrased in (24a) and (24b), where 'strong' and 'weak' refer to entailment patterns (the strong meaning asymmetrically entails the weak one).

(23)

I	tighri	taise	ghurunia.
DEF.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)

(24)

I	tighri	dhen	taise	ghurunia.
DEF.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 (23b), while in downward-entailing contexts it tends to be interpreted inclusively, as in (24a). In order

[10] The proposal in Farkas & de Swart (2010) is formalised in terms of bi-directional optimisation over form-meaning pairs within an Optimality Theory framework. We will set aside this particular formalisation and focus our discussion on the more informal principles behind it.

to account for this pattern, Farkas & de Swart (2010) assume a version of the Strongest Meaning Hypothesis, formulated as in (25), which essentially regulates the choice between the two possible meanings in favour of the strongest of the two (see Dalrymple et al. 1998; Winter 2001, among others).

(25) **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 (23b), according to which the tiger fed more than one pig, over the weaker (23a), according to which the tiger fed one or more pigs. Conversely, the inclusive interpretation is preferred in downward-entailing contexts, since in these contexts it gives rise to the stronger reading; that is, the stronger (24a), according to which the tiger didn't feed one or more pigs, is preferred over the weaker (24b), according to which the tiger didn't feed more than one pig. 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 (25) 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 (26):

(26)

I	tighri	dhen	taise	ghurunia	jati	taise
DEF.FEM.SG.NOM	tiger	NEG	fed	pig.PL	because	fed.3SG
mono	ena!					
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 approach can be readily extended to the abundance inference. In the domain of pluralised mass nouns, a sentence like (27), repeated from above, is associated with the two meanings in (27a) and (27b). In the same way, the negative counterpart in (17), repeated below in (28), is associated with the two meanings in (28a) and (28b).

(27)

Tis	zebras	tis	epesan	zahar-es.
DEF.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 a lot of sugar. EXCLUSIVE (STRONG)

(28)

Tis	zebras	dhen	tis	epesan	zahar-es.
DEF.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 didn't drop a lot of sugar. EXCLUSIVE (WEAK)

In the same way as above, the Strongest Meaning Hypothesis in (25) regulates the choice between the two possible meanings, favouring the strongest between the two. In upward-entailing contexts, that corresponds to the exclusive interpretation in (27b), according to which the zebra dropped a lot of sugar, and in downward-entailing contexts, that corresponds to the inclusive interpretation in (28a), according to which the zebra didn't drop a little or more than a little sugar. In addition, as in the case of count nouns, the strong interpretation of the plural is blocked if it is in conflict with the continuation of the sentence, as illustrated in (29):

(29)

Tis	zebras	dhen	tis	epesan	zahar-es	jati
DEF.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 a lot of 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. This approach is based on 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 (30). 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, (30a) implies (30b).

(30) a.

O	Dhimitris	efaghe	to	milo	i
DEF.MASC.SG.NOM	Dimitri	ate	DEF.NEUT.SG.ACC	apple	or
to	portokali.				
DEF.NEUT.SG.ACC	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: (31a) is typically interpreted as (31b) and not as (31c); 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 (31a) is not generally interpreted as being compatible with such a situation.[11]

[11] The intended interpretation of (31a) here is one in which negation scopes above disjunction. This interpretation is more clearly obtained if negation is higher in the structure as in (i), which is generally interpreted as conveying that I doubt that Dimitri ate the apple and that he ate the orange.

(i)

Amfivalo	oti/an	o	Dimitris	efaghe	to	milo	i	to	portokali.
doubt.1SG	that/whether	DEF.SG.NOM	Dimitris	ate	DEF.SG.ACC	apple	or	DEF.SG.ACC	orange

'I doubt that Dimitri ate the apple or the orange.'

An anonymous reviewer points out that some speakers would prefer the complementizer *an* (if/whether) to *oti* (that). For another group of speakers the two are both grammatical and to a large degree interchangeable. The two authors of the present paper who are native speakers of Greek belong to the latter group.

(31) a. O Dhimitris dhen efaghe to milo i to portokali.
DEF.MASC.SG.NOM Dimitri NEG ate DEF.NEUT.SG.ACC apple or DEF.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 environments that are upward-entailing and disappearing in downward-entailing ones.

The standard approach to deriving scalar implicatures like (30b) 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':

(32) 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 (30b).

This reasoning also naturally explains why (31a) 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 (33), but (33) is not more informative than (31a); in fact it is weaker, and therefore the listener will draw no implicature from (31a).

(33) Dimitri didn't eat the apple **and** the orange.

The implicature approach to multiplicity inferences extends the reasoning above to sentences like (8) and (10a), repeated below in (34) and (35):

(34) I tighri taise ghurunia.
DEF.FEM.SG.NOM tiger fed pig.PL
'The tiger fed pigs.'

(35) I tighri dhen taise ghurunia.
DEF.FEM.SG.NOM tiger NEG fed pig.PL
'The tiger didn't feed pigs.'

Roughly, the idea is that upon hearing a sentence like (34), 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) (36) instead.

(36) The tiger fed **exactly one** pig.

