The Non-Individuation Constraint Revisited: When to Produce Free Choice Items in Multi-Party Dialogue

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Abstract

In this paper we establish a set of conditions on the production of free choice items (FCI) in multi-party dialogue. Thus, we first observe that indefinite constructions are produced when speakers try to lead their addressees into accessing general, scalar rules, called *topoï*. These rules are used in reaching certain conclusions (i.e., deriving the vericonditional status of a sentence). However, the hearers need to be lead into accessing topoï when they do not manage to do this directly from definite sentences. The ability of the hearers to access topoï from definite sentences is assessed by inspecting the history of their *public commitments* in dialogue: if certain commitments are made, then it is *abductively* inferred that a certain topos was used; if so, then the hearers do not need to be "exposed" to utterances containing indefinite constructs. Secondly, an indefinite construction can be linguistically materialized as a FCI when it is not reducible to a referential situation (the *non-individuation constraint*). We thus propose a way of formalizing the non-individuation constraint in a multi-party dialogue setting, using public commitments as actual worlds, and a λ calculus-based formalism for matching the production of indefinite constructs to the accesses to topoï.

1 Introduction

Usually, FCIs are studied in an *interpretation* context, i.e., for deciding when and why an utterance containing a FCI is felicitous, and another one is not (Giannakidou, 2001), (Jayez and Tovena, 2004). In this paper, generation aspects are studied, i.e., when it is appropriate to produce utterances containing FCIs, and this, in a multi-party dialogue context.

For this, we link the notion of FCIs to that of argumentative *topoï*, i.e., general, scalar rules, of the form 'The more / the less P, the more / the less Q', to be read as 'if P (or $\neg P$) to a certain extent, then Q (or $\neg Q$) to a certain extent' (Anscombre, 1995). More precisely, we assume that, for generality, topoï are stored as general rules, λ-abstracted over the particular *types* (viz. human, student, book, hammer, etc.) or *features* (viz. size, quantity, identity) of the entities involved in the rules.

Thus, assuming that indefinite constructions signal abstractions over the particular features of the entities, it results that utterances containing indefinite determinants (e.g., 'some books') can constitute (or readily imply, in a logical sense) one of the two parts of a topos. Moreover, knowing that free choice items (in English, 'any') are a particular form of indefinite constructions, we can conclude that a free choice item (henceforth, FCI) facilitates the access to topoï, from the perspective of the addressee of the utterance that contains it.

Thus, in a dialogue, whenever a speaker wants a hearer to access a certain topos for reaching a certain conclusion, she produces an utterance containing an indefinite construction. And, if this indefinite construction is not reducible to a referential situation (Jayez's non-individuation constraint – NIC (Jayez and Tovena, 2004)), then it is realized, for example, as 'any' in English, or as 'n'importe quel' or 'tout' in French. In order to give a precise formalization of this process, we need to tackle two issues:

1. deciding when it is necessary to explicitly facilitate the access to a topos (i.e., when the addressee of an utterance is, a priori, not able to access the topos directly from the definite utterance), by using an indefinite construc-

tion;

2. deciding when it is possible to realize the indefinite construction as a FCI (i.e., when the NIC is met).

For the first issue, we rely on the public commitments (Kibble, 2006) of the interlocutors: if an interlocutor already committed in the same dialogue, to a conclusion that *would* have been derived by using a topos, then one infers that this interlocutor has already had a *recent* access to the topos, hence it is very likely that she or he might access it again if necessary. Otherwise, one infers that the access to the topos has to be facilitated by λ-abstracting over certain entities in the utterances. These commitments are derived from the (Segmented) Discourse Representation Structure (SDRS) that each dialogue participant builds, as her / his view on the dialogue (Lascarides and Asher, 2009). The SDRSs for the speakers are calculated in the framework of Segmented Discourse Representation Theory (SDRT) (Asher and Lascarides, 2003).

The second issue is tackled by adapting Jayez's formalization of NIC (Jayez and Tovena, 2004) and extending it to a multi-party dialogue context. Thus, the "worlds" are the speakers' public commitments, the hybrid semantics notion of a clause being true *at* a certain world (Blackburn, 2000) is replaced with the notion of a clause being *entailed* from a public commitment (Lascarides and Asher, 2009), and the multi-party interactional context is accounted for by explicitly individualizing the commitments of each dialogue participant, and by studying the (set-theoretic) relations between these commitments.

