Bridging Reference to Eventualities

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Abstract

Bridging anaphora can refer not only to previously introduced discourse entities, but also to abstract entities such as eventualities. The proposal made in this paper is to extend the current account of bridging in SDRT in a way that implicit reference to eventualities can be accounted for. We exploit the idea developed in Frame Semantics that world knowledge is organized in frames. With each eventuality introduced in a discourse, a corresponding frame is evoked in the discourse model. SDRT will be extended to include possibly underspecified representations of frame elements, which can give clues for finding suitable antecedents in bridging anaphora.

1 Introduction

Natural language discourses consisting of several utterances are more than merely stringing the utterances together. Discourses are structured and there are relationships between utterances at various levels. Basically, one can distinguish coherence and cohesion in a discourse. On the one hand, text segments are connected by discourse relations, yielding coherence of a discourse. On the other hand, there are many anaphoric relations within a single utterance as well as spanning bigger distances. They are responsible for cohesion in a text. Various types of anaphora can be distinguished - they can be either direct, e.g. if a pronoun is used, or more indirect, if there is some connection but no direct coreference between discourse entities. Clark (1977) called these cases of anaphora *bridging* anaphora. In a bridging anaphor, an entity introduced in a discourse *stands in a particular relation* to some previously mentioned discourse entity. This bridging relation is not explicitly stated. Yet it is an essential part of the discourse content because the knowledge of these relations is necessary for successfully interpreting a discourse.

Clark differentiated various kinds of bridging inferences. The most prominent type is indirect reference by association, where the antecedent is *closely associated* with a discourse entity mentioned before. There is some literature concerning these cases (cf. Asher and Lascarides, 1998a; Piwek and Krahmer, 2000). Another type of bridging is indirect reference by characterization, where the bridging relation *characterizes a role that*

something implicitly plays in an eventuality[1] mentioned before. Roles can be optional or necessary agents, objects, or instruments. Less work is done on this topic. Koenig and Mauner (1999) deal with reference to thematic arguments, and Bos *et al.* (1995) propose a lexical account for bridging. In this paper, we want to investigate how extralinguistic information sources constrain bridging references to eventualities. We will take Clark's example (1) as a prototypical case.

(1)   a.   John was murdered yesterday.
       b.   The knife lay nearby.

Utterance (1-a) describes a killing event which took place on the day preceding the utterance. The individual referred to by the proper name "John" is the victim of the event. Utterance (1-b) describes a state of the entity denoted by the definite noun phrase "the knife"[2]. This entity is new in the discourse, but stands in an implicit relation to the event described in utterance (1-a): the knife served probably as the instrument of the killing event. This relationship is not expressed by linguistic means. Instead, the hearer has to infer it using contextual knowledge. Apart from understanding the previous utterance, successful interpretation of (1-b) requires some world knowledge: in a murdering event, there must be a victim and a killer, and normally there is also an instrument used for performing the act.

Only by means of this additional knowledge, the hearer can successfully interpret the utterance and connect it to the preceding discourse. In this way, interpretation involves incrementally constructing a structured mental representation of the discourse. It is structured in the sense that rhetorical relations hold between discourse segments. In example (1), utterance (b) is subordinated to (a), providing background information. Neither these relations between utterances nor relations between discourse entities (including eventualities) have necessarily to be expressed directly by linguistic means. They often exist only implicitly, forcing the hearer to infer them using defeasible pragmatic inferences. In a successful interpretation, all information, not only directly expressed but also indirectly inferred, will be part of the discourse model constructed by the hearer in course of interpretation. The discourse model, as Cornish (1999) puts it, is "a constantly evolving representation of the entities, propositions, eventualities, properties, and states, as well as their interrelations, which are introduced into the discourse, or are assumed already to exist therein, at particular points". We adopt Segmented Discourse Representation Theory (SDRT, Asher and Lascarides, 2003) as theory of modelling discourse structure and processes, a theory that has already been formalized in considerable detail.

The remainder of this paper is organized as follows. In section 2, we will summarize the current account of bridging in the framework of SDRT and introduce the basic

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[1]We use the term *eventuality* for uniformly referring to events, states, actions or circumstances.

