The symmetry problem: current theories and prospects*

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Abstract The structural approach to alternatives (Katzir 2007, Fox & Katzir 2011, Katzir 2014) aims at solving the *symmetry problem* of scalar implicatures, but problematic data with indirect and particularised scalar implicatures have been raised (Romoli 2013, Trinh & Haida 2015). In an attempt to address these problems, Trinh & Haida (2015) recently propose to augment the theory with the Atomicity Constraint. In this paper, it is shown that Trinh & Haida's Atomicity Constraint falls short of explaining minimal variants of the original problems, and moreover that it runs into trouble with the inference of sentences involving gradable adjectives like *full* and *empty*. We furthermore discuss how the structural approach suffers from the problem of 'too many lexical alternatives' (Swanson 2010) and the problem of 'too few lexical alternatives.' These three problems epitomise the difficulty of constructing just enough alternatives under the structural approach to solve the symmetry problem in full generality. In light of this, we also discuss two other accounts of the symmetry problem, the Monotonicity Constraint (Horn 1989, Matsumoto 1995) and the approach based on relative informativity and complexity by Bergen, Levy & Goodman (2016), and argue that they also do not provide a general solution to the symmetry problem.

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1 Introduction

1.1 The symmetry problem

Theories of scalar implicatures, while quite diverse, tend to have the following shape: the scalar implicatures of sentence *S* are the negations of alternative sentences (or simply alternatives).[1] For instance, (1a) has the scalar implicature in (1b), and this is derived in reference to the alternative *John did all of the homework*.

(1) a. John did some of the homework.
  b. $\rightsquigarrow$ *John didn't do all of the homework*

A theory of alternatives that explains how alternatives are determined for a given sentence is therefore a crucial part of a theory of scalar implicatures.

An important problem for a theory of alternatives is the so-called *symmetry problem*, which has to do with the question of how to restrict alternatives (Kroch 1972, Fox 2007, Katzir 2007, Fox & Katzir 2011 among others). In order to see the problem, let us consider a concrete example. For (1a) above, for example, we have to make sure that (2) must not be an alternative.

(2) John did some but not all of the homework.

The reason is that if (2) were an alternative, it would generate its negation as a scalar implicature, namely, that John did either none or all of the homework. Since the literal meaning of (1a) says that John did some of the homework, it would, then, follow that John did all of the homework. However, this scalar implicature would contradict the scalar implicature (1b). Thus, in order to explain why (1a) has (1b) as a scalar implicature, it needs to be explained why (2) does not enter the computation of scalar implicatures.

More generally, S with a scalar implicature that $\neg A$ for some alternative A should not have a sentence that means $S \wedge \neg A$ as an alternative. This is because if $S \wedge \neg A$ were an alternative, it would yield a scalar implicature that $\neg(S \wedge \neg A)$, which would contradict what the S says and the scalar implicature $\neg A$. We follow the literature and call alternatives like A and $S \wedge \neg A$ *symmetric alternatives*.[2]

The symmetry problem is, therefore, the problem of how to make sure that A is an alternative to S but not its symmetric alternative $S \wedge \neg A$. It should also be noticed that the fact that (1a) never implicates that John did all the homework implies that

1 There are approaches to scalar implicatures that do not make use of alternative sentences, e.g. Van Rooij & Schulz 2004, 2006 and Fine to appear. Our focus in this paper is the former kind of approach, especially the structural approach to alternatives.

2 The definition of symmetric alternatives from Fox & Katzir 2011 is as follows:

(i) Let S, S_1, S_2 be sentences such that S_1 and S_2 are alternatives to S. We say that S_1 and S_2 are *symmetric alternatives* of S if both of the following are true.
  a. $[\![S_1]\!] \cup [\![S_2]\!] = [\![S]\!]$
  b. $[\![S_1]\!] \cap [\![S_2]\!] = \emptyset$

See Katzir 2014 for a generalised definition of symmetry.

(2) cannot be an alternative to the exclusion of *John did all of the homework*. The theory of alternatives needs to explain this as well.

1.2 Non-weaker alternatives

The symmetry problem suggests that the set of alternatives should be somehow restricted. To make the problem more complicated, there are reasons to believe that the set should be able to contain alternatives that are logically independent of it, in addition to alternatives stronger than the assertion, (contrary to (Neo-)Gricean theories such as Soames 1982, Horn 1972, 1989, Gazdar 1979).

One argument comes the observation that a non-monotonic operator O embedding a scalar term like *some*, $O(\text{some})$, can implicate the negation of $O(\text{all})$ (cf. Chemla & Spector 2011, Spector 2007). Importantly, $O(\text{all})$ is a logically independent alternative to $O(\text{some})$.

To see this concretely, consider (3a), involving a non-monotonic operator, *every letter but A*. The relevant logically independent alternative is (3b).

(3) a. Every letter but A is connected to some of its circles.
 b. Every letter but A is connected to all of its circles.

Assuming that scalar implicatures are cancellable, there are two potential readings for (3a):

(4) a. Reading without the scalar implicature: A is connected with none of its circles, all the other letters are connected with some or all of their circles.
 b. Reading with the scalar implicature: A is connected with none of its circles, all the other letters are connected with some of their circles but not all of the others are connected with all of their circles.

These two readings can be distinguished by the connections that the letters other than *A* have. Concretely, consider the two situations in Figure 1. The picture on the left only makes (4a) true, while the picture on the right makes both (4a) and (4b) true. The difference between these situations is intuitively clear: (3a) is harder to accept as a description of the picture on the left than one of the right. These judgements suggest that the reading with a scalar implicature (4b) is available.

Another argument for including logically independent alternatives comes from contextually-determined alternatives. We will discuss such an example below in (10), where *John smoked pot* counts as an alternative to *John ran*.

For these reasons, we will assume throughout this paper that the set of alternatives includes not only logically stronger alternatives but also logically independent

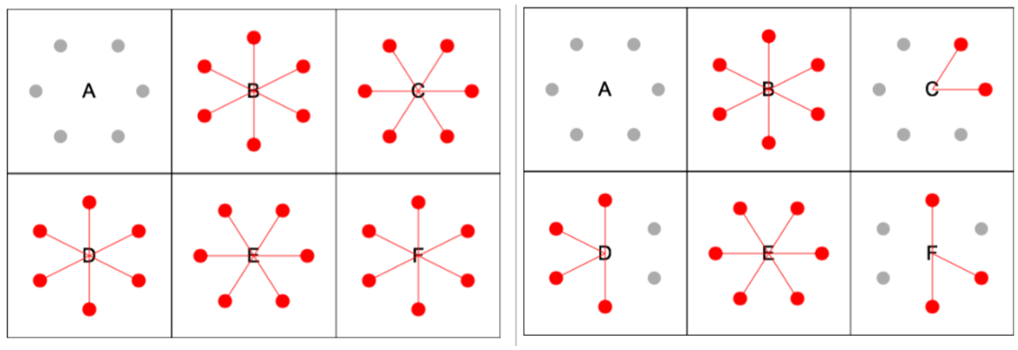

Figure 1 Situations in which only the literal meaning of (3a) is true (left) and both the literal meaning and the meaning with the inference are true (right).

alternatives. Note that with logically independent alternatives, we will have to deal with more symmetric alternatives. That is, for a given sentence S with a scalar implicature $\neg A$ based on an alternative A, the alternative that means $\neg A$ should not be used to generate a scalar implicature, as it would contradict the observed scalar implicature. For instance, (5) should not be an alternative to (1a).

(5) John did not do all of the homework.

1.3 Outline

A classical idea for avoiding the symmetry problem is to assume that alternatives are restricted lexically (Horn 1972, among others). For instance, assuming that *all* is a lexically specified alternative to *some* while *some but not all* is not, we can successfully prevent *some but not all* from entering the computation of scalar implicatures for (1a).

This theory, however, does not lead to a deep explanation of why certain items are alternatives and others are not. In the current literature, three more principled explanations have been proposed, namely, the *structural approach* (Katzir 2007, Fox & Katzir 2011), the *Monotonicity Constraint* (Horn 1989, Matsumoto 1995) and the approach based on relative informativity and complexity (Bergen et al. 2016).

