

The Overtone of Monotonicity under Desire

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Abstract. The goal of this paper is to propose a unified account for different puzzles on upward monotonicity under desire. Conclusions drawn by monotonicity will be shown to license some additional inferences by pragmatic effects. It is assumed that a predicate can convey a potential disjunctive meaning via reinterpretation and hence gives rise to free choice effects. In addition, a logic-based framework is presented to capture free choice inferences and the reinterpretation process.

Keywords: Monotonicity · Desire · Free choice.

1 The Puzzles about Monotonicity under Desire

1.1 Three Puzzles

It is controversial whether verbs expressing desire (e.g. *want*, *hope*) license monotonic inferences in their scope. Several examples have been proposed as evidence for a non-monotonic behaviour under such verbs which led to the development of non-monotonic semantics for bouletic modalities (see [8,9,10,21], etc.). In this section three examples, challenging a monotonic semantics for *want* are introduced.

Asher’s Puzzle. We start with a puzzle presented by Asher ([5]). It shows how upward entailments in desire environments lead to problems. Heim ([8]) reports the puzzle as follows, in which she replaced *hope* in the original case with *want*:

Imagine that Nicholas is not willing to pay the \$3,000 that he believes it would cost him if he flew to Paris on the Concorde, but he would love to fly on the Concorde if he could get the trip for free. Under these circumstances (1-a) is true, yet (1-b) is false, despite the fact that taking a free trip on the Concorde, of course, implies taking a trip on the Concorde.

- (1) a. Nicholas wants a free trip on the Concorde
- b. Nicholas wants a trip on the Concorde

[8]

Heim’s Example In the same article Heim also presents another puzzle about desire, which has a similar logical form of the Good Samaritan paradox³ in deontic logic:

- (2) a. I want to teach on Tuesdays next semester
 b. I want to teach next semester [8]

The inference would be invalid for most speakers. For it is entirely possible to utter (2-a) in a situation where the speaker doesn’t want to teach at all.

Ross’ Paradox under Desire. Another well-known paradox from deontic logic is Ross Paradox⁴ ([15]), concerning the classically valid but intuitively invalid monotonic inference ‘Send the letter! \Rightarrow Send the letter or burn it!’

Crnič ([7]) observed that embedding the two non-finite clauses under *want* gives rise to equally paradoxical results:

- (3) a. John wants to send the letter.
 b. John wants to send the letter or burn it. [7]

1.2 Summary

Various strategies have been proposed to explain the individual cases sketched above, but no uniform solution has emerged so far. In Table 1 we compare the predictions of two prominent existing analyses: Heim ([8]) and von Fintel ([19]).

Table 1. Comparing Predictions of Existing Analyses

Approaches	Ross’ Paradox	Asher’s Puzzle	Heim’s example
Von Fintel	Semantically valid	Pragmatically invalid	Semantically invalid
Heim	Semantically valid	Semantically invalid	Semantically invalid
Our proposal	Pragmatically invalid	Pragmatically invalid	Pragmatically invalid

Heim presents a non-monotonic semantics for *want* which is argued to depend on conditional semantics, and therefore accounts for the failure of the problematic inferences in Asher’s and Heim’s examples in a semantic manner. Von Fintel instead proposes a pragmatic account of the monotonicity failure in Asher’s puzzle combined with a semantic explanation of Heim’s example where the monotonicity failure is argued to follow from the assumption of an independent presupposition. The case of Ross paradox is a bit different. Neither Von Fintel nor Heim has a ready explanation for the puzzling inferences in (3).

³ The paradox was first introduced by Prior ([12]). Åqvist ([4]) reproduced a similar but more popular version of it and provided a clear formulation.

⁴ See [11] which gives a good overview.

We will argue that the problems posed by the three puzzles are pragmatic by nature rather than semantic. Evidence in favor of a pragmatic account of the puzzles comes from examples like the following:

- (4) I don't want to eat any fast food.

As Von Stechow noted ([20]), according to the standard theory of Negative Polarity Items (NPIs), a downward-entailing environment is required for NPI *any* to be licensed. So if *want* is not upward monotonic, then *not want* will not produce a downward entailing environment. Furthermore, if we refuse the upward monotonicity of desire, we would fail to account for the intuitive infelicity of the following sentence:

- (5) Jones wants to buy a green sweater, but she doesn't want to buy a sweater [23]

Therefore we will explore if a upward monotonic analysis of desire can be maintained by combing it with a pragmatic account which can handle these puzzles uniformly. We will propose that all three puzzles can be reduced to the cases of Free Choice (FC) inferences. The process leading to paradox will be clarified in the next section, especially in the case with no overt disjunctive statements. In addition, we develop a formal framework in Sec. 3 based on Aloni's proposal BSML ([2,3]) to capture such reasoning. As a result, we expect to establish further evidence that the puzzles don't provide counter-examples against interpreting bouletic modals monotonically.