Variants of the implicature approach differ in how they derive the alternative over which the multiplicity inference is computed and in turn how the latter is obtained. Sauerland (2003) and Sauerland et al. (2005) derive the multiplicity inference by comparing the presuppositions of the singular with that of the plural, while Zweig (2009), Ivlieva (2013), and Mayr (2015) derive it as a more standard scalar implicature, but computed locally at the level of the predicate rather than at the sentence level. Finally, Spector (2007) derives the multiplicity inference as a recursive/higher-order implicature, arising through a comparison between the plural and the singular enriched with its own implicatures. For concreteness, we adopt Spector's (2007) version of the implicature approach to the multiplicity inference and its predictions. We briefly outline the main ingredients of this account below, but see Appendix A for further details.

As mentioned, Spector (2007) derives the multiplicity inference as a higher order implicature at the global level. The assumption is that at this level both singular and plural are equivalent to (37):

(37) The tiger fed one or more pigs.

However, the singular in (38a) gives rise to its own scalar implicature: (38a) competes with the alternative in (38b), and since the latter is stronger, the hearer will end up concluding that it is false, via the scalar implicature reasoning sketched above. The falsity of (38b) and the truth of (38a) together entail the *exactly one* inference in (39).

(38) a. I tighri taise ena ghuruni.
DEF.FEM.SG.NOM tiger fed one pig.SG
'The tiger fed a pig.'

b. I tighri taise dhio i perissotera ghurunia.
DEF.FEM.SG.NOM tiger fed two or more pig.PL
'The tiger fed two or more pigs.'

(39) The tiger fed one or more pigs and it is not true that the tiger fed two or more pigs.
= The tiger fed exactly one pig.

It is this enriched interpretation of (38a) in (39) that competes with the corresponding plural sentence in (34). That is, given that (39) would have been more informative than (34), the listener will conclude that the speaker must believe that (39) is false. If (34) is true and (39) is false, the result is then precisely the multiplicity inference, as illustrated in (40):

(40) 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 (35) is not associated with a multiplicity inference. The listener will compare (35) to its alternative in (41). (41), however, is weaker than (35) and therefore the listener will not draw any implicature from (35).

(41) 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 (26) above, repeated below in (42).

(42) I tighri dhen taise ghurunia jati taise mono ena!
DEF.FEM.SG.NOM tiger NEG fed.3SG pig.PL because fed.3SG only one
'The tiger didn't feed pigs, because she fed only one!'

This kind of reading also arises with standard scalar items like disjunction; for instance, (43), 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 (43) and extends it to (42). The general way of generating these marked readings involves postulating a local scalar implicature under the scope of negation (Fox & Spector 2018, among others). Scalar implicatures tend not to arise under negation so such readings are correctly predicted to be marked.

(43) 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). Extending Spector (2007) to the mass domain, Kane et al. (2015) assume that at the global level both the singular and the plural in (44) and (45), respectively, are equivalent to (46):[12]

(44) Tis zebras tis epese zahar-i.
DEF.FEM.SG.DAT zebra CL.FEM.SG.DAT fell.3SG sugar-SG
'The zebra dropped sugar.'

(45) Tis zebras tis epesan zahar-es.
DEF.FEM.SG.DAT zebra CL.FEM.SG.DAT fell.3PL sugar-PL
'The zebra dropped sugar.'

(46) The zebra dropped a little or more than a little sugar.

The singular in (44), but not the plural, competes with 'The zebra dropped a lot of sugar'. As the latter is a stronger alternative, upon hearing (44) the hearer concludes that the stronger alternative must be false. Since (44) is true and the alternative 'The zebra dropped a lot of sugar' is false, the hearer concludes that Zebra dropped some but not a lot of sugar, as shown in (47):[13]

(47) The zebra dropped a little or more than a little sugar and it's not true that she dropped a lot of sugar.
= The zebra dropped some sugar but not a lot.

The plural in (45) competes then with this enriched meaning of the singular in (47). Given that it would have been more informative than (45), the listener will conclude that the speaker must think that (47) is false. But, again, if (45) is true and (47) is false, the result is the abundance inference that arises as part of the meaning of the pluralised mass noun, as illustrated in (48):

[12] Extending other implicature accounts such as Mayr (2015) to the mass domain is also possible but requires more explicit assumptions about how the denotation of sentences with pluralised mass nouns is obtained compositionally. We leave this for future research.

[13] Note that this particular implementation of the implicature approach to the abundance inference predicts that a sentence containing a singular mass noun like (44) should be associated with the inference that the zebra dropped some but not a lot of sugar. We leave to future research a more careful investigation of whether this inference is actually present.

(48) The zebra dropped a little or more than a little sugar and it's not true that she dropped some sugar but not a lot.
= The zebra dropped a lot of sugar.

In addition, in the same way as above, we can explain why (17), repeated below in (49), is not associated with any inference.

(49)

Tis	zebras	dhen	tis	epesan	zahar-es.
DEF.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 (49) to its alternative in (50), which is in fact weaker than (49) and therefore the listener will not draw any implicature from (49).

(50) It's not the case that the zebra dropped some sugar but not a lot.

As was the case for the multiplicity inference, the scalar implicature approach will also account for the marked reading of (49) in (51), repeated from above.