[2]There are also cases of referring indefinite noun phrases which convey a bridging relation. In (i), "a knife" clearly refers to the probable instrument of murdering, almost identically as in example (1).

(i)   John was murdered yesterday. A knife lay nearby.

As the literature on bridging mainly focuses on definite descriptions, we will concentrate on utterances involving definites. Different behaviour of indefinites is indicated whenever necessary.

ideas of Frame Semantics before we propose to integrate these two lines of research. Section 3 shows how bridging references can be solved using the proposed account. In section 4, we discuss related approaches, and we conclude in section 5.

2   Using Frame Semantics for Bridging in SDRT

2.1   Bridging in SDRT

We assume that the hearer is familiar with the basics of dynamic semantics (DRT, Kamp and Reyle, 1993). SDRT (Asher and Lascarides, 2003) is an extension of DRT with basically two new expressions: (i) speech act discourse referents, which label content of text segments and keep track of token utterances, and (ii) rhetorical relations, which relate speech act discourse referents. The resulting structures are segmented DRSs (SDRSs).

In SDRT, bridging inferences are seen as "a byproduct of computing how the current sentence connects to the previous ones in the discourse" (Asher and Lascarides, 1998a). Four meta-rules for bridging are stated:
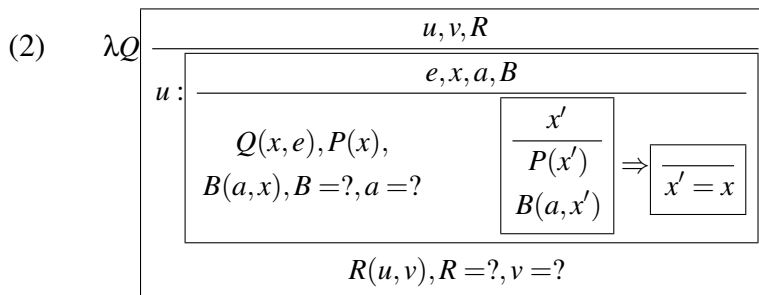
1. **If possible use identity.**

2. **Bridges must be plausible.**

3. **Discourse structure determines bridging.**

4. **Maximize discourse coherence.**

The first rule reflects the empirical preference of resolving anaphora to an identical antecedent. This rule is the preferred rule; if resolution to identity is not possible, then the other rules apply in the indicated order. The second rule means that world knowledge "specifies certain plausible ways of filling the underspecified parameters in the presupposed material". Thus, plausibility relies on world knowledge, but is not precisely defined. We will try to refine this notion in a more constrained way. The third rule states that if a rhetorical relation between the involved discourse segments gives particular clues for resolving the anaphora, then this information is to be used. The fourth rule is one of the most basic principles assumed in SDRT. In discourse interpretation, there is a preference for resolving bridging anaphora in a way that maximizes discourse coherence.

To see more formally how bridging inferences a drawn in SDRT, we will concentrate on the meaning representation of definite descriptions triggering bridging inferences. In Russellian tradition, the denotation of a definite noun phrase can only be given if it fulfills the conditions on existence and uniqueness. This can be written in a short form using the iota operator ι which maps a set containing only one element to this element. An expression $\iota x.P(x)$, representing the core meaning of "the P", denotes x if $\exists x.P(x) \wedge \forall x'[P(x') \rightarrow x' = x]$ is true; if not, it is not defined. Chierchia (1995, p. 221) extends this notion and includes a contextual parameter B for a bridging relation. He claims that "the P" denotes a P that is related by B to an antecedent a to be specified by context. B restricts the domain and must be included in the uniqueness condition.

Building on that, Asher and Lascarides (1998a, p. 87) characterize the meaning of a definite noun phrase as $\lambda Q.Q(\iota x(B(x,a) \wedge P(x)))$. This expression applies a predicate Q (the verb meaning) to the entity x, for which P (the meaning of the NP) is true and that is related by a bridging relation B to some contextually given antecedent a.

This meaning characterization corresponds to the SDRT representation shown in (2). Note that the condition of uniqueness is now represented by the DRS condition consisting of the two small DRSs connected by $\Rightarrow$. The representation of an indefinite noun phrase would be very similar, in the sense that we just leave out the uniqueness condition and keep the rest of the conditions.

