A logical account of free choice imperatives*

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But how many kinds of sentence are there? Say assertion, question, and command? – There are countless kinds [. . .]

Wittgenstein, PU, §23

Abstract

Since Ross's observation that the instruction *Post this letter* does not entail *Post this letter or burn it*, imperatives have constituted a challenge for the logician. Building on ideas from inquisitive semantics, we propose an account in which imperatives are regarded as partial specifications of a set of options. We show that this account avoids Ross's paradox and gives rise to a sensible notion of imperative entailment.

1 A naïve attempt

A hypothesis What is the meaning of an imperative sentence, such as *Close the door*? In the case of a declarative sentence, its meaning is usually taken to lie in its truth conditions, which define what a state of affairs must be like in order for the sentence to be true. In this view, we can think of a declarative sentence as a partial specification of a certain state of affairs.

Technically, states of affairs are modeled by means of the notion of a possible world, and truth conditions for sentences come in the form of a definition of a satisfaction relation $\models$, relating possible worlds to sentences. If $|\varphi| = \{w \mid w \models \varphi\}$ denotes the set of worlds where the declarative sentence φ is true, then φ may be formally thought of as partially specifying a state of affairs by locating it within the set $|\varphi|$.

Is it possible to analyze imperative sentences along similar lines? Can imperatives also be thought of as specifying something, and if so, what?

Unlike declarative, imperatives do not seem to be about a state of affairs. It would not make sense to ask, for instance, whether an imperative is true or false in the actual state of affairs. What *can* meaningfully be asked about an imperative, however, is what type of behaviour, or *conduct*, someone should keep in order to comply with it.

This observation suggests the tempting idea to formulate a semantics for imperatives that departs minimally from the truth-conditional semantics for declaratives. Perhaps imperative sentences are just like declarative sentences after all, except that they talk about something different, namely, about conducts rather than states of affairs. Just like the meaning of an indicative consists in its truth conditions, the meaning of an imperative would then consist in its *compliance conditions*, which define what a conduct must be like in order to comply with the imperative. An imperative sentence would then be regarded as providing a partial specification of a certain conduct.

What conduct one intends to specify when uttering an imperative is a pragmatic matter that will depend largely upon the context. It may be the conduct that the speaker wants

*This article is dedicated to Jeroen, Martin, and Frank, our teachers and mentors. We can hardly imagine how our life would be if we had not met you. Thank you for your guidance and your enthusiasm, for the elegance of your work, and for the clarity and the depth of your thought.

the addressee to keep, or it may be something quite different. If one is giving directions, it will be the conduct that would lead the addressee to the place they want to go. In a mathematical proof, it will be the conduct that would lead the addressee to conclude the statement of the theorem. Notice that, in this respect, imperative sentences do not differ from indicative ones, for which this kind of context dependence also holds. In normal circumstances, one uses declaratives to specify the *actual* state of affairs. But this is not always the case: in a fiction book, for instance, sentences are intended to specify a state of affairs other than the actual one. We will come back to this issue in section 3.

A formal language for imperatives Our first hypothesis is, thus, that the meaning of an imperative lies in its compliance conditions. In order to investigate this proposal more closely, and to see how far the analogy between imperatives and indicatives may be pushed, let us try to adapt to imperatives those logical tools and notions that tradition has made available for declaratives. It turns out that, if we content ourselves with a very minimal approach, this is straightforward.

First, we want to specify a formal language whose formulas will stand for imperatives. We start from a basic language of *action formulas*, which we will take to be formulas in a standard first-order language. Atomic action formulas will stand for basic actions: R for *Run*, Ca for *Call Alf*, Iab for *Introduce Alf to Bea*, and so on. Complex action formulas may then be formed by means of negation (*Don't close the door*), disjunction (*Call Alf or call Bea*) and conjunction (*Close the door and call Alf*). Also, imperatives may be quantified universally (*Call everyone*) and existentially (*Call someone*). Connectives and quantifiers are denoted by their usual symbols $\neg, \vee, \wedge, \forall$ and $\exists$. An *imperative* is a formula $!\varphi$, where φ is an action sentence, that is, an action formula with no free variables.[1]

Compliance conditions Our second task is to give a formal definition of *conduct*. Since conducts will have to be models for our language, our choice of a first-order language leads us naturally to model conducts as first-order models. Let us fix a discourse structure $\mathbb{D}$, consisting of a domain D of individuals and of an interpretation I for constant symbols.

Definition 1.1 (Conducts)**.** A conduct on the discourse structure $\mathbb{D}$ is a function c mapping any $n-$ary relation R to a set $c(R) \subseteq D^n$ of n-tuples.

Thus, a conduct c specifies completely, relative to an assignment, which basic actions formulas are complied with and which are not. It is then up to us to define the compliance conditions for complex formulas. Compliance conditions come with no surprises: a conduct complies with a negation $\neg\varphi$ iff it does not comply with φ; it complies with a disjunction $\varphi\vee\psi$ iff it complies with φ or it complies with ψ; and so on. Formally, we have the following clauses, where $[t]_g$ stands for the individual denoted by the term t under the assignment g, as usual.

Definition 1.2 (Compliance conditions)**.**

1. $c \models_g R(t_1, \ldots, t_n) \iff \langle [t_1]_g, \ldots, [t_n]_g \rangle \in c(R)$
2. $c \models_g \neg\varphi \iff c \not\models_g \varphi$
3. $c \models_g \varphi \vee \psi \iff c \models_g \varphi$ or $c \models_g \psi$
4. $c \models_g \varphi \wedge \psi \iff c \models_g \varphi$ and $c \models_g \psi$
5. $c \models_g \forall x\varphi \iff c \models_{g[x\mapsto d]} \varphi$ for all $d \in D$
6. $c \models_g \exists x\varphi \iff c \models_{g[x\mapsto d]} \varphi$ for some $d \in D$

[1]The reader should not be confused by the fact that, in inquisitive semantics, ! is often used as a shorthand for double negation. We will not make use of that convention here.

The *compliance set* of an action formula φ, notation $|\varphi|_g$, is the set of conducts that comply with φ relative to the assignment g.

$$|\varphi|_g = \{c \mid c \models_g \varphi\}$$

Of course, for sentences, the particular assignment g makes no difference, and reference to it will be dropped.

We could then think of an imperative sentence $!\varphi$ as a partially specifying a conduct by locating it in $|\varphi|$. Given this perspective, it would be natural to say that an imperative $!\varphi$ *entails* an imperative $!\psi$ in case the compliance conditions of φ are at least as stringent as those of ψ, or in other words, if whenever one complies with φ, one automatically complies with ψ as well.