The rest of paper is structured as follows. In Sect. 2, we review how the structural approach of alternatives solves the symmetry problem with examples like (1a), and its problems pointed out by Romoli (2013) and Trinh & Haida (2015). In Sect. 3, we critically discuss Trinh & Haida's (2015) idea to augment the structural approach with the *Atomicity Constraint*, and point out further problems it fails to address. In Sect. 4, we discuss two additional problems for the structural approach, the problem of too many alternatives, and the problem of too few alternatives, which further illustrates the general difficulty of obtaining an adequate set of alternatives under the structural approach. Sect 5 is devoted to discussion of two other accounts of the symmetry problem, the Monotonicity Constraint and the approach based on informativity and complexity. We argue that they also do not provide a full solution to the symmetry problem. We conclude the paper in Sect. 6.

2 The structural approach to alternatives and its problems

2.1 The structural approach

The structural approach to alternatives, advocated by Katzir (2007) and Fox & Katzir (2011), is intended to solve the symmetry problem with a general algorithm for constructing alternatives. The key idea behind it is that alternatives cannot be of higher structural complexity. To illustrate, *some* and *all* are legitimate alternatives, as they are of equal structural complexity, while *some* and *some but not all* are not, as the latter is more complex.

To be more precise, the set of *formal alternatives* is defined as in (6).

(6) The set of *formal alternatives* $F(S)$ of sentence S in context c is the set of sentences derivable by successive replacement of constituents of S with items in the *substitution source* of S in c.

Katzir (2007) defines *substitution source* as in (7) (Fox & Katzir (2011) further employ focus relativity, something we suppress except where relevant; see below).

(7) A item α is in the *substitution source* of S in c if
   a. α is a constituent that is salient in c (e.g. by virtue of having been mentioned); or
   b. α is a sub-constituent of S; or
   c. α is in the lexicon.

The substitution source contains items in the lexicon. So, for instance, one could in principle replace, say, a verb with any other verb in the lexicon. Then, if all formal alternatives were always employed to derive scalar implicatures, the theory would lead to massive over-generation, which is clearly undesirable. To this end, Fox & Katzir (2011) assume that the context specifies a subset C of $F(S)$, which is meant to represent contextually relevant alternatives. In particular, C is assumed to respect the closure condition in (8):[3]

(8) **Closure condition on C**:

a. $C \subseteq F(S)$

b. $S \in C$ and

c. There is no $S_0 \in F(S) \backslash C$ s.t. the meaning of S_0 is in the Boolean closure of C.

The first clause requires C to be a subset of the formal alternatives and the second clause demands what is asserted to be in the set C. Finally, the third clause requires C to include all formal alternatives that express Boolean combinations of the meanings of sentences in C.[4]

The intuition behind (8c) is the following. If it is of interest in the context whether p is true or false, then it is of interest whether $\neg p$ is. Thus if the former is included then so should be the latter, unless there is no formal alternative expressing it. Similarly, if it is relevant in the context whether p is true and whether q is true, then it will be relevant whether their conjunction is. Therefore, no formal alternative that belongs to the Boolean closure of C should be left out.

Finally, the scalar implicatures of S are computed by negating the members of C that are not weaker than S.

Now, let us illustrate this theory with (1a). Crucially, the problematic alternative (2) is excluded by its relative structural complexity. That is, *some but not all* being structurally more complex than *some*, (2) is excluded from F(1a) (see fn.5 below about contextual alternatives). On the other hand, *some* and *all* are equally complex, so *John did all of the homework* will be a formal alternative.

These formal alternatives are now restricted to a subset C that obeys (8). For instance, (9) is a permissible set C of relevant alternatives for (1a) and will yield the attested scalar implicature that John did not do all of the homework.

(9) $C = \{$John did some of the homework, John did all of the homework$\}$

Importantly, although the meanings of (2) and (5) are in the Boolean closure of C, C nonetheless obeys (8), since they are not in F(1a).[5]

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3 is not the only condition on C that has been put forward in the literature. Fox & Katzir (2011) uses a notion of exhaustive relevance, Katzir (2014) discusses the option of pruning inferences after exhaustification, and Crnic, Chemla & Fox (2015) propose a different non-weakening constraint. We will stick to 3 because, as far as we can see, the choice here would be inconsequential for our arguments below. We thank Roni Katzir (p.c.) for discussion on this point.

4 The Boolean closure of C is the smallest set P of propositions that contains the propositions expressed by the members of C and whenever $p,q \in P$, we have $\neg p, (p \wedge q) \in P$.

5 The definition of formal alternatives in (6) allows constituents that are salient in the context to be in the substitution source. One remaining question is whether one can make problematic symmetric

The theory is also capable of dealing with *particularised scalar implicatures* (Hirschberg 1991 among others), which are scalar implicatures generated by contextually salient alternatives. For instance, consider the following example.

(10) *Mary got drunk. What did John do?*
  a. He smoked pot.
  b. ⇝ *John didn't get drunk*

The scalar implicature in (10b) is derived by negating the sentence *He got drunk*. This is a formal alternative to (10a), since the constituent *got drunk* is contextually salient in this example.[6]

2.2 The problem of indirect scalar implicatures

However, the structural theory of alternatives runs into a problem with so-called *indirect implicatures*, as pointed out by Romoli (2013). Indirect scalar implicatures

alternatives salient in the context so that they can be formal alternatives. Katzir (2007) and Fox & Katzir (2011) discuss the following example.

(i) ??Yesterday John did some but not all of the homework and today he did some.

As they admit, however, this sentence is unnatural, so it is difficult to conclude much from it. Notice, however, that the closure condition dictates that it is not possible to have just (2) in C without also having *John did all of the homework* in it. Consequently, the implicature that John did all of the homework will not be expected for (i).

6 An alternative treatment of these particularised scalar implicature is the neo-Gricean treatment by Hirschberg (1991), which builds on the lexical alternatives approach and develops the idea that sets of alternative are created on an *ad hoc* basis according to what is relevant in context and that these are partially ordered by entailment. In this example, an ad hoc scale would give rise to an alternative that John smoked pot and got drunk.

A question is whether all cases that seem to require ad hoc scales can be handled using Fox & Katzir's (2011) complexity account. Take for example the following from Hirschberg 1991:

(i) A: Do you have information on [Kathy M. for maternity] ...?
B: I don't think she has delivered yet.
A: Then she HAS been admitted.
B: Yes.

Given A's response to B's first utterance, the latter arguably implicates that (B thinks that) the woman has been admitted. Such an implicature would seem to require an alternative sentence [I don't think she has been admitted]. Whether this can be derived via (6) is moot since the form of the alternative has a greater level of complexity than the assertion, containing a passive with the particle, [been] as extra linguistic material. Since this is potentially another manifestation of the problem of too few alternatives, discussed below in section 4, we leave it open whether all cases involving ad hoc scales can be handled by Fox & Katzir (2011).

are implicatures of sentences containing strong scalar items in downward entailing contexts like negation. The crucial property of these cases is that unlike the examples we have seen so far, the asserted sentence is structurally more complex than the problematic symmetric alternative, and hence Katzir's (2007) substitution procedure automatically includes them as formal alternatives.

Consider (11a), for example. It has a scalar implicature in (11b), which is obtained by negating (12).

(11) a. John didn't do all of the homework.
b. $\rightsquigarrow$ *John did some of the homework*

(12) John didn't do any of the homework.

The structural approach wrongly predicts that this alternative cannot be negated, due to the presence of its symmetric alternative. Consider first the set of formal alternatives of (11a) that can be constructed according to the definition in (6). To avoid clutter in the examples, we will write alternatives in schematic form from now on, adopting Trinh & Haida's (2015) notation (e.g. **all** = 'John did all of the homework').

