The Overtone of Monotonicity under Desire

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 [8,9,10,18], 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])

The Good Samaritan Paradox under Desire. In the same article Heim also presents another puzzle about desire, which shows a similar pattern with the Good Samaritan paradox[1] in deontic logic:

(2) a. I want to teach on Tuesdays next semester
b. I want to teach next semester

The inference in (2) 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 Paradox[2] ([13]), concerning the classically valid but intuitively invalid monotonic inference 'Send the letter! ⇒ 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.

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

[2] See [11] which gives a good overview.

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 ([16]).

Table 1. Comparing Predictions of Existing Analyses

Approaches	Ross' Paradox	Asher's Puzzle	The Good Samaritan
Von Fintel	Semantically valid	Pragmatically invalid	Semantically invalid
Heim	Semantically valid	Semantically invalid	Semantically invalid
Our propsal	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 Good Samaritan cases in a semantic manner. Von Fintel instead proposes a pragmatic account of the monotonicity failure in Asher's puzzle combined with a semantic explanantion of the Good Samaritan case where the monotonicity failure is argued to follow from the assumption of an independent presupposition. The case of Ross paradox is more subtle. Neither of them has a ready explanation of the puzzling inferences in Ross's paradox.

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 Fintel noted ([17]), 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.

Therefore we aim to provide a pragmatic account which can handle these puzzle uniformly. We will propose that all three puzzles can be reduced to cases of Free Choice (FC) inferences. The process leading to paradox will be clarified in the next section, especially in the case where no overt disjunctive statements exist. 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:

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

The sentence in (5-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 (6) is licensed:

(6) a. John wants to send the letter or burn it
b. $\rightsquigarrow$ It is ok for John to send the letter, **and** it is ok for him to burn it.[3]

However the inference to (6-b) is not justified by the premise (6-a) according to the classical logic. As Crnič observed the inference in (6) 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).

(7) 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 (7-a) to the inference in (6) as follows:

(8) $\Box_J\,(\mathtt{SEND} \vee \mathtt{BURN}) \rightsquigarrow \Diamond_J\mathtt{SEND} \wedge \Diamond_J\mathtt{BURN}$

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. [17,1]. 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:

(9) 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

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

case. But the puzzle hints that there is some additional information that can be acquired from the conclusion (9-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 (9) 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 (9-b):

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

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

(11) 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, she does care for the question "will my mom buy chocolate for me?". The question under discussion makes the predicate *chocolate* salient. Furthermore, we propose, it can influence the way people interpret the predicates that semantically include it. 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 reinterpret 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 that 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 [6,14], 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 (12-a) undergoes a disjunctive reinterpretation and then the disjunctive statement gives rise to a FC inference.

(12) a. Nicholas wants a trip
b. $\Leftrightarrow$ Nicholas wants a free trip or a non-free trip
[by disjunctive reinterpretation]
c. $\rightsquigarrow$ Nicholas is ok with a free trip and he is ok with a non-free trip.
[by $\Box$-FC principle]

As a result, Nicholas' attitude of accepting a non-free trip is concluded, which is unwarranted by the premise. Consequently, the monotonic reasoning in (9) appears to fail.

2.3 Free Choice triggered by Non-disjunctive Statements: the Good Samaritan

The Good Samaritan is repeated in the following:

(13) 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 desires is a teaching under the assumption that it is scheduled for Tuesdays next semester. According to our approach, the sentence in (13-b) can be represented as a disjunctive statement which generates a free choice inference showing the agent's attitude towards accepting teaching on the other days, which is unjustified:

(14) 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 (14), especially if we claim that the example is semantically safe on monotonicity. If the conclusion (13-b) is assumed to be false since it conveys that the agent doesn't show any desire to teach at all, then the premise where the desire of teaching on Tuesday is stated 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 doesn't express a pure desire, instead it shows a conditional desire. If so, our judgement of the conclusion (13-b) should be under the same condition. So the example should be rewritten in the following way:

(15) (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 (7-b):

(16) 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.

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 ([19]), 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:*

Term $t ::= c \mid x$

Formula $\varphi ::= P^n t_1 ... t_n \mid \neg\varphi \mid \varphi \wedge \varphi \mid \varphi \vee \varphi \mid \exists x \varphi \mid \Box \varphi \mid NE$

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:*

- $[Pt_1...t_n]^+ = Pt_1...t_n \wedge NE$
- $[\neg\phi]^+ = \neg[\phi]^+ \wedge NE$
- $[\phi \vee \psi]^+ = ([\phi]^+ \vee [\psi]^+) \wedge NE$
- $[\phi \wedge \psi]^+ = ([\phi]^+ \wedge [\psi]^+) \wedge NE$
- $[\Box\phi]^+ = \Box[\phi]^+ \wedge NE$
- $[\exists x \phi]^+ = \exists x [\phi]^+ \wedge NE$