Definition 1.3 (Entailment, tentative)**.**

- $!\varphi \models !\psi \iff |\varphi| \subseteq |\psi|$

Ross's paradox If this proposal were correct, the distinction between imperatives and declaratives would lie uniquely in what our first-order models stand for: states of affairs in the case of declaratives, conducts in the case of imperatives. There would not, however, be any formal difference between the two cases, since the semantic clauses are exactly the same. In particular, this would mean that declaratives and imperatives share the same logical properties. That is, if $\models_{cl}$ denotes entailment in classical first-order logic, we would have:

$$!\varphi \models !\psi \iff \varphi \models_{cl} \psi$$

This conclusion simply falls out of our basic assumption that the meaning of an imperative lies in its compliance conditions, coupled with what seems to be the natural treatment for connectives and quantifiers.

Surprisingly, this prediction is contradicted by basic counterexamples. As Ross (1941) remarked, the simple disjunctive weakening $!\varphi \models !(\varphi \vee \psi)$ fails for imperatives. When told (1-a), one is not entitled to infer (1-b).

(1) a. Post this letter.
b. Post this letter or burn it.

Yet, it is true that the compliance conditions of (1-a) entail those of (1-b): after all, if one complies with (1-a), and thus post the letter, it is certainly the case that one posts the letter or burns it, and thus one also complies with (1-b). Thus, the failure of this entailment indicates that there is more to the meaning of imperatives than compliance conditions.

The logical puzzle presented by imperatives looks even more interesting if we remark that the contrapositive entailment, $!\neg(p \vee q) \models !\neg p$, does seem valid. From (2-a), one *is* entitled to infer (2-b).

(2) a. Do not post or burn this letter.
b. Do not post this letter.

These surprising data are in need of explanation, but it seems far from obvious what principled notion of entailment could make $!p \models !(p \vee q)$ fail, all the while making $!\neg(p \vee q) \models !\neg p$ hold.

Veltman's puzzle A second example which is puzzling for our tentative approach is pointed out by Veltman (2009). A patient consults two different doctors and gets the following two instructions.

(3) a. Drink milk or apple juice.
b. Don't drink milk.

Intuitively, the two doctors are disagreeing in their advice: one of them must be mistaken. However, our tentative account fails to reflect this intuition. In terms of compliance conditions, the two instructions are perfectly consistent. Thus, if the patient trusts both doctors, we would expect him to infer from (3-a) and (3-b) an instruction to drink apple juice. Obviously, we would like to avoid such a prediction, and to understand what there is to the semantics of $!(p \vee q)$ and $!\neg p$ that makes them contradictory, while their compliance conditions are consistent.

The puzzle of *any* Finally, a problem for the compliance conditions approach arises if we consider imperatives involving indefinite determiners like *some* and *any*. It is common in the linguistic literature to treat both indefinites as existential quantifiers and express their difference in meaning and distribution in terms of the different conditions they impose on their quantificational domain: *some* is assumed to quantify over an implicitly restricted set of alternatives; *any*, instead, is assumed to induce maximal domain widening (eg. Kadmon and Landman, 1993). In their influential article, Kadmon and Landman further assumed that *any* is licensed in a linguistic context only if the induced domain widening is for a reason, namely, the strengthening of the statement made. Such account immediately explains why *any* is licensed in negative contexts (*I didn't buy any card*), while it is ungrammatical in positive episodic sentences (#*I bought any card*). Widening the domain of an existential leads to a stronger statement in the former, but not in the latter.

Going back to imperatives, it is easy to see that if linguists are right in their analysis of *any* and *some*, our tentative logic faces at least two problems. Both problems follow from the fact that widening the domain of an existential in an imperative would result in a weakening on the compliance conditions. Thus, (4-a) would be predicted to entail (4-b), which does not seem intuitively right.

(4) a. Call some doctor.
b. Call any doctor.

Furthermore, if Kadmon and Landman are right, we would wrongly predict *any* to be infelicitous in imperatives. For, domain widening would be without a reason in this case.

This provides yet further grounds to believe that the semantics we hypothesized is too coarse-grained: there must be more to the meaning of an imperative than its compliance conditions. In the next section we will come back to these limitations of the naïve approach to understand more precisely *what* more there can be.

2 Our proposal

The basic idea Let us consider once again Ross's paradox, which constituted the first problem for our tentative account. If we try to ask for intuitions as to *why* the inference from (1-a) to (1-b) is not valid, we typically get answers along the following lines:

(5) Because by telling you to post this letter, I am not granting you the option to burn the letter instead.

The point of departure of our proposal is to take this intuition seriously. Notice that in order to regard (5) as providing an explanation for the non-entailment, one has to take it that (1-b) *does* give the addressee an option to burn the letter rather than posting it. In other words, (1-b) is taken to grant the addressee the freedom to operate a certain choice. In this way, Ross' paradox is explained by saying that the meaning of (1-a) is not stronger than the meaning of (1-b), since the latter includes a certain choice-offering component that the former lacks.

If we take imperatives not only to specify compliance conditions, but also to lay out certain options, Veltman's puzzle can be explained as well: if (3-a) grants a free option to drink milk rather than juice, then this option conflicts with the instruction in (3-b) not to drink milk.

Finally, in terms of granting options we can account for the fact that (4-a) does not entail (4-b): for, if *any* ranges over a wider domain than *some* does, and if both indefinites introduce one option for each individual, then (4-b) will grant more options than (4-a) does, and thus the latter will not be stronger than the former.

In order to implement these intuitions, we have to revise our original view about the meaning of imperatives. We can no longer maintain that an imperative is a partial specification of a definite conduct. Instead, we should regard an imperative as partially specifying a certain *set* of conducts. We will refer to a non-empty set of conducts as an *option set*, and to its elements as *options*. The basic assumption of our revised semantics then reads: the meaning of an imperative consists in a partial specification of a certain option set.

Possibilities In this perspective, the atomic imperative (1-a) can be seen as specifying that all the options are conducts where the letter is posted. In this way, (1-a) constrains the option set "from above", specifying that it is included in the set consisting of all conducts in which the letter is posted.

The disjunctive imperative (1-b) constrains the option set from above as well, specifying that all options are either conducts where the letter is posted, or conducts where the letter is burned. However, the intuition we are building on is that (1-b) also grants the addressee a choice, specifying that the option set contains an option in which the letter is burned, as well as one in which the letter is sent. In this way, (1-b) also constrains the option set "from below", specifying that it must contain at least certain conducts.