(13) $F(\text{11a}) = \{\neg\textbf{all}, \neg\textbf{any}, \textbf{all}, \textbf{some}\}$

Here we would like to negate $\neg$**any** to obtain the inference (11b), but we cannot because we also have the symmetric alternative **some**, generated from (11a) by substituting the NegP in the assertion with its subconstituent VP, and substituting *some* for *all* within the latter, as shown in (14).[7]

(14)		$[_{\text{NegP}}$ not $[_{\text{VP}}$ John did all of the homework]]	(11a)
	$\Rightarrow$	$[_{\text{VP}}$ John did all of the homework]	subconstituent
	$\Rightarrow$	$[_{\text{VP}}$ John did [some] of the homework]	all/some

Given that **some** is in C, the negation of $\neg$**any** contradicts the negation of **some** and hence cannot be negated. Note that it is not possible to use a subset C' of the formal alternatives containing $\neg$**any** but not **some**, i.e. $C' = \{\neg\textbf{all}, \neg\textbf{any}, \textbf{all}\}$, to derive the desired scalar implicature, because C' would violate the closure condition: **some** is both in F(11a) and in the Boolean closure of C' given that $[\![\textbf{some}]\!] = [\![\neg\neg\textbf{any}]\!]$.

It should be noted here that Fox & Katzir (2011) assume an additional constraint on the set of formal alternatives that requires replacements to be performed only on *focussed* parts of the sentence. If focus is narrow enough, i.e. below negation, as in (15a) or (15b), then the offending alternative **some** cannot be generated, as negation

7 For expository purposes, we represent the subject in the VP-internal position and also the verb in the inflected form but nothing crucial hinges on this.

cannot be replaced here.

(15) a. John didn't [do all of the homework]$_F$
b. John didn't do [all of the homework]$_F$

Romoli (2013), however, points out that the scalar implicature is still observed, even when the focus is broad enough to include negation, as in the following example.

(16) What happened at school today?
[John (my favourite student) didn't do all of the homework]$_F$.

Thus the under-generation problem noted above persists for such cases.

2.3 The problem of particularised scalar implicatures

A similar problem arises with the slightly more complex example a particularised implicature in (17) adapted from Trinh & Haida (2015).

(17) Bill went for a run and didn't smoke. What did John do?
John went for a run.
$\rightsquigarrow$ *John smoked*

As evidence for this inference, notice that (17) sounds unnatural in a context in which it is known that John didn't smoke. This parallels the unnaturalness of sentences like (10) and (11a) in contexts in which their implicatures are false – ones which John didn't do any homework and ones in which he did get drunk, respectively.[8]

The implicature of (17) could be derived in principle by negating $\neg$**smoke**, or **run** $\wedge$ $\neg$**smoke** (which together with the assertion, **run**, entails **smoke**). But here again, Fox & Katzir's (2011) system under-generates, for essentially the same reason as above. Assuming that the VPs in (17) are salient, $\neg$**smoke**, **run** $\wedge$ $\neg$**smoke** or both can be generated as formal alternatives, so we have:

(18) $F(17) \supseteq \{\mathbf{run}, \neg\mathbf{run},\ \mathbf{smoke}, \neg\mathbf{smoke},\ \mathbf{run}\wedge\mathbf{smoke},\ \mathbf{run}\wedge\neg\mathbf{smoke}\}$

8 Some speakers pointed out to us that for them (17) tends to have an ignorance inference that the speaker is unsure as to whether John smoked, rather than the scalar implicature that John smoked. We agree that this reading is possible and maybe even the most salient. However, variants of (17), like (i), for which it is very plausible that the speaker is well informed about the relevant activity that she herself has engaged with, the scalar implicature tends to arise more systematically.

(i) Bill went for a run and didn't smoke.
I went for a run.
$\rightsquigarrow$ *I smoked*

However, the closure condition on C requires it to contain the symmetric alternative **run** $\wedge$ **smoke**, if C contains **run** $\wedge\neg$**smoke**, since C must contain **run** itself and any formal alternative in its Boolean closure ($[\![\mathbf{run} \wedge \mathbf{smoke}]\!] = [\![\mathbf{run} \wedge \neg(\mathbf{run} \wedge \neg\mathbf{smoke})]\!]$.) For parallel reasons, if C contains $\neg$**smoke**, it must also contain the symmetric alternative **smoke**.

3 The Atomicity Constraint and its problems

3.1 The Atomicity Constraint

Adopting Katzir's (2007) and Fox & Katzir's (2011) structural approach to alternatives, Trinh & Haida (2015) propose to add one extra constraint on the construction of formal alternatives, the Atomicity Constraint. The Atomicity Constraint prohibits further substitutions on the expressions in the substitution source. Or to put it differently, the Atomicity Constraint effectively forces all constituents in the substitution source to be treated as if they were atomic lexical items, so substitutions within them are prohibited.

Let us see how this solves the problem of indirect scalar implicatures. Remember that the problem with (19a) is that Fox & Katzir's (2011) procedure allows us to construct both the needed alternative in (20a) and its symmetric alternative in (20b).

(19) a. John didn't do all of the homework.
b. $\rightsquigarrow$ *John did some of the homework*

(20) a. John didn't do some of the homework.
b. John did some of the homework.

The atomicity constraint correctly blocks the generation of the offending alternative (20b). To see this, consider how it could be derived. We know the substitution source includes the atomic item *some*. Using this, let us try the following derivation.

(21) a. [$_{\text{NegP}}$ not [$_{\text{VP}}$ John did all of the HW]] (19a)
b. $\boxed{_{\text{VP}}\text{ John did all of the HW}}$ subconstituent
c. $\boxed{_{\text{VP}}\text{ John did [some] of the HW}}$ *all/some

This derivation violates the Atomicity Constraint because after the second step, the subconstituent VP is now treated as an atom (as indicated by the box here), and its sub-part, *some*, cannot be replaced in the third step.

Note that first substituting *some* for *all* and substituting the newly formed [$_{\text{VP}}$ did some of the homework] for the NegP is not possible, simply because this VP is not in the substitution source. It is not a subconstituent of the assertion and it is not salient in the context. Consequently, the symmetric alternative (20b) (=**some**) is not generated, and the correct indirect scalar implicature can be generated by negating (20a) (= $\neg$**some**).[9]

Let us now also see how Trinh & Haida's (2015) particularised scalar implicature example (17) is accounted for. The solution is essentially identical. Consider the first part of (17) in (22). Consider in particular the constituent α = [$_{\text{T'}}$ went for a run and didn't smoke]. Without the Atomicity Constraint, the offending alternative **run** $\wedge$ **smoke** could be derived as follows:

(22) Bill $\boxed{[_\alpha \text{ went for a run and didn't smoke}]}$

(23)		[John went for a run]]	the prejacent
	$\Rightarrow$	[John $\boxed{_{\text{T'}} \text{ went for a run and didn't smoke}}$]	T'/α
	$\Rightarrow$	[John $\boxed{_{\text{T'}} \text{ went for a run and } [_{\text{VP}} \text{ smoked}]}$]	NegP/smoked

The Atomicity Constraint rules out this derivation, as the T' in the second step is atomic, and the replacement in the last step is forbidden. As a result, the formal alternatives do not include the offending alternative **run** $\wedge$ **smoke** and C can be $\{$**run**, **run** $\wedge \neg$**smoke**$\}$, which gives rise to the correct scalar implicature.

We can also construct other formal alternatives from (22), in particular, (24a) and (24b), given the saliency of VPs in (22).

(24) a. John $\boxed{[_\beta \text{ didn't smoke}]}$

b. John $\boxed{[_\gamma \text{ smoked}]}$

Given the closure condition, we cannot have one of (24a) and (24b) in C without having the other. However, this causes no problem, since neither is in the Boolean closure of $\{$**run**, **run** $\wedge \neg$**smoke**$\}$ and so they can be excluded.

9 What if this VP is contextually salient instead? Consider the following example.

(i) Two weeks ago, John did all of his homework. Last week, he did some. And this week, he didn't do all of his homework.
$\leadsto$ *John did some of his homework*

The discourse is perhaps not completely natural. However, if one can establish that the last sentence has the inference that John did some of the homework, this would not be predicted, since [$_{\text{VP}}$ John did some of the homework] is in the substitution source by virtue of having been uttered in the previous sentence, so the scalar implicature should be absent in this case.

Both Fox & Katzir (2011) and Trinh & Haida (2015) are aware of this potential problem, and they propose that contextually salient alternatives are only optionally in the substitution source (see Fox & Katzir 2011: fn. 23 and Trinh & Haida 2015: fn. 22). With this assumption, the scalar implicature is optionally derived for (i), which appears to be a correct prediction, as the scalar implicature could be seen as an optional inference.