Both these adaptations are given a unified formalization by using a non-typed λ calculus for representing the "indefiniteness". However, the entities on which these λ-abstractions apply are semantically typed (viz. agent, object, patient, and modifier[1]).

In this paper, after first presenting the unified λ calculus formalism used throughout the paper, we discuss aspects related to generating indefinite constructs in dialogue, namely the issue of accessing argumentative topoï. Then, we show how public commitments can be used as an *abductive* "hint" for deciding whether an interlocutor has already had access to a topos in the current dialogue. We also provide an extension to Jayez's NIC (Jayez and Tovena, 2004) to multi-party dialogue contexts. Finally, an extended example of a multi-partry dialogue is presented for demostrating the adequacy of the proposed framework.

[1]A semantic type of predicate is also needed for specifying the logical form of an utterance, but in this study abstractions (whence indefinite constructions) over predicates are not considered.

2 Generating Free Choice Items in Multi-Party Dialogue

2.1 Theoretical Issues

We start from (Jayez and Tovena, 2004)'s study, that we extrapolate to multi-party dialogue utterance production. Thus, according to (Jayez and Tovena, 2004), FCIs satisfy three criteria: (i) they are not natural in affirmative episodic utterances; (ii) they are possible in generic and/or imperative and/or conditional utterances; (iii) FCIs implicate that the entities they are applied on in utterances can be freely chosen between the members of a set of entities.

For utterance production, Jayez's NIC is equivalent to the situation of producing a λ-abstracted utterance, where the β-reduction process is blocked (i.e., $\lambda p.Q(p)@\pi$ is impossible); this is equivalent to saying that a FCI is not reducible to a referential situation.

The NIC should be verified when an utterance ought to contain an indefinite construction (signaled, at a semantic level, by a λ-abstraction over an entity in the utterance). This indefinite construction could be specified at a semantic level in order to facilitate the access to certain topoï (Anscombre, 1995), (Popescu and Caelen, 2008). This is, in turn, necessary for the addressee of an utterance to reach certain conclusions (hinted at by the speaker), by way of these topoï. The speaker thus increases the argumentative *strength* (Popescu and Caelen, 2008) of its utterances.

Consider, for instance: '*Any* house would be OK for me!'; a part of its semantic form (that emphasizes the logical object of the utterance) is:

$\lambda X.(\mathsf{[object]}(X) \wedge \mathsf{equals}(X, \text{'house'}) \wedge ...)$.

Via such an expression, its addressee can reach a topos of the form: 'The more one has a house for long-term habitation, the happier one is', i.e., in logical form:

$(\lambda X.(\mathsf{[object]}(X) \wedge \mathsf{equals}(X, \text{'house'})))_+, (\lambda Y.(\mathsf{[agent]}(Y) \wedge \mathsf{happy}(Y)))_+$.

The predicates [object] and [agent] designate the semantic roles of the object of the action reported in an utterance, and the agent performing this action, respectively; equals/2 is true if and only if its two arguments are bound to the same value.

The usage of abstractions for facilitating the access to topoï is needed because, unlike the "ideal" situation assumed in (Popescu and Caelen, 2008), where addressees automatically perform the required λ-abstractions for accessing appropriate topoï, real dialogue agents (e.g., humans) have only partial reasoning capabilities (i.e., either they just do not perform the required lambda abstractions, or they do not perform it in due time – they perform it too late, i.e., not before the interlocutor's *subsequent* speech turn). In multi-party dialogue the situation is even thornier, because certain participants might be able to perform λ abstractions, certain might not. The use of indefinites is thus a means to tune this ability for *certain* addressees, which might yield a behavior of *selective cooperativity* in dialogue.

On the other hand, as pointed out by (Jayez and Tovena, 2004) among others, FCIs are used in emphatic, that is, *illocutionary marked* utterances (Vanderveken, 1990 1991). Thus, indefinites should be checked for their realizability as FCIs bearing in mind that such utterances have a strong degree of illocutionary force. Example: 'Any book is a waste of time', or, in logical form:

$\lambda X.([\text{object}](X) \wedge \text{equals}(X, \text{'book'}))$,

with: $\nexists\xi|\lambda X.([\text{object}](X) \wedge \text{equals}(X, \text{'book'}))@\xi$ (i.e., the β-reduction on X is blocked). This will be, by convention, written in a condensed form as:

$\lambda X.([\text{object}](X) \wedge \text{equals}(X, \text{'book'}))\neg@$.