2 Disjunctive Meaning Emerges

2.1 Free Choice Inferences under Desire

Consider again the problem posed by Ross' paradox, which is repeated below:

- (6) a. John wants to send the letter.
b. John wants to send the letter or burn it.

The sentence in (6-b) may convey that John has a positive attitude towards both sending and burning the letter. This positive attitude shows that the two options concerning the letter are acceptable to John, i.e., at least they are not unwanted. In [7], Crnič uses *it is ok...* to represent the weaker attitude. We will employ the same expression in our proposal. It follows that the inference in (7) is licensed:

- (7) a. John wants to send the letter or burn it
b. \leadsto It is ok for John to send the letter, **and** it is ok for him to burn it.⁵

⁵ The inference is drawn when we read the sentence (6-b) in a way where the scope of the modality *want* is over the disjunctive statement, namely it has a wide scope.

However the inference to (7-b) is not justified by the premise (7-a) according to the classical logic. As Crnič observed the inference in (7) has the same form of well known FC inferences. One of the observations in the FC literature is that a conjunctive meaning of possibility modals can be derived from a disjunctive necessity modal statement. It can be denoted as \Box -free choice, which is different from the commonly held FC inferences from \Diamond -modal to \Diamond -modal (\Diamond -FC).

- (8) a. \Box -free choice
John ought to mail the letter or burn it. So he is allowed to mail it and he is allowed to burn it $[\Box(p \vee q) \rightsquigarrow \Diamond p \wedge \Diamond q]$
- b. \Diamond -free choice
You may take chocolates or ice cream. So you may take chocolates, and you may take ice cream $[\Diamond(p \vee q) \rightsquigarrow \Diamond p \wedge \Diamond q]$

In the paper, we analyse the semantics of desire verbs in Hintikka's style. In what follows, the modality *want* is treated as \Box , and the weaker desire *it is ok...* is interpreted as \Diamond . Then we can apply the principle in (8-a) to the inference in (7) as follows:

$$(9) \quad \Box_J (\text{SEND} \vee \text{BURN}) \rightsquigarrow \Diamond_J \text{SEND} \wedge \Diamond_J \text{BURN}$$

As shown, the conclusion of a weaker desire to burn the letter can be drawn as a FC inference. However, it is absurd to deduce from someone's willingness to send a letter her acceptance of burning it. This is why the puzzle appears to be paradoxical.

A similar strategy to the puzzle can be found in [7], and some literature also applies the principle of FC to analyze the deontic Ross' paradox concerning imperatives or permissions, e.g. [20,1]. In the present paper, we will provide a formal account of FC inferences under bouletic modalities based on [2], where the FC inference is assumed to be derived as a product of the interaction of literal meanings and pragmatic factors. Before that, we explore if the analysis proposed above is also applicable to the other two puzzles.

2.2 Free Choice triggered by Non-disjunctive Statements: Asher's puzzle

Asher's puzzle is repeated below:

- (10) a. Nicholas wants a free trip on the Concorde
b. Nicholas wants a trip on the Concorde

The most apparent difference between Ross' paradox and Asher's puzzle is that there is no overt disjunctive statement in the latter example, which would be required to trigger a FC inference. Our strategy doesn't seem to work for this case. But the puzzle hints that there is some additional information that can be acquired from the conclusion (10-b), which leads us to refute the inference. So what makes the Asher's puzzle paradoxical, we will argue, is very similar to Ross' paradox.

What information is drawn to give us to think that the reasoning in (10) is odd? The conclusion conveys that Nicholas just wants a trip, no matter what kind of trip it is. Accordingly we are lead to believe that he probably wants a free trip or one that is not free. However the premise only announces Nicholas' desire for a free trip, and it provides nothing to justify his desire to any non-free trips. Therefore it seems that the following inference can be drawn from (10-b):

(11) Nicholas is ok with a non-free trip on the Concorde.

This would be the inference we would trigger if the original sentence were reinterpreted as a disjunction:

(12) Nicholas wants a trip on the Concorde \Leftrightarrow Nicholas wants a free or non-free trip on the Concorde.

