Negation in dialogue

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Abstract

We consider the nature of negation in dialogue as revealed by semantic phenomena such as negative dialogue particles, psycholinguistic experimentation, and dialogue corpora. We examine alternative accounts of negation that can be used in TTR (Type Theory with Records), and conclude that an alternatives-based account which relates to the psychological notion of negation in simulation semantics is most appropriate. We show how this account relates to questions under discussion, dialogical relevance, and metalinguistic negation.

1 Introduction

Negation is one of the fundamental logical operators. It is also an essential component of any theory of questions and their answers in dialogue. Despite its fundamental nature, a comprehensive, formal account of the coherence of negative utterances in dialogue is still very much an open question. In this paper we start by considering various fundamental semantic desiderata an account of negation needs to fulfill. We then develop an account that attempts to satisfy these desiderata in the TTR (Type Theory with Records) framework (Cooper, 2005a; Cooper, 2005b; Cooper, fthc; Ginzburg, 2012). Finally we consider briefly the issue of the coherence of negative utterances in dialogue, sketching a treatment that offers a unified account of "ordinary" and "metalinguistic" negation (Horn, 1989).

2 Basic desiderata

In this section we specify desiderata any account of negation in dialogue needs to fulfill. The first one is the most basic requirement, a *sine qua non* and is the basis for *disagreement* in dialogue. The others concern the meaning of negative dialogue particles, negative force, the presuppositions of negative polar questions, and finally psycholinguistic evidence.

1. **Incompatibility between p and $\neg p$**

   This requirement can be stated for any theory of propositions, as in (1a); a version specific to situation theoretic or type theoretic conceptions is given in (1b):

   (1) a. It is not the case that p and $\neg p$ are simultaneously true.

   b. $s : T$ implies it's not the case that $s :/ T$; $s : \neg T$ implies it's not the case that $s : T$

2. **The need for a semantic type NegProp**

   The proper treatment of dialogue particles such as English 'No.' requires the semantics to refer to a subtype of the class of propositions that are *negative*.

   When its antecedent is positive, 'No' negates the proposition in question, as in (2a). However, when its antecedent is negative, 'No' absorbs one of the negations; this includes antecedents whose negativity arises from a negative quantifier, as in (2d):[1]

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[1] Ginzburg and Sag (2000) claimed that the negative absorption property of 'No' is simply a preference; that there is po-

(2) a. A: Did Jo leave? B: No (= Jo did not leave.).

   b. A: Jo didn't leave. B: No (= Jo did not leave.).

   c. A: Did Jo not leave? B: No (= Jo did not leave.).

   d. A: Did no one help Bo? B: No (=No one helped Bo.)

Given this, the meaning of 'No' requires a specification as in (3): 'No' resolves to a negative proposition, which is a *simple answer* to MaxQUD.[2]

(3)
$$\begin{bmatrix} \text{phon : no} \\ \text{cat.head = adv[+ic] : syncat} \\ \text{dgb-params.max-qud : PolQuestion} \\ \text{cont : NegProp} \\ c1 : \text{SimpleAns(cont,max-qud)} \end{bmatrix}$$

One might perhaps be tempted to think that this phenomenon is morphological or syntactic and that there is no need to introduce a type of negative propositions into the semantic domain. The issue is a little complex and non-semantic information certainly plays a role. Consider the examples in (4) (based on examples taken up by one of the reviewers)

(4) a. A: Jo didn't do squat. B: No (= Jo did nothing)

   b. A: Jo did squat. B: $^?$No/$^{??}$Yes/Right (= Jo did nothing)

The construction *(not)...squat* is behaving here like French *(ne)...pas*. That is, *squat*

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tential for ambiguity. They developed an account thereof using polyadic quantification. It seems to us though that the non-affirmative reading requires a distinct tune: a rise fall, whereas the affirmative reading is most naturally associated with a fall. Moreover, we think that the double negation reading is possible only for cataphoric 'no' as in (i); if the follow up sentence is omitted, a reading with a single negation ensues, regardless of intonation.

 (i) A: Did no one help Bo? B: No, someone did help him get up.

[2]We rely here on the notion of simple answerhood from Ginzburg and Sag (2000) which associates the set $\{p, \neg p\}$ as the simple answers of a polar question p?.

when not occurring with morphological negation is strengthened to become a negative in its own right, similar to *bugger all*, which does not, however, occur with morphological negation in the relevant sense.