When several variables are involved, those where λ abstractions are possible are marked by the β-reduction operator, preceded by the modal possibility operator ($\Diamond$). Thus, for '*Any* book makes us waist *some* time (reading it).', we have:

$\lambda X\lambda Y.([\text{object}](X) \wedge \text{equals}(X, \text{'book'}) \wedge [\text{mod}](Y) \wedge \text{equals}(Y, \text{'time'}) \wedge \text{waist}(.., X, Y))\Diamond@\neg@$.

Thus, here the β-reduction on Y can be performed.

The multi-party dialogue context imposes constraints concerning the selectivity of the speakers, according to their *dynamic profile*, i.e., their demonstrated ability to perform λ-abstractions for accessing topoï. The dynamic profiles of the speakers are *dialogue-wise*, in the sense that they are not persistent from one conversation session to another. These profiles are captured via the *public commitments* of the speakers: if a speaker commits her/himself to a fact, then he *must have* performed the required reasoning for this, e.g., access some topoï for deriving certain conclusions (associated – i.e., resulting from, or leading to – that fact). The reliance on public commitments in this way for determining the speakers' ability of accessing topoï is a form of abductive reasoning (i.e., $(P \Rightarrow Q) \wedge Q/ > P$, where ">" means "normally", deafeasibly (Asher and Lascarides, 2003)). The commitments are expressed as user-specific SDRSs (cf. (Lascarides and Asher, 2009)).

A thorny issue concerning the abductive reasoning discussed above concerns the uniqueness of the premise (Hobbs et al., 1993): how do we know that a hearer committed to a fact by accessing a certain topos, and not in another way (e.g., by trusting the speaker, by following her order, or by modus ponens-like reasoning on facts in her/his own knowledge base)? An answer is that, in our case, we assume no a priori concerning trust (i.e., interlocutors do not a priori trust each other), social hierarchies are not assumed between dialogue partners (i.e., there are no orders simply followed) and, moreover, that abductive reasoning is not fragile, i.e., when a speaker *might* have gotten committed to a fact via a topos, we assume that this was, indeed the case. However, we should relax this constraint and provide a more fine-grained distinction between the situation where a topos is more likely to have been used, or static knowledge might have been used.

A general procedure for producing FCIs goes as follows:

1. for an utterance to generate (labeled by π, with $K(\pi)$ its logical form), check if it has the potential of facilitating the addressee to reach a certain conclusion (or, in another parlance, to commit him/herself to a certain fact), via a topos, τ; if so, then go to step 2; otherwise, feed the utterance into a surface realizer (e.g., canned phrase-based) and stop;

2. check whether the addressee has the ability of accessing this topos τ directly from the non-indefinite form of the utterance (i.e., check whether that topos might have been already used for reaching some commitments in the

current commitment store of the addressee); if so, then feed the utterance into a surface realizer (e.g., canned phrase-based) and stop; otherwise, go to step 3;

3. perform a λ-abstraction over some relevant entities or the determinants of these entities in $K(\pi)$, so that the abstracted logical form, denoted by $\overline{K(\pi)}$ can constitute a premise for τ (i.e., $\tau = (\{|\neg\}\overline{K(\pi)}, \{|\neg\ K(\pi'))$, where $K(\pi')$ is the conclusion to be reached);

4. if β-reduction is possible by relying on the current contents of the commitment stores of the addressees of utterance π, then generate the λ-abstracted entities as indefinites; otherwise, generate them as FCIs (e.g., in English, 'any').

The first step of the algorithm is checked by performing all the possible combinations of λ-abstractions on the determinants (modifiers in our parlance, as discussed above) and by matching the abstracted logical forms of the utterance, to topoï premises. Then, the appropriate potentially useful lambda abstracted logical forms are kept for the third step of the algorithm, if the second step is not successful (i.e., the user can directly access the required topos from the non-abstracted logical form – i.e., non-indefinite utterance).

The second step of the algorithm is basically tackled by inspecting the content of the commitment store of the addressee after each dialogue *round*[2]: for each fact that the addressee is committed to (a fact is an SDRS, that represents the "view" of the addressee on the dialogue that has been taken place so far (Lascarides and Asher, 2009)), it is checked, based on the whole commitment store of the speaker, how this fact might have been "reached", from a logical point of view: if this fact could have been obtained by using a (optionally, β-reduced) topos as a premise[3], then it is inferred that this topos is already "fresh" in the memory of the addressee, hence, it is very likely that it is accessed again, if needed.