3.2 Problems

We now show that there are still instances of the symmetry problem that the Atomicity Constraint does not account for. We discuss two sets of new data. One is based on variants of Trinh & Haida's (2015) example (17) with a particularised implicature. The other has to do with the indirect scalar implicature that gradable adjectives like *full* or *empty* under negation.

3.2.1 Particularised scalar implicatures

What is crucial for Trinh & Haida's (2015) explanation of (17) is that the first part makes salient the conjunctive constituent α in the box in (25).

(25) Bill $\boxed{[_\alpha \text{went for a run and didn't smoke}]}$

This constituent allows us to construct the alternative in (26), the negation of which is the attested implicature that John did smoke. Crucially, given the Atomicity Constraint, the alternative *John went for a run and smoked* is not included.

(26) John [$_{\text{T'}}$ went for a run] prejacent
⇒ John $\boxed{[_\alpha \text{ went for a run and didn't smoke}]}$ T'/α
⇒ John $\boxed{[_\alpha \text{ went for a run and } \boxed{\text{smoked}}]}$ *NegP/VP

The situation changes however, when conjunction is absent or in a different place. Consider for instance (27), which has the same inference that John smoked.

(27) Bill went for a run. He (also) didn't smoke. What did John do?
John went for a run.
⇝ *John smoked*

(27), however, does not contain the crucial conjunctive constituent. Consider the following constituents (27) makes salient:

(28) Bill [$_\beta$ went for a run]. He [$_\gamma$ didn't [$_\phi$ smoke]]

Clearly none of β, γ or ϕ will be of help: by substituting them for T' in (29) we can create the alternatives in (30). From (30), we cannot create a set of alternatives which will allow us to conclude that John smoked.

(29) John [$_{\text{T}'}$ went for a run]

(30) {John $\boxed{[_\beta \text{ went for a run}]}$, John $\boxed{[_\phi \text{ smoked}]}$, John $\boxed{[_\gamma \text{ didn't smoke}]}$}

The desired scalar implicature would obtain if the alternative ¬**smoke** is negated, but, as mentioned above, this cannot be done due to its symmetric counterpart **smoke**. And **smoke** cannot be excluded from C due to the closure condition. In addition, crucially, this time we do not have the conjunctive alternative **run** $\wedge$ ¬**smoke**, which allowed us to derive the implicature before.[10]

One might wonder if having multiple sentences as one alternative could help. That is, if the solution lies in making use of the two sentences together *Bill went for a run. He didn't smoke* as a single atomic constituent. While having multiple sentences as an alternative is a plausible move, and probably an independently justified one, to create the necessary alternative *John went for a run. He didn't smoke*, we would have to substitute into such alternative and this is exactly what the atomicity constraint prohibits.

Furthermore, the problem can also be re-created by placing the conjunction in a different place in the structure. Consider (31), which has the same inference.

(31) Bill went for a run and he (also) didn't smoke. What did John do?
John went for a run.
$\rightsquigarrow$ *John smoked*

Here the constituent α containing conjunction corresponds to the whole sentence, (32). Therefore there is no way to construct the needed alternative, without violating the Atomicity Constraint.

(32) [$_\alpha$ [Bill went for a run] and [he didn't smoke]]

(33)

	[John went for a run]]	the prejacent
$\Rightarrow$	$\boxed{\text{[}_{TP}\text{ Bill went for a run and he didn't smoke]}}$	TP/α
$\Rightarrow$	$\boxed{\text{[}_{TP}\ \boxed{\text{John}}\text{ went for a run and he didn't smoke]}}$	*Bill/John

3.2.2 Gradable adjectives

Another instance of the symmetry problem that the Atomicity Constraint fails to account for involves indirect scalar implicatures generated by adjectives like *full* or *empty* under negation. Consider the following example, for instance.

(34) The glass isn't full.

10 Fox & Katzir (2011) and Trinh & Haida (2015) allow contextually salient constituents to be optionally ignored. Would this help in any way here? It would appear to make things worse, because if the salient constituent *didn't smoke* is ignored, we will end up having the following set of alternatives: $C = \{\textbf{run}, \textbf{smoke}\}$ From this set and the assertion we should conclude that John didn't smoke, which is the opposite of what we want to obtain.

a. $\rightsquigarrow$ *The glass is not empty/is a bit filled*
b. $\not\rightsquigarrow$ *The glass is empty*

This sentence has a robust inference that the glass is not empty.[11] and it does not implicate that the glass is empty. Similarly, (35) has the opposite scalar implicature:[12]

(35) The glass isn't empty.
a. $\rightsquigarrow$ *The glass is not full/not completely filled*
b. $\not\rightsquigarrow$ *The glass is full*

Trinh & Haida (2015), however, predict exactly the opposite for these cases. That is, they predict that a sentence like (34) and (35) should be able to have a scalar implicatures in (34b)/(35b), and not the one in (34a)/(35a).

Notice that if the sentence *The glass is empty* were an alternative to (34), it would generate the desired inference, but the Atomic Constraint prohibits it from being a formal alternative. So the first question for them is how to derive the actually observed inference.

There is, in fact, a way to derive the observed scalar implicature, once we look more closely at the syntax/semantics of the sentences above. It is often assumed

11 One might ask at this point whether this could be a presupposition rather than an implicature. While this is a possibility that we cannot exclude altogether, we think that the tests for presuppositionality, as imperfect as they are, suggest that this is not the case. For instance, a Hey wait a minute! response to (ia) as in (ib) appears infelicitous (von Fintel 2004).

(i) a. The glass is full.
b. ??Hey wait a minute, I didn't know it wasn't empty!

Similarly, a sentence like (iia) doesn't appear to us to project the inference that the glass is not empty, or at least not more than a sentence like (iiia) projects the inference that some of the students came.

(ii) a. Is the glass full?
b. ? $\rightsquigarrow$ *the glass is not empty*

(iii) a. Did all of the students come?
b. ? $\rightsquigarrow$ *some of the students came*

12 How can we be sure that an inference like (34b) is absent, given that it is actually compatible with the literal meaning of (34)? One argument comes from Hurford's constraint (see Chierchia, Fox & Spector 2012 among others). One test would be to construct a sentence where the second disjunct entails the first unless the first disjunct can have the inference that we are investigating. Given these assumptions, the following contrast indicates that the inference is not there.

(i) a. ??Either the glass isn't full or it is partially filled.
b. Either the glass is empty or it is partially filled.

that a sentence with a positive adjective involves the silent positive morpheme POS (Bartsch & Vennemann 1975, von Stechow 1984, Kennedy 1999) as in (36) for (34).

(36) The glass is [not [POS full]]

The main function of POS is to introduce the standard of fullness in the context, which is typically the maximal fullness for the glass (Kennedy 2007, McNally 2011). It is also assumed that it occupies the same syntactic position as other modifiers of gradable adjectives like *partly, half*, etc. Then it is not too far-fetched to assume under the structural theory of alternatives that POS can be replaced with these modifiers to give rise to alternatives of the following form.

(37) The glass is [not [half/partly full]]

These alternatives are stronger, and negating them would gives us something that resembles the inference that the glass is not empty.

So far so good. However, if this were the source of the scalar inference, the following sentences should also have similar scalar implicatures, which does not seem to be the case.

(38) a. This neighbourhood is not safe.
$\not\rightsquigarrow$ *This neighbourhood is not dangerous.*
b. John is not tall.
$\not\rightsquigarrow$ *John is not small.*
c. The glass is not transparent.
$\not\rightsquigarrow$*The glass is not opaque.*

One might wonder if the scale structures of these adjectives and their (in)compatibility with modifiers like *partly* and *half* might explain the difference here. However, notice that we picked three adjectives cutting across the absolute/relative distinction and differing with respect to their scale structure: *safe* has a upper closed scale, *transparent* has a fully closed one and *tall* a fully open scale (Kennedy 2007 among others). Thus the scale structure is not a relevant factor. In particular, *transparent* could combine with the same kind of modifiers as *full* but it still does not give rise to the scalar implicature indicated above.

