# Disjunctions in state-based semantics

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# Introduction

- Free choice (FC) inferences:
  (1) a. Wide scope FC: $\Diamond a \vee \Diamond b \rightsquigarrow \Diamond a \wedge \Diamond b$
  b. Narrow scope FC: $\Diamond(a \vee b) \rightsquigarrow \Diamond a \wedge \Diamond b$
- Classical examples:
  (2) Deontic FC [Kamp 1973]
  a. You may go to the beach or (you may go) to the cinema.
  b. $\rightsquigarrow$ You may go to the beach and you may go to the cinema.

  (3) Epistemic FC [Zimmermann 2000]
  a. Mr. X might be in Victoria or (he might be) in Brixton.
  b. $\rightsquigarrow$ Mr. X might be in Victoria and he might be in Brixton.
- Long-standing debate on the status of FC inferences:
  - FC inferences as pragmatic implicatures [Schulz, Alonso-Ovalle, Klinedinst, Fox, Franke, Chemla, . . . ]
  - FC inferences as semantic entailments [Zimmermann, Geurts, Aloni, Simons, Barker, . . . ]
- Main goal
  - Discuss notions of disjunction proposed in state-based semantics with emphasis on their potential to account for FC either as a pragmatic or as a semantic inference
- Why state-based semantics (SBS)?
  - SBS particularly suitable to capture the inherent epistemic and/or alternative-inducing nature of disjunctive words in natural language

# Outlook

- The paradox of free choice permission
  - Pragmatic and semantic solutions
- Three notions of disjunction in state-based semantics:
  1. Classical disjunction: $\vee_1$
  2. Disjunction in dependence/assertion logic: $\vee_2$
  3. Disjunction in inquisitive/truthmaker semantics: $\vee_3$
- Three state-based systems for FC:
  1. System A: semantic account of narrow scope FC employing $\vee_3$;
  2. System B: semantic account of narrow & wide scope FC employing (enriched) $\vee_2$;
  3. System C: pragmatic account of FC employing $\vee_1$.
- Conclusions
  - Standard arguments in favour or against semantic/pragmatic accounts of FC will not be able to decide between the three;
  - All systems accounts for narrow scope FC;
  - Only system B accounts for wide scope FC;
  - System C will predict a difference between epistemic and deontic FC;
  - Possibly a combination of the three needed to account for the full range of free choice phenomena.

# The paradox of free choice

- Free choice permission in natural language:

(4) You may (A or B) $\rightsquigarrow$ You may A

- But (5) not valid in standard deontic logic (von Wright 1968):

(5) $\Diamond(\alpha \vee \beta) \rightarrow \Diamond\alpha$ [Free Choice Principle]

- Plainly making the Free Choice Principle valid, for example by adding it as an axiom, would not do (Kamp 1973):

(6)
1. $\Diamond a$ [assumption]
2. $\Diamond(a \vee b)$ [from 1, by modal addition]
3. $\Diamond b$ [from 2, by free choice principle]

- The step leading to 2 in (6) uses the following valid principle:

(7) $\Diamond\alpha \rightarrow \Diamond(\alpha \vee \beta)$ [Modal Addition]

- Natural language counterpart of (7), however, seems invalid, while natural language counterpart of (5) seems to hold, in direct opposition to the principles of deontic logic:

(8) You may A $\not\rightsquigarrow$ You may (A or B)

# Reactions to paradox

- Paradox of Free Choice Permission

(9)
1. $\Diamond a$ [assumption]
2. $\Diamond(a \vee b)$ [from 1, by modal addition]
3. $\Diamond b$ [from 2, by free choice principle]

- Pragmatic solutions: step leading to 3 unjustified, free choice is merely a pragmatic inference, a conversational implicature
- Semantic solutions: FC inferences as semantic entailments, step leading to 3 justified, while step leading to 2 no longer valid
- In this talk:
  1. Systems A/B: semantic accounts of FC inference
  2. System C: pragmatic account of FC inference
- Why both?
  - Once we bring indefinites into the picture a purely pragmatic or a purely semantic approach to FC is untenable;
  - (Canonical) arguments for/against semantic/pragmatic approaches are inconclusive.

# Free choice: semantics or pragmatics?

## Arguments in favour of semantic account of FC disjunction

- Free choice inferences are hard to cancel:

(10) Mary is patriotic or quixotic, in fact both. [scalar]

(11) You may go to Paris or London, ??in fact you may not go Paris. [free choice]

- In contrast to scalar implicatures, FC inferences seem to be part of what is said (Mastop, Aloni):

(12) MOTHER: You may do your homework or help your father in the kitchen.
SON GOES TO THE KITCHEN.
FATHER: Go to your room and do your homework!
SON: But, mom said I could also help you in the kitchen.