For this, we set, for each accessible rule or fact for performing reasoning, a priority, in inverse proportion with the recency of its access; this is practically handled by putting each newly accessed knowledge rule or fact in a stack. Then, when reasoning must be performed, first the stack is checked for each rule or fact and, if no appropriate rule or fact is found in the stack, then the commitment store is checked[4], and finally, the static knowledge base (e.g. a task or domain ontology for artificial agents (Caelen and Xuereb, 2007)). Once such a fact or rule is actually *used* in performing the reasoning, it is placed in the stack.

The results of the first two steps of the procedure are combined so that the appropriate λ abstraction of $K(\pi)$ is used as a premise for selecting, in the third step, the appropriate topos τ, that, according to the second step, the addressee might *not* have reached directly from the non-abstracted logical form.

By far the most difficult, the fourth step of the algorithm boils down to implementing Jayez's non-individuation constraint in the context of utterance production in multi-party dialogue. Deciding whether a β-reduction of a λ-abstracted utterance is blocked is a delicate task, because reasoning is needed on the joint commitments of the speaker *and* addressees. For this, we start from Jayez's formalization of NIC (Jayez and Tovena, 2004), where the hybrid logic "at" (@)operator is replaced by the notion of entailment (i.e., an expression such as $@_w\Phi$, read as 'Φ is true *at* w, where w is a (possible or real) world' is replaced by $w \models \Phi$, read as 'Φ is entailed from w', which is less restrictive than the former, because in our case we consider that the worlds are the interlocutors' public commitments, which are real from the perspective of each 'owner' of such a commitment store, and a clause is true 'at' such a commitment if it already is in that commitment. However, all we need here is that the clause can be inferred from that commitment and, optionally, static knowledge from the knowledge base).

In a multi-party dialogue setting, each participant has a set of worlds "opened" after each speech turn is produced; common ground is reached "at" (in a hybrid logical sense) the worlds (i.e., public commitments) that are "opened" by all the participants (i.e., the intersection of the set of

[2]A round in dialogue is a series of speech turns, produced by each speaker before the same speaker produces a new speech turn.

[3]The topoï are represented as λ-abstractions over entities, or over determiners of the entities – see above, but also (Popescu and Caelen, 2008).

[4]Note that this is not a technical redundancy, because in the stack of each interlocutor we put only rules or facts that he/she has *accessed*, i.e., read from the knowledge base *or* from her/his commitment store, not the facts *resulted* from these reasoning processes and placed in the commitment store.

commitments "opened" by each speaker). We thus arrive at a definition of common ground which is consistent with the recent formalization provided in (Lascarides and Asher, 2009) for the notion of common ground. Although we will not further delve into this issue here, it remains nevertheless relevant for a fine-grained decision regarding the selective use of FCIs for specific addressees of an utterance (cf. also the discussion below).

Thus, when a speaker L_{i_0} wants to produce an utterance to addressees L_i specified by a set $I \subseteq \{1, ..., N\} \setminus \{i_0\}$, where N is the number of speakers in the multi-party dialogue, the β-reduction of the λ-abstracted logical form $\overline{K(\pi)}$ is possible when either one of four constraints are met (they mirror Jayez's constraints (Jayez and Tovena, 2004)). First, we assume, in line with (Jayez and Tovena, 2004), that the logical form of the utterance π can be written as:

$K(\pi) = \mu_1(\{\exists|\forall\}K(P)\mu_2(K(Q)))$,

where μ_1 and μ_2 are modal operators (semantically, $\Box$ or $\Diamond$, and textually, verbs such as 'need', 'must', or, respectively, 'might', 'could')[5], and P and Q are clauses (that optionally contain negations, $\neg$). Thus, from the perspective of the speaker, L_{i_0}:

1.(a) $\bigcup_\Phi\{\Phi : CS_{L_{i_0}} \models \Phi \wedge CS_{L_{i_0}} \models \mu_1\mu_2\Phi\} \models \exists X : P(X) \wedge Q(X)$;

1.(b) $\bigcup_\Phi\{\Phi : CS_{L_{i_0}} \models \Phi \wedge CS_{L_{i_0}} \models \mu_1\mu_2\Phi\} \models \exists X : P(X) \wedge \neg Q(X)$;