In addition to this problem of explaining the variation among gradable adjectives, Trinh & Haida's (2015)'s system also predicts unwanted inferences. More specifically, it predicts the inference in (34b) for (34), due to the alternative ¬**empty** which is obtained by simple lexical substitution of *empty* for *full*. This problem persists regardless of whether POS is assumed or not.

(39) The glass is [not [POS full]]

⇒ The glass is [not [POS $\boxed{\text{empty}}$]] full/empty

This inference would be correctly blocked if the alternative **empty** was available, but as remarked above, the Atomicity Constraint would prohibit **empty** from becoming a formal alternative. That is, the following derivation is illicit.

(40) the glass is [not [POS full]]
⇒ [the glass is $\boxed{[\ \text{POS}\ \boxed{\text{full}}\ ]}$ NegP/AP
⇒ [the glass is $\boxed{[\ \text{POS}\ \boxed{\text{empty}}\ ]}$ *full/empty

Notice that this is precisely what gave Trinh & Haida (2015) the solution for the earlier examples (11a) and (17). Not having the Atomicity Constraint, Fox & Katzir (2011) do not run into this problem, but, as we have seen, they fail to account for (11a) and (17), as explained above. These observations are, therefore, connected in that Trinh & Haida (2015) solution for one creates a problem for the other.

Finally, one might wonder if an alternative like *The glass is not partly full* could be used to block the unwanted inference for Trinh & Haida (2015). Indeed, if such an alternative is present in the sets of alternatives, it makes the alternative *The glass is not empty* not excludable. However, since it is not in the Boolean closure, there is no reason to assume that it *must* be in C. C is allowed to simply be {The glass is not full, The glass is not empty}, and the unwanted inference is still predicted in this case.

3.3 Section summary

To summarise, Trinh & Haida's (2015) Atomicity Constraint faces two issues. One problem comes from variants of the type of case they proposed as problematic for Fox & Katzir (2011). Without the conjunction in the 'right' place, the crucial alternative **run** $\wedge$ ¬**smoke** cannot be in the substitution source. The other problem is the indirect scalar implicatures of gradable adjectives like *full* or *empty*. Here, the Atomicity Constraint backfires as it prevents the symmetric alternative **empty** to be in the substitution source, resulting in the wrong scalar implicature. Trinh & Haida's (2015) Atomicity Constraint, therefore, only solves the original examples (11a) and (17) but it is not a general solution.

4 Two more problems for the structural approach

In the this section, we will discuss two further problems that illustrate the general difficulty of deriving the correct set of relevant alternatives under the structural approach, independently of the Atomicity Constraint.

4.1 Too few lexical alternatives

One potential problem is that of under-generation where the needed formal alternative cannot be generated under the assumptions of the structural approach to alternatives. For instance, in Japanese, deontic possibility and necessity are expressed by constructions that are structurally clearly different. Consider the following examples.

(41) John-wa ki-te yoi.
John-TOP come-GERUND good
'John is allowed to come.'

(42) a. John-wa ko-naku-te-wa nar-anai/ike-nai.
John-TOP come-NEG-GERUND-TOP become-NEG/go-NEG
'John must come.'

b. John-wa kuru hitsuyoo-ga aru.
John-TOP come necessity-NOM exist
'John needs to come.'

(41) expresses deontic possibility with the predicate *yoi*, which is morphologically an adjective. On the other hand, the sentences expressing deontic necessity in (42) do not involve adjectives. Specifically, (42a) involves a verbal stem (either *nar-* or *ike-*) with the negative suffix *-(a)nai*. This makes the main predicate morphologically more complex than in (41). Generally, the structural approach to alternatives assumes that adding negation complicates the structure, so it is unlikely that (42a) can be derived from (41) by substitution and deletion alone.[13] In addition, the topic marking on the gerundive subject here is obligatory, while adding it would make (41) unacceptable.

13 One might wonder if the suffixal nature of the negation *-(a)nai* in (42a) allows (42a) to be a structural alternative to (41). That is, if substitution is an operation over (phonological) words rather than over morphemes, *nar-anai/ike-nai* would be just as complex as *yoi*. However, observe that (i) has a scalar implicature that John met some of the students, just like its English translation ((i) has a (contrastive) topic marking on the quantified object to facilitate the wide scope reading of the negation).

(i) John-wa subete-no gakusei-to-wa aw-anakatta.
John-TOP all-GEN student-with-TOP meet-NEG.PAST
'John didn't meet all of the students.'

If the negated verb *aw-nakatta* 'didn't meet' were as structurally complex as the positive counterpart *atta* 'met', then (ii) would be one of the structural alternatives for (i), and would wrongly block the observed scalar inference.

(ii) John-wa nanninka-no gakusei-to-wa at-ta.
John-TOP some-GEN student-with-TOP meet-PAST
'John met some of the students.'

This could be taken as suggesting that the gerundive clause is in syntactically distinct positions in (41) and (42a). Similarly, (42b) is unlikely to be derivable from (41) with substitution and deletion. It involves an existential construction with the existential verb *ar*-, where the subject is not a gerundive clause but a nominal *hitsuyoo* 'necessity' with a complement clause.

Despite this structural difference, however, (41) has the same scalar implicature as the English translation, i.e. that John is not required to come. As evidence for this inference, like its English counterpart, (41) is very unnatural in a context in which John is required to come. However, it is not at all clear how (42) could be generated in the structural approach from (41) (which presumably have a structure like (43)).

(43) [John-wa] [ki-te [yoi]].

A possible response to this might be to assume that there actually is a grammatical alternative to (41) that expresses deontic necessity (e.g. **[John-wa] [ki-te [**doi**]]*) but is made unacceptable and practically unusable for some independent reasons, to which computation of scalar implicatures is somehow oblivious to.[14] Then, the desired scalar implicature could be generated based on this unacceptable sentence. However, a solution like this commits one to non-trivial assumptions about the theory of lexicon and acquisition of lexical items (cf. Schlenker 2008).

4.2 Too many lexical alternatives

For the symmetry problem created by *some but not all*, the solution under the structural approach to alternatives crucially relies on what is and is not lexicalised. In particular, it is important that there is no constituent of the same or less structural complexity as *some* and *all*, which means 'some but not all' in the lexicon.

Swanson (2010), however, points out that there do appear to be other scalar items, whose symmetric alternative *is* lexicalised. He raises examples like the following, where the scalar items are *permitted* and *sometimes*.

(44) a. Going to confession is permitted.
b. $\rightsquigarrow$ Going to confession is optional.
c. $\not\rightsquigarrow$ Going to confession is required.

(45) a. The heater sometimes squeaks.
b. $\rightsquigarrow$ The heater intermittently/occasionally squeaks.
c. $\not\rightsquigarrow$ The heater constantly squeaks.

The sentences in (b) and (c) appear to be symmetric alternatives, analogous to **just some** and **all**, yet (a) yields the implicature indicated in (b) – and never that in (c) –

14 Thanks to Andreas Haida (p.c.) for suggesting a possibility along these lines, and related discussion.

exactly analogous to the case with *some*. This instantiation of the symmetry problem appears to straightforwardly resist Fox & Katzir's (2011) and Trinh & Haida's (2015) structural approach.[15] As Swanson (2010) himself suggests, one could try to supplement the theory with a constraint that excludes the problematic lexical items in some principled way, e.g., by resorting to their relative low frequency. This too, however, appears a non-trivial addition to the theory.

5 Alternative approaches

In addition to the structural theory of alternatives, other theories that are currently available on the market also do not provide a general solution to the symmetry problem. We will discuss two theories: the Monotonicity Constraint (Horn 1989, Matsumoto 1995), and the second is the interaction of informativity and complexity in the Rational Speech-Acts framework proposed by Bergen et al. (2016).

5.1 The Monotonicity Constraint

Horn 1989 and Matsumoto 1995 propose the *Monotonicity Constraint* on lexical scales as a way to solve the symmetry problem (Matsumoto calls it the *Scalarity Condition*). Roughly put, the monotonicity constraint states that the scale-mates must be either all positive or all negative. This solves the symmetry problem for *some* with respect to *some but not all* as follows: *some* and *all* are positive, while *some but not all* is neither positive nor negative, so it cannot be part of the same scale.