(5) a. *Jo didn't do bugger all. (= Jo did nothing)

   b. A: Jo did bugger all.
      B: $^?$No/$^{??}$Yes/Right (= Jo did nothing)

Admittedly, the reply *No* sounds odd in the cases where there is no morphological negation but in our judgement the reply *Yes* (as opposed to *Right*) sounds even worse and this would be hard to account for on a purely morphological account. The danger with a purely morphological account would be that one would end up with a heterogeneous list of morphemes such as *not*, *squat* and *bugger all* associated with varying effects on appropriate responses and miss the generalization that semantic negation is playing an important role in the choice of response.

3. **Constructive Negation and Negative Situation Types**

It is widely recognized that positive Naked Infinitive (NI) sentences describe an agent's perception of a situation/event, one which satisfies the descriptive conditions provided by the NI clause, as in (6a,b). More tricky is the need to capture the 'constructive' nature of negation in negative NI sentences such as (6c,d). These reports mean that *s* actually possesses information which rules out the descriptive condition (e.g. for (6c) Mary avoiding contact with Bill), rather than simply lacking concrete evidence for this (e.g. Ralph shutting his eyes.). As Cooper (1998) points out, Davidsonian accounts (e.g. Higginbotham (1983)), are limited to the far weaker (6f):

(6) a. Ralph saw Mary serve Bill.

   b. $\text{Saw(R,s)} \land s : \text{Serve(m,b)}$.

   c. Ralph saw Mary not serve Bill.

   d. Ralph saw Mary not pay her bill.

   e. $\text{Saw(R,s)} \land s : \neg \text{Serve(m,b)}$.

f. Saw(R,s) $\land$ s :/$Serve(m,b)$

Cooper (1998) provides axioms on negative SOAs (infons) in situation semantics that attempt to capture this, as in (7a,b). (7a) states that if a situation s supports the dual of σ, then s also supports positive information that precludes σ being the case. (7b) tells us that if a situation s supports the dual of σ, then s also supports information that defeasibly entails that σ is the case.

(7) a. $\forall s, \sigma[s : \overline{\sigma}$ implies
$\exists(Pos)\psi[s : \psi$ and $\psi \Rightarrow \overline{\sigma}]]$
b. $\forall s, \sigma[s : \overline{\sigma}$ implies
$\exists(Pos)\psi[s : \psi$ and $\psi > \sigma]]$

The appeal to negative situation types can also be motivated dialogically. 'No' has an additional use which expresses a negative view towards an event or situation (the *NegVol(ition)* use). This is exemplified in (8):

(8) a. [A opens freezer to discover smashed beer bottle] A: (Oh) No! ('I do not want *this* (the beer bottle smashing) to happen')

b. [Little Billie approaches socket holding nail] Parent: No Billie ('I do not want *this* (Billie putting the nail in the socket) to happen')

The need to distinguish the NegVol use from the use we discussed earlier is suggested *inter alia* by (9). This demonstrates that there is potential for misunderstanding between the two 'no' 's in a single context. B's answer has two readings, the (implausible) one where B disputes A having questions for him and the readily available one, where he refuses to answer any questions.

(9) A: I have some questions for you. B: No.

One possible analysis of the NegVol use is given in (10):

(10)
$$\begin{bmatrix} \text{phon} : \texttt{no} \\ \text{cat.head} = \text{adv[+ic]} : \text{syncat} \\ \text{dgb-params} = \begin{bmatrix} \text{sit1} : \text{Rec} \\ \text{spkr} : \text{Ind} \end{bmatrix} : \text{RecType} \\ \text{cont} = \neg\text{Want(spkr,sit1)} : \text{Prop} \end{bmatrix}$$

In fact, one could argue that this content should be strengthened to (11) or, given its non-defeasability, it could be viewed as a conventional implicature.

(11) Want(spkr,sit1'), $sit1' : \neg T$

Regardless, the appeal to a negative situation type seems called for, that is, $s : \neg T$ (s is a witness for *not T*) rather than $s \;/\!\!\!\!/\, T$, s is *not* a witness for T.

4. **$\mathbf{p}? \neq \neg\mathbf{p}?$**

In the classical formal semantics treatments for questions the denotation of a positive polar interrogative $p?$ is identical to that of the corresponding negative polar $\neg p?$ (Hamblin, 1973; Karttunen, 1977; Groenendijk and Stokhof, 1997, for example). This is because the two interrogatives have identical exhaustive answerhood conditions. Indeed Groenendijk and Stokhof (1997), p. 1089 argue that this identification is fundamental. There are a number of reasons to avoid this identification. First, as (12a) indicates, 'Yes' is infelicitous after a negative polar question; Hoepelmann (1983) suggests that a question like (12b) is likely to be asked by a person recently introduced to the odd/even distinction, whereas (12c) is appropriate in a context where, say, the opaque remarks of a mathematician sow doubt on the previously well-established belief that *two is even*. Ginzburg and Sag (2000) argue that the latter can be derived from the factuality conditions of negative situation types, given in (7).