(51)

Tis	zebras	dhen	tis	epesan	zahar-es	jati
DEF.FEM.SG.DAT	zebra	NEG	CL.FEM.SG.DAT	fell.3PL	sugar-PL	because
tis	epese	mono	lighi	zahar-i!		
CL.FEM.SG.DAT	fell.SG	only	little	sugar-SG		

'The zebra didn't drop a lot of sugar, because she dropped just a little!'

In sum, both the ambiguity and the implicature approach can account for the different readings associated with plural morphology across the mass and count divide, in particular for the pattern of sensitivity to monotonicity that they exhibit. In the next subsection, we turn to the different predictions they make in relation to the status of positive and negative plural sentences in certain contexts, and the comparison between (preschool-aged) children and adults on the interpretation of these sentences. These predictions motivated the previous experiments reported in Tieu et al. (2014; 2018), which investigated multiplicity inferences, as well as the present study, which extends the investigation of the predictions of both approaches to the abundance inference.

2.3 Predictions

2.3.1 Adults

Sensitivity to monotonicity As discussed, both the ambiguity and the scalar implicature approach 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.

Response patterns in positive and negative targets On the other hand, the two approaches differ with respect to the relationship between the positive and negative targets, when the multiplicity inference is not satisfied in the context, as in (52):

(52) **Context:** The tiger fed only one pig.
a. The tiger fed pigs.
b. The tiger didn't feed pigs.

That is, while both approaches predict that (52a) and (52b) should mostly be rejected in the given context, the assumed source of rejection is different. On the ambiguity approach, both (52a) and (52b) are simply false in the given context. That is, (52a) is interpreted as

'The tiger fed more than one pig' and (52b) is interpreted as 'The tiger didn't feed one or more pigs'; both are false when the tiger only fed one pig. The ambiguity approach therefore predicts the same status for (52a) and (52b) in the given context.[14]

The implicature approach, on the other hand, predicts that (52a) and (52b) clash with the context above for different reasons: while in (52a) it is the implicature – the multiplicity inference – that is false in the context, (52b) is simply false in the context by virtue of its literal meaning. In other words, under the implicature approach, (52a) and (52b) have a different status in the given context.

Summarising, the ambiguity approach predicts no difference in the response patterns of the positive and negative targets in a context in which the multiplicity inference is not satisfied, while the implicature approach is compatible with a different response pattern for the negative and positive sentences in the same context.[15]

2.3.2 Children

As discussed in Tieu et al. (2018), 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 (Chierchia et al. 2001; Gualmini et al. 2001; Noveck 2001; Papafragou & Musolino 2003; Foppolo et al. 2012, among many others). For example, children typically accept sentences such as (53) in situations where the stronger alternative (53a) is also true. This observation has usually been taken to indicate that children fail to compute the implicature in (53b).

(53) To liontaraki kuvalise merika apo
DEF.NEUT.SG.NOM lion carried SOME of
ta mila!
DEF.NEUT.PL.ACC apples
'The lion carried some of the apples!'
a. The lion carried all of the apples.
b. ⇝ *The lion didn't carry all of the apples.* SCALAR IMPLICATURE

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; Hochstein et al. 2016; Singh et al. 2016; Skordos & Papafragou 2016; Tieu et al. 2016; 2017c, 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 (54) and (55) below, or at least to do so less often than adults do.[16,17]

[14] The two could also potentially be judged true by overriding the Strongest Meaning principle and assigning the weaker interpretation. What is important for us is that this applies equally to both of the sentences.

[15] Note also that the homogeneity approach (Križ 2017) discussed briefly in footnote 8 predicts the same status for the positive and negative cases and therefore, everything being equal, predicts the same pattern of responses in both cases.

[16] We focus here on the prediction of the account by Spector (2007). The predictions of other approaches, like the local approach by Mayr (2015) and others might differ if the level at which implicatures are calculated (local vs. global) plays a role in children's (and adults') computation of such implicatures. The predictions of Sauerland (2003) and Sauerland et al. (2005) on the other hand, depend on the acquisition of the Maximize Presupposition principle and its restrictions.

[17] The recursive nature of the multiplicity and abundance inference derivation in Spector's (2007) approach (see Appendix A) could in principle play a role here by for instance adding processing complexity. This in

(54) I tighri fed.3SG ghurunia.
DEF.FEM.SG.NOM tiger fed pig.PL
'The tiger fed pigs.'
a. The tiger fed one or more pigs.
b. ⇝ *The tiger fed more than one pig.* MULTIPLICITY INFERENCE

(55) Tis zebras tis epesan zahar-es.
DEF.FEM.SG.DAT zebra CL.FEM.SG.DAT fell.3PL sugar-PL
'The zebra dropped sugar.'
a. The zebra dropped a little or more than a little sugar.
b. ⇝ *The zebra dropped a lot of sugar.* ABUNDANCE INFERENCE

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. 2018; Tieu & Romoli 2018):

(a) Children have only acquired the exclusive meaning of plurals;
(b) Children have only acquired the 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.[18,19]

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turn could add to the difficulty children might have in calculating these inferences. We note here, however, that the results of Tieu et al.'s (2016) study comparing free choice inferences and scalar implicatures suggest that children do not have problems with recursive computation of implicatures per se (at least under the assumption that free choice is derived via recursive computation of the implicature process, Fox 2007).