(13) MOTHER: Mary is patriotic or quixotic.
FATHER: She is both.
SON: ??But, mom said she is not both.

# Free choice: semantics or pragmatics?

## Argument in favour of pragmatic account of FC disjunction

- Free choice effects systematically disappear in negative contexts:

(14) No one is allowed to eat the cake or the ice-cream.

a. $\equiv \neg\exists x \Diamond(\phi(x) \vee \psi(x))$

b. $\not\equiv \neg\exists x(\Diamond\phi(x) \wedge \Diamond\psi(x))$

(14) never means (14-b), as would be expected if free choice effects were semantic entailments rather than pragmatic implicatures (Alonso-Ovalle 2005).

## Is this argument really conclusive?

- Our semantic systems A/B will account for the facts in (14);
- Our pragmatic system C, which predicts the availability of embedded FC implicatures (like Chierchia, Fox), will need adjustments to account for (14).

# State-based semantics

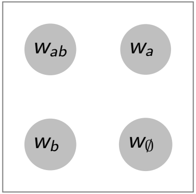
- In a state-based semantics formulas are interpreted wrt states rather than possible worlds

## Language

- The target language $L$ contains a set of sentential atoms $A = \{p, q, \dots\}$ and is closed under negation ($\neg$), conjunction ($\wedge$), disjunction ($\vee$), and a possibility modal ($\Diamond$).

## Worlds and States

- $w$ is a possible world iff $w : A \to \{0, 1\}$;
- A state $s$ is a set of possible worlds; ($\neq$ Fine 2015)
- Logical space for $A = \{a, b\}$:



## Basic semantic clauses

$$\begin{array}{rcl} s \models p & \text{iff} & \forall w \in s : w(p) = 1 \\ s \models \neg\phi & \text{iff} & \forall w \in s : \{w\} \not\models \phi \\ s \models \phi \wedge \psi & \text{iff} & s \models \phi \;\&\; s \models \psi \end{array}$$

## Entailment

- $\phi \models \psi$ iff $\forall s : s \models \phi \;\Rightarrow\; s \models \psi$.

## Distributivity

- $\phi$ is distributive, if $\forall s : s \models \phi \Leftrightarrow \forall w \in s : \{w\} \models \phi$.

## Facts

- $p$, $\neg\phi$ are distributive;
- $\emptyset \models \phi$, if $\phi$ is distributive;
- Relative to the distributive fragment of our language, this logic is classical.

## Three notions of disjunction

$s \models \phi \vee_1 \psi$ iff $\forall w \in s : \{w\} \models \phi$ or $\{w\} \models \psi$ (classical)

$s \models \phi \vee_2 \psi$ iff $\exists t, t' : t \cup t' = s$ & $t \models \phi$ & $t' \models \psi$ (dependence/assertion logic)

$s \models \phi \vee_3 \psi$ iff $s \models \phi$ or $s \models \psi$ (inquisitive/truthmaker semantics)

## Facts

1. $(\phi \vee_1 \psi) \equiv \neg(\neg\phi \wedge \neg\psi)$

If $\phi, \psi$ are distributive,

2. $(\phi \vee_1 \psi) \equiv (\phi \vee_2 \psi)$
3. $(\phi \vee_3 \psi) \models (\phi \vee_{1/2} \psi)$, but $(\phi \vee_{1/2} \psi) \not\models (\phi \vee_3 \psi)$

Counterexample: $\{w_a, w_b\} \models a \vee_{1/2} b$, but $\{w_a, w_b\} \not\models a \vee_3 b$

## Three notions of disjunction

$s \models \phi \vee_1 \psi$ iff $\forall w \in s : \{w\} \models \phi$ or $\{w\} \models \psi$ (classical)

$s \models \phi \vee_2 \psi$ iff $\exists t, t' : t \cup t' = s \;\&\; t \models \phi \;\&\; t' \models \psi$ (dependence/assertion logic)

$s \models \phi \vee_3 \psi$ iff $s \models \phi$ or $s \models \psi$ (inquisitive/truthmaker semantics)

## Different conceptualisations for different notions of disjunction

- $\vee_{1/2}$ makes sense if $s \models \phi$ reads as
  - "agent in state $s$ has enough evidence to assert $\phi$" (assertion logic);
- $\vee_3$ makes sense if $s \models \phi$ reads as
  - "$\phi$ is true because of fact $s$" (truthmaker semantics);
  - "$s$ contains enough information to resolve $\phi$" (inquisitive semantics).