In what follows we will argue for the feasibility for such reinterpretation. Imagine a scenario where a kid, who really wants chocolate, is shopping with her mother. In this situation, what she cares about is "will my mom buy chocolate for me?". This can be seen as a *Question under Discussion* (QUD, see [13,14]) in this context. The answers to this polar question are introduced as topics which bring our attention to the predicate *chocolate*, which hence becomes salient. Furthermore, we propose that salient predicates can influence the way people interpret the predicates that semantically include them. Suppose the mother says to the girl "Let's go to buy some snacks", then the girl will wonder "Are we going to buy chocolate?". In this case, the predicate *snacks* is naturally reinterpreted via *chocolate* as a disjunctive predicate "chocolate or any other snacks that are not chocolate". Namely, snacks is semantically divided into two categories: one includes chocolates, and the other includes snacks which are not chocolates.

We propose that a predication, in conversations, can be reinterpreted as a disjunctive statement and so convey a disjunctive meaning. In Asher's case, the predicate *trip* in (1-b) can be interpreted as *free trip or non-free trip*. This reinterpretation is possible because $\forall x Qx$ and $\forall x ((Qx \wedge Px) \vee (Qx \wedge \neg Px))$ are logically equivalent and therefore can be substituted *salva veritate*. We need to emphasize that, in our proposal, a predicate only can be disjunctively reinterpreted by predicates that describe the objects within its denotation, i.e. by predicates which are semantically included ($P \subset Q$). We call them *sub-predicates*.

Evidence from the Exemplar Theory w.r.t concept learning in cognitive psychology shows that concepts are typically represented as remembered (hence salient) instances (see [6,16], etc.). So in a conversation, although the semantics of a predicate (such as *trip*) is clear to the recipients, people typically focus only on a part of the objects in its extension. As a result we obtain a disjunctive representation of the predicate consisting of the union of the salient objects (first disjunct) and the remaining objects (second disjunct). The latter is normally denoted as the negation of the former.

So far, we have proposed that predicates in conversations can be reinterpreted leading to disjunctive representations. In addition, we have two constraints:

- In a disjunctive reinterpretation of a predicate Q , the disjuncts are always *sub-predicates* of Q .
- The sub-predicates should be *salient* in the context.

In this way, the process from *Nicholas wants a trip* to *Nicholas is ok with a free trip and is ok with a non-free trip* can be clarified. First (13-a) undergoes a disjunctive reinterpretation and then the disjunctive statement gives rise to a FC inference.

- (13) a. Nicholas wants a trip
 b. \Leftrightarrow Nicholas wants a free trip or a non-free trip
 [by disjunctive reinterpretation]
 c. \leadsto Nicholas is ok with a free trip and he is ok with a non-free trip.
 [by \square -FC principle]

As a result, Nicholas' attitude of accepting a non-free trip is derived, which is unwarranted by the premise. Consequently, the monotonic reasoning in (10) appears to fail.

2.3 Free Choice triggered by Non-disjunctive Statements: Heim's example

Heim's example is repeated in the following:

- (14) a. I want to teach on Tuesday next semester.
 b. I want to teach next semester.

We assume that *want* takes wide scope. Then what the agent wants are teaching events that are scheduled for Tuesdays next semester. According to the explanation of our proposal, the sentence in (14-b) can be represented as a disjunctive statement which generates a free choice inference showing the agent's attitude towards accepting teaching events on the other days, which is unjustified:

- (15) a. I want to teach next semester.
 b. I want to teach on Tuesday or teach on the other days next semester.
 c. I'm ok to teach the days that are not Tuesday next semester.

Let us add a few more words for those who might doubt the analysis for this example in (15), especially if we claim that the example is semantically valid by monotonicity. If the conclusion (14-b) is assumed to be false since it conveys that the agent doesn't show any desire to teach at all, then the premise stating the desire of teaching on Tuesday should be also rejected. Unless the original meaning of the premise is that if the agent has to teach next semester, she accept to teach on Tuesdays. In other words, the example shows a conditional desire. If so, our judgement of the conclusion (14-b) should be under the same condition, i.e. 'if I have to teach'. So the example should be rewritten in the following way:

- (16) If I have to teach next semester

- a. I'm ok to teach on Tuesday next semester.
- b. I'm ok to teach next semester.