(2) λQ

$$
\begin{array}{|c|}
\hline
u,v,R \\
\hline
u: \begin{array}{|c|} \hline e,x,a,B \\ \hline Q(x,e),P(x), \quad \begin{array}{|c|} \hline x' \\ \hline P(x') \\ B(a,x') \end{array} \Rightarrow \begin{array}{|c|} \hline x'=x \\ \hline \end{array} \\ B(a,x),B=?,a=? \\ \hline \end{array} \\
\hline
R(u,v),R=?,v=? \\
\hline
\end{array}
$$

There are two underspecifications to be specified by pragmatic inference: Firstly, a coherence relation $R(u,v)$ has to be established. According to Asher and Lascarides (1998b), a definite description triggers a coherence relation between the current utterance u and some previous utterance v. Secondly, in the bridging relation $B(a,x)$, the parameters B and a have to be specified (Asher and Lascarides, 1998a). For direct anaphora, B is *identity*. For indirect reference by association, B can be *part-of* or *member-of*. For indirect reference by characterization, B is a thematic role, e.g. *agent*, *theme*, or *instrument*. The question we want to go further into is what kind of information can we exploit to help us drawing these inferences.

2.2   Frame Semantics and FrameNet

To get clues for the resolution of this kind of bridging inferences, we propose to exploit an idea already mentioned in Gardent *et al.* (2003), but not further pursued. The idea is to use Frame Semantics, developed by Fillmore (1976), and subsequent work on FrameNet (Baker *et al.*, 1998; Fillmore *et al.*, 2003). This framework is based on the central assumption that world knowledge is organized in frames. Basic units are frames and lexical units. Frames are mental representations of stereotypical situations, whose elements can only be defined by relating one to another. A lexical unit is a pairing of a word with a meaning; polysemous words are represented by several lexical units. Every lexical unit **evokes** a particular frame and can only be understood in relation to that frame.

FrameNet (Baker *et al.*, 1998) is a lexical resource providing a body of annotated sentences based on frame semantics. The database contains around 10,000 lexical units, 800 semantic frames and over 120,000 example sentences. Frames are hierarchically organized: e.g. the frame *Killing* inherits the properties from the more general frame *Transitive_action*, which in turn inherits from the abstract frame *Event*. A frame con-

sists of various **Frame Elements**, kinds of entities that can participate in a frame. They are defined in relation to a frame, and correspond roughly to thematic roles in an event. Sometimes, conceptually necessary Frame Elements do not show up in a sentence. This is the case of omitted agents in passive sentences (Constructional Null Instantiation, CNI), missing obligatory elements that can be inferred from the context (Definite Null Instantiation, DNI), or implicit arguments of certain transitive verbs that are used intransitively, e.g. verbs as *eat*, *bake* (Indefinite Null Instantiation, INI). For illustration, the *Killing* frame is described below in Fig. 1, and one of the lexical units evoking that frame, the verb *murder*, is characterized in Fig. 2.[3]

Definition: A Killer or Cause causes the death of the Victim.

Core Frame Elements :

FE	description	inherited FE	semantic type
Killer	The person or sentient entity that causes the death of the Victim	Agent	sentient
Victim	The living entity that dies as a result of the killing	Patient	sentient
Instrument	The device used by the Killer to bring about the death of the Victim	Instr.	physical entity
Cause	An inanimate entity or process that causes the death of the Victim	Cause	
Means	The method or action that the Killer or Cause performs resulting in the death of the Victim	Means	state of affairs

Non-Core Frame Elements: Beneficiary, Manner, Place, Purpose, Time, ...

Lexical Units: annihilate.v, annihilation.n, ..., murder.n, murder.v, murderer.n, ..., terminate.v

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Figure 1: The *Killing* frame

As can be seen in Fig. 2, there are three cases among the 23 annotated sentences in the FrameNet database containing the lexical unit *murder.v* in which the *Killer* was not expressed at all (CNI), and the *Victim* showed up as external argument of the verb. This configuration is typical for passive sentences like (1).