$$\{w_a, w_b\} \models a \vee_{1/2} b, \text{ but } \{w_a, w_b\} \not\models a \vee_3 b$$

## Three notions of disjunction

$s \models \phi \vee_1 \psi$ iff $\forall w \in s : \{w\} \models \phi$ or $\{w\} \models \psi$ (classical)

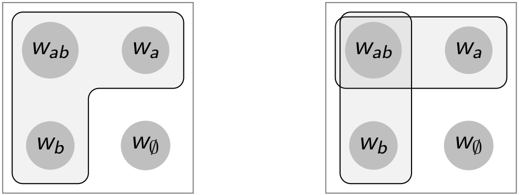
$s \models \phi \vee_2 \psi$ iff $\exists t, t' : t \cup t' = s \; \& \; t \models \phi \; \& \; t' \models \psi$ (dependence/assertion logic)

$s \models \phi \vee_3 \psi$ iff $s \models \phi$ or $s \models \psi$ (inquisitive/truthmaker semantics)

## Different semantic contents generated by different notions

Let $\phi, \psi$ be distributive and logically independent.

1. $\{s \mid s \models \phi \vee_3 \psi\}$ is inquisitive, i.e. it contains more than one maximal state, aka alternative;
2. $\{s \mid s \models \phi \vee_{1/2} \psi\}$ is not inquisitive.




(a) classical: $a \vee_{1/2} b$ (b) inquisitive: $a \vee_3 b$

# Four notions of modality

$s \models \Diamond_1\phi$ iff $s \cap info(\phi) \neq \emptyset$ & $s \cap info(\phi) \models \phi$ (context-sensitive, epistemic)

$s \models \Diamond_2\phi$ iff $\forall w \in s : \exists w' : wRw'$ & $\{w'\} \models \phi$ (relational, deontic)

$s \models \Diamond_3\phi$ iff $\forall s' \in Alt(\phi) : s \cap s' \neq \emptyset$ & $s \cap s' \models \phi$ (alt-sensitive, context-sensit)

$s \models \Diamond_4\phi$ iff $\forall w \in s : \forall s' \in Alt(\phi) : \lambda v.wRv \cap s' \neq \emptyset$ (alt-sensitive, relational)

$info(\phi) = \cup\{s \mid s \models \phi\}$ & $Alt(\phi) = \{s \mid s \models \phi \text{ \& } \neg\exists s' : s' \models \phi \text{ \& } s \subset s'\}$

- $\Diamond_1$ inspired by illegitimacy of asserting both "it might be that $\phi$" and "it is not the case that $\phi$" in a single context (Veltman, Yalcin):
  - Epistemic contradiction: $\Diamond_1\phi \wedge \neg\phi \models \bot$
  - Non-factivity: $\Diamond_1\phi \not\models \phi$
- $\Diamond_2$ is a classical modal operator interpreted wrt a relational structure:
  - No modal contradiction: $\Diamond_2\phi \wedge \neg\phi \not\models \bot$
  - Non-factivity: $\Diamond_2\phi \not\models \phi$
- $\Diamond_{3/4}$ are alternative-sensitive versions of $\Diamond_{1/2}$ motivated by phenomena of free choice (Aloni 2002):
  - $s \models \Diamond_{3/4}\phi$ iff $\forall w \in s : s/\lambda v.wRv$ is consistent with all maximal states (alternatives) which support $\phi$
- If $\phi$ is not inquisitive: $\Diamond_1\phi \equiv \Diamond_3\phi$ & $\Diamond_2\phi \equiv \Diamond_4\phi$

# Some facts

## Facts concerning distributivity

- Context-sensitive $\Diamond_{1/3}\phi$ are not distributive
- Relational $\Diamond_{2/4}\phi$ are distributive

## Facts concerning disjunction

- $(\phi \vee_{1/3} \psi) \not\models (\phi \vee_2 \psi)$
  Counterexample: $\{w_a\} \models \Diamond_1 a \vee_{1/3} \Diamond_1 b$, but $\{w_a\} \not\models \Diamond_1 a \vee_2 \Diamond_1 b$
- $(\phi \vee_2 \psi) \not\models (\phi \vee_1 \psi)$
  Counterexample: $\{w_a, w_\emptyset, w_b\} \models \Diamond_1 a \vee_2 \Diamond_1 b$, but $\{w_a, w_\emptyset, w_b\} \not\models \Diamond_1 a \vee_1 \Diamond_1 b$
- If $\phi, \psi$ are distributive, $(\phi \vee_1 \psi) \equiv (\phi \vee_2 \psi)$, $(\phi \vee_3 \psi) \models (\phi \vee_{1/2} \psi)$