[18] It is reasonable to assume that without a guiding principle like the Strongest Meaning Hypothesis, children will charitably select the true interpretation in the context, in which case they may potentially behave in a non-adult-like manner in both upward- and downward-entailing contexts, depending on what readings the context makes true.

[19] Tieu et al.'s (2017b) study on plural predicate conjunction provides some evidence that 4–6-year-old children might actually be adult-like in relation to the Strongest Meaning principle, at least in that domain. However, we think it is fair to say that it is still very much open how children at this age behave more generally with respect to this principle.

2.3.3 Comparison among inferences

The formal theories of inferences we have outlined do not make direct predictions about processing or acquisition. They do, however, make general predictions about whether these inferences should be classified together or not. Based on this, we can make progress in our understanding of these inferences by comparing them directly, in the spirit of Chemla & Bott (2014: 394):

> "Methodologically, we showed how to use processing data to inform linguistic classification enterprises. It requires both a careful examination of modern linguistic theories and a realization of their predictions at a cognitively relevant level. Unfortunately, specific cognitive implementations of formal theories are often missing or highly underspecified. By targeting *comparisons* between different types of inferences, however, progress can be made on the classification task without being committed to distort the formal models or post-hoc cognitive reconstructions of them."

This approach has recently been applied to study the processing of various inferences in adults and their acquisition by young children.[20] Comparing inferences is relevant for our purposes because the implicature and ambiguity approaches also differ when we look specifically 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 in fact complicated by the fact that adults' rates of implicature computation have been reported to vary quite widely across different lexical scales (van Tiel et al. 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. (2018), we argue that if we look at the comparison between the scalar implicature of *some* and the multiplicity and abundance inferences across different populations, keeping the context and paradigm constant, there remains an expectation of a uniform pattern, regardless of whether the three inferences differ within a single population. Based on Tieu et al. (2018), we can formulate the uniformity prediction of the implicature approach as follows:

(56) **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. Whatever data we obtain about this relationship therefore will not constitute an argument for nor against the ambiguity approach. As we will discuss further below, however, the data from the multiplicity and abundance inferences alone will

[20] In addition to Chemla & Bott (2014), see also Tieu et al. (2016) on free choice, Singh et al. (2016) and Tieu et al. (2017c) on the inferences of disjunction, Tieu et al. (2014; 2018) on multiplicity inferences, Tieu et al. (2017a) on homogeneity, Cremers et al. (2017) on exhaustive readings of embedded questions, Cremers et al. (to appear) on temporal inferences, and Chemla & Bott (2013) and Romoli & Schwarz (2015) on certain presuppositions.

suffice to bear directly on the ambiguity approach, in particular posing a challenge for the approach.

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.[21]

In the next section, we briefly describe Tieu et al.'s (2014; 2018) 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 in Greek.

3 Previous studies

We will focus here on the experiments reported in Tieu et al. (2014; 2018), as they are the most relevant for our purposes. For an overview of experimental work on semantic approaches to plurality, see Tieu & Romoli (2018).

Tieu et al. (2014; 2018) 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 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 had a small amount of food and was only able to feed one pig. At the end of the story, the puppet uttered either the test sentence in (57a) or (57b).

(57) a. PUPPET: Emily fed pigs! *Plural positive target*
b. PUPPET: Emily didn't feed pigs! *Plural negative target*

Participants were expected to accept the positive (57a) 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 (57b) if they accessed only 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; 2018) tested 28 English-speaking 4- and 5-year-olds and 43 adult native speakers of English. The adult participants rejected positive targets like (57a) 92% of the time, but accepted negative targets like (57b) 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.

[21] As pointed out by an anonymous reviewer, a case in which the two approaches would make similar predictions is the case in (51), in which the continuation forces a reading with the abundance inference under negation. In fact, this would be an interesting test of the hypothesis that children go through a stage in which they only have the inclusive interpretation, as they should then find sentences like (51) unacceptable. We leave this to future research.

In a second experiment, Tieu et al. (2018) 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, the zebra picked a single banana at the orchard, and the puppet uttered the test sentence in (58a); 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 (59a). In both cases, participants were expected to accept the test sentence if they accessed only the literal meaning, and to reject the sentence if they computed the relevant inferences, i.e. (58b) and (59b).

(58) a. Zebra picked bananas.
b. ⇝ *Zebra picked more than one banana*

(59) a. Lion carried some of the apples.
b. ⇝ *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 (2018) 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. (2018) 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 (2018) 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 et al. 2017a).

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. Each participant received 10 target trials and 8 control trials. A full list of the materials can be found in Appendix B.

In the scalar implicature condition (adapted from Tieu et al. 2014; 2018), 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 (60) (see Figure 1 for the final slide of the story):

(60) **Context:** The lion carried all of the apples.
[E:] Okay, Ellie, so the tiger didn't carry any oranges. What about apples?
[P:] To liontaraki kuvalise merika apo ta mila!
DEF.NEUT.SG.NOM lion carried SOME of DEF.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 (61) and (62) for examples of the multiplicity and abundance targets, respectively; Figure 2 provides the corresponding pictures.

