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More free choice and more inclusion: An experimental investigation of free choice in nonmonotonic environments*

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Abstract Disjunctions in the scope of possibility modals give rise to a conjunctive inference, generally labeled ‘free choice.’ A prominent approach derives free choice as a kind of scalar implicature. In this paper, we focus on the predictions of two main type of accounts within this approach, with the goal of investigating what implicature-generating algorithm best captures free choice and related data. The first is based on a standard algorithm for computing implicatures, which proceeds by negating (or ‘excluding’) alternatives to a sentence and adding the information so obtained to the assertion. The second proceeds by directly conjoining alternatives to the assertion (or ‘including’ them). This paper provides evidence that discriminates between the exclusion and the inclusion accounts. We focus on sentences involving possibility modals and disjunctions in the scope of nonmonotonic quantifiers: our key example is *Exactly one girl cannot take Spanish or Calculus*. We report on an inferential task experiment testing this case. We find clear evidence that the sentence has a free-choice-type reading, on which it suggests that one girl cannot take either Spanish or Calculus and all of the others can choose between the two. This is challenging for exclusion accounts, but in line with the predictions of inclusion accounts. This case constitutes, therefore, an argument for inclusion accounts.

Keywords: free choice, nonmonotonic quantifiers, inferential task, semantics, pragmatics

1 Introduction

Disjunctions in the scope of possibility modals give rise to a conjunctive inference, generally labeled ‘free choice’ (Kamp 1974). For example, (1) suggests that Iris can take Spanish and can take Calculus (and hence she can ‘choose’).

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(1) Iris can take Spanish or Calculus. $\Diamond(s \vee c)$
$\rightsquigarrow$ *Iris can take Spanish and she can take Calculus* $\Diamond s \wedge \Diamond c$

The problem with the inference in (1) is that it doesn't follow from standard semantics for modals in combination with a boolean analysis of disjunction. Free choice has sparked a whole industry of theories in philosophy of language and semantics since the seventies (see Meyer 2018 for an overview).

In this paper, we focus on a prominent approach to free choice, which tries to derive it as a scalar implicature. In particular, we consider data that distinguishes between different versions of the implicature account, with the goal of discovering what implicature-generating algorithm works best. We compare two types of account. The first proceeds by negating (or 'excluding') alternatives to a sentence and adding the information so obtained to the assertion. Accounts in this vein are the standard approach to implicature, and have been successful at capturing free choice and related phenomena (Alonso Ovalle 2005; Fox 2007; Klinedinst 2007; Chierchia 2013; Franke 2011; Santorio & Romoli 2017; Chemla 2010). The second and more recent account proceeds directly by conjoining (or 'including') alternatives to the content asserted by a sentence. (Bar-Lev & Fox 2017).

The literature contains one main empirical argument that distinguishes between exclusion and inclusion accounts. In an experimental study of free choice in complex sentences, Chemla (2009) found that free choice arises under negative quantifiers, e.g. in sentences like (2).

(2) No girl must take both Spanish and Calculus $\neg\exists x\Box(Sx \wedge Cx)$
$\rightsquigarrow$ *Every girl can choose between Spanish and Calculus* $\neg\exists x\Box Sx \wedge \neg\exists x\Box Cx$

This embedded effect can be accommodated by inclusion theories, but not exclusion theories. Hence sentences like (2) provide an argument for inclusion theories.

This paper is a further exploration in the exclusion/inclusion debate. We consider another case where the two accounts make divergent predictions, namely sentences involving nonmonotonic quantifiers. Our key examples are (3) and (4). (3) has a reading on which disjunction is read conjunctively in the upward entailing component of the quantifier, and disjunctively in the downward entailing one (Bassi & Bar-Lev 2016). This reading suggests that one girl has free choice between Spanish and Calculus, and no other girl can take either of the two. We represent the sentence and this inference schematically as in (3-b); we call this reading THE-ONE-FC reading.[1]

(3) a. Exactly one girl can take Spanish or Calculus.

1 More precisely, the sentence should be represented as talking about the cardinality of the intersection between the set of girls and the set of those who can take Spanish or Calculus, $|\{x : \mathbf{girl}(x)\} \cap \{y : Py \vee Qy\}| = 1$. We will abbreviate as above for reasons of space.

$\rightsquigarrow$ *One girl can take Spanish and she can take Calculus and all of the others cannot take either one* THE-ONE-FC

b. $|\{x : \Diamond(Sx \vee Cx)\}| = 1$
$\rightsquigarrow |\{x : \Diamond(Sx \vee Cx)\}| = |\{x : \Diamond Sx \wedge \Diamond Cx\}| = 1$

Both exclusion and inclusion accounts can predict the THE-ONE-FC reading. We compare (3) with its counterpart involving negation taking scope over the possibility modal, as in (4). To our knowledge, examples like (4) have not been discussed previously. We ask whether (4) gives rise to a reading that (similarly to (3)) suggests that one girl cannot take either Spanish or Calculus and all of the others can choose between the two (what we call the 'ALL-OTHERS-FC' reading).