(12) a. A: Didn't Bo leave? B: #Yes. A: You mean she did or she didn't.
b. Is 2 an even number?
c. Isn't 2 an even number?

A third consideration is the need to distinguish the contextual background of such interroga-

tives. In languages such as French and Georgian there exist dialogue particles which presuppose respectively a positive (negative) polar question as MaxQUD:

(13) a. A: Marie est une bonne étudiante? B: Oui / #Si.

b. A: Marie n'est pas une bonne étudiante? B: #Oui / Si.

5. **Strong equivalence of p and $\neg\neg p$**

While the data we have just considered argues for distinguishing p? from $\neg p$?, one also needs to ensure that these questions have identical exhaustive answerhood relations in order to capture the equivalence of (14):

(14) a. Bo knows whether Rita arrived.

b. Bo knows whether Rita did not arrive.

Since the exhaustive answers to p? and $\neg p$? have in common the element $\neg p$, in order to ensure that (14) holds, it needs to be the case that:

(15) A knows p iff A knows $\neg\neg p$

The easiest way to enforce this is, of course, for the two propositions to be identical. However, to the extent that (16b) is English, it argues against such an identification, since it suggests that doubly negated propositions are negative:

(16) a. A: Bo left? B: No (= Bo did not leave).

b. A: It's not the case Bo didn't leave? B: No (= Bo left).

c. A: C'est pas vrai que Marie n'est pas une bonne étudiante B: #Oui / Si

One might argue that the inclusion of 'the case' and 'true' ('vrai') is enough to give us a different proposition with different predicates. However, the same argument can be made in a language like English which (perhaps marginally) also allows pure double negation.

(17) a. A: Bo didn't not leave B: No (= Bo left)

6. **Psycholinguistic results about processing negative sentences**

There is a large body of work on the processing of negation, reviewed recently in Kaup (2006). Kaup argues that the approach that accords best with current evidence is an experiential-simulations view of comprehension.[3] On this view, comprehenders construct mental simulations — grounded in perception and action — of the states of affairs described in a text. Kaup offers experimental evidence that comprehending a negative sentence (e.g. *Sam is not wearing a hat*) involves simulating a scene consistent with the negated sentence. She suggests that indeed initially subjects simulate an "unnegated" scene (e.g. involving Sam wearing a hat). Tian et al. (2010) offer additional evidence supporting the simulationist perspective. However, they argue against the "two step" view of negation (viz. unnegated and then negated), in favour of a view driven by dialogical coherence, based on QUD.

3 Varieties of negation for TTR

We now attempt to develop an account of negation within the framework TTR (Type Theory with Records). We use TTR here because it has been used extensively in the analysis of dialogue (see e.g. Ginzburg and Fernández (2010)) and because it is a synthetic framework that allows one to combine the insights of *inter alia* Montague Semantics, Situation Semantics, and Constructive Type Theory.

3.1 Possible Worlds

The classical possible worlds view of propositions as sets of possible worlds gives us negation as set complementation. This does not distinguish between positive and negative propositions and thus fails Desideratum 2. While possible worlds are not incompatible with a type theoretic approach, they do not sit happily with a rich type theory such as TTR. Propositions are standardly regarded as types rather than sets of possible worlds in such a framework.

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[3]These ideas have their origins in much earlier work on mental models (Johnson-Laird, 1983).

3.2 Intuitionistic negation

The standard way of introducing negation into type theory is to use the type $\bot$, the empty type. In terms of TTR we say that $\{a \mid a : \bot\} = \emptyset$ no matter what is assigned to the basic types, thus giving $\bot$ a modal character: it is not only empty but *necessarily* empty. If T is a type then $\neg T$ is the function type $(T \to \bot)$. This works as follows: if T is a type corresponding to a proposition it is "true" just in case there is something of type T (i.e. a witness or proof) and "false" just in case there is nothing of type T. Now suppose there is a function of type $\neg T$. If there is something a of type T then a function f of type $\neg T$ would have to be such that $f(a) : \bot$. But $\bot$, as we know, is empty. Therefore there cannot be any function of type $\neg T$. The only way there can be a function of type $\neg T$ is if T itself is empty. Then there can be a function which returns an object of type $\bot$ for any object of type T, since, T being empty, it will never be required to return anything.