An important question is whether a linguistic expression denoting an eventuality, e.g. a verb, evokes at most one frame, exactly one frame, or more than one frame[4]. As said above, in FrameNet, a *lexical unit* is defined as a pairing of a word with a sense. For a polysemous word, "the separate senses of the word correspond to the different (sets of) frames that the word can participate in. When a word's sense is based on a

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[3]Definitions are taken from the FrameNet Database, obtainable from the International Computer Science Institute, Berkeley, California (http://framenet.icsi.berkeley.edu/).

[4]I owe the examples to an anonymous reviewer who drew my attention to this point.

Lexical Entry: murder.v

- Frame elements and their syntactic realizations

  Killer   CNI.– (3), NP.Ext (15), PP[by].Dep (5)
  Victim   NP.Ext (8), INI.– (1), NP.Obj(14)

- Frame elements and valence patterns

frame element	realized as			
Killer	NP.Ext	NP.Ext	PP[by].Dep	CNI.–
Victim	NP.Obj	INI.–	NP.Ext	NP.Ext
(23)	(14)	(1)	(5)	(3)

Figure 2: Lexical entry *murder.v*

particular frame, the word evokes the frame" (Fillmore *et al.*, 2003). For example, the verb "break" can evoke, among others, the frame *Experience_bodily_harm* (e.g. in "I broke my leg") or the frame *Render_nonfunctional* (in "I guess I broke the doorknob"). Thus, interpretation of a text requires assumptions about which frame is relevant in the given context. Take the verb "eat": it could be associated with a set of frames, e.g. a restaurant frame, a family home frame, a wild-animals-in-the-open frame, etc. The question is how the right frame ends up being selected. We would suggest to choose the most general frame fitting in the given context. For "eating" this would be the frame *Ingestion*. Due to the hierarchical structure of FrameNet, any frame involving eating would inherit the properties and frame elements of this frame. Of course, in case that there are various very divergent senses of a word, the selected frame perhaps is too general to be helpful for our purposes. But still, FrameNet provides in many cases very useful information for discourse interpretation.

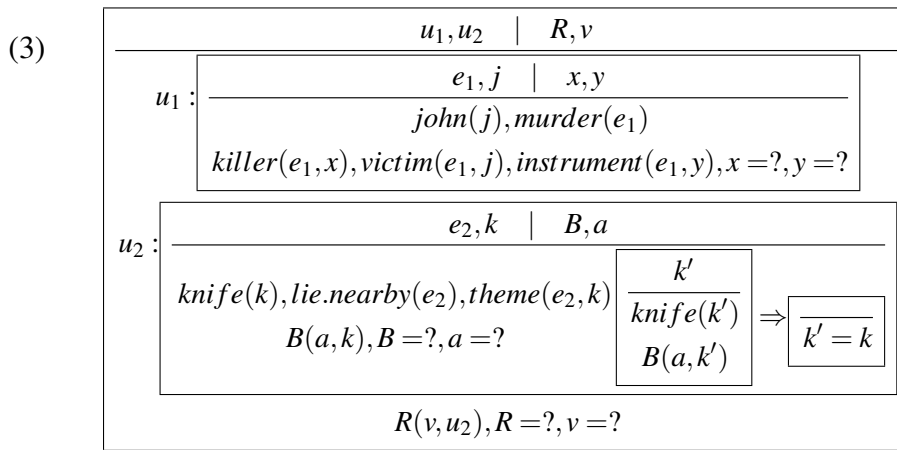## 2.3   Proposal: Integrate FrameNet and SDRT

Each eventuality introduced in a discourse evokes a corresponding frame in the discourse model. Its frame elements correspond to all relevant (necessary or optional) thematic roles of the event. We propose to include for all core frame elements a representation in the discourse model, i.e. in the SDRS of the current utterance[5]. In case that some participant of a frame is not expressed linguistically, its representation remains underspecified. These elements can be further specified by subsequent information, provided that the discourse referent for the eventuality remains accessible for anaphoric reference. We will spell out in more detail how this works in section 3. Before that, we will discuss how frame elements can be represented in SDRT, and how they help to determine

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[5]For expository purposes, we will ignore non-core frame elements, as well as the core frame elements *Cause* and *Means*, but surely a more sophisticated discourse model must contain additional representations of spatial and temporal coordinates. However, they do not add to the main points we want to make in this paper.

discourse relations.