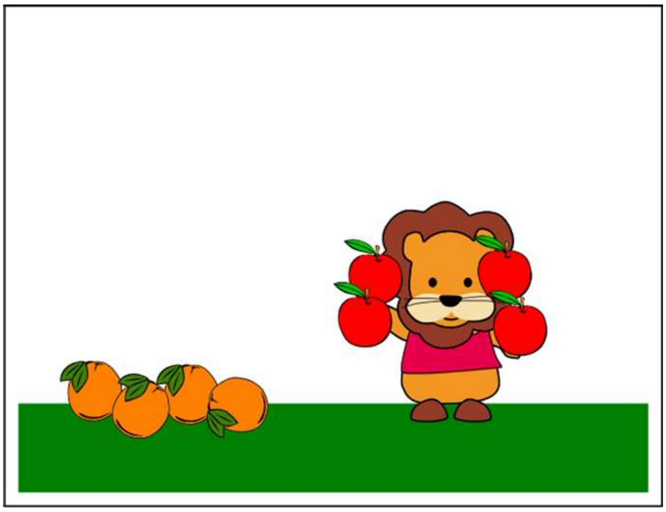

Figure 1: Target image for (60).

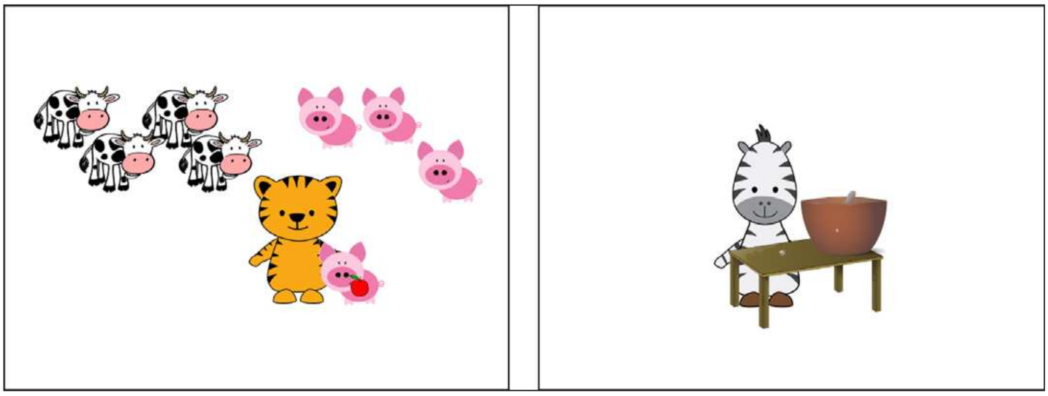

Figure 2: Target image for (61) and (63) (left), in which the tiger only fed one pig, and for (62) and (64) (right), in which the zebra only dropped a little bit of sugar.

(61) **Multiplicity inference target:** The tiger is visiting the farm today. Look at these cows and pigs! The tiger wants to feed the animals, but she only has a little bit of food. The tiger feeds this pig over here. Now she has no more food, so she 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!
DEF.FEM.SG.NOM tiger fed.3SG pig.PL
'The tiger fed pigs!'

(62) **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. She is very careful not to drop anything on the table. The zebra is very careful and she 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?

[P:] Tis zebras tis epesan zahar-es!
DEF.FEM.SG.DAT zebra CL.FEM.SG.DAT fell.3PL sugar-PL
'The zebra dropped sugar!'

Both kinds of inferences were presented in the positive, as in (61) and (62), and in the negative, as in (63) and (64) (accompanying the stories in (61) and (62), respectively):[22]

(63)

I	tighri	dhen	taise	ghurunia!
DEF.FEM.SG.NOM	tiger	NEG	fed.3SG	pig.PL

'The tiger didn't feed pigs!'

(64)

Tis	zebras	dhen	tis	epesan	zahar-es!
DEF.FEM.SG.DAT	zebra	NEG	CL.FEM.SG.DAT	fell.3PL	sugar-PL

'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. *The tiger fed more than one pig/The 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. *The tiger didn't feed any pig/The zebra didn't 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 exclusive interpretation (i.e. *The tiger fed more than one pig/The zebra dropped a lot of sugar*) and would therefore give a non-maximal reward to the puppet in contexts like (61) and (62). In downward-entailing contexts, on the other hand, the Strongest Meaning Hypothesis would favour the inclusive interpretation of the sentence (i.e. *The tiger didn't feed any pig/The zebra didn't 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 (65) and (66). In the positive example in (65), the multiplicity inference is satisfied; in the negative example in (66), the sentence refers to the other mentioned set of objects.

(65) **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!
DEF.FEM.SG.NOM	chicken	fed.3SG	cat.PL

'The chicken fed cats!'

(66) **Negative control:** The tiger loves to visit the petting zoo. Look at these turtles and mice! The tiger wants to feed the animals, but she only has a little bit of food. The tiger feeds these four turtles over here. Now she has no more food, so she 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.

[22] To keep things interesting for children, we varied the actual stories across the positive and negative conditions.