# Facts about free choice

- Dependence/assertion logic $\vee_2$ in combination with context-sensitive $\Diamond_{1/3}$ gives us wide scope FC (Hawke & Steiner-Threlkeld 2015):

$$\Diamond_{1/3}a \vee_2 \Diamond_{1/3}b \models \Diamond_{1/3}a \wedge \Diamond_{1/3}b$$
$$a \vee_2 b \not\models \Diamond_{1/3}a \wedge \Diamond_{1/3}b$$

- Inquisitive/truthmaker $\vee_3$ with alternative-sensitive $\Diamond_{3/4}$ gives us narrow scope FC inference (Aloni 2002, 2007):

$$\Diamond_{3/4}(a \vee_3 b) \models \Diamond_{3/4}a \wedge \Diamond_{3/4}b$$

- But problems under negation:

$$\neg(\Diamond_{1/3}a \vee_2 \Diamond_{1/3}b) \not\models \neg\Diamond_{1/3}a \wedge \neg\Diamond_{1/3}b$$
$$\neg\Diamond_{3/4}(a \vee_3 b) \not\models \neg\Diamond_{3/4}a \wedge \neg\Diamond_{3/4}b$$

# System A: semantic account of narrow scope free choice

- We adopt the following:
  - inquisitive $\vee_3$;
  - alternative-sensitive (context-sensitive) $\Diamond_3$ for epistemic modals;
  - alternative-sensitive (relational) $\Diamond_4$ for deontic modals.
- The semantics consists in a simultaneous recursive definition of two notions (see e.g. Fine)
  - $s \vdash \phi$ interpreted as $s$ provides enough evidence for verifying/resolving $\phi$;
  - $s \dashv \phi$ interpreted as $s$ provides enough evidence for falsifying/rejecting $\phi$.
- Adopting a bilateral system allows us to get better predictions for free choice under negation (similar strategy as in Roelofsen and Groenendijk (InqS), Willer 2015).

# System A: definitions

## Semantic clauses

$$
\begin{array}{rcl}
s \vdash p & \text{iff} & \forall_\exists w \in s : w(p) = 1 \\
s \dashv p & \text{iff} & \forall_\exists w \in s : w(p) = 0 \\
s \vdash \neg\phi & \text{iff} & s \dashv \phi \\
s \dashv \neg\phi & \text{iff} & s \vdash \phi \\
s \vdash \phi \wedge \psi & \text{iff} & s \vdash \phi \;\&\; s \vdash \psi \\
s \dashv \phi \wedge \psi & \text{iff} & s \dashv \phi \text{ or } s \dashv \psi \\
s \vdash \phi \vee_3 \psi & \text{iff} & s \vdash \phi \text{ or } s \vdash \psi \\
s \dashv \phi \vee_3 \psi & \text{iff} & s \dashv \phi \;\&\; s \dashv \psi \\
s \vdash \Diamond_3\phi & \text{iff} & \forall s' \in Alt(\phi) : s \cap s' \neq \emptyset \;\&\; s \cap s' \vdash \phi \\
s \dashv \Diamond_3\phi & \text{iff} & \forall s' \in Alt(\phi) : s \cap s' = \emptyset \text{ or } s \cap s' \dashv \phi \\
s \vdash \Diamond_4\phi & \text{iff} & \forall_\exists w \in s : \forall s' \in Alt(\phi) : \lambda v.wRv \cap s' \neq \emptyset \\
s \dashv \Diamond_4\phi & \text{iff} & \forall_\exists w \in s : \forall s' \in Alt(\phi) : \lambda v.wRv \cap s' = \emptyset
\end{array}
$$

Support-entailment: $\phi \models_A \psi$ iff $\forall s : s \vdash \phi \Rightarrow s \vdash \psi$

# System A: predictions

- System A diverges from the treatment of negation in basic inquisitive semantics (InqB):

$$\phi \vee_3 \psi \quad \equiv_A \quad \neg(\neg\phi \wedge \neg\psi)$$
$$\neg\neg\phi \quad \equiv_A \quad \phi$$

- Narrow scope FC as semantic entailment (well-behaving under negation): [$\Diamond \mapsto \Diamond_{3/4}$ & $\vee \mapsto \vee_3$]

$$\Diamond(\phi \vee \psi) \quad \models_A \quad \Diamond\phi \wedge \Diamond\psi$$
$$\neg\Diamond(\phi \vee \psi) \quad \models_A \quad \neg\Diamond\phi \wedge \neg\Diamond\psi$$