2.(a) $CS_{L_{i_0}} \models \exists X : P(X) \wedge \forall\Gamma : \Gamma \equiv (\mu_1(\{\exists|\forall\}K(P')\mu_2(K(Q')))) \wedge CS^+_{L_{i_0}} \leftarrow CS_{L_{i_0}} \cup \{\Gamma\} \Rightarrow CS^+_{L_{i_0}} \models P(X) \wedge Q(X)$;

2.(b) $CS_{L_{i_0}} \models \exists X : P(X) \wedge \forall\Gamma : \Gamma \equiv (\mu_1(\{\exists|\forall\}K(P')\mu_2(K(Q')))) \wedge CS^+_{L_{i_0}} \leftarrow CS_{L_{i_0}} \cup \{\Gamma\} \Rightarrow CS^+_{L_{i_0}} \models P(X) \wedge \neg Q(X)$.

Again, following, in spirit, (Jayez and Tovena, 2004), for each sequent of the form $CS_L \models \Phi$, we rewrite the expressions above, by replacing CS_L with $\overline{CS_L}$, where $\overline{CS_{L_i}} \subseteq CS_{L_i}$ is the minimal commitment store such that $\overline{CS_{L_i}} \models \Phi$.

The first two constraints specify when utterances can describe referential situations associated with descriptive linguistic performance (i.e., a particular state of a world is described), whereas the latter two concern referential situations associated with exhaustiveness, i.e., utterances containing FCIs can satisfy the constraints 2 while given a universal interpretation, e.g. 'He read *any* book on the reading list' (lit. 'He read *every* book on the reading list')[6].

For extending this to multi-party dialogue, we consider that L_j, with $j \in I$, is an addressee of utterance π. Thus, $\overline{K(\pi)}$ is β-reducible if:

$\Psi = CS_{L_{i_0}}\Delta CS_{L_j} \not\models \neg(\exists X : P(X) \wedge \{|\neg\}Q(X))$,

where Δ is the symmetric difference operator (for two sets A and B, $A\Delta B = (A\backslash B)\cup(B\backslash A)$). Otherwise, the β-reduction of the λ-abstraction $\overline{K(\pi)}$ of the semantic form $K(\pi)$ of utterance π is not possible.

However, as pointed out in (Jayez and Tovena, 2004), the β-reduction of the lambda abstracted form of π is also blocked when, although the actual lambda abstracted π is referential, its vericonditional status is deduced from a fact (or a rule) that does not make reference to particular individuals (e.g., a *hard* topos (Popescu and Caelen, 2008), that is, a natural law of the form 'The more an x is greater than a value δ, the better x is').

We formalize this idea by stating that the β-reduction of the lambda abstracted form of π is also blocked when there is a hard topos τ such that $CS_{L_{i_0}} \models K(\pi) \wedge CS_{L_{i_0}} \setminus \{\tau\} \not\models K(\pi)$. However, according to (Jayez and Tovena, 2004), τ can also be simply a λ-abstracted clause with a non-β-reducible term (by virtue of the NIC, i.e., the constraints 1 and 2 above); a hard topos is only a particular case of such a clause.

2.2 Multi-Party Dialogue Examples

The various situations that the mechanism proposed here has to deal with for generating FCIs are illustrated by the tree depicted in Figure 1, where decisions are made according to the following pragmatic constraints:

(i) the addressees (must / do not need to) access a topos for reaching a certain conclusion,

(ii) this topos (must / does not need to) be elicited by using indefinite constructions,

(iii) the NIC (is / is not) satisfied,

(iv) the indefinite utterance (depends on / does not depend of) a hard topos.

[5]These operators can also be void, e.g., for partially or purely assertive utterances.

[6]This example is borrowed from (Jayez and Tovena, 2004).

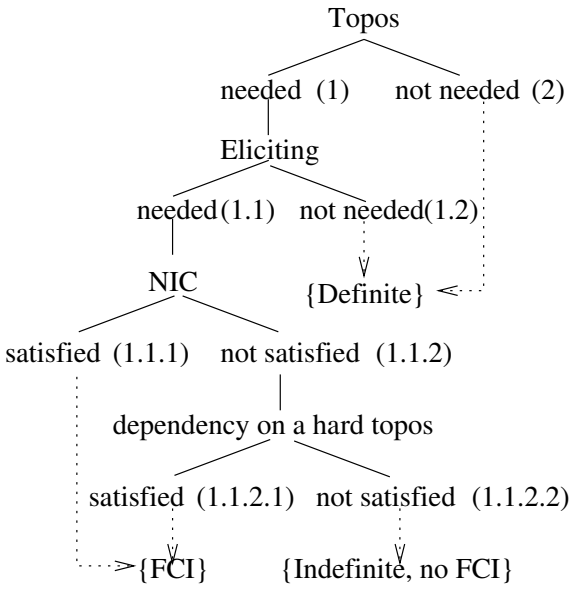

Figure 1: Decisions on the generation of FCIs.