This gives us a notion of negative type, that is a function type whose range type is $\bot$, which can be made distinct from positive types (which could be anything other than a negative type, though in practice we use record types as the basis for our propositions). In this way we fulfil Desideratum 2.

However, intuitionistic negation does not fulfil Desideratum 5. Standardly in intuitionistic logic $p \to \neg\neg p$ is a theorem but $\neg\neg p \to p$ is not a theorem. The intuition is this: if you have a proof of p then you can't have a proof that you don't have a proof of p. However, if you don't have a proof that you don't have a proof of p, that does not mean that you have a proof of p. You may simply not be able to prove p one way or the other. (Intuitionistic logic rejects the law of the excluded middle.) In terms of our types this cashes out as follows: suppose that there is something a of type T – then there will be a function of type $\neg\neg T$. We know already that $\neg T$ must be empty if there is something of type T. But if $\neg T$ is empty then this fulfils the condition for there being a function of type $\neg\neg T$. How do we know that there actually is such a function? We can argue that it has to do with the fact that a is of type T, thus providing evidence that $\neg T$ is empty and thus providing the basis for a function of type $\neg\neg T$. This last step in the argument is not entirely clear and it is not ob-

vious that modelling negation in terms of functions in the way we have proposed gets the inference from T to $\neg\neg T$.

Suppose now that we have a function of type $\neg\neg T$. Then $\neg T$ must be empty. But the fact that we have no function from objects of type T to $\bot$ does not mean that T is non-empty. It may be empty but we do not have the required function available.

3.3 Deriving classical negation from intuitionistic negation

The confusion that arises in section 3.2 arises from unclarity about what functions there are. An attractive feature of type theory is the willingness to work with an intensional notion of function related to computational procedures rather than the extensional notion of a set of ordered pairs (i.e. the *graph* of an intensional function) which is used in standard set theory. There are two aspects to this intensional notion of function. One is that there can be distinct functions which correspond to the same graph (if you like, two ways of computing the same results from the same input). Another is, that there may be some function graphs for which there is no intensional function (if you like, the function is not computable, or alternatively, we do not know how to compute it). The route back to something more like classical negation is to give up the second of these. That is, we require that for any set of ordered pairs, there is a function corresponding to it. We maintain intensionality of functions by keeping the first aspect, namely we allow there to be more than one function with the same graph. This will have consequences for negation. We will obtain $p \leftrightarrow \neg\neg p$ and $p \lor \neg p$.

Suppose that there is something a of type T. We know that $\neg T$ must be empty is there is something of type T. If $\neg T$ is empty, then there will be a function of type $\neg\neg T$. It is a function with the empty graph.

Now suppose that we have a function of type $\neg\neg T$. Then $\neg T$ must be empty. If T had been empty, then there would have been a function of type $\neg T$. Therefore T must be non-empty.

Thus while $\neg\neg T$ and T are distinct types with distinct objects falling under them, they are nevertheless equivalent in the sense that they will either both be empty or both be non-empty. They are "truth-conditionally equivalent". In this way we can have

both Desideratum 2 and Desideratum 5.

3.4 Infonic negation in situation semantics

In situation semantics there was a notion of infonic negation. Infons were constructed from predicates, their arguments and a polarity. One view of infons was as types of situations. Thus the infon $\langle\langle\text{run},\text{sam},1\rangle\rangle$ represents the type of situation where Sam runs and the negative infon $\langle\langle\text{run},\text{sam},0\rangle\rangle$ represents the type of situation where Sam does not run. Negating an infon involved flipping its polarity. In addition, as we described in section 2, Cooper (1998) proposed that for a situation to support a negative infon σ it also had to support a positive infon incompatible with the positive version of σ.

In TTR types constructed from predicates represent types of situations and thus play a similar role to infons in situation theory. Thus what we have available are types such as run(sam) and, assuming the kind of negation in section 3.3, ¬run(sam). However, the negation is not really like infonic negation. It requires that the type run(sam) is empty, that is, that there are no situations in which Sam runs. This is distinct from a type of situations in which Sam does not run. This means that we do not yet have a way of fulfilling Desideratum 3.[4]

3.5 Negation in simulation semantics

The work on negation in simulation semantics discussed in section 2 is related to the discussion of infonic negation and in particular to the idea that there has to be something positive which is incompatible with the negation. Thus we do not have yet have the TTR tools we need to deal with the kind of analysis suggested in simulation semantics either.