A first informal formulation of the Monotonicity Constraint is given in (46) (see the Appendix for a more precise formalisation).

(46) The alternatives for a sentence S are those sentences S' which result from substituting any scalar item τ in S with its scale-mates, where scale-mates are constrained to be:
  a. Upward monotone if τ is upward monotone.
  b. Downward monotone if τ is downward monotone.

15 It has been pointed out to us that some of the examples above are more convincing than others. For instance, it is unclear that *occasionally* really has the problematic meaning *sometimes but now always*: it is unclear whether (i) is contradictory, as it should be predicted by such meaning. *Intermittently*, on the other hand, appears more convincingly upper bounded: (ii) appears to be contradictory.

(i) All logicians occasionally make errors, and some do so constantly.

(ii) ??It rains intermittently everywhere in the Netherlands and in Amsterdam it rains constantly.

Katzir (2007, 2014) presents two related types of counterexamples to the Monotonicity Constraint. We discuss both cases below and sketch why we think neither of them is conclusive. Furthermore, we argue that the Monotonicity Constraint cannot account for some of the data discussed above, and so this constraint can at best be a partial solution to the symmetry problem.

Katzir's first counter-argument against the Monotonicity Constraint comes from sentences like that in (47a). (47a) suggests that the speaker doesn't doubt that at least three semanticist will sit in the audience, an inference which could be obtained by negating the alternative in (47b). (47b), however, would not be an allowed alternative given the Monotonicity Constraint as *exactly three* and *three* differ in their Monotonicity.

(47) a. I doubt that exactly three semanticists will sit in the audience.
b. I doubt that three semanticists will sit in the audience.

As pointed out to us by Wataru Uegaki (p.c.), however, there is a minimal amendment of the Monotonicity Constraint which could deal with cases like (47). That is, one could add to (46) the condition that if τ is non-monotonic, then the alternatives are allowed to contain scalar terms of any monotonicity. In other words, this amounts to restricting the constraint to alternatives involving scalar terms that are not non-monotonic. Then, the Monotonicity Constraint would allow for the inference to the negation of (47b) from (47a).

Katizr's second counter-argument against the Monotonicity Constraint comes from (48).[16]

16 Katzir also observes that without *required*, the sentence sounds odd, and lacks the scalar inference that John did all of the homework.

(i) John did some of the homework yesterday. #And he did just some of the homework today.

He points out that this data point does not adjudicate between theories of alternatives. First, it is compatible with the Monotonicity Constraint, according to which, the first sentence can only have a scalar implicature to the effect that John didn't do all of the homework yesterday. Then, the second sentence here would be infelicitous, because the contrastive interpretation would be contradictory, as John did the same thing on both days. Katzir argues, however, that (i) does not favor the Monotonicity Constraint, because the structural theory also predicts the lack of the scalar inference, due to the symmetry of *some* and *just some*. One potential remaining problem for the structural theory is, however, the infelicity of (i). If the contextual alternative *just some* is included, the structural theory predicts no scalar implicature for the first sentence. Then, it should be as felicitous as (ii), contrary to fact.

(ii) John did some or all of the homework yesterday. And he did just some of the homework today.

(48) John was required to do some of the homework yesterday. And he is required to do just some of the homework today.

As Katzir points out, one can infer from (48) not only that John was not required to do all of the homework yesterday, but also that he was not required to do just some of the homework yesterday (which is to say, that he was allowed to do all of the homework yesterday). He claims that in order to derive this inference, *some* and *just some* need to be able to be scale-mates, at least in this context, again in violation of the Monotonicity Constraint.

One way to counter this problem is by further modifying the Monotonicity Constraint above in order to include not only the case in which a non-monotonic scale-mate is contained in the assertion but also one in which it is contained among the alternatives (see Appendix for a formulation along these lines). However, we think that it is not clear whether the inference in question is due to a scalar implicature to begin with. Notice in particular that the two sentences in (48) naturally stand in a contrastive relation, which could be responsible for the inference. That is, one tends to read *today* in the second sentence as a contrastive topic, which generates an exhaustive inference that today is the only day (among the salient days) where John is required to do just some of the homework.[17] Since *yesterday* is salient in the given context, one infers that John is not required to do just some of the homework. Notice importantly that according to this analysis, the relevant inference is not coming from the first sentence but from the second sentence, and it is not required to assume that *some* and *just some* are scale-mates.

To reinforce this point, we observe that the inference disappears when the second sentence is changed to something that does not lead to a contrastive interpretation, as in (49).

(49) John was required to do some of the homework yesterday. He did just some, before going to bed.

It should be remarked that the lack of the inference in (49) is not problematic *per se* for the structural theory, as one could assume that *just some* is only optionally in the scale (see fn. 12 above), and the pragmatic difference between the two examples somehow matters for whether to include *just some*. The point we want to make here is simply that (48) does not pose an immediate threat to the Monotonicity Constraint.

While Katzir's (2007) arguments against the Monotonicity Constraint are not conclusive and a (minimally revised version) of such constraint could account for many of the problematic cases discussed above, it cannot, however, account for all them. In particular, notice that as formulated above (and modified or not to

17 See Buring to appear for an introduction to contrastive topics.

accommodate the case of non-monotonic scalar terms) the Monotonicity Constraint is silent about items that have no monotonicity. For example, functions of type $\langle e,t \rangle$ have no monotonicity, because e is not a a type over which monotonicity (with respect to generalized entailment) is defined (see Appendix for more details). As a consequence, no restrictions are placed on cases like Trinh & Haida's example. If all the relevant alternatives must be included, then, no inference is predicted there.[18]

Therefore, while the Monotonicity Constraint could be adopted to solve some of the cases of the symmetry problem, it would anyway not be a general solution for all the problematic cases discussed in the present paper.

5.2 The RSA approach

In a recent paper, Bergen et al. (2016) propose an alternative approach to the symmetry problem, which, they claim, provides a 'straightforward solution' to the problem.[19] In this subsection, we first summarize the gist of the account in relation to the symmetry problem and the cases which can successfully cover. We will then move to cases, which, as far as we can see, remain problematic for this account. We conclude that the RSA approach, as it stands, does not provide a full solution to the symmetry problem either.

5.2.1 The account: complexity and relative informativeness

Bergen et al. (2016) adopt and extends the Rational Speech-Act (RSA) framework (Frank & Goodman 2012, Goodman & Stuhlmüller 2013). We believe, however, that the crucial ingredients they use in relation to the symmetry problem are relatively independent from the details of this approach, so we will focus on such ingredients and the role they play as a solution to the problem.

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18 It should be mentioned that the Monotonicity Constraint could be used here, once it is assumed that VPs denote functions of type $\langle \langle et,t \rangle ,t \rangle$ (and proper names undergo Montague Lift). However, this would make *run* upward entailing, *did not smoke* downward entailing, and *run and not smoke* non-monotonic, so we would still not have the set of alternatives we need.

The same is true for the adjective cases discussed above. In particular, for sentences like (ia), the Monotonicity constraint is silent with respect to choosing between the alternatives (ib) and (ic) and therefore no inference is predicted. In other words, the Monotonicity account does not over-generate by predicting the negation of the alternative in (ib), but it undergenerates in that it doesn't predict an inference to the negation of (ic). See section 3.3.2 for discussion.

(i) a. The glass isn't full.
b. The glass isn't empty.
c. The glass is empty.

19 Thanks to Noah Goodman and Leon Bergen for discussion on the points in this subsection.

The following three assumptions are particularly relevant: (i) while there are sets of alternatives for scalar implicature computation, there is no notion of ‘scalar’ alternative, (ii) complexity has a cost, and (iii) a notion of ‘relative’ informativity is a factor in deciding among alternatives. Recall that the structural approach uses no real notion of ‘scale’ and the cost of complexity arises as a by-product of the way the alternative algorithm is defined. Therefore, with respect to (i)-(iii) points above, the RSA approach and the structural one only differ with respect to point (iii).

To illustrate the way that Bergen et al.’s (2016) account works, consider (50) and its set of alternatives (51), which, unlike in the structural approach, include both **all** and **just some** (or **some-but-not-all**) alternatives.

(50) John saw some of the students.