In such case, our analysis is still applicable, as the predicate *teach* can be reinterpreted as *teach on Tuesdays* or *teach on the non-Tuesdays*. Then we can apply the principle of \diamond -FC in (8-b):

- (17) a. I'm ok to teach next semester.
- b. I'm ok to teach on Tuesdays or the other days next semester.
- c. I'm ok to teach on Tuesdays next semester **and** I'm ok to teach on other days next semester.

Notice that we started by saying that Heim's example has similar logical structure with the Good Samaritan paradox. Because in the premise (14-a), the proposition in the scope of desire can be formulated as a conjunction: 'having teachings next semester **and** the teachings are scheduled on Tuesdays', but not both of these two conjuncts are desired. In fact, there are also more direct Good Samaritan cases under desire. For instance,

- (18) a. The government wants that people who are at risk of getting COVID are vaccinated.
- b. The government wants that people are at risk of getting COVID.

We do not want to claim that our analysis of disjunction applies to all the Good Samaritan cases under desire. We believe that other solutions also could be given. For example, we take a general analysis to the Good Samaritan paradox from deontic logic (e.g [17]). The main cause of the paradox in (18) is the scope ambiguity. Let us assume that no one wants people to be at risk of getting COVID⁶. The relative clause 'who are at risk of getting COVID-19' is an expression that serves as an adjective so it can behave as the predication. So we have the following equivalence:

- (19) People who are at risk of getting COVID are vaccinated \Leftrightarrow people are at risk of getting COVID and these people are vaccinated

Two readings of (18-a) can be observed:

- (20) **Wide scope:**
The government wants that (people are at risk of getting COVID **and** these people are vaccinated)
 $\Box(\exists x(\text{COVID } x \wedge \text{VACC } x))$
- (21) **Narrow scope:**
There are some people at risk of getting COVID and the government wants them to be vaccinated
 $\exists x(\text{COVID } x \wedge \Box \text{VACC } x)$

⁶ If this assumption is false, then why do we think (18-b) is problematic.

If we take the wide scope reading of (18-a), then (18-a) will be false because of the assumption $(\Box \neg \exists x \text{COVID } x)$. If we take the narrow scope reading, then (18-b) cannot be derived by monotonicity.

Similarly, for the example in (14), we could also thinking of taking the proposition ‘having teachings next semester’ outside the scope of desire to block the monotonic inference. This is also an effective solution. But neither the analysis of disjunction we proposed nor the solution of scope ambiguity justify a non monotonic semantics for the desire modality.

To conclude, we have shown how we can use the FC to clarify why the three puzzles appear to be paradoxical. In the next section, we will employ a logical framework *Bilateral State-based Modal Logic* (BSML) and its first-order version (QBSML) based on [2,3] to give a formal account for the FC inferences.

3 A Formal Account for Free Choice

3.1 The Framework

In [2], Aloni proposed a formal account of FC inference in *Bilateral State-based Modal Logic* (BSML). On this account FC and related inferences are a consequence of a tendency operative in conversation which Aloni calls *neglect zero*. On the neglect-zero hypothesis, people when interpreting a sentence construct representations of the world and in doing so they systematically neglect models that validate sentences by virtue of some empty configuration (zero-model). In what follows we sketch the first-order version QBSML ([3]) and apply it to our analysis with some additional assumptions.

The core idea of BSML is providing a method to formalize the *neglect-zero* effects by employing the non-emptiness atom (NE) from team logic ([22]), which is added as a part of the syntax.

Definition 1 (Language $\mathcal{L}_{\mathcal{D}}$). *The language $\mathcal{L}_{\mathcal{D}}$ is defined as following in BNF:*

$$\begin{aligned} \text{Term } t &::= c \mid x \\ \text{Formula } \varphi &::= P^n t_1 \dots t_n \mid \neg \varphi \mid \varphi \wedge \varphi \mid \varphi \vee \varphi \mid \exists x \varphi \mid \Box \varphi \mid \text{NE} \end{aligned}$$

As mentioned, the operator \Box stands for the verb *want*, and \Diamond , which stands for *it is ok...*, can be defined as the dual of \Box : $\Diamond \phi := \neg \Box \neg \phi$.