However, there is one important aspect of using types for semantics which we feel is important for simulation semantics. The point is independent of negation although it becomes particularly clear in the case of negation. Simulation semantics talks in terms of representations as mental pictures. However, we believe that the mental representations need to be rather more underspecified than pictures tend

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[4]In earlier pre-TTR work relating type theory with records to situation semantics (Cooper, 1996) there was a more direct modelling of infons with polarity fields. However, this was abandoned in later work.

to be. Consider the fact that the simulation semantics for negation involves a mental representation of the corresponding positive sentence in addition to that of the negative sentence. Thus 'He's not wearing a hat' involves a mental picture of the person in question wearing a hat. But if you have a picture of a person wearing a hat you should have information about what kind of hat it is. If this were the way things worked one might expect dialogues such as (18) to be coherent.

(18)   A: He's not wearing a hat
        B: What kind of hat are you thinking of?

Pictures being visual representations cannot be as underspecified as types may be. Thus there can be a type of situation where somebody is wearing a hat which gives no clue as to what kind of hat it is. We believe that mental simulations could involve the activation of neurological implementations of types in the sense of TTR and that only some of these types correspond to mental pictures.

3.6 Austinian propositions and alternatives-based negation

Following Ginzburg (2012), we introduce situation semantics style Austinian propositions into TTR. These are objects of type (19).

$$(19)\quad \begin{bmatrix} \text{sit} & : & Rec \\ \text{sit-type} & : & RecType \end{bmatrix}$$

An example of an Austinian proposition of this type would be (20).

$$(20)\quad \begin{bmatrix} \text{sit} & = & s \\ \text{sit-type} & = & \begin{bmatrix} c_{\text{run}}\text{:run(sam)} \end{bmatrix} \end{bmatrix}$$

The idea is that an Austinian proposition p is true just in case $p.\text{sit} : p.\text{sit-type}$.

From (20) we can derive the (fully specified) subtype of (19) in (21).

$$(21)\quad \begin{bmatrix} \text{sit}=s & :Rec \\ \text{sit-type}=\begin{bmatrix} c_{\text{run}}\text{:run(sam)} \end{bmatrix} & :RecType \end{bmatrix}$$

If we wish we can use the type (21) for the kind of negation we discuss in section 3.3. However, here we are interested in a stronger kind of negation corresponding to infonic negation. This will involve a notion of incompatible types. Two types

T_1 and T_2 are *incompatible* just in case for any a not both $a : T_1$ and $a : T_2$ no matter what assignments are made to basic types. Incompatibility thus means that there is necessarily no overlap in the set of witnesses for the two types. Using the notion of "model" defined in Cooper (fthc), that is, an assignment of objects to basic types and to basic situation types constructed from a predicate and appropriate arguments, we can characterize the set of witnesses for a type T with respect to "model" M, $[T]^M$, to be $\{a \mid a :_M T\}$ where the notation $a :_M T$ means that a is a witness for type T according to assignment M. We can then say that two types T_1 and T_2 are *incompatible* if and only if for all M, $[T_1]^M \cap [T_2]^M = \emptyset$.[5]

We define a notion of *Austinian witness* for record types closed under negation where the negation of type T, $\neg T$ is defined as the type $(T \to \bot)$ as in section 3.3.

(22) 1. If T is a record type, then s is an Austinian witness for T iff $s : T$

2. If T is a record type, then s is an Austinian witness for $\neg T$ iff $s : T'$ for some T' incompatible with T

3. If T is a type $\neg \neg T'$ then s is an Austinian witness for T iff s is an Austinian witness for T'

The intuitions behind clauses 2 and 3 of (22) are based on the intuitive account of intuitionistic negation. Clause 2 is based on the fact that a way to show that s being of type T would lead to a contradiction is to show that s belongs to a type that is incompatible with T. Clause 3 is based on the fact that if you want to show that a function of type $(T \to \bot)$ would lead to a contradiction is to show a witness for T.

An Austinian proposition
$$\begin{bmatrix} \text{sit} & = & s \\ \text{sit-type} & = & T \end{bmatrix}$$
is *true* iff s is an Austinian witness for T.