- Allowing to pre-encode what should happen under negation, bilateral systems are more descriptive than explanatory.
- No account of wide scope FC:

$$\Diamond\phi \vee \Diamond\psi \quad \not\models_A \quad \Diamond\phi \wedge \Diamond\psi$$

# System B: semantic account of wide and narrow scope FC

- Adopt $\vee_2$ and $\Diamond_1$ [thanks to J. Groenendijk for this suggestion]
- Crucially, in semantic clause for atoms $s$ is required to be non-empty:

$$s \vdash p \quad \text{iff} \quad s \neq \emptyset \ \& \ \forall w \in s : \forall w \in s : w(p) = 1$$
$$s \vdash \phi \vee_2 \psi \quad \text{iff} \quad \exists t, t' : t \cup t' = s \ \& \ t \vdash \phi \ \& \ t' \vdash \psi$$
$$s \vdash \Diamond_1 \phi \quad \text{iff} \quad s \cap info(\phi) \vdash \phi$$

- In this system: a state $s$ supports a disjunction iff $s$ can be split into two non-empty substates, each supporting one of the disjuncts, e.g.
  - $\{w_a, w_b\}$, $\{w_{ab}\}$ support $(a \vee b)$;
  - but $\{w_a\}$, $\{w_b\}$ no longer support $(a \vee b)$.
- To account for negation facts we adopt again a bilateral system:
  - $s \vdash \phi$ interpreted as "agent in $s$ has enough evidence to assert $\phi$";
  - $s \dashv \phi$ interpreted as "agent in $s$ has enough evidence to reject $\phi$".

# System B: definitions (still under construction)

## Semantic clauses

$$
\begin{array}{rll}
s \vdash p & \text{iff} & \forall_{\exists} w \in s : w(p) = 1 \\
s \dashv p & \text{iff} & \forall_{\exists} w \in s : w(p) = 0 \\
s \vdash \neg\phi & \text{iff} & s \dashv \phi \\
s \dashv \neg\phi & \text{iff} & s \vdash \phi \\
s \vdash \phi \wedge \psi & \text{iff} & s \vdash \phi \ \& \ s \vdash \psi \\
s \dashv \phi \wedge \psi & \text{iff} & s \dashv \phi \ \text{ or } s \dashv \psi \text{ or } \exists t, t' \neq \emptyset : t \cup t' = s \ \& \ t \dashv \phi \ \& \ t' \dashv \psi \\
s \vdash \phi \vee_2 \psi & \text{iff} & \exists t, t' : t \cup t' = s \ \& \ t \vdash \phi \ \& \ t' \vdash \psi \\
s \dashv \phi \vee_2 \psi & \text{iff} & s \dashv \phi \ \text{ and } s \dashv \psi \\
s \vdash \Diamond_1 \phi & \text{iff} & s \cap \mathit{info}(\phi) \vdash \phi \\
s \dashv \Diamond_1 \phi & \text{iff} & s \dashv \phi
\end{array}
$$

Support-entailment: $\phi \models_B \psi$ iff $\forall s : s \vdash \phi \ \Rightarrow s \vdash \psi$

# System B: predictions

- We derive narrow scope and wide scope FC:
  1. $\Diamond_1(a \vee_2 b) \models_B \Diamond_1 a \wedge \Diamond_1 b$
  2. $\Diamond_1 a \vee_2 \Diamond_1 b \models_B \Diamond_1 a \wedge \Diamond_1 b$
- FC effects are more fine-grained than in system A:
  3. $\Diamond_1(a \vee_2 (a \wedge b)) \models_B \Diamond_1 a \wedge \Diamond_1 (a \wedge b)$
  4. $\Diamond_1 a \vee_2 \Diamond_1 (a \wedge b) \models_B \Diamond_1 a \wedge \Diamond_1 (a \wedge b)$
- FC effects also for plain disjunction and $\Box$: ($\neq$ system A)
  5. $(a \vee_2 b) \models_B \Diamond_1 a \wedge \Diamond_1 b$
  6. $\Box_1(a \vee_2 b) \models_B \Diamond_1 a \wedge \Diamond_1 b$ ($\Box_1 \equiv \neg\Diamond_1\neg$)
- FC effects disappear under negation:
  7. $\neg\Diamond_1(a \vee_2 b) \models_B \neg\Diamond_1 a \wedge \neg\Diamond_1 b$
  8. $\neg(\Diamond_1 a \vee_2 \Diamond_1 b) \models_B \neg\Diamond_1 a \wedge \neg\Diamond_1 b$
  9. $\neg(a \vee_2 b) \models_B \neg a \wedge \neg b$
- But, behaviour under negation is postulated rather than predicted;
- Logic is highly non-standard, e.g. we lose addition:
  - $a \not\models_B (a \vee b)$
- System B predicts obligatory, but not embeddable FC effects:
  - Possibly correct for disjunction under epistemics, but what about deontics? And what about (FC) indefinites?