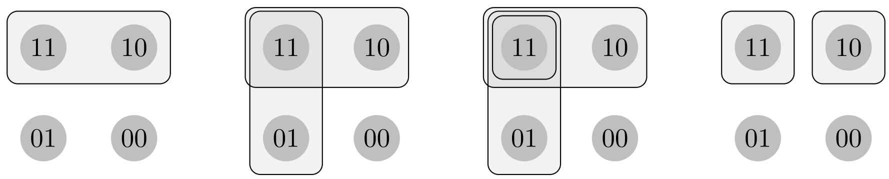
In general, we will assume that an imperative $!\varphi$ constrains the option set from above by specifying that all options are conducts that comply with φ, in the sense of definition 1.2; that is, the option set s must be as small as to be included in $|\varphi|$. Moreover, $!\varphi$ constrains the option set from below by specifying that, for any possible way to comply with φ, there is at least one option $c \in s$ that complies with φ in that specific way; that is, the option set s must be as large as to be consistent with any way to comply with φ.

However, for this idea to yield an account we need our semantics for action formulas to tell us not only what it takes to comply with φ, but also what are the *ways* to comply with φ. In other words, it must allow us to distinguish, at least in some cases, different possibilities for φ to be realized. For this purpose, we adopt the possibility semantics proposed in chapter 6 of Ciardelli (2009), which builds on the tradition of inquisitive semantics (Groenendijk, 2009; Ciardelli, 2009; Groenendijk and Roelofsen, 2009, a.o.). This semantics recursively defines the *ways* in which a formula may be realized, or in the case of our action formulas, complied with.[2]

Definition 2.1 (Possibility semantics for action formulas)**.**
The meaning $[\![\varphi]\!]_g$ of an action formula φ relative to an assignment g is defined recursively as follows:

1. $[\![\varphi]\!]_g = \{|\varphi|_g\}$ if φ is atomic
2. $[\![\varphi \vee \psi]\!]_g = [\![\varphi]\!]_g \cup [\![\psi]\!]_g$
3. $[\![\varphi \wedge \psi]\!]_g = \{s \cap t \mid s \in [\![\varphi]\!]_g , t \in [\![\psi]\!]_g , \text{ and } s \cap t \neq \emptyset\}$
4. $[\![\neg\varphi]\!]_g = \omega - \bigcup[\![\varphi]\!]_g$

[2]This semantics is closely related to the intuitionistic truth-maker semantics recently proposed by Fine (2013), which would also provide a suitable basis for our account.



(a) $[\![Ca]\!]$ (b) $[\![Ca \vee Cb]\!]$ (c) $[\![Ca \vee Cb \vee (Ca \wedge Cb)]\!]$ (d) $[\![Ca \wedge (Cb \vee \neg Cb)]\!]$

Figure 1: Possibilities for four action sentences.

5. $[\![\exists x\varphi]\!] = \{s \mid s \in [\![\varphi]\!]_{g[x\mapsto d]} \text{ for some } d \in D\}$
6. $[\![\forall x\varphi]\!]_g = \{\bigcap_{d\in D} s_d \mid s_d \in [\![\varphi]\!]_{g[x\mapsto d]} \text{ for all } d \in D, \text{ and } \bigcap_{d\in D} s_d \neq \emptyset\}$

The clauses may be read as follows: there is only one way for a conduct to comply with an atomic formula, namely, to satisfy the compliance conditions; a way to comply with $\varphi \vee \psi$ is either a way to comply with φ, or a way to comply with ψ; a way to comply with $\varphi \wedge \psi$ is the combination of a way to comply with φ and a way to comply with ψ; there is just one way to comply with $\neg\varphi$, namely, not to comply with φ in any way; a way to comply with $\exists x\varphi$ is a way to comply with $\varphi[^d/_x]$ for some individual d; finally, a way to comply with $\forall x\varphi$ is a combination of one way to comply with $\varphi[^d/_x]$ for each individual d.

We call $!\varphi$ a *basic imperative* in case φ has only one possibility, and a *choice imperative* if φ has at least two possibilities.

For concreteness, suppose our domain D contains just two individuals, Alf and Bea, denoted by constants a and b. And suppose our language contains just one predicate symbol C, for "call". There are just four conducts over $\mathbb{D}$ for this language: the conduct in which both Alf and Bea are called, denoted 11; the conduct in which Alf is called and Bea is not, denoted 10; the conduct in which Bea is called and Alf is not, denoted 01; and the conduct in which neither Alf nor Bea are called, denoted 00. Figure 1 depicts the sets of possibilities for some formulas relative to this very simple setting.

The next proposition says that a conduct c complies with an imperative φ iff it complies with φ in one of the ways specified by the above definition.

Proposition 2.2.
For any imperative φ, any conduct c and any assignment g,

$$c \in |\varphi|_g \iff c \in p \text{ for some } p \in [\![\varphi]\!]_g$$

This means, in particular, that the compliance semantics of the previous section can be recovered from the possibility semantics that we have just introduced. For any formula φ, we can simply let $|\varphi|_g := \bigcup [\![\varphi]\!]_g$. Since the semantics of an imperative $!\varphi$ will depend both on the compliance conditions of φ, and on the possibilities for φ, the fact that both these aspects are encoded by $[\![\varphi]\!]$ guarantees that our semantics is compositional.

Exclusive strengthening A situation similar to Ross's paradox arises if we consider a conjunctive imperative $!(p \wedge q)$ and a disjunctive one, $!(p \vee q)$.

(6) a. Call Alf and Bea.
b. Call Alf, or Bea.

Intuitively, (6-a) does not entail (6-b). To account for this non-entailment along our lines, it is not sufficient to postulate that (6) grants the option to call Bea. For, (5) does so, too.

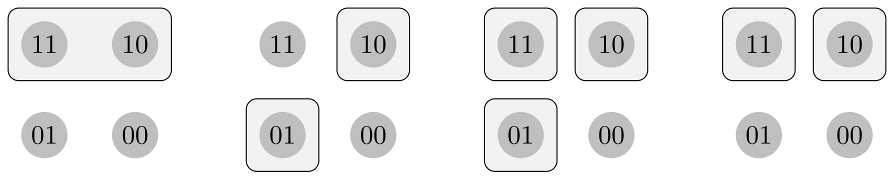


Figure 2: Exclusive strengthening of the sets of possibilities in Figure 1.