The numbers between parentheses identify the possible paths in the tree.

From Figure 1 and from the manner the NIC is stated (in terms of public commitments and need to topoï access), it results that in a dialogue, the number of FCIs produced by the interlocutors tends to lower as the dialogue progresses, unless new topoï are brought forth. This can be seen from the following example of dialogue between four speakers, concerning a book reservation topic.

> L_1: Hello, I would like to read a book by A. Uthor.
>
> L_2: Take this one, it is better than *any* other!
>
> L_1: OK, but how about this one (another book, different from L_2's referent – n.a.), what do you think?
>
> L_2: Yes, that one is good as well.
>
> L_3: But, sir, how about the book "B. O. O. K." by A. Uthor?
>
> L_1: That one as well, it is better than *any* other book.
>
> L_4: Oh, yeah, all the customers have taken **any* book of this author!
>
> L_3: I have read this one, it was better than *any* of A. Uthor's books!

The *any* in L_2's first turn is justified by the fact that we are in a situation that corresponds to path (1.1.1) on the tree in Figure 1. This is true, because L_2 needs to elicit the topos 'the more a book is better than other comparable books, the more interesting it is for the reader' or, in λ-abstracted form:

$\tau = (\lambda X \lambda Y.(\textsf{[object]}(X) \wedge \textsf{equals}(X, \text{'book'}) \wedge \textsf{[patient]}(Y) \wedge \textsf{equals}(Y, \text{'book'}) \wedge \textsf{better}(X, Y)))_+, (\lambda Z \lambda T.(\textsf{[agent]}(Z) \wedge \textsf{equals}(Z, \text{'reader'}) \wedge \textsf{[object]}(T) \wedge \textsf{equals}(T, \text{'book'}) \wedge \textsf{interesting}(T, Z) \wedge [T \equiv X]))_+$.

The predicate $\textsf{better}/2$ is a shorthand notation for the fact that the value of the first argument is higher than the value of the second, on a certain scale. The conjunct $[T \equiv X]$ is a procedure that states that T and X are different names for the same variable.

In L_2's second turn, no indefinite construction is used, because the same topos τ as above is already present in L_1's stack of accessed knowledge ζ_{L_1} (see Section 2.1), as brought forth by L_2's first turn; hence, the situation corresponds to path (1.2) on the tree in Figure 1.

However, in its third turn, addressed to L_3, L_1 uses the FCI *any*, because the topos τ from above needs to be elicited again, as $\tau \notin \zeta_{L_3}$ yet (L_2's first turn was addressed to L_1 only, and we assume that if an utterance has not been addressed to an interlocutor, then the latter does not update its commitment store with the effects of this utterance).

L_4's use of *any* in its dialogue turn is not felicitous, because the NIC is violated. Indeed, the verb in the past ('has taken') entails that the concrete actions associated to that utterance are already present in L_4's commitment store:

$CS_{L_4} \ni \exists X, Y : \textsf{[object]}(X) \wedge \textsf{[agent]}(Y) \wedge \textsf{equals}(X, \text{'book'}) \wedge \textsf{equals}(Y, \text{'customer'}) \wedge \textsf{borrow}(Y, X)$.

This situation thus corresponds to path (1.1.2.2) on the tree in Figure 1.

In the last turn of L_3, a similar argument as above entails that NIC is violated and hence, the situation cannot correspond to path (1.1.1) on the tree in Figure 1. However, since L_3's utterance is addressed to L_4, who needs the topos τ being elicited ($\tau \notin \zeta_{L_4}$), the utterance is felicitous by virtue of path (1.1.2.1), because it is dependent on a hard topos of the type: 'For an entity x has a feature δ_x, the more δ_x is higher than a certain value δ, the more x is a better entity, on an appropriate

scale'.