[E:] Okay, Ellie, so the tiger didn't feed any turtles. What about mice?
[P:] I tighri dhen taise pontikia!
DEF.FEM.SG.NOM tiger NEG fed.3SG mouse.PL
'The tiger didn't feed mice!'

The remaining four control trials corresponded to negation controls. These 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 dynamically selected either the clearly true target sentence (uttered in a pre-recorded videoclip) or the clearly false target, depending on how participants were responding to the critical target trials. These controls allowed us to ensure that participants could properly interpret negation independently of the plural, and also allowed us to balance the overall number of minimal and maximal rewards given across the experiment.

(67) **Negation control:** The frog loves to color shapes with his paint. Look at these stars and hearts! The frog wants to paint the shapes, but he only has a little bit of his favourite yellow paint. The frog paints these four stars over here. Now he has no more paint, so he leaves the hearts colorless. So remember, the frog only painted these four stars here! Now let's see if Ellie's paying attention.
[E:] Okay, Ellie, can you tell us something about the story?
[P':] O vatrahos dhen evapse tis kardhies!
DEF.MASC.SG.NOM frog NEG painted DEF.FEM.PL.ACC heart.PL
'The frog didn't paint the hearts!'
[P'':] O vatrahos dhen evapse ta asteria!
DEF.MASC.SG.NOM frog NEG painted DEF.NEUT.PL.ACC star.PL
'The frog didn't paint the stars!'

To sum up, each participant received 2 training items, followed by 10 test trials: 6 critical plural targets (3 positive, 3 negative) and 4 scalar implicature targets, and 8 control trials: 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 percentage of 1-, 2-, and 3-strawberry responses to the positive and negative count noun targets. We fitted a mixed effects ordinal regression model to the plural data with Group (baseline: adults), Polarity (baseline: positive), and their interaction as fixed effects, and by-participant intercepts and by-participant slopes for Polarity as random effects. The model revealed significant effects of Polarity ($\beta = -7.93$, $z = -5.32$, $p < .001$) and Group ($\beta = 4.01$, $z = 4.17$, $p < .001$), and no interaction between Polarity and Group ($p > .05$). Overall, participants were more likely to give lower ratings to the negative target sentences, children tended to give higher rewards than adults, and this between-group difference did not vary across the polarities.

4.2.2 Mass noun condition

Figure 4 displays the percentage of 1-, 2-, and 3-strawberry responses to the positive and negative mass noun targets. We fitted a mixed effects ordinal regression model to the plural mass noun data with Group (baseline: adults), Polarity (baseline: positive), and their interaction as fixed effects, and by-participant intercepts and by-participant slopes for

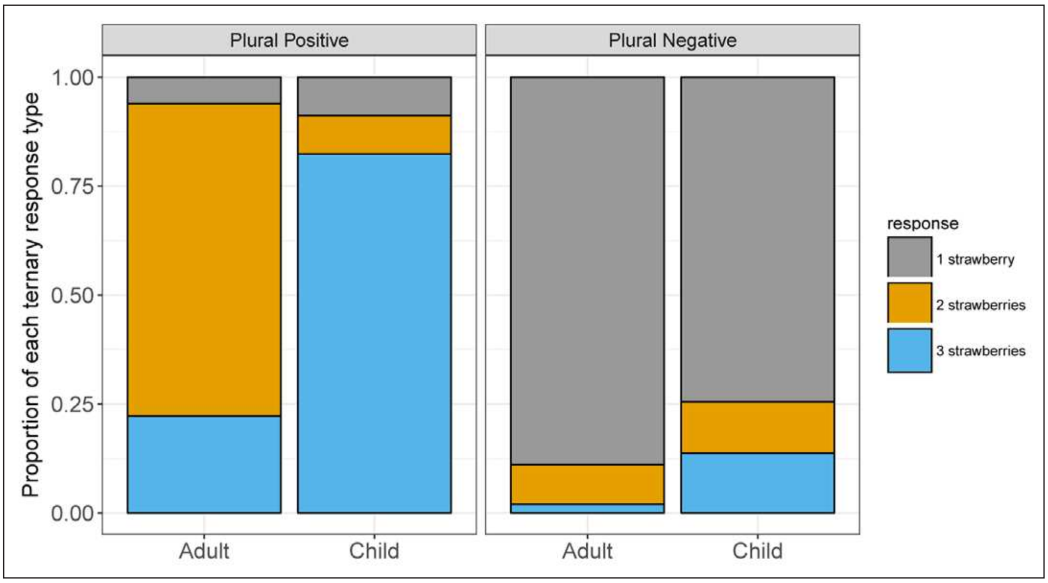

Figure 3: Count nouns: Proportion of 1-, 2-, and 3-strawberry responses to positive and negative targets.