# Epistemic vs deontic free choice (Aloni & Franke)

- A number of constructions in various languages display different behaviour in the scope of epistemic and deontic modals:
  - Romanian epistemic determiner *vreun* [Fălăuș 2009,11,12]
    - Licensed under epistemics, not licensed under deontics
  - Slovenian concessive scalar particle *magari* [Crnič 2011, 2012]
    - Licensed under deontics, not licensed under epistemics
  - German epistemic determiner *irgendein* [Kratzer & Shimoyama 02]
    - Gives rise to different inferences under the two modals [Aloni & Port 2011]
- Common (implicit) assumption recent analyses:
  - Deontic and epistemic modals differ in the way they license free choice inferences MODAL VARIABILITY HYPOTHESIS (MVH)
    - Epistemic FC: well-behaved pragmatic inference

      (15) $\Diamond_e/\Box_e(a \vee b) \rightsquigarrow \Diamond_e a \wedge \Diamond_e b$ (non-embeddable)

    - Deontic FC: more able to penetrate into the compositional computation of semantic values

      (16) $\Diamond_d/\Box_d(a \vee b) \rightsquigarrow \Diamond_d a \wedge \Diamond_d b$ (embeddable)

# Further evidence for MVH: Universal free choice (UFC)

- Deontic FC-inferences associated with disjunction can take scope under universal quantifiers, so-called *universal free choice*:

(17) Deontic [Chemla 2009]

a. All of the boys may go to the beach or to the cinema.

b. $\rightsquigarrow$ All of the boys may go to the beach and all of the boys may go to the cinema.

c. $\forall x \Diamond_d(\phi \vee \psi) \rightsquigarrow \forall x(\Diamond_d \phi \wedge \Diamond_d \psi)$

[$\Rightarrow$ evidence against globalist accounts]

- Universal free choice does not arise as readily for epistemic modals:

(18) Epistemic [Geurts & Pouscoulous 2009, van Tiel 2011]

a. According to the professor, every research question might be answered by a survey or an experiment.

b. ?? $\rightsquigarrow$ According to the professor, every research question might be answered by a survey, and, according to the professor, every research question might be answered by an experiment.

[$\Rightarrow$ evidence against localist accounts]

# System C: pragmatic account of narrow scope free choice

- We interpret $s \models \phi$ as $\phi$ is assertable in state $s$ (unilateral system)
- Entailment as support preservation: $\phi \models_C \psi$ iff $\forall s : s \models \phi \Rightarrow s \models \psi$
- We adopt the following:
  - Or $\mapsto \vee_1$ $\Rightarrow \vee$
  - Epistemic modality $\mapsto \Diamond_1$ (context-sensitive) $\Rightarrow \Diamond_e$
  - Deontic modality $\mapsto \Diamond_2$ (relational) $\Rightarrow \Diamond_d$
- Narrow FC inferences derived as implicatures which can be incorporated
  - Implicatures generated via calculation of optimal states (Schulz)
  - Incorporation of implicatures in terms of $+I$ operation (Aloni 2012)
- Relevant predictions:
  - Narrow scope epistemic and deontic free choice derived as implicatures for both $\Diamond$ and $\Box$;
  - Only deontic free choice as embeddable implicatures.

## FC as implicatures

- Derivation of FC inference as (quantity) implicature is not trivial
- We want to derive:

(19) You may (A or B) $\rightsquigarrow$ you may A

- But natural gricean reasonings do not give us the desired effect:

(20)
a. Speaker S said *may(A or B)* rather than *may(A and B)*, which would also have been relevant;
b. *may(A and B)* is more informative than *may(A or B)*;
c. If S had the info that *may(A and B)*, she would have said so by QUANTITY;
d. Thus S has no evidence that *may(A and B)*;
e. S is well informed;
f. Thus *may(A and B)* is false.

(21)
a. Speaker S said *may(A or B)* rather than *may(A)*, which would also have been relevant;
b. *may(A)* is more informative than *may(A or B)*;
c. If S had the info that *may(A)*, she would have said so by QUANTITY;
d. Thus S has no evidence that *may(A)*;
e. S is well informed;
f. Thus *may(A)* is false.