Note that we have now preserved the distinction between negative and positive propositions from section 3.3 but that we now have something of the effect of infonic negation as discussed in section 2 in virtue of our use of incompatible types. Negation of Austinian propositions will be classical in the sense that

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[5]Notice that this definition of incompatibility is independent of our definition of negation below.

$$\begin{bmatrix} \text{sit} & = & s \\ \text{sit-type} & = & T \end{bmatrix}$$
is true iff
$$\begin{bmatrix} \text{sit} & = & s \\ \text{sit-type} & = & \neg\neg T \end{bmatrix}$$
is true. However, it is non-classical in the sense that it can be the case that neither
$$\begin{bmatrix} \text{sit} & = & s \\ \text{sit-type} & = & T \end{bmatrix}$$
nor
$$\begin{bmatrix} \text{sit} & = & s \\ \text{sit-type} & = & \neg T \end{bmatrix}$$
is true. We also capture desideratum 4: we follow Ginzburg and Sag (2000) in analyzing polar questions as 0-ary propositional abstracts. However, whereas they appealed to a complex *ad hoc* notion of simultaneous abstraction emanating from Seligman and Moss (1997), we rely on a standard type theoretic notion of abstraction, couched in terms of functional types. For instance, (12b) and (12c) would be assigned the 0-ary abstracts in (23a) and (23b) respectively. These are *distinct* functions from records of type $[]$ (in other words from all records) into the corresponding Austinian propositions. The *simple answerhood* relation of (Ginzburg and Sag, 2000) recast in TTR will ensure that the exhaustive answer to p? are $\{p, \neg p\}$, whereas to $\neg p$? they are $\{\neg p, \neg\neg p\}$, so the exhaustive answers are equivalent, as needed.

(23)

a.
$$\lambda r:[](\begin{bmatrix} \text{sit} & = \text{s} \\ \text{sit-type} & = \begin{bmatrix} \text{c} : \text{EvenNumber(2)} \end{bmatrix} \end{bmatrix})$$

b.
$$\lambda r:[](\begin{bmatrix} \text{sit} & = \text{s} \\ \text{sit-type} & = \begin{bmatrix} \text{c} : \neg \text{EvenNumber(2)} \end{bmatrix} \end{bmatrix})$$

This kind of negation seems therefore to fulfil all our desiderata from section 2.

In order to be fully viable *incompatibility* needs to be further restricted using some notion of *alternativehood* (Cohen, 1999). In some cases what the alternatives amount to is fairly straightforward and even lexicalized—classifying the table as *not black* requires evidence that it is green or brown or blue, say. But in general, figuring out the alternatives, as

Cohen illustrates, is of course itself context dependent, relating *inter alia* to issues currently under discussion.

4 Characterizing contexts for negation

We have already discussed the contextual presuppositions of dialogue particles like 'No' (NegVol and propositional use), 'Si', and 'Oui'. NegVol 'no' merely presupposes an event/situation concerning which the speaker can express her disapproval. Whereas the propositional uses require the QUD–maximality of p?, where p is the proposition they affirm/negate. In KoS (Ginzburg and Fernández, 2010; Ginzburg, 2012, for example), the felicity of these particles in a post-assertoric or post-polar query context is assured by the following update rule:

(24)   polar-question QUD–incrementation $=_{def}$

$$\begin{bmatrix} \text{pre} : \begin{bmatrix} \text{spkr: Ind} \\ \text{addr: Ind} \\ \text{p : Prop} \\ \text{LatestMove.cont =} \\ \text{Ask(spkr,addr,p?)} \\ \vee \text{Assert(spkr,addr,p) : IllocProp} \end{bmatrix} \\ \text{effects} : \begin{bmatrix} \text{qud} = \left\langle \text{p?, pre.qud} \right\rangle : \text{list(Question)} \end{bmatrix} \end{bmatrix}$$

All the desiderata we postulated come together in analyzing dialogues such as the ones in (25,26).

(25)   [B approaches socket with nail]
A: No. (a) Do you want to be electrocuted?
/(b) Don't you want to be electrocuted?
B: No.
A: No.

In (25) B's initial action provides the background for A's initial utterance of 'No', in which A ultimately expresses a wish for the negative situation type ¬StickIn(B,nail,socket) (desideratum 3). (25a) would be a reasonable question to ask in such a context, whereas (25b) suggests social services need to be summoned. This illustrates desideratum (4). Assuming (25a) were uttered B's response asserts the negation of the proposition $p_{\text{electr(B)}}$:

$$\begin{bmatrix} \text{sit = s0} \\ \text{sit-type =} \begin{bmatrix} \text{c : Want(B,electrocuted(B))} \end{bmatrix} \end{bmatrix}.$$

For this to reflect appropriately the force of B's utterance, this needs to be the proposition $\neg p_{\text{electr(B)}}$:

$$\begin{bmatrix} \text{sit = s0} \\ \text{sit-type =} \begin{bmatrix} \text{c : } \neg \text{ Want(B,electrocuted(B))} \end{bmatrix} \end{bmatrix}$$

which is incompatible with $p_{\text{electr(B)}}$ (satisfying desideratum 1). A can now agree with B by uttering 'No' given that MaxQUD : NegProp (desideratum 2).