(4) a. Exactly one girl cannot take Spanish or Calculus.
?$\rightsquigarrow$ *One girl cannot take either Spanish or Calculus and all of the others can take Spanish and can take Calculus* ALL-OTHERS-FC

b. $|\{x : \neg\Diamond(Sx \vee Cx)\}| = 1$
$\rightsquigarrow |\{x : \neg\Diamond(Sx \vee Cx)\}| = |\{x : \neg(\Diamond Sx \wedge \Diamond Cx)\}| = 1$

Crucially, the predictions of the two accounts diverge for (4). Exclusion theories do *not* predict the ALL-OTHERS-FC reading, while inclusion theories *do* predict it. Given the similarity between the sentences in (3) and (4) and the difference in predictions, pairs like this yield a further test for deciding between implicature-computing algorithms.

Against this background, we tested sentences like (3) and (4) using an inferential task (building on Chemla 2009; Chemla & Spector 2011 and Gotzner & Romoli 2017). We found clear evidence for both readings. This yields a new empirical argument for inclusion accounts, and against exclusion accounts.[2]

The paper is organized as follows. In §2, we discuss in detail the implicature account of free choice and the exclusion/inclusion debate. In §3, we report on the experiment investigating free choice effects under nonmonotonic quantifiers. §4 discusses the results and their implications for the debate. We conclude in §5.

2 Background

A prominent approach analyzes free choice as a kind of scalar implicature. The main argument for this approach is that free choice tends to disappear under negation and other downward entailing environments, which is a signature feature of implicatures.

2 We should note that implicature approach is not the only way to derive free choice: a different line of theorizing tries to derive free choice as a semantic effect. In this paper, we only focus on the implicature approach to free choice. For alternative semantic views see Goldstein 2018; Willer 2017; Aloni 2016; Starr 2016 among others.

For illustration, notice that (5), the negative counterpart of our initial example (1), does not typically convey the negation of the free choice meaning. That is, (5) does not merely suggest that Iris doesn't have free choice between Spanish and Calculus, but rather that she can choose neither (this is sometimes called a 'dual prohibition' reading).

(5) Iris can't take Spanish or Calculus.
$\not\rightsquigarrow$ *It's not the case that Iris can take Spanish and she can take Calculus*
$\rightsquigarrow$ *Iris cannot take Spanish and she cannot take Calculus*

Another argument for the implicature approach comes from the well-known observation that free choice inferences are cancelable (cf. Simons 2005; Fox 2007). That is, while (1) strongly suggest a free choice inference, we can force a reading without this inference in context. E.g., we can add a continuation incompatible with this inference, as in (6).

(6) Iris can take Spanish or Calculus, I don't remember which.

The implicature approach nicely captures these and other data points. In the following, we focus on the debate within the implicature approach. The key question we ask is what mechanism for implicature computation will generate free choice. We start by reviewing the two main families of accounts in the literature, i.e. exclusion and inclusion accounts.

2.1 Exclusion accounts

Exclusion accounts proceeds by 'excluding' alternatives, i.e. by conjoining negations of alternatives to the content of the sentence asserted. While exclusion accounts differ in a variety of ways, these differences are irrelevant for us. We use Fox's (2007) for illustration, but the same conclusions apply to all exclusion accounts we are aware of.

Fox 2007 starts from a grammatical approach to implicatures (Fox 2007, Chierchia 2004; Chierchia, Fox & Spector 2012; Magri 2009; Meyer 2013, Chierchia 2013 a.o.). On this approach, scalar implicatures are derived via a covert exhaustivity operator that is present in the syntax. Following custom, we represent the exhaustivity operator as 'EXH'. EXH takes as arguments a sentence and a set of alternatives and returns the conjunction of the sentence with the negation of a subset of the alternatives—i.e., the alternatives that are 'innocently excludable' (more on this notion below).

The meaning of EXH on the exclusion theory, together with a definition of innocent exclusion, is in (7). '*C*' stands for a set of salient alternatives to a sentence.

(7) a. $[[\textsc{exh}^{\mathrm{IE}}]](C)(p)(w) = p(w) \wedge \forall q \in IE(p,C)[\neg q(w)]$
b. $IE(p,C) = \bigcap\{C' \subseteq C : C'$is a maximal subset of C s.t. $\{\neg q : q \in C'\} \cup \{p\}$ is consistent$\}$

In plain English: EXH$^{\mathrm{IE}}$ looks at all the maximal consistent subsets of alternatives to a sentence, and negates all alternatives that are in all those subsets. Roughly, the effect is to strengthen the sentence as much as possible, while avoiding contradictions and arbitrary choices between alternatives. Let us illustrate how this derives the exclusive reading of disjunction in a simple sentence like (8).

(8) Iris took Spanish or Calculus.
$\rightsquigarrow$ *Iris didn't take both Spanish and Calculus*

(8) is parsed as involving a covert exhaustivity operator, as in (9). We assume that the alternatives of (8) are in (10).[3]

(9) EXH$^{\mathrm{IE}}$ [Iris took Spanish or Calculus]

(10) $\left\{\begin{array}{ll} \text{Iris took Spanish or Calculus} & (s \vee c) \\ \text{Iris took Spanish} & s \\ \text{Iris took Calculus} & c \\ \text{Iris took Spanish and Calculus} & (s \wedge c) \end{array}\right\}$

Given the alternatives in (30), only the conjunctive alternative $(s \wedge c)$ is excludable. This is because there are only two maximal consistent subsets of excludable alternatives, $\{s, s \wedge c\}$ and $\{c, s \wedge c\}$, and only the conjunctive alternative appears in both. This yields the intuitively correct prediction, i.e. the implicature in (8).