In order to integrate FrameNet data in SDRT, we adopt a neo-Davidsonian style of event semantics (Parsons, 1990), assuming that lexical units expressing eventualities include an implicit event argument in their semantic representation. Thematic roles in an event are represented as conditions in form of predicates, whose first argument is this event argument. For instance, the sentence "John eats an apple" gets a semantic representation $\exists e \exists j \exists a [eat(e) \wedge agent(e,j) \wedge theme(e,a) \wedge john(j) \wedge apple(a)]$. Equipped in this way, we can express the underspecified semantic content of (1) as shown in (3).

According to FrameNet data (Baker *et al.*, 1998), in course of interpreting the utterance, the *Killing* frame is evoked by the verb "murder". Its core frame elements show up in the SDRS as $killer(e_1,x)$, $victim(e_1,j)$ and $instrument(e_1,y)$. Similarly, the verb "lie" (in its sense "lie nearby") evokes the frame *Being_located*, with only one core frame element $theme(e_2,k)$.

(3)

$$
\begin{array}{|c|}
\hline
u_1, u_2 \quad | \quad R, v \\
\hline
u_1: \begin{array}{|c|}
\hline
e_1, j \quad | \quad x, y \\
\hline
john(j), murder(e_1) \\
killer(e_1,x), victim(e_1,j), instrument(e_1,y), x=?, y=? \\
\hline
\end{array} \\
u_2: \begin{array}{|c|}
\hline
e_2, k \quad | \quad B, a \\
\hline
knife(k), lie.nearby(e_2), theme(e_2,k) \quad \begin{array}{|c|}\hline k' \\ \hline knife(k') \\ B(a,k') \\ \hline \end{array} \Rightarrow \begin{array}{|c|}\hline k'=k \\ \hline \end{array} \\
B(a,k), B=?, a=? \\
\hline
\end{array} \\
R(v,u_2), R=?, v=? \\
\hline
\end{array}
$$

Thanks to the hierarchical structure of the FrameNet database, the *Killing* frame inherits the properties of the more general abstract frame *Transitive_action*, which in turn inherits from *Event*. The frame *Being_located* inherits the frame elements of the abstract frame *State*. As assumed in Asher and Lascarides (2003), the occurrence of an event followed by a state is a strong indicator for the presence of a BACKGROUND relation between the discourse segments containing the eventualities. This can be expressed by a default rule (4) [6] (cf. Asher and Lascarides, 2003, p. 207, Vieu and Prévot, 2004, p. 486). Thus, in example (1), a BACKGROUND relation R between u_1 and u_2 can be assumed.

(4) $u_1 : event(e_1) \wedge u_2 : state(e_2) > \text{BACKGROUND}(u_1,u_2)$

3   Resolving Bridging References

Resolving bridging anaphora requires two problems to be solved: (i) the correct antecedent to which the anaphor is to be connected has to be found, and (ii) the nature of the bridging relation itself must be identified. For solving (i), possible antecedents must be identified, and impossible ones must be ruled out. For solving (ii), it is helpful

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[6]'>' is a nonmonotonic conditional operator. *A > B* means: *if A then normally B*.

to restrict possible relations to conditions on discourse referents already present in the discourse model or at least evoked.

3.1   Constraints on Anaphoric Reference

Accessibility for anaphoric reference is constrained by general discourse principles such as the Right Frontier Constraint (RFC, Polanyi, 1988; Webber, 1988). Basically, this constraint draws a distinction between coordinating and subordinating discourse relations: a coordinating relation pushes the right frontier to the right, closing off its attachment point, and a subordinating relation extends the right frontier downwards, leaving open its attachment point. In SDRT, an antecedent for an anaphoric expression must be DRS-accessible on the right frontier (Asher and Lascarides, 2003). Asher & Lascarides' meta-rule "discourse structure determines bridging" (see section 2.1) is captured by this constraint. Recent work on SDRT (Vieu and Prévot, 2004) has revealed that BACK-GROUND should be considered as subordinating by default. Accordingly, in (1), u_1 lies on the right frontier of the discourse, and e_1 is accessible for anaphoric reference in u_2. So the discourse structure tells us that, in principle, a bridging relation can be established. Now, the question remains of how to build the bridge between the knife and the killing event. As seen in the last section, FrameNet data can give important clues to establish discourse relations. But this knowledge is not always sufficient to resolve bridging references. In (1), the presence of a BACKGROUND relation alone is not enough to motivate the bridge. Which further information can we obtain from FrameNet?