A *pragmatic enrichment function* (denoted by $[\cdot]^+$) is defined in terms of a systematic intrusion of NE in the process of interpretation:

Definition 2 (Pragmatic enrichment). *A pragmatic enrichment function is a mapping $[\cdot]^+$ from the NE-free fragment of language $\mathcal{L}_{\mathcal{D}}$ to $\mathcal{L}_{\mathcal{D}}$ such that:*

$$\begin{aligned} - [Pt_1 \dots t_n]^+ &= Pt_1 \dots t_n \wedge \text{NE} & - [\phi \wedge \psi]^+ &= ([\phi]^+ \wedge [\psi]^+) \wedge \text{NE} \\ - [-\phi]^+ &= \neg [\phi]^+ \wedge \text{NE} & - [\Box \phi]^+ &= \Box [\phi]^+ \wedge \text{NE} \\ - [\phi \vee \psi]^+ &= ([\phi]^+ \vee [\psi]^+) \wedge \text{NE} & - [\exists x \phi]^+ &= \exists x [\phi]^+ \wedge \text{NE} \end{aligned}$$

For the semantics, we treat \square as a bouletic modality in a classical Hintikka's style.

Definition 3 (Model \mathcal{M}).

A model for $\mathcal{L}_{\mathcal{D}}$ is a tuple $\mathcal{M} = \langle W, D, R, I \rangle$, where W is a set of possible worlds and D is a non-empty domain. R is bouletic accessibility relation on W . We define the abbreviation $R(w_i) = \{v \in W \mid w_i R v\}$, which denotes the set of worlds accessible from w_i . $I: W \times \mathcal{C} \cup \mathcal{P}^n \rightarrow D \cup \mathcal{P}(D^n)$ is an interpretation function which assigns entities to individual constants and sets of n -tuples of entities to predicate letters relative to worlds $w \in W$.

An information state in the first-order modal framework is defined as a set of indices. An index i is a pair $i = \langle w_i, g_i \rangle$ where $w_i \in W$ and $g_i = \mathcal{V} \rightarrow D$. By the indices, an information state can encode information about the value of variables in worlds. Now we can define the semantic clauses for $\mathcal{L}_{\mathcal{D}}$. We only show the semantics for the bouletic operator \square here. The other semantics clauses can be found in [3].

Definition 4 (Semantics). Let \mathcal{M} be a model for language $\mathcal{L}_{\mathcal{D}}$ and s be a state, we define what it means for a formula ϕ to be supported or anti-supported at s .

$$\begin{aligned} \mathcal{M}, s \models \square\phi & \text{ iff } \forall i \in s, R(w_i)[g_i] \models \phi \\ \mathcal{M}, s \models \square\phi & \text{ iff } \forall i \in s, \text{ there is } X \subseteq R(w_i) \text{ and } X \neq \emptyset \text{ and } X[g_i] \models \phi \end{aligned}$$

The abbreviation $X[g_i]$ is defined as follows:

$$- X[g_i] = \{ \langle w, g_i \rangle \mid w \in X \}$$

Since we define $\diamond\phi$ as $\neg\square\neg\phi$, the semantics for $\diamond\phi$ can be given as:

$$\begin{aligned} \mathcal{M}, s \models \diamond\phi & \text{ iff } \forall i \in s, \text{ there is } X \subseteq R(w_i) \text{ and } X \neq \emptyset \text{ and } X[g_i] \models \phi \\ \mathcal{M}, s \models \diamond\phi & \text{ iff } \forall i \in s, R(w_i)[g_i] \models \phi \end{aligned}$$

Notice that the notion of disjunction in BSML is different from the connective in classical logic, and comes from team logic and dependence logic ([18,22]). The semantics of a disjunction $\phi \vee \psi$ can be defined as follows:

$$\begin{aligned} \mathcal{M}, s \models \phi \vee \psi & \text{ iff } \exists t, t': t \cup t' = s \text{ and } \mathcal{M}, t \models \phi \text{ and } \mathcal{M}, t' \models \psi \\ \mathcal{M}, s \models \phi \vee \psi & \text{ iff } \mathcal{M}, s \models \phi \text{ and } \mathcal{M}, s \models \psi \end{aligned}$$

In the framework, \square - and \diamond -FC inferences can be derived from pragmatically enriched disjunctions. Proofs can be found in [3].

Fact 1 (FC inference)

$$\begin{aligned} - \diamond\text{-FC: } & \diamond[(Pa \vee Pb)]^+ \models \diamond Pa \wedge \diamond Pb \\ - \square\text{-FC: } & \square[(Pa \vee Pb)]^+ \models \diamond Pa \wedge \diamond Pb \end{aligned}$$

We have two constraints stated in Sec. 2. To address our puzzles, we need to formalise them in our framework.