This algorithm, by itself, is insufficient to derive free choice, but it can be enriched in a number of ways. Fox 2007 (building on Kratzer & Shimoyama 2002) derives free choice by running the exclusion algorithm recursively.[4] For illustration, consider again (1). Crucially, Fox assumes that (1) is parsed as involving two occurrences of EXH$^{\mathrm{IE}}$.[5] On this parsing, the outermost EXH$^{\mathrm{IE}}$operates on alternatives that have been already exhaustified by the innermost EXH$^{\mathrm{IE}}$. In particular, the alternatives include the exhaustified disjuncts, which are innocently excludable.[6] The negation of these two alternatives, together with the content of the assertion,

3 How the alternatives for exhaustification are determined is an important issue for all implicature accounts. In fact, this is a controversial issue in the literature, we will return to it later in the discussion section. For relevant discussion see Breheny, Klinedinst, Romoli & Sudo 2017 and references therein.

4 For alternative exclusion accounts, see Alonso Ovalle 2005; Klinedinst 2007; Franke 2011; Santorio & Romoli 2017; Chemla 2010.

5 On the parsing that involves only one occurrence of EXH$^{\mathrm{IE}}$, the prediction is that we simply exclude the conjunctive alternative, exactly as it happens for (8).

6 There is only one maximal excludable set of alternatives, $\{\Diamond s \wedge \neg\Diamond c, \Diamond c \wedge \neg\Diamond s, \Diamond(s \wedge c)\}$.

give rise to the free choice effect (see the schematic computation in (13)).

(11) $\textsc{exh}^{\text{IE}}[\textsc{exh}^{\text{IE}}$[Iris can take Spanish or Calculus]]

(12) $$\left\{\begin{array}{ll} \textsc{exh}^{\text{IE}}[\text{Iris can take Spanish or Calculus}] & \Diamond(s \vee c) \wedge \neg\Diamond(s \wedge c) \\ \textsc{exh}^{\text{IE}}[\text{Iris can take Spanish}] & \Diamond s \wedge \neg\Diamond c \\ \textsc{exh}^{\text{IE}}[\text{Iris can take Calculus}] & \Diamond c \wedge \neg\Diamond s \\ \textsc{exh}^{\text{IE}}[\text{Iris can take Spanish and Calculus}] & \Diamond(s \wedge c) \end{array}\right\}$$

(13) $[[\textsc{exh}^{\text{IE}}[\textsc{exh}^{\text{IE}}[\text{Iris can take Spanish or Calculus}]]]] =$
$\Diamond(s \vee c) \wedge \neg[\Diamond s \wedge \neg\Diamond c] \wedge \neg[\Diamond c \wedge \neg\Diamond s] = \Diamond(s \vee c) \wedge \Diamond s \leftrightarrow \Diamond c =$
$\Diamond(s \vee c) \wedge \Diamond s \wedge \Diamond c$

The account can be extended to more complex cases, as we point out below. Before that, we turn to sketching inclusion accounts.

2.2 Inclusion accounts

Inclusion accounts are a recent development in the literature; at the time of writing there is only one such account of free choice in the literature, namely Bar-Lev & Fox (2017). (Though see Santorio (2018) for a similar proposal for handling similar phenomena in conditional antecedents.) Like exclusion accounts, Bar-Lev & Fox's algorithm works by conjoining with the assertion the negation of innocently excludable alternatives. In addition, it also conjoins to the assertion a subset of other alternatives, without passing through negation (hence the label 'inclusion'). Hence inclusion accounts work by adding an extra step to the exclusion algorithm.

The new algorithm requires a definition of innocently includable alternatives:

(14) $II(p,C) = \{C'' \subseteq C : C''$is a maximal subset of C such that $\{r : r \in C''\} \cup \{p\} \cup \{\neg q : q \in IE(p,C)\}$ is consistent $\}$

In plain English: innocently includable alternatives are those that are in all maximal subsets of alternatives that can be conjoined consistently with the assertion and with the negation of innocently excludable alternatives.

Based on (14), the definition of $\textsc{exh}^{\text{II}}$ is then straightforward: $\textsc{exh}^{\text{II}}$ conjoins the prejacent with all the innocently includable alternatives and the negation of all innocently excludable ones.

(15) a. $[[\textsc{exh}^{\text{II}}]](C)(p)(w) =$
$p(w) \wedge \forall q \in IE(p,C)[\neg q(w)] \wedge \forall r \in II(p,C)[r(w)]$

To illustrate how $\textsc{exh}^{\text{II}}$ works, let's consider again (1). Assume the sentence is now parsed as involving one occurrence of $\textsc{exh}^{\text{II}}$, as in (16). We assume that the alternatives are the same as above (repeated in (17)).