The frame element *instrument* in the killing frame must have a semantic type (in the FrameNet sense) "physical_entity". It can be a weapon, but in principle any other physical entity could be used for killing, e.g. hands (5) or a lamp (6).

(5)   John killed Mary. He strangled her.

(6)   John killed Mary. He stunned her with a lamp.

On the other hand, the lexical unit "knife" evokes the frame *Weapon* bearing a semantic type "artifact", indicating the possibility that it could serve as an instrument in a killing event. But as noted in the informal FrameNet description, knives are not necessarily designed as weapons. So this knowledge does not really help us to resolve the bridging relation, at least in the present state of FrameNet. The only knowledge we can use is that there is no clash of semantic types: both knives and killing instruments are physical entities. As far as that we can capture the intuition behind Asher & Lascarides' meta-rule that "bridges must be plausible". It is little more than saying that interpretations must be consistent. In fact, as Zeevat (2006) suggests, selecting the most plausible interpretation given the context and the utterance entails a preference for consistent over inconsistent interpretations. Thus, using FrameNet data, we at least partly get an approximation to the plausibility constraint, which, nevertheless, is a probabilistic notion while consistency is either fulfilled or not. A full, gradual notion of plausibility is surely better captured by some kind of probabilistic system than by an all-or-nothing notion of consistency.

Looking again at the four meta-rules, we find as first rule "if possible use identity". This rule seems to be subsumed by a very general constraint in discourse in-

terpretation, sometimes called DOAP "Don't overlook anaphoric possibilities". This principle is essentially stating that if there is an anaphoric trigger, we must try to find an antecedent. This preference can be captured by a general low ranked default saying that, unless otherwise indicated, (semantically compatible) discourse referents can be assumed to be equal. Formal details on how *Equality by Default* constrains anaphoric reference are described in Cohen (2007).

As noted above, with the presence of a discourse relation between u_1 and u_2, the discourse referents in u_1 are accessible for anaphoric reference in u_2. So, with Equality by Default, we can assume that a is equal to e_1. Thus, the bridging relation $B(a,k)$ can be specified as $instr(e_1,k)$. As a byproduct, the underspecified variable y in the condition $instr(e_1,y)$ in u_1 can be resolved to k, yielding that instrument and knife refer to the same entity. Although k is not accessible in u_1, it is accessible in the superordinated SDRS compromising both utterances, and therefore, after processing the second utterance, the underspecification can be resolved. Note that these inferences are defeasible and can be overridden by subsequent information. Nevertheless, if the bridging relation can be resolved, the discourse turns out to be more coherent. This captures the intuition behind Asher & Lascarides' fourth meta-rule "maximize discourse coherence" (MDC). Now consider discourse (7).

(7)   a. John was murdered yesterday. b. # The book lay nearby.