We must rely on the fact that (6) grants the option of calling Bea *and not Alf*, as well as the option to call Alf and not Bea. The same point can be made with regards to (7):

(7) To get credit for the course, write a paper or give a presentation.

When told (7), a student would be entitled to conclude not only that writing a paper is possible, but also that writing a paper is *sufficient* to get credit, that there is an option for getting credit in which she writes a paper *and does not give a presentation*.

To generalize and formalize this idea, we need to describe how possibilities are exhaustively strengthened relative to a given set of alternatives. For this purpose, we borrow the definition of exclusive strengthening assumed by Menéndez-Benito (2005) and Roelofsen and van Gool (2010).

Definition 2.3 (Exclusive strengthening of a possibility)**.**
Suppose π is a set of conducts, and Π is a set of sets of conducts.
The exclusive strengthening of π relative to Π is the set of conducts:

$$\mathsf{exc}(\pi, \Pi) = \pi - \bigcup\{\pi' \in \Pi \mid \pi \not\subseteq \pi'\}$$

We can then exclusively strengthen a set of possibilities by strengthening each possibility relative to the set.

Definition 2.4 (Exclusive strengthening of a set of possibilities)**.**
Let Π be a set of sets of conducts. The exclusive strengthening of Π is the set:

$$\mathsf{exc}\Pi = \{\mathrm{exc}(\pi, \Pi) \mid \pi \in \Pi\}$$

Figure 2 shows the result of exclusively strengthening the sets of possibilities in figure 1. The following proposition states two general facts about the operation of exclusive strengthening: first, it always delivers a set of mutually exclusive possibilities; and second, it has no effect when applied to a set which already consists of mutually exclusive possibilities.

Proposition 2.5.
Let Π be a set of sets of conducts. We say that Π is a set of mutually exclusive possibilities if for any distinct $\pi, \pi' \in \Pi$, $\pi \cap \pi' = \emptyset$. Then:

1. For any Π, $\mathsf{exc}\Pi$ is a set of mutually exclusive possibilities.
2. If Π is a set of mutually exclusive possibilities, then $\mathsf{exc}\Pi = \Pi$.
   In particular, if Π is a singleton, then $\mathsf{exc}\Pi = \Pi$.

Semantics We are now ready to define formally what the semantics of an imperative amounts to. An imperative $!\varphi$ is satisfied by an option set s in case (i) all conducts in s comply with φ and (ii) s is consistent with the exclusive strengthening of each possibility for φ with respect to the others.

Definition 2.6 (Semantics for imperatives)**.**
Let s be an option set, i.e., a non-empty set of conducts.
We say that s satisfies an imperative $!\varphi$, notation $s \Vdash !\varphi$, in case:

1. $s \subseteq |\varphi|$;
2. for all $\pi \in \mathsf{exc}[\![\varphi]\!]$, $s \cap \pi \neq \emptyset$.

The meaning $[\![!\varphi]\!]$ of the imperative is the set of those option sets by which it is satisfied:

$$[\![!\varphi]\!] = \{s \mid s \Vdash !\varphi\}$$

Imperative entailment and equivalence can then be defined in the natural way: an imperative entails another if any option set that satisfies the former also satisfies the latter; and two imperatives are equivalent if they are satisfied by the same states. In other words, entailment and equivalence amount to meaning inclusion and meaning identity, as usual.[3]

Definition 2.7 (Entailment, equivalence)**.** Let $!\varphi, !\psi$ be imperatives.

- $!\varphi \models !\psi \iff [\![!\varphi]\!] \subseteq [\![!\psi]\!]$
- $!\varphi \equiv !\psi \iff [\![!\varphi]\!] = [\![!\psi]\!]$

3 Predictions

Let us now look in detail at some predictions yielded by the semantic account proposed in the previous section.

Atomic imperatives Consider as a first example an atomic imperative like (8), formalized as $!Ca$.

(8) Call Alf.

The sentence Ca has only one possibility, namely, $|Ca|$, which by proposition 2.5 implies that exclusive strengthening has no effect: $\mathsf{exc}[\![Ca]\!] = \{|Ca|\}$. Thus, an option set s satisfies Ca iff (i) $s \subseteq |Ca|$ and (ii) $s \cap |Ca| \neq \emptyset$. However, since option sets are non-empty by definition, (i) entails (ii). So, $!Ca$ is satisfied by any non-empty subset of $|Ca|$. What (8) conveys, then, is simply that all options are conducts where Alf is called. In the restricted setting that we assume to draw our pictures, the option sets satisfying Ca are represented in figure 3(c).

A moment's reflection reveals that the simple semantic behavior we just observed for an atomic imperative depends only on the fact that atomic imperatives are *basic*. The same conclusion can thus be drawn for basic imperatives in general.

Proposition 3.1 (Satisfaction for basic imperatives)**.**
If $!\varphi$ is a basic imperative, i.e., $[\![\varphi]\!] = \{|\varphi|\}$, then:

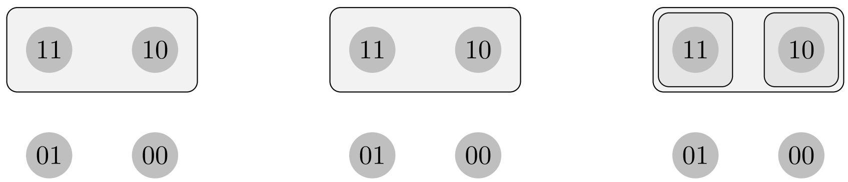
$$s \Vdash !\varphi \iff s \subseteq |\varphi|$$

Now suppose $!\varphi$ and $!\psi$ are basic imperatives. By definition, $!\varphi \models !\psi$ holds iff for any $s \Vdash !\varphi$ we also have $s \Vdash !\psi$; but the previous proposition makes it clear that this is the case iff $|\varphi| \subseteq |\psi|$. So, we have the following result.

Proposition 3.2 (Satisfaction for basic imperatives)**.**
Let φ and ψ be basic interrogative sentences.

$$!\varphi \models !\psi \iff |\varphi| \subseteq |\psi|$$

[3] To obtain a completely general notion, we would also have to quantify over the domain structure $\mathbb{D}$ that we are holding fixed here. This subtlety will not affect our discussion.