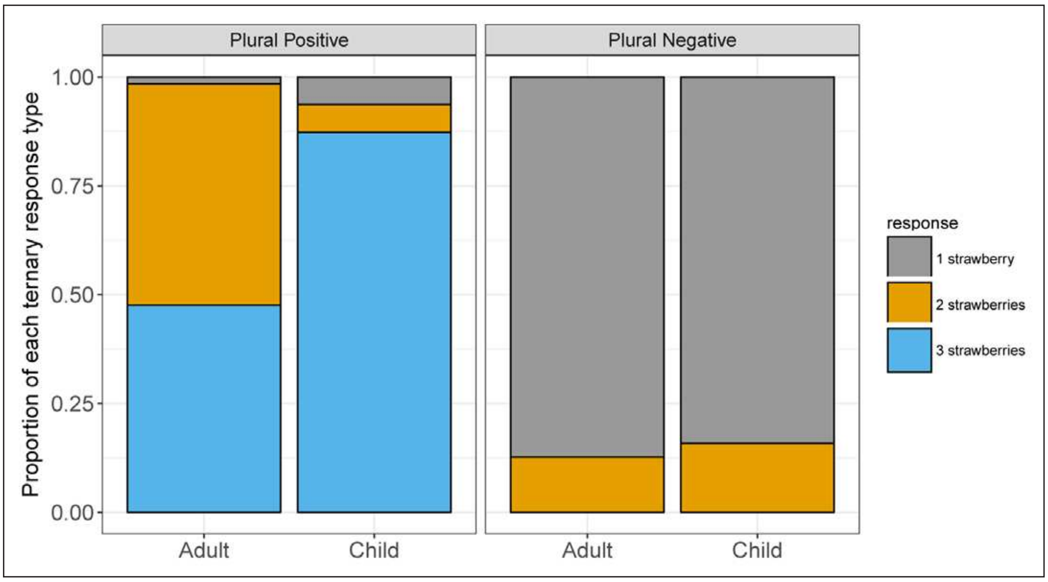

Figure 4: Mass nouns: Proportion of 1-, 2-, and 3-strawberry responses to positive and negative targets.

Polarity as random effects. The model revealed significant effects of Polarity (β = –5.33, z = –6.43, $p < .001$) and Group (β = 2.02, z = 3.59, $p < .001$), and a significant interaction between Polarity and Group (β = –1.76, z = –1.99, $p < .05$). Overall, participants were more likely to give lower ratings to the negative target sentences, children tended to give higher rewards than adults, and there was less of a difference between adults and children on the negative targets compared to the positive targets.

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 5 displays the proportions of reward types given in response to these targets, across the two groups.

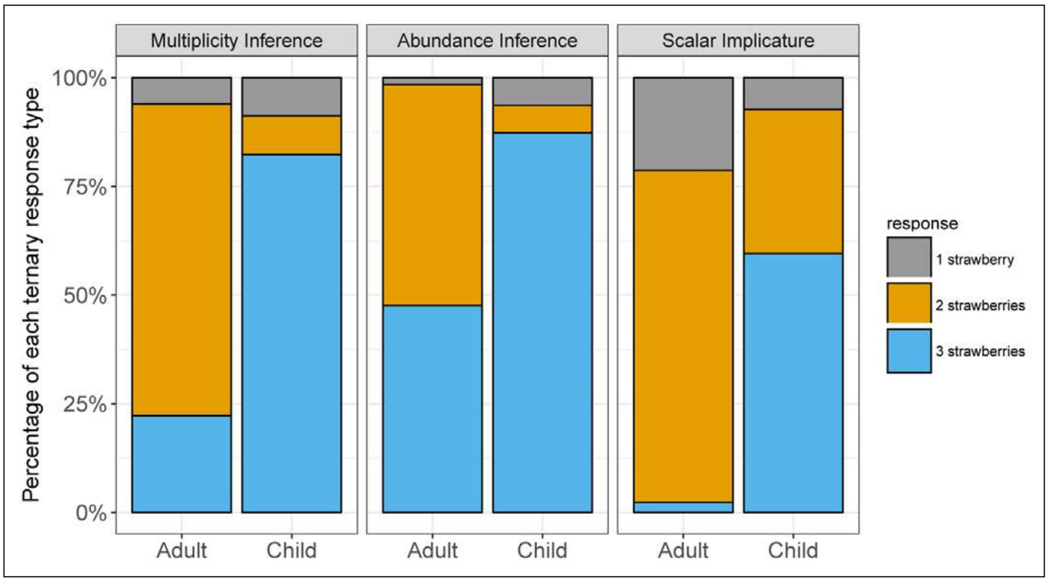

Figure 5: Percentage of 1-, 2-, and 3-strawberry responses across inferences and groups.

We fitted a mixed effects ordinal regression model to the positive plural and scalar implicature data, with Group (baseline: adults), Inference Type (baseline: multiplicity inferences), and their interaction as fixed effects, and random by-participant intercepts. The model revealed a significant effect of Group, with children giving higher rewards than adults ($\beta = 3.21$, $z = 6.35$, $p < .001$). The model also revealed significant effects of Inference Type, with participants giving higher rewards for the mass noun targets than for the count noun targets ($\beta = 1.10$, $z = 2.62$, $p < .01$), and lower rewards for the scalar implicature targets than for the count noun targets ($\beta = -1.54$, $z = -5.39$, $p < .001$). There were no significant interactions between Group and Inference Type when comparing count nouns to mass nouns nor when comparing count nouns to scalar implicatures (both $p > .05$). In sum, children tended to give higher rewards than adults overall, participants computed fewer abundance inferences than multiplicity inferences, participants computed more scalar implicatures than multiplicity inferences, and the difference between children and adults did not vary significantly across the count noun and mass noun conditions nor across the count noun and scalar implicature conditions.