# Fox 2006: a syntactic/pragmatic solution

- Fox' account:
  - ignorance implicatures derived by gricean reasoning [⇒ not embeddable]
  - scalar implicatures instead are represented in the grammar by the *exh* operator (with a meaning akin to that of 'only') [⇒ embeddable]
  - FC implicatures as result of recursive application of *exh*: [⇒ embeddable]

(22) $exh(A')(exh(A)(\Diamond(a \vee b))) = \Diamond(a \vee b) \wedge \neg\Diamond(a \wedge b) \wedge \Diamond a \wedge \Diamond b$

[under certain assumptions on $A$ and $A'$]

- In the account I will sketch below:
  - Ignorance implicatures & epistemic FC [⇒ not embeddable]
  - Scalar implicatures and deontic FC [⇒ embeddable]

⇒ the divide between ignorance vs scalar implicatures is derived, not postulated

⇒ a distinction between epistemic FC vs deontic FC is predicted: only the latter is embeddable

# Implicatures in a state-based semantics

- Implicatures generated via calculation of optimal states:
  - *opt*$(\phi)$: set of states considered optimal for a speaker of $\phi$
  - Implicatures of $\phi$: what holds in any state in *opt*$(\phi)$ (Schulz 2005)

(23) $\phi \rightsquigarrow \psi$ iff $\forall s \in opt(\phi) : s \models \psi$ and $\phi \not\models \psi$

  - Algorithms to compute *opt*$(\phi)$ based on Gricean principles and/or game-theoretical concepts (Aloni 2007, Franke 2009, 2011)
- Illustrations (Franke 2009, 2011): [assume $W = \{w_a, w_b, w_{ab}, w_\emptyset\}$]

(24) a. $a \vee b$ [plain disjunction]
b. $opt(a \vee b) = \{\{w_a, w_b\}\}$
c. predicted implicatures: $\Diamond_e a \wedge \Diamond_e b$, $\neg(a \wedge b)$, ...

$\Rightarrow$ ignorance and scalar implicatures derived for plain disjunction

## FC-implicatures in a state-based semantics

- Illustrations (Franke 2009,2011): [assume $W = \{w_a, w_b, w_{ab}, w_\emptyset\}$]

(25) a. $\Diamond_e(a \vee b)$ [epistemic possibility]
b. $opt(\Diamond_e(a \vee b)) = \{\{w_a, w_b\}, \{w_a, w_b, w_\emptyset\}\}$
c. pred. implicatures: $\Diamond_e a \wedge \Diamond_e b$, $\neg\Diamond_e(a \wedge b)$, ...

(26) a. $\Box_e(a \vee b)$ [epistemic necessity]
b. $opt(\Box_e(a \vee b)) = \{\{w_a, w_b\}, \{w_a, w_b, w_{ab}\}\}$
c. predicted implicatures: $\Diamond_e a \wedge \Diamond_e b$, $\neg\Box_e(a \wedge b)$, ...

(27) a. $\Diamond_d(a \vee b)$ [deontic possibility]
b. $opt(\Diamond_d(a \vee b)) = \{\{w \rightarrow [w_a, w_b] \mid w \in W\}, \{w \rightarrow [w_a, w_b, w_\emptyset] \mid w \in W\}\}$
c. pr. implicatures: $\Diamond_d a \wedge \Diamond_d b$, $\neg\Diamond_d(a \wedge b)$, ...

(28) a. $\Box_d(a \vee b)$ [deontic necessity]
b. $opt(\Box_d(a \vee b)) = \{\{w \rightarrow [w_a, w_b] \mid w \in W\}, \{w \rightarrow [w_a, w_b, w_{ab}] \mid w \in W\}\}$
c. predicted implicatures: $\Diamond_d a \wedge \Diamond_d b$, $\neg\Box_d(a \wedge b)$, ...