(a) $[\![Ca]\!]$ (b) $\mathsf{exc}[\![Ca]\!]$ (c) $[\![!Ca]\!]$

Figure 3: Meaning of a basic imperative

These facts show that, as far as basic interrogatives are concerned, our naïve attempt to identify meaning with compliance conditions was essentially right after all. For, proposition 3.1 shows that the semantics of a basic interrogative is fully determined by its compliance conditions, while proposition 3.2 shows that entailment between basic interrogatives amounts to inclusion of compliance sets, and thus to entailment in classical first-order logic. However, we are now going to see that things work very differently when it comes to choice imperatives.

Disjunction The prime example of choice imperatives are disjunctive imperatives like (9), which we represent as $!(Ca \vee Cb)$.

(9) Call Alf, or call Bea.

The action sentence $Ca \vee Cb$ has two possibilities, namely, $|Ca|$ and $|Cb|$. The exclusive strengthening of this set of possibilities, depicted in figure 4(b), consists again of two possibilities, namely, $|Ca \wedge \neg Cb|$ and $|Cb \wedge \neg Ca|$. In order to satisfy $Ca \vee Cb$, an option set should thus fulfill the following requirements:

1. $s \subseteq |Ca \vee Cb|$
2. $s \cap |Ca \wedge \neg Cb| \neq \emptyset$ and $s \cap |Cb \wedge \neg Ca| \neq \emptyset$

The first condition requires that s contain only options that comply with $Ca \vee Cb$. The second requires that s contain an option that complies with $Ca \wedge \neg Cb$ and an option that complies with $Cb \wedge \neg Ca$.

In the simple setting of our pictures, where domain consists only of Alf and Bea, there are only two option sets that satisfy $!(Ca \vee Cb)$, namely, $\{10, 01\}$ and $\{10, 01, 11\}$. Thus, $!(Ca \vee Cb)$ implies that (i) the conduct 00 in which neither Alf nor Bea is called is *not* an option and (ii) that the conducts 10 and 01, in which only one among Alf and Bea is called, *are* options; the only thing that remains undetermined about the option set is whether the conduct 11 in which both Alf and Bea are called is an option as well.

Clearly, our semantics avoids Ross's paradox: it is not the case that every option set satisfying $!Ca$ also satisfies $!(Ca \vee Cb)$. In fact, the opposite is true: *no* option sets satisfying $!Ca$ can satisfy $!(Ca \vee Cb)$; for, in order to satisfy $!(Ca \vee Cb)$, an option set must contain a conduct that complies with $Cb \wedge \neg Ca$, and therefore it must fail to satisfy $!Ca$. Thus, not only does $!Ca$ not entail $!(Ca \vee Cb)$: it is incompatible with it.

Consider now another disjunctive imperative, (10), formalized as $!(Ca \vee Cb \vee (Ca \wedge Cb))$.

(10) Call Alf, or Bea, or both.

In addition to the possibilities $|Ca|$ and $|Cb|$, the action term $Ca \vee Cb \vee (Ca \wedge Cb)$ also has a third possibility, $|Ca \wedge Cb|$. Exclusively strengthening these possibilities we get $|Ca \wedge \neg Cb|$, $|Cb \wedge \neg Ca|$, and $|Ca \wedge Cb|$. In order to satisfy $!(Ca \vee Cb \vee (Ca \wedge Cb))$, then, an option set

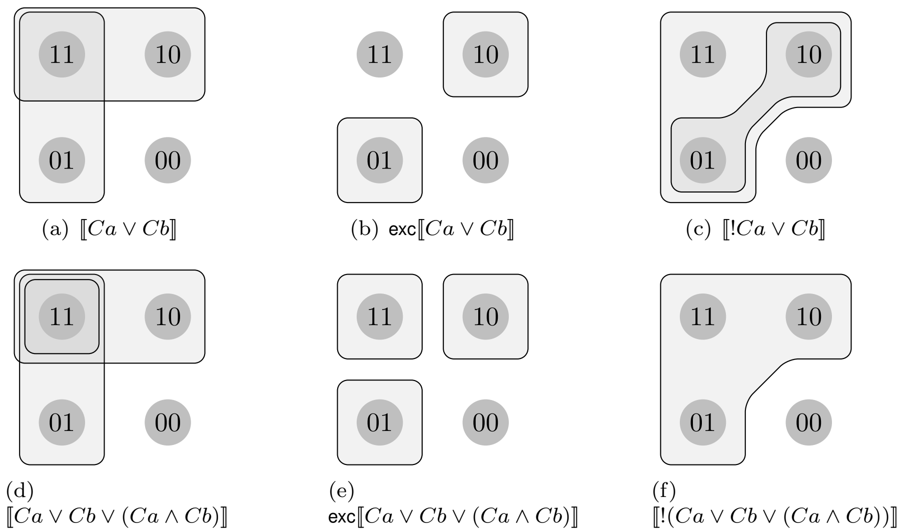


Figure 4: Meaning of two disjunctive imperatives

must satisfy the same conditions we saw for $!(Ca \vee Cb)$, plus, it must be consistent with $|Ca \wedge Cb|$.

In words, the difference between (9) and (10) lies in the fact that the former leaves it unspecified whether there is an option to call both Alf and Bea, whereas the latter implies that there is. In the setting of our pictures, there is only one option set that satisfies $!(Ca \vee Cb \vee (Ca \wedge Cb))$, namely, $\{10, 01, 11\}$.

Notice that $!(Ca \vee Cb \vee (Ca \wedge Cb))$ entails $!(Ca \vee Cb)$, but not the other way around. Intuitively, this is as it should be, since the former lays out more precisely than the latter what the options are.

As a third example of disjunctive imperative, consider (11), formalized as $!(Ca \vee \neg Ca)$.

(11) Call Alf, or don't call him.

The sentence $Ca \vee \neg Ca$ has two possibilities, namely $|Ca|$ and $|\neg Ca|$. Since these possibilities are already mutually exclusive, proposition 2.5 guarantees that exclusive strengthening has no effect. In order to satisfy $Ca \vee \neg Ca$, then, an option set must satisfy the following conditions:

1. $s \subseteq |Ca \vee \neg Ca|$
2. $s \cap |Ca| \neq \emptyset$ and $s \cap |\neg Ca| \neq \emptyset$

The first condition is trivially satisfied, since any conduct complies with $Ca \vee \neg Ca$: after all, in any conduct, either Alf is called, or he isn't. We are left with the second condition: s must contain an option that complies with Ca, and an option that complies with $\neg Ca$. Thus, while $Ca \vee \neg Ca$ is a classical tautology—which means that every conduct complies with it—its meaning in possibility semantics is non-trivial. As a consequence, $!(Ca \vee \neg Ca)$ is not a trivial imperative: it conveys that there are both an option to call Alf, and an option not to call him. This seems to square well with intuitions about sentences such as (11), which are indeed used non-trivially, typically accompanied by "as you wish" or similar locutions, in order to specify the availability of certain options.