3 Discussion

In this paper we have proposed a framework for predicting the production of FCIs in multi-party dialogue. For this, we started from previous work of (Jayez and Tovena, 2004) on the interpretation of FCIs in monologue utterances. Thus, we extended this work to generation in multi-party dialogue situations. For this, several adjustments had to be made:

(i) establishing a reason for generating indefinite constructions (i.e., the need to determine the addressees to access certain topoï for deriving certain conclusions),

(ii) providing an interpretation for the concept of "world", *at* which a certain clause is true (i.e., assimilating such a world to the commitment stores of the speaker and the addressees),

(iii) restating the non-individuation constraint in terms of speakers commitments and of a model-theoretic entailment relation, instead of Blackburn's hybrid logic "at" operator (Blackburn, 2000),

(iv) unifying the processing steps required to make the decision to generate a FCI, by using a lambda calculus-inspired formalism.

However, several points have been left untackled, with respect to the study of (Jayez and Tovena, 2004) concerning the interpretation of FCIs. Thus, the issue of the quantificational profile of FCIs has not been addressed: for instance, in French some FCIs are existential (such as 'n'importe quel' – lit. 'no matter which'), while others are universal (such as 'tout' – lit. 'any', as in 'Tout abus sera puni' – 'Any abuse will be punished'). Then, the thorny problem of FCIs applied on negative predicates has not been addressed either: for instance, constructions like 'John refused **any* book' (in French, 'Jean a refusé **n'importe quel* livre') are not felicitous; investigating how one can know this in generation, without resorting to a bare list of negative predicates, remains a topic of further research.

Then, in adapting Jayez's hybrid logic notion of truth at a world, we could have used a construction more akin to the original one in (Jayez and Tovena, 2004) by conflating λ-abstraction to "at" operators. Thus, in formalizing the fact that in a commitment store it is true that $\lambda X.\Phi(X)$ and that β-reduction is not possible in this expression, we could have written, for a speaker L_i, $@_{CS_{L_i}}[\lambda X.\Phi(X)\neg@]$, instead of $CS_{L_i} \models \lambda X.\Phi(X)\neg@$. But, if we had kept Jayez's account, we would have stated a stronger condition than one actually needs, namely that the lambda abstraction $\overline{\Phi}$ of Φ were actually already available as true in CS_{L_i}; however, we only need that $\overline{\Phi}$ be *entailed* from CS_{L_i}, because a monotonic deduction scheme is used (Popescu and Caelen, 2008).

Concerning the differences between languages, for the English FCI 'any' one has two French rough translations, 'n'importe quel' (lit. 'no matter which') and 'tout' (lit. 'any'). Jayez's study shows that the two French FCIs differ in that for 'tout', the set of potential alternative referents is not rigid (or a priori fixed, known), whereas for 'n'importe quel', the set of potential alternatives is fixed in advance, rigid. At a formal level, this situation could be captured by a logical form like:

$[\lambda X.([\mathsf{object}](X) \wedge \mathsf{equals}(X, ...) \wedge ... \wedge \mathsf{SubsetOf}(X, Set))\neg@]\wedge(...\wedge\mathsf{value}(Set, \nu)\wedge...)$

for 'n'importe quel' (i.e., the λ-abstracted X belongs to a set Set that is a priori initialized with a value, ν). Consider for example: 'Prends *n'importe quel livre* [dans la bibliothèque – n.a.]' ('Take *no matter which / any* book [in the library]'), versus 'Prends **tout* livre [dans la bibliothèque]' ('Take *any* book [in the library]'). For 'tout', the conjunct concerning the properties of the set Set should be explicitly $\neg\mathsf{value}(Set, \nu)$ or, in a Prolog-like environment, it would suffice that no restriction apply on Set. Take for example, 'Punis *tout* délit' ('Punish *any* misdemeanor') – unlike the set of possible books in the library, the set of misdemeanors is not a priori specified.

The framework presented in this paper can be applied in artificial agents as well, for endowing them with the capability of generating contextually-relevant answers in dialogues around a specified task (e.g., book reservation in a public library). Thus, dialogue modeling frameworks that explicitly address utterance generation as an important aspect (see, e.g., (Stent, 2001), or (Popescu, 2008)) could benefit from the proposal described in this paper for generating FCIs in dialogue. However, in order to do this, a series of adjustments might be appropriate, such as simplifying the computation of the commitment stores of the interlocutors. Indeed, keeping whole user-specific dialogue SDRSs in the commitment stores might be more than one needs. In the model-

theoretic framework proposed in this paper, the entailment ($\models$) operation needs a model, i.e., a set of rules and facts in the left-hand side; the fine-grained SDRS representation (with scoping constraints over referents (Asher, 1993)) is not needed. We might thus adopt the strategy of computing the commitment stores in a manner akin to (Maudet et al., 2006).