(51) {John saw all of the students, John saw just some of the students}

Let us partition the space of logical possibilities as worlds in which John met none of the students, John met all of the students and where John met some but not all of the students, indicated respectively as $\neg\exists$, $\forall$ and $\exists\wedge\neg\forall$. The ‘informativeness’ of each alternative in (51), in the sense of how many partitions of worlds they are true in, is the same as the other’s, and greater than the assertion, **some**.[20] What makes the difference here, in the same way as in the structural approach, is the difference in complexity between **all** and **just some**. In particular, in the way the RSA reasoning works, the fact that **just some** is more costly than **all** makes it so that uttering **all** to mean $\forall$ is more likely than uttering **just some** to mean $\exists\wedge\neg\forall$. Therefore the listener will reason that the speaker would have been more likely to use **all**, if she wanted to communicate $\forall$, than how likely she would have been to use **just some**, if she wanted to communicate $\exists\wedge\neg\forall$. This in turn gives the hearer reason to conclude that the speaker intended meaning when she uttered **some** is more likely to be $\exists\wedge\neg\forall$ than $\forall$. Further higher-order iterations of this reasoning strengthen this conclusion.

As we know from above, in the case of indirect scalar implicatures arising from sentences like (52), there is, however, no difference in complexity between the two corresponding symmetric alternatives in (53).[21] And therefore in this case complexity cannot be used to break symmetry (and this was in fact one of the

20 This is because while **some** is true in both $\exists\wedge\neg\forall$ and $\forall$ worlds, **all** is only true in $\forall$ worlds, while **just some** only in $\exists\wedge\neg\forall$ ones.

21 And one can also consider the problematic alternative *John saw some students* to be less complex than the other, *John saw none of the students*. This depends from whether we consider the latter alternative to be decomposed as *John didn’t see some of the students* and whether we consider syntactic structure to be part of the notion of complexity (as opposed to just utterance length as measure in number of words). While there are compelling arguments for the decomposition of *none* as in *not some* (see Sauerland 2000 among many others), this is certainly not an assumption that Bergen et al. (2016) have to make, and they do not appear to be making it, so we will put it aside here.

problematic cases for the structural account by Fox & Katzir (2011) and required the addition of Atomicity by Trinh & Haida (2015)).

(52) John didn't see all of the students.

(53) {John saw some of the students, John saw none of the students}

While it can not rely on complexity for the case of (52), the RSA approach can, however, exploit the other ingredient mentioned above, namely 'relative' informativeness, to create an asymmetry between the two alternatives. To illustrate, consider a partition of the space of possibilities again as in $\{\neg\exists, \forall, \exists \wedge \neg\forall\}$. This time **some** and **none**, while equally complex, differ in how informative they are, with **none** only being true in $\neg\exists$ worlds, while **some** being true both in $\exists \wedge \neg\forall$ and $\forall$ ones. This difference makes it so that the speaker would have been more likely to use **none** to communicate $\neg\exists$ than to use **some** to communicate $\neg\forall \wedge \exists$. In virtue of this, the hearer will conclude that it is more likely that the speaker wanted to communicate the $\exists \wedge \neg\forall$ than the $\neg\exists$ one, by using **not all**. Again, further iterations of this reasoning strengthens this conclusion.

Finally, the approach makes also good predictions in the other problematic case for the structural approach coming from sentences like (54), which, as discussed, intuitively gives rise to the inference that the glass is not empty.

(54) The glass is not full.

(55) {The glass is not empty, The glass is empty}

To illustrate, consider the alternatives of (54) in (55), and assume a partition of the logical space in which either the glass is empty, it is neither full nor empty, or it is full: $\{\text{EMPTY}, \neg\text{EMPTY} \wedge \neg\text{FULL}, \text{FULL}\}$. Given these assumptions, the two alternatives differ in informativeness, with **not empty** being true in both FULL and $\neg\text{EMPTY} \wedge \neg\text{FULL}$ worlds, while **empty** only being true in EMPTY worlds. And, in addition, **not empty** is clearly more complex than **empty**. This creates a situation in which **not empty** is less likely to be used to communicate $\neg\text{FULL} \wedge \neg\text{EMPTY}$ than **empty** is used to communicate EMPTY. And again, this is the reason why the listener will correctly conclude that the speaker wanted to communicate $\neg\text{FULL} \wedge \neg\text{EMPTY}$ rather than EMPTY when using **not full**.

In sum, the RSA approach, by combining a notion of complexity with one of relative informativity, is successful in the case of direct and indirect scalar implicatures, as well as in the case of gradable adjectives under negation as in (54). There are, however, a number of problems we can see for this approach, to which we turn in the next subsection.

5.2.2 Problematic cases

Starting from a general consideration, Bergen et al. (2016), unlike Fox & Katzir (2011), do not provide a general theory of alternatives and leave instead vague how these sets of alternatives is chosen. As they say, they assume the relevant sets of alternatives on a 'case by case' basis and, in general, their approach 'allows arbitrary sets of grammatical utterances to be considered as alternatives' (Bergen et al. 2016: p.14). If this is the case, however, they would have to provide a way in which the arbitrary sets of alternatives chosen do not include the 'wrong' symmetric alternative to the exclusion of the other, giving rise, therefore, to unattested inferences.[22]

That is to say, if the model really allows for arbitrary sets of alternatives, what is it that prevents us to chose the alternatives in (56) for (50), which presumably would incorrectly predict the inference from (50) that John saw all of the students? And similarly, what does prevent (52) to only have the alternatives in (57), incorrectly predicting the inference that John saw none of the students?[23]

(56) {John saw just some of the students}

(57) {John saw some of the students}

On the other hand, Bergen et al. (2016) suggest that the fact that their model can derive the attested scalar implicatures, while allowing symmetric alternatives among the possible alternative utterance the speaker might have used, constitutes suggestive evidence that 'every grammatical sentence in a language can be considered as an alternative during pragmatic reasoning.' (Bergen et al. 2016: p.10). It seems to us unrealistic to suppose that conversational participants always reason over all possible alternative utterances, relative to a space of possible observed states of affairs. But if this can indeed be maintained, then the problem above would not arise.

Regardless of this more general consideration about the choice of the alternative sets, we think there are more specific issues with the RSA account of the symmetry problem. The general shape of the problematic cases that we discuss below is the following. If we take a step back to see how the RSA model can deal with the two cases discussed, we see that unwanted alternatives do not impact on the reasoning process to the extent that they have a lower utility vis a vis the assertion, when compared to the utility of the attested alternative vis a vis the assertion. More concretely, the approach was successful with the cases above because the symmetry

22 Recall that this problem was avoided by the structural approach by adopting a notion of relevance and the closure condition in 3.

23 They could assume that the reasoning apply only to alternatives that are made salient in the context. But then, it is unclear even what makes, **all** apparently automatically salient when **some** is uttered, even where **just some** has been made salient by the previous utterance, as discussed above in footnote 7 and extensively in Fox & Katzir 2011.

between alternatives was broken either by complexity, or relative informativity, or a combination of both. Thus, if we find cases where the symmetric alternatives have comparable relative utility both with respect to complexity and relative informativity, we should expect symmetry again.

To make this idea more concrete, suppose for a moment that, **just some** in (50) was no more costly than the alternative **some** and **all**. In that case, the presence of **just some** as an alternative would impact on the conditional probability that the speaker would use **just some** in a $\exists \wedge \neg\forall$ situation to the same extent that the presence of **all** would in an $\forall$ situation. Leaving the hearer unable to infer which state holds, whether it is $\exists \wedge \neg\forall$ or $\forall$. Of course the problem in this case does not arise precisely because **just some** is more complex than **all**. Below, however, we discuss three cases where the set of alternatives creates this kind of symmetry situation.