Conjunction A simple conjunctive interrogative, such as $!(Ca \wedge Cb)$, is easily seen to be a basic interrogative. Thus, it has the sort of simple semantics described by proposition 3.1: it conveys that all options are conducts that comply with $Ca \wedge Cb$. Notice moreover that proposition 3.2 implies that, as one expects, $!(Ca \wedge Cb)$ entails both $!Ca$ and $!Cb$.

A more interesting example is provided by the conjunction of a basic interrogative with a choice interrogative. Consider for instance (12), formalized as $!(Ca \wedge (Cb \vee Cc))$.

(12) Call Alf, and call Bea or Carla.

The sentence $Ca \wedge (Cb \vee Cc)$ has two possibilities, namely, $|Ca \wedge Cb|$, and $|Ca \wedge Cc|$. Applying exclusive strengthening to these possibilities we get $|Ca \wedge Cb \wedge \neg Cc|$ and $|Ca \wedge Cc \wedge \neg Cb|$. Thus, an option set s satisfies the imperative $!(Ca \wedge (Cb \vee Cc))$ in case:

1. $s \subseteq |Ca \wedge (Cb \vee Cc)|$
2. $s \cap |Ca \wedge Cb \wedge \neg Cc| \neq \emptyset$ and $s \cap |Ca \wedge Cc \wedge \neg Cb| \neq \emptyset$

The first clause requires that all options in s be conducts in which Alf is called, as well as at least one of Bea and Carla. Now, in view of what the first clause already requires, the second clause may be simplified to $s \cap |\neg Cc| \neq \emptyset$ and $s \cap |\neg Cb| \neq \emptyset$. Thus, what the second clause requires is that s be compatible with not calling Carla, and with not calling Bea.

Notice that $!(Ca \wedge (Cb \vee Cc))$ entails $!Ca$: for, every $s \Vdash !(Ca \wedge (Cb \vee Cc))$ consists entirely of options complying with Ca, whence $s \Vdash !Ca$. Moreover, $!(Ca \wedge (Cb \vee Cc))$ entails $!(Cb \vee Cc)$: for, every $s \Vdash !(Ca \wedge (Cb \vee Cc))$ consists entirely of options complying with $Cb \vee Cc$, and it contains one option complying with $Cb \wedge \neg Cc$ and one complying with $Cc \wedge \neg Cb$, which means that $s \Vdash !(Cb \vee Cc)$. Again, these results are intuitive: after all, (12) lays out the available options more precisely than either of (13-a) and (13-b).

(13) a. Call Alf.
b. Call Bea or Carla.

Negation According to our definition of possibilities, negative imperatives $!\neg\varphi$ are always basic imperatives. As such, they have the simple sort of semantics described in proposition 3.1: $!\neg\varphi$ conveys that all options are conducts that do not comply with φ, and that is all. Thus, free choice effects associated with items such as disjunction disappear under negation. In particular, entailment between negative imperatives coincides with entailment in classical logic, as guaranteed by proposition 3.2. Thus, for instance, $!\neg(Ca \vee Cb) \models !\neg Ca$ holds, which accounts for the observation, made in section 1, that the contrapositive of Ross's invalid inference is valid: from (14-a), one can infer (14-b).

(14) a. Do not call Alf or Bea.
b. Do not call Alf.

Existential quantifier Consider now an existential imperative, $!\exists xCc$. The possibilities for $\exists xCx$ are all the sets of the form $|Cd|$ for some individual $d \in D$.[4] Exclusively strengthening this set of possibilities yields all sets of the form $|Cd| \cap (\bigcap_{d' \neq d} |\neg Cd'|)$. Thus, in order to satisfy $\exists xCx$, an option set s must satisfy the following conditions.

1. $s \subseteq |\exists xCx|$
2. for any $d \in D$, $s \cap |Cd| \cap (\bigcap_{d' \neq d} |\neg Cd'|) \neq \emptyset$

That is, $!\exists xCx$ implies that (i) every option is a conduct in which someone is called, and (ii) for every individual d, there is an option in which d, and no one else, is called. Now, in view of this second component, it is no longer true that enlarging the quantificational domain of an existential in an imperative leads to a weaker meaning. Assuming that *some* quantifies

[4] For ease of exposition, we will sloppily allow individuals to be used as individual constants of the language.

over a contextually restricted set of alternatives, while *any* induces domain widening, we can thus explain the inference failure in (15):

(15) a. Call someone. $\not\Rightarrow$
b. Call anyone.

In particular, if d is any individual in the domain of discourse, from (15-b) the addressee can infer that there is an option to call d, and no one else. The same inference cannot be drawn from (15-a), since d may not belong to the implicitly restricted domain of *someone*.

Furthermore, adopting a slightly modified version of Kadmon and Landman's analysis, we have an explanation of why *any* is licensed in imperative sentences. Although widening the domain of an existential in an imperative does not give rise to a stronger meaning, it does give rise to a meaning which is not entailed by the original one. This is sufficient reason, we would like to suggest, for domain widening to occur.

Universal quantifier To complete this quick tour of our semantics, let us consider a universally quantified imperative like (16), formalized as $!\forall x(Cx \vee Ex)$.

(16) For every woman, call her or send her an email.

Our possibility semantics assigns to the action sentence $\forall x(Cx \vee Ex)$ the following set of possibilities:

$$[\![\forall x(Cx \vee Ex)]\!] \quad = \quad \{\bigcap_{d\in D} s_d \mid \text{ for each } d \in D,\ s_d = |Cd| \text{ or } s_d = |Ed|\}$$

Some calculation shows that applying exhaustive strengthening yields the following result:

$$\mathsf{exc}[\![\forall x(Cx \vee Ex)]\!] \quad = \quad \{\bigcap_{d\in D} s_d \mid \text{for } d \in D,\ s_d = |Cd \wedge \neg Ed| \text{ or } s_d = |Ed \wedge \neg Cd|\}$$

What is needed for an option set s to satisfy $!\forall x(Cx \vee Ex)$, then, may be described as follows: first, every option in s is such that every woman is either called, or an email is sent to her; secondly, for any way of assigning each woman to exactly one of the two actions, calling and emailing, there exists an option in s that implements that way.