(16) EXH^{II}[Iris can take Spanish or Calculus]

(17) $$\left\{\begin{array}{ll} \text{Iris can take Spanish or Calculus} & \Diamond(s \vee c) \\ \text{Iris can take Spanish} & \Diamond s \\ \text{Iris can take Calculus} & \Diamond c \\ \text{Iris can take Spanish and Calculus} & \Diamond(s \wedge c) \end{array}\right\}$$

As before, the innocently excludable alternative is only $\Diamond(s \wedge c)$. We can, however, now ask what the innocently includable alternatives are. As Bar-Lev & Fox (2017) show, there is only one subset of includable alternatives, $\{\Diamond(s \vee c), \Diamond s, \Diamond c\}$. Thus we can include them all and obtain the free choice meaning of the sentence.

(18) $[\![\text{EXH}^{\text{II}}[\text{Iris can take Spanish or Calculus}]]\!] =$
$\Diamond(s \vee c) \wedge \neg\Diamond(s \wedge c) \wedge \Diamond s \wedge \Diamond c$

2.3 Exclusion and inclusion: differences in predictions

Exclusion and inclusion accounts make identical predictions for basic cases of free choice. But they diverge for more complex sentences. In particular, Chemla (2009) has found that free choice effects arise robustly when a clause involving disjunction scoping under a modal appears embedded under quantifiers. For an example, consider (19).

(19) Every girl can take Spanish or Calculus $\quad \forall x \Diamond(Sx \vee Cx)$
$\rightsquigarrow$ *Every girl can choose between Spanish and Calculus* $\quad \forall x(\Diamond Sx \wedge \Diamond Cx)$

Chemla finds that (18) has a reading suggesting that every girl can choose to take Spanish and can choose to take Calculus. Similarly, (20) has a reading suggesting that every girl has the option of avoiding Spanish as well as the option of avoiding Calculus.[7]

(20) No girl must take both Spanish and Calculus $\quad \neg\exists x \Box(Sx \wedge Cx)$
$\rightsquigarrow$ *Every girl can choose between avoiding Spanish and avoiding Calculus*
$\neg\exists x \Box Sx \wedge \neg\exists x \Box Cx$

(19) is predicted by exclusion approaches (together with the assumption that implicatures can be computed locally; see Chemla 2009 for discussion), but (20) is not. Bar-Lev & Fox (2017) use this as an empirical argument against exclusion accounts,

7 To better see the similarity between the two cases consider the equivalence between $\neg\exists x \Box(Sx \wedge Cx)$ and $\forall x \Diamond(\neg Sx \vee \neg Cx)$, and that the free choice inference in (20) is equivalent to $\forall x(\Diamond\neg Sx \wedge \Diamond\neg Cx)$.

and for inclusion accounts.

In what follows, we turn to novel data involving nonmonotonic quantifiers. As for (20), the predictions of the two accounts again diverge.

2.4 Free choice under nonmonotonic quantifiers: predictions

Consider again (3) and (4) and their potential free choice readings.

(3) a. Exactly one girl can take Spanish or Calculus.
$\rightsquigarrow$ *One girl can take Spanish and she can take Calculus and all of the others cannot take either one* THE-ONE-FC
b. $|\{x : \Diamond(Sx \vee Cx)\}| = 1$
$\rightsquigarrow |\{x : \Diamond(Sx \vee Cx)\}| = |\{x : \Diamond Sx \wedge \Diamond Cx\}| = 1$

(4) a. Exactly one girl cannot take Spanish or Calculus.
?$\rightsquigarrow$ *One girl cannot take either Spanish or Calculus and all of the others can take Spanish and can take Calculus* ALL-OTHERS-FC
b. $|\{x : \neg\Diamond(Sx \vee Cx)\}| = 1$
$\rightsquigarrow |\{x : \neg\Diamond(Sx \vee Cx)\}| = |\{x : \neg(\Diamond Sx \wedge \Diamond Cx)\}| = 1$

Let us explore first the predictions of the exclusion account, starting with the THE-ONE-FC reading. Suppose that we parse (3) as in (21). It is routine to check that, if we parse the sentence as involving only one exhaustivity operator, only the conjunctive alternative is innocently excludable. But, as it happens for our basic case of free choice (8), we can derive free choice if we exhaustify recursively (cf. Spector 2007 for a similar case with the inference of plurals). Suppose we parse the sentence as:[8]

(21) EXH^{IE}[EXH^{IE}[Exactly one girl can take Spanish or Calculus]]

Using the schematic representation for the prejacent, $|\{x : \Diamond(Sx \vee Cx)\}| = 1$, we can represent the alternatives as in (22).

8 We are assuming a meaning of *exactly one* as in (i). Moshe Bar-Lev (p.c.) suggests treating *exactly n* as simply meaning the same as the bare numeral *n*, which is then however obligatorily exhaustified. This would have implications for the predictions of the exclusion accounts. We do not pursue this option here and leave it for further work.