$\Rightarrow$ FC-implicatures derived for disjunction under epistemic and deontic modals

# Uptaking implicatures via $+I$

- Originally from update semantics (Aloni 2012): After updating with $\phi$ one can uptake the implicatures of $\phi$ via merging with $\cup opt(\phi)$:

(29) $\sigma[\phi + I] = \sigma[\phi] + \cup opt(\phi)$ [propositional case: $+ = \cap$]

- Static state-based version:

(30) $s \models \phi + I$ iff $s \models \phi$ & $s \subseteq \cup opt(\phi)$

## Illustration

- Ignorance and scalar implicatures both derived for plain disjunctions, but only scalar implicatures can be incorporated via $+I$:
  - $(a \vee b) \rightsquigarrow \neg(a \wedge b), \Diamond_e a \wedge \Diamond_e b$
  - $(a \vee b) + I \models_C \neg(a \wedge b)$ [scalar]
  - $(a \vee b) + I \not\models_C \Diamond_e a \wedge \Diamond_e b$ [ignorance]
    Counterexample $\{w_a\} \models (a \vee b) + I$, but $\{w_a\} \not\models \Diamond_e a \wedge \Diamond_e b$
- Crucial difference between scalar and ignorance implicatures:
  - Scalar implicatures are persistent (survive information growth); ignorance implicatures are non-persistent
  - Only persistent info can be uptaken in a non vacuous fashion!

# System C: free choice inferences

- Narrow scope free choice as an implicature:

$$\Box_e/\Diamond_e(\phi \vee \psi) \quad \rightsquigarrow \quad \Diamond_e\phi \wedge \Diamond_e\psi$$
$$\Box_d/\Diamond_d(\phi \vee \psi) \quad \rightsquigarrow \quad \Diamond_d\phi \wedge \Diamond_d\psi$$

- Only deontic free choice as embeddable implicature:

$$\Box_e/\Diamond_e(\phi \vee \psi) + I \quad \not\models_C \quad \Diamond_e\phi \wedge \Diamond_e\psi$$
$$\Box_d/\Diamond_d(\phi \vee \psi) + I \quad \models_C \quad \Diamond_d\phi \wedge \Diamond_d\psi$$

$\Rightarrow$ Only deontic FC-inferences can infiltrate compositional semantics

# Application: Universal free choice

⇒ Universal free choice predicted for deontics but not for epistemics:

(31) Deontic

a. All of the boys may go to the beach or to the cinema.

b. $\rightsquigarrow$ All of the boys may go to the beach and all of the boys may go to the cinema.

c. $\forall x(\Diamond_d(\phi \vee \psi) + I) \models \forall x(\Diamond_d \phi \wedge \Diamond_d \psi)$

(32) Epistemic

a. Every research question might be answered by a survey or an experiment.

b. ?? $\rightsquigarrow$ Every research question might be answered by a survey, and every research question might be answered by an experiment.

c. $\forall x(\Diamond_e(\phi \vee \psi) + I) \not\models \forall x(\Diamond_e \phi \wedge \Diamond_e \psi)$

- UFC sometimes possible for epistemics but only in contexts where epistemic info is at issue. In these cases epistemic modals should be formalised as relational modals.

# What about negation?

- Potential problem: $+I$ overgenerates, if unconstrained: (33-b) wrongly predicted as possible reading of (33):

(33) None of the boys may go to the beach or to the cinema.

a. $\neg\exists x \Diamond_d(\phi \vee \psi)$
$\rightsquigarrow$ All of the boys are not permitted to go to either.

b. $\neg\exists x(\Diamond_d(\phi \vee \psi) + I)$ $[\equiv \neg\exists x(\Diamond_d(\phi \vee \psi) \wedge \Diamond_d\phi \wedge \Diamond_d\psi)]$
$\rightsquigarrow$ All of the boys are permitted one option, but none is free to choose.

- Proposal: $+I$ never applies unless needed:
  1. to create stronger/more relevant statement
  2. to rescue polarity items
- Consequences:
  - $+I$ does not apply in downward-entailing environments as in (33), where it would create a weaker statement;
  - But $+I$ can apply in UFC sentences like (31) where it creates stronger statements.

# Conclusion

## Summary

Three state-based systems for FC inference:

- System A: inquisitive $\vee_3$ + alternative-sensitive $\Diamond_3$ and $\Diamond_4$
  - narrow scope FC as entailments (well-behaving under negation)
  - uniform account of deontic and epistemic FC
  - no account of wide scope FC
- System B: assertion $\vee_2$ + context-sensitive $\Diamond_1$
  - Narrow and wide scope FC as entailments (well-behaving under negation)
  - FC effects also for plain disjunction and under $\Box$
  - logic is highly non-standard
  - no account of interaction deontics and epistemics
- System C: classical $\vee_1$ + context-sensitive $\Diamond_1$ and relational $\Diamond_2$
  - narrow scope FC as implicatures (both $\Diamond$ and $\Box$)
  - only deontic FC as embeddable implicature

## Open issues

- How to deal with (free choice) indefinites in any of these systems;
- How to deal with implication (and SDA) in any of these systems.