(26) exemplifies a dialogical application of desideratum 5. In (26(1)) A asserts p_1:

$$\begin{bmatrix} \text{sit = s0} \\ \text{sit-type =} \begin{bmatrix} \text{c : Leave(Bill)} \end{bmatrix} \end{bmatrix}.$$

In (26(2)) B retorts with $\neg p_1$, whereas in (26(3)) A disagrees with B and affirms $\neg\neg p_1$. Clearly, as per desideratum 5, we need this to imply p_1, but this need not be identified with p_1, as exemplified by the fact that C's utterance (26(4)) can be understood as agreement with A, not with B:

(26)   A: (1) Bill is leaving.
B:(2) No.
A: (3) That can't be true.
C(4): No.

What of the VP adverb 'not', in other words sentential negation?[6] The rule in (24) provides a class of contexts in which clauses of the form 'NP ¬ VP' are felicitous, namely ones in which p? is MAX-QUD , where p = cont('NP VP'). However, this characterization is partial, as demonstrated by examples like (27), all drawn from (Pitts (2009)), who collected them from the International Corpus of English (GB).[7] (27a,b) do not explicitly raise the issues, respectively, *Was there a chemical attack on Israel?* and *Is the studio open at that time?*. (27c) is an instance of 'metalinguistic negation' in that it does not dispute content, but form, whereas (27d) is an instance of intra-utterance self–correction:

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[6]A full treatment of the complements of 'not' is well beyond the scope of this paper, though we speculate it can be derived from the condition we provide for the VP case by appropriate "type shifting".

[7]http://www.ucl.ac.uk/english-usage/
projects/ice-gb/

(27) a. The army will only confirm that missiles have fallen in Israel . . . It was not a chemical attack . . . [S2B-015#106] (Pitts' [137])

b. I haven't got enough hours in the day . . . unless I start teaching at midnight. But the studio's not open then. [S1A-083#170] (Pitts' [141])

c. A: there's lots of deers and lots of rabbits. B: It's not deers - it's deer. [S1A-006#261] (Pitts' [107])

d. I might have to do the after-dinner speech at our annual, well, not annual, our Christmas departmental dinner. (Pitts' [112])

We propose a generalization of the characterization that derives from (24). The latter licensed expressing $\neg p$ if p has been asserted or p? queried, whereas (28) licenses $\neg p$ if asking p? is a *relevant move* given the current dialogue gameboard:

(28)   Given a dialogue gameboard dgb0, a negative proposition $\neg p$ is felicitous in dgb0 iff the move 'A ask p?' is relevant in dgb0. ($\neg p$ **is felicitous iff the current context raises the issue of whether p.**)

(28) presupposes substantive notions of relevance or question raising. For the former we appeal to the notion of relevance developed in KoS (see (Ginzburg, 2010)). For the latter see the framework of *Inferential Erotetic Logic* (IEL) e.g. (Wiśniewski, 2001; Wiśniewski, 2003). We exemplify an account of (27a) with the latter and (27c) with the former.

A key component of the analysis in IEL is the use of *m(ultiple)-c(onclusion) entailment* (Shoesmith and Smiley, 1978)—the truth of a set X of premises guarantees the truth of at least one conclusion. Given this, the question evocation can be defined as in (29):

(29) p evokes a question Q iff X mc-entails dQ, the set of simple answers of Q, but for no $A \in dQ, X \models A$

According to this definition (30a) evokes (30b):

(30) a. Missiles have fallen in Israel.

b. Was there a chemical attack in Israel?

In KoS an utterance u by A in which $u1$ is a sub–utterance of u permits B to accommodate in u's immediate aftermath the issue (31a). This is *inter alia* the basis for explaining why (31c) is a coherent follow up to (31b) and can get the resolution (31d).

(31) a. What form did A intend in $u1$?

b. A: There's lots of deers there.

c. B: Deers?

d. Did A intend the form 'deers' in $u1$?