As argued, we do not think that a predicate can always be interpreted as a disjunctive statement. It happens only if one of its sub-predicates becomes

salient in the context. To capture these, we define a *reinterpretation function* which only applies in case saliency is satisfied. Let Nfo be the set of all NE-free formulas of $\mathcal{L}_{\mathcal{D}}$, and Prt be the set of all atomic predication. A *reinterpretation function* $\|\text{Nfo}\|_{\text{P}_x}$ is a mapping from $\text{Nfo} \times \text{Prt}$ to NE-free formulas of $\mathcal{L}_{\mathcal{D}}$:

Definition 5 (Reinterpretation function).

$$\begin{aligned} - \|\mathcal{Q}\bar{x}\|_{\text{P}_x} &= \begin{cases} P_{\mathcal{Q}\bar{x}} \vee \neg P_{\mathcal{Q}\bar{x}} & \text{if } P \subset Q \\ \mathcal{Q}\bar{x} & \text{otherwise} \end{cases} & - \|\phi \vee \psi\|_{\text{P}_x} &= \|\phi\|_{\text{P}_x} \vee \|\psi\|_{\text{P}_x} \\ - \|\neg\phi\|_{\text{P}_x} &= \neg\|\phi\|_{\text{P}_x} & - \|\exists x\phi\|_{\text{P}_x} &= \exists x \|\phi\|_{\text{P}_x} \\ - \|\phi \wedge \psi\|_{\text{P}_x} &= \|\phi\|_{\text{P}_x} \wedge \|\psi\|_{\text{P}_x} & - \|\Box\phi\|_{\text{P}_x} &= \Box\|\phi\|_{\text{P}_x} \end{aligned}$$

The function intuitively says that, a predicate Q can be reinterpreted syntactically as $\lambda x[P_{\mathcal{Q}x} \wedge \neg P_{\mathcal{Q}x}]$ (where $P_{\mathcal{Q}x}$ stands for $Px \wedge Qx$) if P is a sub-predicate of Q , namely if the denotation of P is the proper subset of the denotation of Q . Notice that, in (Q)BSML, classically logically equivalent formulas can give rise to different pragmatic effects under the pragmatic enrichment $[\cdot]^+$, e.g. it is possible to have a counterexample where $[\exists x Qx]^+$ is supported but $[\exists x((Px \vee \neg Px) \wedge Qx)]^+$ is not. So it is not trivial to reinterpret a predicate disjunctively in our system.

Consequently, a formula $\varphi(\|\mathcal{Q}\bar{x}\|_{\text{P}_x})$ can be rewritten as $\varphi(P_{\mathcal{Q}\bar{x}} \vee \neg P_{\mathcal{Q}\bar{x}})$ by replacing Q in φ by $\lambda x[P_{\mathcal{Q}x} \vee \neg P_{\mathcal{Q}x}]$. Then, with the function of pragmatic enrichment, the examples in which there is no overt disjunctive statements now can be explained by FC.

3.2 Puzzles Revisited

The Ross' paradox can be explained by Fact 1 directly. As for the other two puzzles, the inferences leading to apparently pragmatic failure can be processed as follow:

Asher's puzzle

$$\begin{aligned} &\Box\exists x[\|\text{TRIP } x\|_{\text{FREE}}]^+ \\ &\models \Box\exists x[(\text{FREE}_{\text{TRIP}} x \vee \neg\text{FREE}_{\text{TRIP}} x)]^+ \\ &\models \Diamond\exists x(\neg\text{FREE}_{\text{TRIP}} x) \end{aligned}$$

Heim's example

$$\begin{aligned} &\Box\exists x[\|\text{TEACH } x\|_{\text{TTUE}}]^+ \\ &\models \Box\exists x[(\text{TTUE}_{\text{TEACH}} x \vee \neg\text{TTUE}_{\text{TEACH}} x)]^+ \\ &\models \Diamond(\neg\text{TTUE}_{\text{TEACH}} x) \end{aligned}$$

Both inferences can be verified by the definition of reinterpretation function and Fact 1. Also, if we think of the inferential pattern of the Heim's example to be (16), then it can be analyzed by \Diamond -FC.

4 Conclusion

We discussed three puzzles arising for monotonic semantics for desire verbs, and proposed a uniform pragmatic account for them. In our proposal, monotonicity under desire has been maintained, and thereby we provide evidences for the idea that classical semantics for *want* predicts correctly on monotonicity.

We propose that FC effects can be triggered by statements without overt disjunctions, since predicates in the sentences can be reinterpreted as disjunctive. As a result some additional inferences are drawn from monotonic reasoning, some of which are not justified by the premise. We then employ the logic QBSML extended with a reinterpretation function to capture the reasoning.

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