(i) $[\![\text{exactly one}]\!] = \lambda P \lambda Q |P \cap Q| = 1$

(22)
$$\left\{\begin{array}{ll} \text{EXH}^{\text{IE}}[\text{Exactly one girl can take S or C}] & |\{x : \Diamond(Sx \vee Cx)\}| = 1 \\ \text{EXH}^{\text{IE}}[\text{Exactly one girl can take S}] & |\{x : \Diamond Sx\}| = 1 \wedge \neg(|\{x : \Diamond Cx\}| = 1) \\ \text{EXH}^{\text{IE}}[\text{Exactly one girl can take C}] & |\{x : \Diamond Cx\}| = 1 \wedge \neg(|\{x : \Diamond Sx\}| = 1) \\ \text{EXH}^{\text{IE}}[\text{Exactly one girl can take S and C}] & |\{x : \Diamond(Sx \wedge Cx)\}| = 1 \end{array}\right\}$$

As it happened for the derivation of free choice in simple sentences, the two alternatives involving only one disjunct are innocently excludable. The conjunction of the assertion and the negation of those two alternatives yields free choice.

(23)
$$\begin{array}{l} |\{x : \Diamond(Sx \vee Cx)\}| = 1 \wedge \neg(|\{x : \Diamond Sx\}| = 1 \wedge \neg|\{x : \Diamond Cx\}| = 1) \wedge \\ \neg(|\{x : \Diamond Cx\}| = 1 \wedge \neg|\{x : \Diamond Sx\}| = 1) \\ \rightsquigarrow |\{x : \Diamond(Sx \vee Cx)\}| = |\{x : \Diamond Sx \wedge \Diamond Cx\}| = 1 \end{array}$$

Crucially, this reasoning cannot be replicated to derive ALL-OTHERS-FC. For brevity, we only consider the case where we exhaustify recursively. It's easy to check that one round of exhaustification also won't work. We assume the parsing in (24) and the alternatives in (25).

(24) $\text{EXH}^{\text{IE}}[\ \text{EXH}^{\text{IE}}[\text{Exactly one girl cannot take Spanish or Calculus}]\ ]$

(25)
$$\left\{\begin{array}{l} |\{x : \neg\Diamond(Sx \vee Cx)\}| = 1 \\ |\{x : \neg\Diamond Sx\}| = 1 \wedge \neg(|\{x : \neg\Diamond Cx\}| = 1) \\ |\{x : \neg\Diamond Cx\}| = 1 \wedge \neg(|\{x : \neg\Diamond Sx\}| = 1) \\ |\{x : \neg\Diamond(Sx \wedge Cx)\}| = 1 \end{array}\right\}$$

Now, the relevant alternatives (i.e. the ones involving just the two disjuncts) are innocently excludable, as it happened for the positive case. But in this case the strengthened meaning we get is not sufficient to generate free choice. The meaning is the following:

(26)
$$\begin{array}{l} |\{x : \neg\Diamond(Sx \vee Cx)\}| = 1 \wedge \neg(|\{x : \neg\Diamond Sx\}| = 1 \wedge \neg|\{x : \neg\Diamond Cx\}| = 1) \wedge \\ \neg(|\{x : \neg\Diamond Cx\}| = 1 \wedge \neg|\{x : \neg\Diamond Sx\}| = 1) \end{array}$$

Informally, (26) says: exactly one student is forbidden from taking both Spanish and Calculus; also, either it's not the case that exactly one student is forbidden from taking Spanish or exactly one student is forbidden from taking Calculus; also, either it's not the case that exactly one student is forbidden from taking Calculus or exactly one student is forbidden from taking Spanish. These conditions all hold in a situation where there is one student who is not allowed to take either of Spanish or Calculus, some others are not allowed to take Spanish, and some others are not allowed to take Calculus. This scenario makes true (26) while obviously not validating the ALL-OTHERS-FC reading.

Let us turn now to the predictions of the inclusion account. Crucially, we need to make assumptions about the set of alternatives in play.[9] We assume that *exactly one* is replaceable with *some* and that the negation can be deleted. This follows naturally from a theory of alternatives like Katzir 2007.

(27) EXH$^{\text{II}}$[Exactly one girl can take Spanish or Calculus]

(28) $$\left\{\begin{array}{l} |\{x:\Diamond(Sx\vee Cx)\}|=1\\ |\{x:\Diamond Sx\}|=1\\ |\{x:\Diamond Cx\}|=1\\ |\{x:\Diamond(Sx\wedge Cx)\}|=1\\ |\{x:\Diamond(Sx\vee Cx)\}|\geq 1\\ |\{x:\Diamond Sx\}|\geq 1\\ |\{x:\Diamond Cx\}|\geq 1\\ |\{x:\Diamond(Sx\wedge Cx)\}|\geq 1 \end{array}\right\}$$

Given this bigger set of alternatives, we can show that only the conjunctive alternatives $|\{x:\Diamond(Sx\wedge Cx)\}|=1$ and $|\{x:\Diamond(Sx\wedge Cx)\}|\geq 1$ are excludable.

At the same time, all the other alternatives are includable. In particular, crucially for us, $|\{x:\Diamond Sx\}|=1$ and $|\{x:\Diamond Cx\}|=1$ are includable. Together with the assertion, these alternatives directly entail THE-ONE-FC. Informally, here is why: exactly one student can take Spanish or Calculus and exactly one can take Spanish and exactly one can take Calculus; the only case in which all these three claims can be true is if they all have the same witness.

Consider now the negative case in (29), with the alternatives in (30). Notice that the *some*-alternatives have been added and negation has been deleted (adding also the *exactly one*-alternatives without negation and the *some*-alternatives with negation doesn't change anything).