Thus, we assume that the commitment store CS_{L_i} for each user L_i in a dialogue, contains the semantics of the utterances that L_i has produced, along with the semantics of the utterances from the other interlocutors, that L_i has agreed with (this is indicated by rhetorical relations between these utterances and utterances of L_i), and finally, along with the *negated* semantics of the utterances of other speakers, that L_i did *not* agree with, along with the rhetorical relations that emphasize this fact (e.g. *P-Corr* (Plan Correction) or *Contrast* (Asher and Lascarides, 2003)).

For example, consider the following dialogue, between two speakers L_i and L_j, the former being a customer and the latter, a librarian:

> L_j: You can still borrow three books!
>
> L_i: So, I can take this one as well?
>
> L_j: Yes, you can take it, sir.

This interaction contains a question of L_i, that is in an $Elab_q$ relation to the first utterance of L_j; the subsequent answer of L_j is in an *Elaboration* relation to the first utterance, since, indeed the two turns of L_j achieve the same effect (from the point of view of the task that the dialogue tries to help resolving) as a unique turn of L_j:

> L_j: 'You can still borrow three books, so, for instance, you can take book 'X' that you want'

where book 'X' and 'this one' in L_i's question, refer to the same object in the physical world.

The commitment store of L_i, after she had asked the question, is a set:
$CS_{L_i} = \{K(\pi_1), K(\pi_2), \Sigma_{Elab_q(\pi_1,\pi_2)}\}$,
where π_1 and π_2 denote the first utterance of L_j and the first utterance of L_i (the question) respectively, $K(\pi)$ is the logical form of utterance π, and $\Sigma_{Elab_q(\pi_1,\pi_2)}$ denotes the SDRT semantics of the rhetorical relation $Elab_q(\pi_1, \pi_2)$, which specifies that utterance π_2 is a question such that any relevant answer elaborates on utterance π_1 (Asher and Lascarides, 2003).

References

Jean-Claude Anscombre. 1995. Topique or not topique: formes topiques intrinsèques et formes topiques extrinsèques. *Journal of Pragmatics*, 24:115–141.

Nicholas Asher and Alex Lascarides. 2003. *Logics of Conversation*. Cambridge University Press, UK.

Nicholas Asher. 1993. *Reference to Abstract Objects in Discourse*. Kluwer Academic Publisher, Dordrecht, Netherlands.

Patrick Blackburn. 2000. Representation, reasoning and relational structures: A hybrid logic manifesto. *Logic Journal of the IGPL*, 8:339–365.

Jean Caelen and Anne Xuereb. 2007. *Interaction et pragmatique - jeux de dialogue et de langage*. Hermès Science, Paris.

Anastasia Giannakidou. 2001. The meaning of free choice. *Linguistics and Philosophy*, 24:659–735.

Jerry Hobbs, Mark Stickel, and Douglas Appelt. 1993. Interpretation as abduction. *Artificial Intelligence*, 63:69–142.

Jacques Jayez and Lucia Tovena. 2004. Free choiceness and non-individuation. *Linguistics and Philosophy*, 28:1–71.

Rodger Kibble. 2006. Reasoning about propositional commitments in dialogue. *Research on Language and Computation*, 4(2-3):179–202.

Alex Lascarides and Nicholas Asher. 2009. Grounding and correcting commitments in dialogue. *Journal of Semantics*, (to appear).

Nicolas Maudet, Philippe Muller, and Laurent Prvot. 2006. Social constraints on rhetorical relations in dialogue. In *Proceedings of the 2nd SIGGen Workshop Constraints in Discourse*, pages 133–139, Maynooth, Ireland, July 7-9. ACL.

Vladimir Popescu and Jean Caelen. 2008. Argumentative ordering of utterances for language generation in multi-party human-computer dialogue. *Argumentation*, [DOI: 10.1007/s10503-008-9122-y].

Vladimir Popescu. 2008. *Formalisation des contraintes pragmatiques pour la génération des énoncés en dialogue homme-machine multi-locuteurs*. Ph D Thesis, Grenoble Institute of Technology.

Amanda Stent. 2001. *Dialogue Systems as Conversational Partners: Applying Conversational Acts Theory to Natural Language Generation for Task-Oriented Mixed-Initiative Spoken Dialogue*. Ph D Thesis, University of Rochester.

Daniel Vanderveken. 1990-1991. *Meaning and Speech Acts*. Cambridge University Press, UK.