First, consider an utterance of (56) in a context in which it is relevant whether John saw many of the students. In such a case, we intuitively conclude from (56) that John saw many of the students. Let us consider a model then where the alternatives are as in (58) and consider the space of possibilities, $\{\neg\exists, \exists \wedge \neg\text{MANY}, \text{MANY} \wedge \neg\forall, \forall\}$:

(58) {John saw some of the students, John saw many of the students,
John didn't see many of the students, John saw none of the students,
John saw all of the students}

Here is a model where the unwanted alternative, **many**, has equal, (if not higher) relative utility vis a vis the assertion in $\text{MANY} \wedge \neg\forall$ situations, when compared to **not many**, vis a vis the assertion in $\exists \wedge \neg\text{MANY}$ situations. This means that the hearer could not decide whether it is more likely that the speaker intended to convey a $\text{MANY} \wedge \neg\forall$ interpretation than a $\exists \wedge \neg\text{MANY}$ one. Thereby the hearer would not be able to conclude that the intended interpretation was that John saw many but not all of the students.

When we turn to ad hoc cases, we can also create examples with alternatives that are arguably equally complex and informationally equivalent, in the sense above. Consider the sentence in (59) in a context in which Peter, John, and Sue are the relevant individuals. Intuitively, here we would want to derive the inference that Sue didn't pass. Let's assume that the relevant logical alterantives are $\{p \wedge j \wedge s, p \wedge j \wedge \neg s\}$. Now it becomes crucial what alternative utterances we reason over. If we consider a model of the conversation that includes (60a) and (60b), we can see that they are equally informative and, if anything, (60b) is less complex than (60a). It appears therefore that we cannot obtain the inference which corresponds to the negation of (60a).

(59) Peter and John passed.

(60) a. Peter and John and Sue passed.
b. Just Peter and John passed.

The example raises a question about which alternatives should be considered in the speaker's and hearer's reasoning. We note that if the alternative utterances considered for (59) included an alternative like 'Peter, John and not Sue passed' rather than (60b), then the correct inference could be derived (as the latter is more complex than (60a) and would therefore be penalised with respect to (59a)).

In the same way, Bergen et al. (2016) makes incorrect predictions for Trinh & Haida's (2015) original case repeated in (61), where the alternatives are also symmetric in terms informativity (e.g. *Bill run and didn't smoke* and *Bill run and smoked*). If anything, given that the latter is less complex, they predict the opposite inference that Trinh & Haida (2015) predicts: that is, they predict the inference that John didn't smoke.[24]

(61) Bill ran and didn't smoke.
John only ran.
$\rightsquigarrow$ *John smoked*

In sum, the RSA approach provides an interesting perspective to the symmetry problem, in particular by combining a notion of complexity with a notion of relative informativity in order to constraint the alternatives for implicature computation. As we sketched above, however, we do not think as it stands it constitutes a solution to all problematic cases of the symmetry problem discussed above.

6 Concluding Remarks

The structural approach to alternatives advocated by (Katzir 2007, Fox & Katzir 2011) is one of the few systematic accounts of the symmetry problem that are

24 In some cases, as pointed out to us by Tue Trinh (p.c.), this inference might actually be there. For instance, cases like (i) and (ii), intuitively give rise to the inference that John didn't smoke, rather than the one that he did smoke.

(i) Bill ran and didn't smoke.
John only ran. He didn't smoke either.

(ii) Bill ran and didn't smoke.
John only ran too.

The problem for Bergen et al. (2016) remains in cases like the original context by Trinh & Haida (2015), which does give rise to the opposite of the inference above (i.e. that John did smoke) as not predicted by Bergen et al. (2016).

available in the current literature. We argued that while it successfully accounts for certain instantiations of the symmetry problem, it does not handle others. In particular, the following problems remain: the problem of indirect and particularised scalar implicatures, the problem of too few lexical alternatives, and the problem of too many lexical alternatives. We argued that Trinh & Haida's (2015) Atomicity Constraint does not constitute a general solution to the first problem. Moreover, such a constraint has little to say about the other problems. Therefore, we concluded that the structural approach, in its current form, does not fully solve the symmetry problem.

We also considered two alternative accounts: a (revised version of) the Monotonicity Constraint and the RSA approach by Bergen et al. (2016). As we discussed, however, both of these are insufficient by themselves to solve the symmetry problem. We thus conclude that the symmetry problem still remains as an important open challenge for theories of alternatives and scalar implicature.

7 Appendix

In this section, we define the Monotonicity Constraint more formally. Following the standard convention, we define monotonicity in terms of generalized entailment ($\Rightarrow$) among functions of conjoinable types.

(62) *Conjoinable types*

a. t is a conjoinable type.

b. If σ is a type and τ is a conjoinable type, then $\langle \sigma, \tau \rangle$ is a conjoinable type.

c. Nothing else is a conjoinable type.

(63) If τ is a conjoinable type and $x, y \in D_\tau$, then $x \Rightarrow y$ iff either of the following is the case:

a. $\tau = t$ and $x \rightarrow y$; or

b. $\tau = \langle \sigma_1, \sigma_2 \rangle$ and for each $z \in D_{\sigma_1}$ $x(z) \Rightarrow y(z)$

Monotonicity is standardly defined as follows:

(64) Let σ and τ be conjoinable types, and $f \in D_{\langle \sigma, \tau \rangle}$.

a. f is *upward monotonic* iff whenever $x, y \in D_\sigma$ and $x \Rightarrow y$, $f(x) \Rightarrow f(y)$.

b. f is *downward monotonic* iff whenever $x, y \in D_\sigma$ and $y \Rightarrow x$, $f(x) \Rightarrow f(y)$.

c. f is *non-monotonic* iff f is neither upward monotonic nor downward monontonic.

Horn suggests that the polarity of determiners corresponds to their monotonicity with respect to their first argument. However, according to this definition, *some* is upward monotonic, while *all* is downward monotonic (and *most* is non-monotonic). In order for *some* and *all* to be scale-mates, the monotonicity constraint must target the second argument. Let us define the notion of monotonicity with respect to a particular argument as follows.

(65) Let $\sigma_1,\dots,\sigma_n$ be conjoinable types (for $n \geq 1$), $\tau = \langle\sigma_1,\dots,\langle\sigma_n,t\rangle\rangle$, and $f \in D_\tau$. Then, for any $m(1 \leq m \leq n)$:

a. f is *upward monotonic* in the mth argument iff for each $z_1 \in D_{\sigma_1},\dots,z_{m-1} \in D_{\sigma_{m-1}}$, whenever $x,y \in D_{\sigma_m}$ and $x \Rightarrow y$, $f(z_1)\cdots(z_{m_1})(x) \Rightarrow f(z_1)\cdots(z_{m_1})(y)$.

b. f is *downward monotonic* in the mth argument iff for each $z_1 \in D_{\sigma_1},\dots,z_{m-1} \in D_{\sigma_{m-1}}$, whenever $x,y \in D_{\sigma_m}$ and $y \Rightarrow x$, $f(z_1)\cdots(z_{m_1})(x) \Rightarrow f(z_1)\cdots(z_{m_1})(y)$.

c. f is *non-monotonic* in the mth argument iff f is neither upward monotonic nor downward monotonic in the mth argument.

The Monotonicity Constraint needs to ignore the monotonicity with respect to the first argument and only target the monotonicity with respect to the second argument. A further complication arises, when we consider other scales. Modals, for example, are considered to be one-place functions, so for them, the Monotonicity Constraint should be about their (sole) argument. To uniformly deal with these cases, let us state the Monotonicity Constraint as about the monotonicity of the last argument.

(66) *Monotonicity Constraint*
Two items x and y of the conjoinable type $\langle\sigma_1,\dots,\langle\sigma_n,t\rangle\rangle$ must not be scale-mates if x and y disagree in monotonicity in the nth argument.

This will allow scales like $\langle$*some*, *all*$\rangle$ and $\langle$*allowed*, *required*$\rangle$, but not scales like $\langle$*some*, *some but not all*, *all*$\rangle$ or $\langle$*few*, *all*$\rangle$.

Similarly as what done above, (66) can be then modified in order to incorporate the idea that non-monotonic scale mates are not subject to the monotonicity constraint. That is, (67) is compatible with non-monotonic scalar item to be scale-mate or either upward or downward scalar item, therefore allowing both of Katzir's (2007) cases discussed above.

(67) *Monotonicity Constraint*
Two items x and y of the conjoinable type $\langle\sigma_1,\dots,\langle\sigma_n,t\rangle\rangle$, which are not non-monotonic , must not be scale-mates if x and y disagree in monotonicity in the nth argument.

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