(29) EXH$^{\text{II}}$[Exactly one girl cannot take Spanish or Calculus]

(30) $$\left\{\begin{array}{l} |\{x:\neg\Diamond(Sx\vee Cx)\}|=1\\ |\{x:\neg\Diamond Sx\}|=1\\ |\{x:\neg\Diamond Cx\}|=1\\ |\{x:\neg\Diamond(Sx\wedge Cx)\}|=1\\ |\{x:\Diamond(Sx\vee Cx)\}|\geq 1\\ |\{x:\Diamond Sx\}|\geq 1\\ |\{x:\Diamond Cx\}|\geq 1\\ |\{x:\Diamond(Sx\wedge Cx)\}|\geq 1 \end{array}\right\}$$

The only excludable alternatives are the conjunctive ones $|\{x:\neg\Diamond(Sx\wedge Cx)\}|=1$

9 It's easy to check that these assumptions would not have made a difference for the exclusion case.

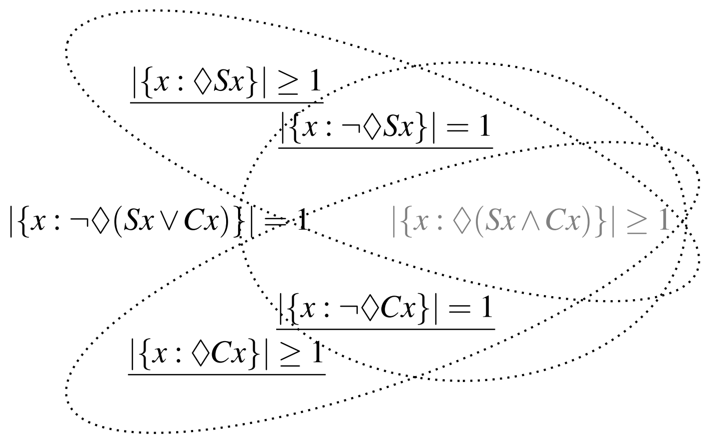

Figure 1 Innocently excludable and innocently includable alternatives for (4).

and $|\{x : \Diamond(Sx \wedge Cx)\}| \geq 1$.

The includable ones are again all the others, giving rise to the reading we want. It's useful to visualize alternatives in a diagram (see Figure 1). The innocently excludable alternatives are in gray, the innocently includable ones are underlined. The dotted ellpses represent maximal sets of innocently excludable alternatives. We represent only some of the alternatives to avoid clutter.

Notice: the crucial reason why we predict ALL-OTHERS-FC is that the alternatives $|\{x : \neg\Diamond Sx\}| = 1$ and $|\{x : \neg\Diamond Cx\}| = 1$ are included. These alternatives say, respectively, that exactly one girl cannot take Spanish and exactly one girl cannot take Calculus. Given the proposition asserted, it must be that there is exactly one girl who is the target of all these prohibitions. It follows that all the others are allowed to take Spanish and allowed to take Calculus.

In summary: the inclusion account (given some assumptions about alternatives) can derive both readings. The empirical question now is whether both readings are there. We turn to this in the experiment section below. As we show, in our results we do find evidence for both readings, which yields an argument for inclusion.

3 The Experiment

3.1 Goals and Rationale

The goal of our experiment was to investigate whether disjunctions in the scope of nonmonotonic quantifiers give rise to free choice readings. Experimental evidence for free-choice readings in the case of (20) has been provided by Chemla (2009) but no study to date has tested the corresponding inferences of (4). In our study, we employ a inferential task that builds on recent experimental work on implicature in upward and downward entailing contexts (in particular Chemla & Spector 2011; Gotzner & Romoli 2017).

We used a 2x4 design with each of the two types of sentences (3) and (4), call it 'POSITIVE' and 'NEGATIVE,' respectively, presented in four inference conditions: TRUE, FALSE, COMPATIBLE and FREE-CHOICE. The first two conditions are a simple baseline for truth and falsity, while the third one is a baseline for compatibility with the target sentence, i.e. the presented statement is simply compatible with the sentence but not an inference (cf. Gotzner & Romoli 2017). The comparison between the compatible and the free choice condition in both the POSITIVE and NEGATIVE variants is a measure of their potential free choice readings.

Exclusion theories predict a free choice reading for the POSITIVE (3) but not NEGATIVE condition (4). Accordingly, endorsements of the FREE CHOICE condition should be higher than for the COMPATIBLE and FALSE conditions only in the POSITIVE variant (i.e., there should be an interaction between polarity and inference condition). By contrast, inclusion theories predict the free choice reading for both variants. Therefore these accounts predict the same differences between the FREE-CHOICE and COMPATIBLE condition in each polarity condition (i.e., no interaction).

3.2 Methods

3.2.1 Participants

We recruited 60 Participants with U.S. IP addresses via Amazon's Mechanical Turk and screened them for native language. They received 80 cents for participation in the study. All participants indicated their native language to be English (27 male, 31 female, mean age 35.6).

3.2.2 Materials

Participants saw sentences like (3) and (4) across the four inference conditions, true, false free-choice and compatible. Each participant saw all experimental conditions in four different scenarios, totaling in 16 experimental items. The order of presentation was pseudo-randomized for each scenario.