Crucially, the choice component prevents universal variants of Ross's paradox: in our system, $\forall xCx \not\models \forall x(Cx \vee Ex)$, thus predicting that from (17-a), one may not infer (17-b).

(17) a. Post every letter.
b. For every letter, post it or burn it.

On the other hand, as one should expect, $!\forall x(Cx \vee Ex)$ entails any instance of the form $!Cd \vee Ed$. Provided Bea is in the intended domain, from (16) one can infer (18).

(18) Call Bea or send her an email.

Aside: imperative shades The imperative mood is traditionally associated with the task of issuing commands. In language after language, its very name carries trace of this association. Since Schmerling (1982), it has often been noted that imperatives are used for a great variety of functions besides issuing orders: for giving directions, as in (19-b), offering advice, as in (19-c), and even granting permissions, as in (19-d).

(19) a. Turn out the music!
b. At the traffic light, turn left or take the subway.
c. Try this bread, it's delicious!
d. Go ahead, take a beer!

It is worth remarking that, from the point of view of our account, (19-b-d) are just as good as (19-a). Semantically, all there is to an imperative is a partial description of a set of options. It is not built into the meaning of the imperative what these options are supposed to represent. They may be the conducts desired by the speaker, as in (19-a), but they may also be the conducts *recommended* by the speaker, as in (19-c), the conducts *invited* by the speaker, as in (19-d), or the conducts that will yield a certain outcome, as in (19-b). In this way, the semantic contribution of the imperatives in (19-a-d) can be understood uniformly across these examples, without having to invoke a special status, and a "deviant" interpretation, for any of them. Of course, much remains to be said as to how the context and certain specialized expressions help to determine what the options specified by an imperative are supposed to represent, but, if our approach is on the right track, these issues will not impinge on the core workings of imperative semantics.

4 Discussion and an open problem

Imperatives and free choice Building on ideas from inquisitive semantics, we have proposed a logical account of imperatives which derives the entailment failures in (20) and (21):

(20) a. Post this letter! $\not\Rightarrow$
b. Post this letter or burn it!

(21) a. Call some doctor! $\not\Rightarrow$
b. Call any doctor!

Intuitively the most natural interpretation of the imperatives (20-b) and (21-b) is one presenting a choice between different possibilities:

(22) a. Post this letter or burn it! $\Rightarrow$
b. You may post the letter and you may burn it.

(23) a. Take any card! $\Rightarrow$
b. You may take card a, you may take card b, ...

Different views on the status of free choice inferences like those in (22) and (23) have been defended in the linguistic literature: they have been taken to be purely pragmatic implicatures, or to have the status of semantic entailments. On the view defended in this article, free choice inferences in choice-offering imperatives are matters of entailment. Just to make the discussion more synthetic, let us make use of formulas $\Diamond\varphi$, where φ is an action formula, to be interpreted as in (24), and let entailment be defined among imperatives and such basic modal formulas. Then we can easily derive the inference patters in (25):

(24) $s \Vdash \Diamond\varphi$, in case $s \cap |\varphi| \neq \emptyset$

(25) a. $!(p \vee q) \models \Diamond p$ and $!(p \vee q) \models \Diamond q$
b. $!\exists x P(x) \models \Diamond P(a)$

The main evidence in favor of a semantic account of free choice in imperatives comes from the fact that such inferences do not seem to be cancelable, as illustrated by the following two examples from Aloni (2007) (which are modified versions of examples from Hamblin (1987) and Mastop (2005) respectively). Veltman's puzzle discussed in section 1 shows a similar point.

(26) GRANDMA: Take any card!
KID GETS UP TO PICK A CARD.

GRANDMA: ??? Don't you dare take the ace!

(27) MOTHER: Do your homework or help your father in the kitchen!
SON GOES TO THE KITCHEN.
FATHER: Do your homework!
SON: But, mom told me I could also help you in the kitchen!

On the other hand, it is a well known fact that free choice inferences disappear under negation. Imperative (28-a) cannot be used to deny that the addressee may choose whether to post the letter or burn it, and (28-b) cannot be used to deny that the addressee may choose which card to take.

(28) a. Don't post this letter or burn it!
b. Don't take any card!

It is quite common in the semantic literature to take the disappearance of an inference in downward entailing contexts as the most reliable indication of its conversational implicature status (e.g. Kratzer and Shimoyama, 2002; Alonso-Ovalle, 2006). These authors seem to hold that only conversational implicatures can systematically disappear in downward entailing contexts. We disagree: our semantic analysis derives the right interpretation for the negative imperatives in (28), while proposing a semantic account of free choice, and therefore it shows that we do not need to treat free choice effects as conversational implicatures in order to derive their systematic disappearance in downward entailing contexts.

Comparison with other approaches Recently, a number of alternative logics for imperatives have been proposed to account for Ross's paradox in a dynamic framework (e.g. Mastop, 2005; Veltman, 2009). On these systems, an imperative sentence performatively changes the to-do list of some agent. In particular, Velman's system is quite close to our own, building on the same core insight, that free-choice imperatives do not only place constraints, but also grant "explicit permissions". In his system, this insight is implemented in terms of imperatives setting up alternative to-do lists. These explicit permissions, Veltman notes, cannot be taken away easily, as the puzzle that we have taken from him shows (example (3)). To account for this observation—to derive, for instance, the inconsistency of $!(p \vee q)$ and $!\neg p$—Veltman introduces an explicit rule that produces inconsistency in case one of the background alternatives conflicts with an incoming imperative, or if, conversely, the background conflicts with one of the alternatives offered by the imperative. A pleasant feature of the account we proposed is that, as we have seen, it derives the same result without resorting to a specific stipulation to this effect.

Another subtle difference between Veltman's account and our own shows up with respect to example (27). This example bears some resemblance to Veltman's puzzle, in that there is a feeling of disagreement in the directions the two parents are giving to the kid. Under Veltman's account, however, $!(p \vee q)$ and $!p$ are consistent; the child, it seems, should conclude that he has to do his homework, and he may also help his father in the kitchen (but is not obliged to). Under own account, as we discussed above, $!(p \vee q)$ and $!p$ are *in*consistent, thus accounting for the child's puzzled reaction.

Turning back to more general considerations, the update approaches of Mastop and Veltman are promising in that they derive (20) from the performative nature of imperatives. However, they only discuss the propositional case, and it is unclear to us how they can be extended to the first-order case to account for (21) and (26) as well.