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: 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, is in line with an implicature account of multiplicity and abundance inferences, and suggests 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; 2018). 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.[23] 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 plural inferences. The pattern of analogous differences between children and adults across the three inferences also supports a unified approach to the effects of plural morphology across the mass and count divide. Let us now discuss in further detail some of the specific findings and their implications.

5.1 Adults

5.1.1 Sensitivity to polarity

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 (68) and (69) in contexts in which the tiger fed exactly one pig and in which the zebra dropped a small amount of sugar, respectively.

(68) a. I tighri taise ghurunia.
DEF.FEM.SG.NOM tiger fed.3SG pig.PL
'The tiger fed pigs.'

b. I tighri dhen taise ghurunia.
DEF.FEM.SG.NOM tiger NEG fed.3SG pig.PL
'The tiger didn't feed pigs.'

(69) a. Tis zebras tis epesan zahar-es.
DEF.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.
DEF.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; 2018), and is unsurprising on both the ambiguity and the implicature approaches.

5.1.2 Response patterns for positive and negative targets

The results also clearly show that adults responded differently to the positive and negative cases: they tended to give the intermediate value in the positive case but the lowest value in the negative case, as can be seen in Figures 3 and 4. This pattern is in line with – and even expected on – the implicature approach, which can account for the pattern straightforwardly by mapping the lowest value to falsity of the literal meaning and the intermediate value to the falsity of the implicature. By contrast, it is less clear how the ambiguity approach might capture this difference between the positive and negative response patterns, since it does not predict any difference in the status of the source of

[23] It is worth keeping in mind that Farkas & de Swart (2010), Grimm (2013), and Martí (2017) are exclusively concerned with count nouns; therefore only the results from our count noun condition can bear directly on their proposals. The results from the mass noun condition on the other hand represent an *extension* of the ambiguity approach to the mass domain, which we have discussed in detail above. The same holds for the implicature approach. We would argue that these extensions are both justified and necessary, in pursuing a unified account of multiplicity and abundance inferences in a language like Greek, which allows for pluralisation across both domains.

rejection in the positive and negative cases.[24] In sum, the asymmetry across the polarities in adults is more in line with the implicature approach than the ambiguity approach.[25]

5.2 Children

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 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 (70a) and (71a), but to interpret it inclusively in sentences like (70b) and (71b).

Indeed in our experiment adults mostly rejected sentences like (70a) and (71a) as well as sentences like (70b) and (71b) 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.

(70) PLURALISED COUNT NOUNS:

a. I tighri taise ghurunia.
DEF.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 ghurunia.
DEF.FEM.SG.NOM tiger NEG fed pig.PL
'The tiger didn't 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)

(71) PLURALISED MASS NOUNS:

a. Tis zebras tis epesan zahar-es.
DEF.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 a lot of sugar. EXCLUSIVE (STRONG)

b. Tis zebras dhen tis epesan zahar-es.
DEF.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)
(ii) The zebra didn't drop a lot of sugar. EXCLUSIVE (WEAK)

[24] The difference in the positive and negative response patterns is also problematic for the homogeneity approach in Križ (2017), which also predicts the same source of rejection for both cases, and hence the same pattern of responses in the two cases.

[25] Thanks to Alexandre Cremers for discussion of this point.

The child participants, on the other hand, mostly accepted sentences like (70a) and (71a), and rejected sentences like (70b) and (71b) 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 exclusive meaning of plurals;
(b) Children have only acquired the 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. 2018 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 inclusive meaning true will also make the exclusive 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 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.

This pattern, however, is expected within the implicature approach, which predicts parallel patterns 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, is in line with a unification of the effects of plural morphology across the mass and count divide in terms of an implicature account.

5.4 Variability in derivation rates across inferences

One additional finding from our experiment 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., *ghurunia* 'pigs' vs. *ghuruni* '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'). As pointed out by an anonymous reviewer, it is not intuitively obvious which pairs should be perceived as more distant compared to others; such potential differences in semantic distance would have to be tested and compared along the lines of van Tiel et al. (2014).

The second factor is related to the nature of the scale, namely whether the scale is bounded 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.[26]

[26] 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-bounded (see for example Link 1983; Krifka 1989). Alternatively, under the assumption that the denotation of mass nouns is formed from vague atoms (e.g., Chierchia 1998; 2010), 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.

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 the diversity of scalar terms (van Tiel et al. 2014).

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; 2018), 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. However, the fact that adults tended to use the intermediate rather than minimal reward in the positive condition compared to the negative condition is in line with the implicature approach, but poses a challenge for the ambiguity one. In addition, the results from children are also challenging for the ambiguity approach and 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. 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; 2018), 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.

Abbreviations

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

Additional Files

The additional files for this article can be found as follows:

- **Appendix A.** The implicature approach in more detail. DOI: https://doi.org/10.5334/gjgl.531.s1
- **Appendix B.** Experimental materials. DOI: https://doi.org/10.5334/gjgl.531.s1

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Competing Interests

The authors have no competing interests to declare.

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