We asked participants if and to what extent they would infer a given candidate inference on a scale from 0 to 100%, with 0% representing that a statement did not follow and 100% that it definitely followed.

For each scenario a context was given. Below, we present an example trial that participants saw with sentence (3) in the free-choice condition. All context sentences and items can be found in the Appendix.

Context: We are at the beginning of the year waiting for the teacher to give instructions on what classes we can take. The school offers; a number of classes such as Algebra, Calculus, Logic, Physics, Chemistry, Literature, History, Spanish, French and English.

We know already that no student is allowed to take all classes. The teacher gives further instructions:

"Exactly one student can take Spanish or calculus"

suggests that

One student can choose between Spanish and calculus and all others can take neither one

___% YES

0 % = definitely not, 100 % = definitely yes

In the TRUE condition, participants were expected to accept the given statement (i.e., judgments close to 100 %) whereas in the FALSE condition they should clearly reject the statement (i.e., judgments close to 0 %). Note that our TRUE condition is an entailment which should be judged as true no matter which reading participants adopt. In the critical free-choice conditions, participants judged the candidate inferences.

To ensure that the COMPATIBLE condition really served as a baseline for compatibility we had two versions of the COMPATIBLE conditions with identical sentences but different polarity in the second conjunct (e.g., COMPATIBLE +: *One student can take either Biology or English, and all others can take Logic* VS. COMPATIBLE -: *One student can take either Biology or English, and all others cannot take Logic*). Therefore, if participants were to endorse one version accommodating contextual assumptions they would not be able to use the same assumptions to endorse its negation.

3.3 Results

The graph in Figure 3.3 shows the mean % of YES responses across conditions. As can be seen from the graph, the TRUE condition was rated highest, followed by the FREE CHOICE, COMPATIBLE, and FALSE conditions in both polarity conditions. The graph presents an average of the two versions of the compatible condition since respective judgments were similar across the two versions.[10]

10 We ran separate mixed model analyses for the two experiment versions and found that the COMPATIBLE conditions was rated significantly lower than the FREE CHOICE condition and higher than the FALSE baseline condition in both versions. As in the overall model reported in Table 1, no interaction between polarity and the target FREE CHOICE condition was present.

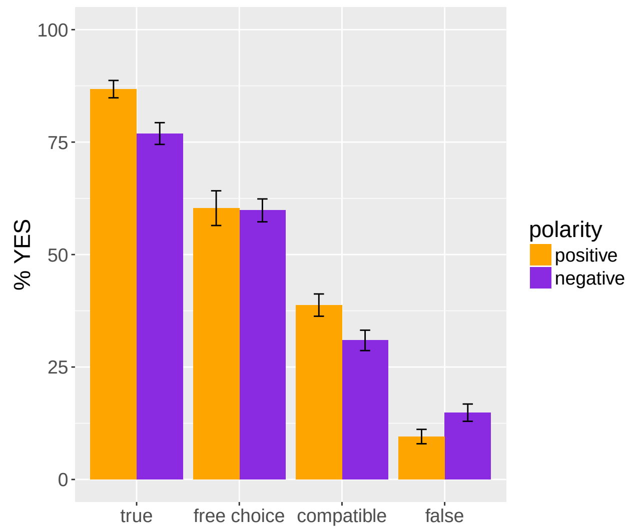

Figure 2 % YES by polarity (POSITIVE VS. NEGATIVE) and inference condition (TRUE, FREE CHOICE, COMPATIBLE and FALSE). The rate of endorsement reflects the degree to which a candidate inference follows. Error bars represent SEM.

We ran a series of mixed models to test statistical significance across conditions. First, we computed an omnibus model with sum coding of all factors. In particular, we included fixed effects for polarity, inference condition and their interaction as well as random slopes for participants and scenario. The results of the mixed model are summarized in Table 1.

The model revealed main effects for all comparisons across inference conditions. That is, the FREE CHOICE condition was rated significantly higher than the grand average ($p < .01$) while the COMPATIBLE and FALSE conditions were rated significantly lower ($p < .0001$, respectively). There was a marginal main effect of polarity ($p = .08$) and a significant interaction across polarity in the FALSE condition ($p < .01$). Crucially, there was no significant interaction between polarity and the FREE-CHOICE condition ($p = .35$).

Second, we ran two separate models to assess whether individual comparisons across inference conditions are significant in both polarity conditions. For these models we set the target FREE CHOICE condition as the reference level (treatment coding). The models for the two polarity conditions revealed that in each case the FREE CHOICE condition was rated significantly lower than the TRUE condition (POSITIVE: p-value $< .0001$; NEGATIVE: p-value $< .05$). Crucially, the FREE CHOICE

	Estimate	SE	t-value	p-value
(Intercept)	47.02	2.03	23.15	
FREE CHOICE	12.95	1.86	6.98	0.004
COMPATIBLE	-12.45	1.43	-8.73	0.0001
FALSE	-35.07	1.44	-24.29	0.0001
Polarity	1.55	0.88	1.77	0.083
FREE CHOICE : Polarity	-1.31	1.40	-0.94	0.350
COMPATIBLE : Polarity	2.32	1.41	1.65	0.100
FALSE : Polarity	-4.23	1.41	-3.00	0.003

Table 1 Results of mixed effects model with sum coding of polarity and inference condition.

condition was rated higher than both the COMPATIBLE and FALSE baseline conditions in the POSITIVE and NEGATIVE cases (all p-values <.0001).