5 Conclusions

In this paper we propose a number of logical, semantic, and psycholinguistic desiderata for the theory of negation, a key ingredient in any account of questions and answers in dialogue. One way to satisfy these desiderata involves a synthesis of the intuitionistic and situation semantic treatments of negation, one that can be effected in TTR. We then sketch how a theory of coherence for negative propositions can be developed on the basis of a dialogical notion of relevance.

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References

Ariel Cohen. 1999. How are alternatives computed? *Journal of Semantics*, 16(1):43.

Robin Cooper. 1996. Information states, attitudes and dependent record types. In Lawrence Cavedon, Patrick Blackburn, Nick Braisby, and Atsushi Shimojima, editors, *Logic, Language and Computation, Volume 3*, pages 85–106. CSLI Publications, Stanford.

Robin Cooper. 1998. Austinian propositions, Davidsonian events and perception complements. In Jonathan Ginzburg, Zurab Khasidashvili, Jean Jacques Levy, Carl Vogel, and Enric Vallduvi, editors, *The Tbilisi Symposium on Logic, Language, and Computation: Selected Papers*, Foundations of Logic, Language, and Information, pages 19–34. CSLI Publications, Stanford.

Robin Cooper. 2005a. Austinian truth, attitudes and type theory. *Research on Language and Computation*, 3:333–362.

Robin Cooper. 2005b. Records and record types in semantic theory. *Journal of Logic and Computation*, 15(2):99–112.

Robin Cooper. fthc. Type theory and semantics in flux. In Ruth Kempson, Nicholas Asher, and Tim Fernando, editors, *Handbook of the Philosophy of Science*, volume 14: Philosophy of Linguistics. Elsevier, Amsterdam.

Jonathan Ginzburg and Raquel Fernández. 2010. Computational models of dialogue. In Alex Clark, Chris Fox, and Shalom Lappin, editors, *Handbook of Computational Linguistics and Natural Language*, Oxford. Blackwell.

Jonathan Ginzburg and Ivan A. Sag. 2000. *Interrogative Investigations: the form, meaning and use of English Interrogatives*. Number 123 in CSLI Lecture Notes. CSLI Publications, Stanford: California.

Jonathan Ginzburg. 2010. Relevance for dialogue. In Paweł Łupkowski and Matthew Purver, editors, *Aspects of Semantics and Pragmatics of Dialogue. SemDial 2010, 14th Workshop on the Semantics and Pragmatics of Dialogue*, Poznań. Polish Society for Cognitive Science. ISBN 978-83-930915-0-8.

Jonathan Ginzburg. 2012. *The Interactive Stance: Meaning for Conversation*. Oxford University Press, Oxford.

Jeroen Groenendijk and Martin Stokhof. 1997. Questions. In Johan van Benthem and Alice ter Meulen, editors, *Handbook of Logic and Linguistics*. North Holland, Amsterdam.

C. L. Hamblin. 1973. Questions in montague english. In Barbara Partee, editor, *Montague Grammar*. Academic Press, New York.

James Higginbotham. 1983. The logic of perceptual reports: An extensional alternative to situation semantics. *Journal of Philosophy*, 80(2):100–127.

Jacob Hoepelmann. 1983. On questions. In Ferenc Kiefer, editor, *Questions and Answers*. Reidel.

Laurence Horn. 1989. *A Natural History of Negation*. University of Chicago Press, Chicago.

Philip N. Johnson-Laird. 1983. *Mental Models*. Harvard University Press.

Lauri Karttunen. 1977. Syntax and semantics of questions. *Linguistics and Philosophy*, 1:3–44.

Barbara Kaup. 2006. What psycholinguistic negation research tells us about the nature of the working memory representations utilized in language comprehension. *Trends in Linguistics Studies and Monographs*, 173:313–350.

Aly Pitts. 2009. *Metamessages of denial: the pragmatics of English negation*. Ph.D. thesis, Cambridge University.

Jerry Seligman and Larry Moss. 1997. Situation Theory. In Johan van Benthem and Alice ter Meulen, editors, *Handbook of Logic and Linguistics*. North Holland, Amsterdam.

D.J. Shoesmith and T.J. Smiley. 1978. *Multiple-conclusion logic*. Cambridge University Press.

Ye Tian, Richard Breheny, and Heather Ferguson. 2010. Why we simulate negated information: A dynamic pragmatic account. *The Quarterly Journal of Experimental Psychology*, 63(12):2305–2312.

Andrzej Wiśniewski. 2001. Questions and inferences. *Logique et Analyse*, 173:5–43.

Andrzej Wiśniewski. 2003. Erotetic search scenarios. *Synthese*, 134:389–427.