As far as we know, the only previous attempt to capture both (20) and (21) is Aloni (2007). On that account, *any* and *or* are treated as operators which introduce sets of propositional alternatives. The imperative operator is then analyzed as a quantifier over these sets of alternatives. Choice imperatives are distinguished from basic imperatives in that they involve genuine sets of propositional alternatives. The logic we have presented in this article share these characteristics with Aloni (2007), but, as we will argue, it improves on it both empirically and conceptually.

First of all, Aloni (2007) generates alternative propositions via a dynamic semantics (Dekker, 2002) supplemented with a mechanism of propositional quantification (Fine, 1970). In the present article, instead, we use the framework of first-order inquisitive semantics developed in Ciardelli (2009). Besides its greater simplicity, the latter formalism has an important empirical advantage. In Aloni, alternative propositions are generated by dynamically active existential propositional quantifiers in interaction with disjunction and existential individual quantification. One of the predictions of that system is that within a *static* operator, i.e. an operator that blocks anaphoric links between a term that occurs in its scope and a pronoun outside of it (cf. Groenendijk and Stokhof, 1991), no alternatives are generated, and, therefore, no choice-offering readings can arise. Negation and the universal quantifiers are both examples of static operators. Aloni's prediction, however, is only borne out in the case of negation. Negative imperative are never choice-offering (cf. example (28)), but universal ones may be. For example, (29-b) grants for each letter the permission to post it or burn it, which explains why it is not entailed by (29-a).

(29) a. Post every letter! $\not\Rightarrow$
b. For every letter, post it or burn it!

In the present semantics, where the potential to generate alternatives is not related to the dynamic nature of the scoping operator, this problem does not arise.

Another important difference between the present account and Aloni's system concerns the nature of the predicted free choice inference. In Aloni (2007) choice-offering disjunctive and existential imperatives grant the permission to freely choose one of the relevant possibilities and execute it. That is, we have the following free-choice inferences:

(30) a. $!(p \vee q) \models \Diamond p$ and $!(p \vee q) \models \Diamond q$
b. $!\exists x P(x) \models \Diamond P(a)$

On the present account, instead, choice imperatives have the stronger entailment that each possibility may be executed *in isolation*. That is, in our account, the following holds:

(31) a. $!(p \vee q) \models \Diamond(p \wedge \neg q)$ and $!(p \vee q) \models \Diamond(q \wedge \neg p)$
b. $!\exists x P(x) \models \Diamond(P(a) \wedge \forall x \neq a(\neg P(x)))$

As an argument in favor of (31), we have already considered (32):

(32) To pass the seminar, write a paper or take an oral exam.

Assume one gets credit for an oral exam (obligatory) combined with either giving a presentation or writing a paper. Aloni (2007) predicts (32) to be a correct description of the available options in the given scenario. On our account, where the stronger (31-a) is valid, we predict that (32) does *not* correctly describe the available options in the given scenario. A correct description, that is, an imperative that would be satisfied by an option option set like the one of our scenario, is, e.g., (33).

(33) To pass the seminar, take an oral exam and either give a presentation, or write a paper.

The next example from Menéndez-Benito (2005) illustrates the same point for *any*-imperatives. Consider imperative (35) used in scenario (34):

(34) Scenario: One of the rules of the card game Canasta is: when a player has two cards that match the top card of the discard pile, she has two options: (i) she can

take all the cards in the discard pile or (ii) she can take no card from the discard pile (but take the top card of the regular pile instead).

(35) Take any card from the discard pile!

Intuitively, (35) would not count as an instruction to choose option (i), contrary to what Aloni predicts. Again, by validating the stronger (31-b), the present system avoids this problem.

Exclusive strengthening vs contextual exhaustification Before concluding, there is one loose end that we should attend to. For our account of the seminar and the canasta examples discussed above it is crucial that, in order to satisfy an imperative $!\varphi$, an option set must be consistent with any possibility in the *exclusively strengthened* value of φ, rather than in its plain set of possibilities. However, our approach faces a problem. Consider the following two imperatives:

(36) a. Call Alf, or call both Alf and Bea. $!(Ca \vee (Ca \wedge Cb))$
b. Call Alf, or call Alf but not Bea. $!(Ca \vee (Ca \wedge \neg Cb))$

Although the sets of possibilities of these two imperatives are different, their exclusively strengthened values turn out to be the same. Therefore, (36-a) and (36-b) are predicted to be equivalent: both specify that all options are conducts in which Alf is called, and that there is an option in which Bea is called, and an option in which she is not called.

In order to give a solution to this problem, we may substitute the notion of exclusive strengthening with a more general, context-dependent notion of *exhaustification*. When told that Alf and Bea called, people normally conclude that nobody else called. In the linguistic literature this is called an exhaustive interpretation of the sentence (Groenendijk and Stokhof, 1984). Exhaustification is a context-dependent notion: which possibilities are excluded depends on the set of relevant alternatives. If the possibility that Carla called is not relevant in the context, from "Alf and Bea called" we are not entitled to conclude that Carla did not call.

In the given definition of exclusive strengthening, possibilities are exhaustified with respect to other possibilities for the sentence. In the following, more general notion of exhaustification, possibilities are exhaustified with respect to a set Σ of contextual alternatives.

Definition 4.1 (Exhaustification)**.**
Let Π, Σ be two sets of sets of conducts. The *exhaustification* of Π relative to Σ is the set:

$$\mathsf{exc}_\Sigma \Pi = \{\mathsf{exc}(\pi, \Sigma) \mid \pi \in \Pi\}$$

Let us consider again (36-a) and (36-b). In a context in which you wonder whether you should call Alf or Bea, we may take the set of relevant possibilities to be $\Sigma = \{|Ca|, |Cb|\}$. With respect to this set of relevant possibilities, we get the following exhaustive values:

- $\mathsf{exc}_\Sigma [\![Ca \vee (Ca \vee Cb)]\!] = \{|Ca \wedge \neg Cb|, |Ca \wedge Cb|\}$
- $\mathsf{exc}_\Sigma [\![Ca \vee (Ca \vee \neg Cb)]\!] = \{|Ca \wedge \neg Cb|\}$
- $\mathsf{exc}_\Sigma [\![Ca]\!] = \{|Ca \wedge \neg Cb|\}$

By strengthening possibilities relative to contextual alternatives, we would then correctly predict that only (36-a) grants the option to call both Alf and Bea. (36-b) is predicted to be pragmatically anomalous, as it would express the same meaning as the basic imperative $!Ca$ (*Call Alf*), but in a less perspicuous way. A further investigation of this pragmatic notion of exhaustification and its impact on our interpretations of imperative constructions must be left to another occasion.

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