These results suggest that (3) has a free choice reading, as predicted by both exclusion and inclusion theories: the FREE CHOICE condition was differing from both the COMPATIBLE and FALSE condition. Crucially, we found parallel differences in the case of (4), suggesting that participants computed the free choice inference to a similar extent in the POSITIVE and NEGATIVE polarity conditions. Taken together, our findings provide a challenge for exclusion theories, and support for inclusion theories.

4 Discussion

The experimental results provide a straightforward argument for inclusion accounts, and against exclusion accounts. The point is very simple: exclusion accounts undergenerate for the case of ALL-OTHERS-FC readings, while inclusion accounts yield exactly the right predictions. More specifically, we found that participants were more likely to endorse THE-ONE-FC reading than a FALSE control and a statement that was merely compatible with the target sentence. Further, we found corresponding differences across conditions in the negative condition version probing the ALL-OTHERS-FC reading.[11]

While the basic point is straightforward, there is a potential complication arising from the generalization of the prediction to all DPs of the form *exactly n*.[12]

11 Note that there was an interaction across polarity in the FALSE condition. This arguably reflects the fact that the expected response is reversed compared to the other inference conditions and participants might have been more likely to make mistakes with negation.

12 Thanks to Moshe Bar-Lev and Danny Fox for discussion on this point.

Consider the following variant of (4).

(31) Exactly two girls cannot take Spanish or Calculus.

While we have not tested (31) experimentally, our intuitions converge on the judgment that it behaves exactly like (4): it gives rise to a similar ALL-OTHERS-FC reading (in this case, this reading amounts to the proposition that everyone aside from the two girls is allowed to take Spanish and is allowed to take Calculus). If this intuition was correct, it would gives rise to a potential problem. If we assume that *exactly one* is among the alternatives to *exactly two* (as e.g. Katzir's theory predicts, at least as a possibility), then the derivation of the ALL-OTHERS-FC effect for (31) is blocked.

Let us explain briefly why. Recall that, in our derivation of the ALL-OTHERS-FC effect for (4), it was crucial that the two alternatives *Exactly one girl cannot take Spanish* and *Exactly one girl cannot take Calculus* were includable. Similarly, to derive free choice for (31) we would need to include *Exactly two girls cannot take Spanish* and *Exactly two girls cannot take Calculus*. But these alternatives are not includable if their *exactly one*-counterparts are in the alternative sets.

We think this difficulty is part of a general problem that arises when nonmonotonic alternatives are at play. While we cannot address this issue in full here, let us point towards the beginning of a solution. There is independent evidence that the generation of alternatives for nonmonotonic sentences proceeds in a somewhat more limited way than what is predicted by Katzir. In particular, an item like *exactly one* does not seem to be among the alternatives of *exactly two*.

While this is not a full account of the difficulty, we can show that the problem is unrelated to free choice. Rather, it concerns orthogonal issues regarding alternatives and nomonotonicity.

To support our claim, we consider an example in which similar restrictions on the generation of alternatives are needed. Consider:

(32) Exactly two students failed both Spanish and Calculus.
$\rightsquigarrow$ *Some (other) student(s) failed Spanish but not Calculus and some student(s) failed Calculus but not Spanish*

As we point out, (32) intuitively has a reading on which it triggers a kind of 'distributivity' implicature, on which some other student(s) failed Spanish but not Calculus, and some student(s) failed Calculus but not Spanish. This reading is immediately predicted by both exclusion and inclusion theories if we assume that the alternatives for (32) are the ones we get by replacing the conjunction with the conjuncts:

(33) $$\left\{ \begin{array}{ll} \text{Exactly two students failed both Spanish and Calculus} & |\{x : \neg Sx \wedge \neg Cx)\}| = 2 \\ \text{Exactly two students failed Spanish} & |\{x : \neg Sx)\}| = 2 \\ \text{Exactly two students failed Calculus} & |\{x : \neg Cx)\}| = 2 \end{array} \right\}$$

However, the derivation is blocked if we assume that the set of alternatives includes also the corresponding *exactly one* alternatives, i.e. *Exactly one student failed Spanish* and *Exactly one student failed Calculus*. (Similarly for any alternative that we get by replacing *two* by any other numeral.) This suggests that these alternatives are somehow prevented from being in the alternative set. We leave it to future work to discuss exactly what algorithm produces this result.

5 Conclusion

In this paper, we reported on an experiment testing sentences involving nonmonotonic quantifiers like *Exactly one girl cannot take Spanish or Calculus*, and its potential free choice reading suggesting that one girl cannot take either Spanish or Calculus and all of the others can choose between the two. In our results, we found clear evidence for this free choice reading. As we pointed out, this is challenging for the exclusion implicature theories of free choice, but in line with inclusion accounts like Bar-Lev & Fox 2017. This case constitutes, therefore, a further argument for inclusion accounts. If we want to pursue an implicature approach to free choice, the evidence seems to suggest that it should be an inclusion account.

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