For the semantics, we treat $\Box$ 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 $\mathcal{M} =< W, D, R, I >$, 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: $W \times \mathcal{C} \cup \mathcal{P}^n \to D \cup \mathcal{P}(D^n)$ 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=$< w_i, g_i >$ where $w_i \in W$ and $g_i = \mathcal{V} \to D$. 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 $\Box$ 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.*

$\mathcal{M}, s \vDash \Box\phi$ *iff* $\forall i \in s$, $R(w_i)[g_i] \vDash \phi$
$\mathcal{M}, s \dashv \Box\phi$ *iff* $\forall i \in s$, *there is* $X \subseteq R(w_i)$ *and* $X \neq \varnothing$ *and* $X[g_i] \dashv \phi$

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

– $X[g_i] = \{< w, g_i > \mid w \in X\}$

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

$\mathcal{M}, s \vDash \Diamond\phi$ iff $\forall i \in s$, there is $X \subseteq R(w_i)$ and $X \neq \varnothing$ and $X[g_i] \vDash \phi$
$\mathcal{M}, s \dashv \Diamond\phi$ iff $\forall i \in s$, $R(w_i)[g_i] \dashv \phi$

Notice that the notion of disjunction in BSML is different from the connective in classical logic, and comes from team logic and dependence logic ([15,19]). The semantics of a disjunction $\phi \vee \psi$ can be defined as follows:

$\mathcal{M}, s \vDash \phi \vee \psi$ iff $\exists t, t'$:$t \cup t'$=s and $\mathcal{M}, t \vDash \phi$ and $\mathcal{M}, t' \vDash \psi$
$\mathcal{M}, s \dashv \phi \vee \psi$ iff $\mathcal{M}, s \dashv \phi$ and $\mathcal{M}, s \dashv \psi$

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

Fact 1 ($\Box$-FC inference)

$\Box[(Pa \vee Pb)]^+ \vDash \Diamond Pa \wedge \Diamond Pb$

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* $\|\texttt{Nfo}\|_{\texttt{Px}}$ is a mapping from `Nfo`×`Prt` to `NE`-free formulas of $\mathcal{L}_{\mathcal{D}}$:

Definition 5 (Reinterpretation function).

- $\|Q\vec{x}\|_{P\vec{x}} = \begin{cases} P_Q\vec{x} \vee \neg P_Q\vec{x} & if\ P \subset Q \\ Q\vec{x} & otherwise \end{cases}$
- $\|\neg\phi\|_{P\vec{x}} = \neg \|\phi\|_{P\vec{x}}$
- $\|\phi \wedge \psi\|_{P\vec{x}} = \|\phi\|_{P\vec{x}} \wedge \|\psi\|_{P\vec{x}}$
- $\|\phi \vee \psi\|_{P\vec{x}} = \|\phi\|_{P\vec{x}} \vee \|\psi\|_{P\vec{x}}$
- $\|\exists x\phi\|_{P\vec{x}} = \exists x \|\phi\|_{P\vec{x}}$
- $\|\Box\phi\|_{P\vec{x}} = \Box \|\phi\|_{P\vec{x}}$

The function intuitively says that, a predicate Q can be reinterpreted syntactically as $\lambda x[P_Q x \wedge \neg P_Q x]$ (where $P_Q x$ 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 $\varphi(\|Q\vec{x}\|_{P\vec{x}})$ can be rewritten as $\varphi(P_Q\vec{x} \vee \neg P_Q\vec{x})$ by replacing Q in φ by $\lambda x[P_Q x \vee \neg P_Q x]$. 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

$\Box\exists x[\|\mathtt{TRIP\ x}\|_{\mathtt{FREE}}]^+$
$\vDash \Box\exists x[(\mathtt{FREE}_{\mathtt{TRIP}}\ x \vee \neg\mathtt{FREE}_{\mathtt{TRIP}}\ x)]^+$
$\vDash \Diamond\exists x(\neg\mathtt{FREE}_{\mathtt{TRIP}}\ x)$

The Good Samaritan

$\Box\exists x[\|\mathtt{TEACH}\ x\|_{\mathtt{TTUE}}]^+$
$\vDash \Box\exists x[(\mathtt{TTUE}_{\mathtt{TEACH}}\ x \vee \neg\mathtt{TTUE}_{\mathtt{TEACH}}\ x)]^+$
$\vDash \Diamond(\neg\mathtt{TTUE}_{\mathtt{TEACH}}\ x)$

Both inferences can be verified by the definition of reinterpretation function and Fact 1. Also, if we consider the inferential pattern of the Good Samaritan to be (15), 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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