This discourse is - in a neutral context - less coherent than (1), and we would like to explain why. In example (1), the knowledge that a knife is a kind of weapon that can serve as an instrument in a killing event licenses the bridging inference. In example (7), such a connection cannot be found. Again, a BACKGROUND relation can be inferred, but the role that "the book" could play in the killing event is less clear than that of a knife. Although there is no clear semantic connection between "the book" and any evoked core frame element, there is no clash of semantic types, and a bridging relation to the instrument could be plausible. Nevertheless, as no sense of "book" evokes a frame similar to *Weapon*, it remains unclear what nature has the bridging relation, and the discourse seems less coherent. Note again, if the context provides additional evidence that the book is a probable killing instrument, e.g. by being contaminated with poison, the bridging inference indeed can be drawn. To summarize the principles we need for bridging resolution, we remain with the following constraints on anaphoric reference:
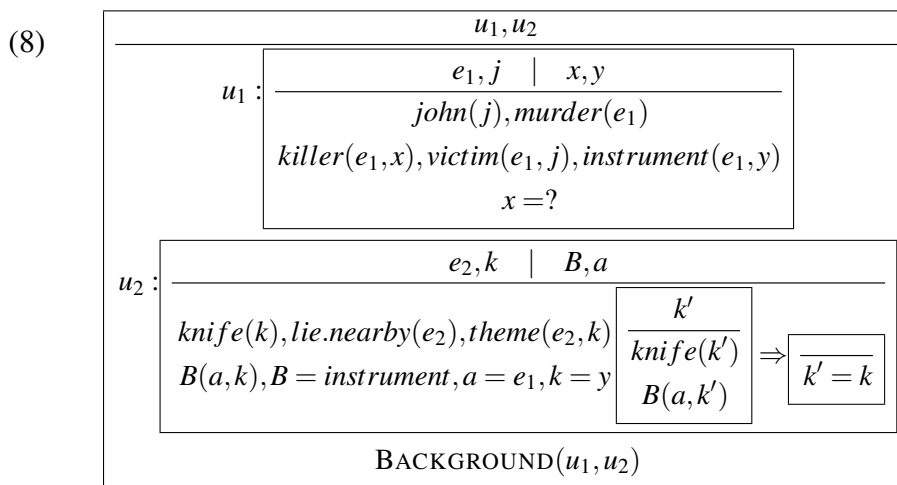
- DOAP

- PLAUSIBLE or CONSISTENT

- RFC

- MDC

Note that they are not meant to be special meta-rules designed for bridging resolution, they rather seem to be more general constraints to be obeyed in discourse interpretation. They could be seen as constraints in optimality theoretic pragmatics, but we will not adopt a particular framework here, as we leave open the question whether the

ranking of these constraints should be left as stated above. For a related discussion, see Zeevat (2006).

3.2 Weak Discourse Referents

For illustration, a pragmatically enriched SDRS for discourse (1) is shown in (8). Note that as the murderer is not mentioned at all, his referent could not be resolved and its representation remains underspecified.

(8)

$$
\begin{array}{|l|}
\hline
u_1, u_2 \\
\hline
u_1: \begin{array}{|c|}
\hline
e_1, j \quad | \quad x, y \\
\hline
john(j), murder(e_1) \\
killer(e_1, x), victim(e_1, j), instrument(e_1, y) \\
x = ? \\
\end{array} \\
u_2: \begin{array}{|c|}
\hline
e_2, k \quad | \quad B, a \\
\hline
knife(k), lie.nearby(e_2), theme(e_2, k) \\
B(a, k), B = instrument, a = e_1, k = y
\end{array}
\begin{array}{|c|}
\hline
k' \\
\hline
knife(k') \\
B(a, k')
\end{array} \Rightarrow \begin{array}{|c|}
\hline
k' = k \\
\hline
\end{array} \\
\mathrm{BACKGROUND}(u_1, u_2) \\
\hline
\end{array}
$$

As suggested by the SDRT representations, we now have to deal with two different kinds of discourse entities: *regular* discourse referents introduced by linguistic expressions, and *weak* discourse referents which are not (yet) expressed linguistically. *Weak Discourse Referents* are abstract entities which are evoked or activated in course of the interpretation process. A linguistic expression does not introduce them directly, rather indirectly by virtue of the frame evoked by a lexical unit. They often remain underspecified, but can be specified by subsequent anaphoric reference. This is what happens with the killing instrument. Its identification with the knife helps to render the discourse more coherent. If the knife in the second sentence had nothing to do with the first sentence, the discourse would be rather incoherent, at least after uttering the second sentence.

The distinction between two types of discourse referents is not entirely new, e.g. Kamp and Rossdeutscher (1994) assume "schematic discourse referents". Furthermore, this assumption could be generalized in the sense that all discourse referents are assigned finer-grained weights on a scale according to their salience, instead of distinguishing just two kinds of referents. We leave this point to further investigation.

Our proposal is to restrict the search space for suitable antecedents for bridging anaphora to take into account only accessible regular and weak discourse referents. In this way, the resolution of bridging inferences can be considerably constrained. In our model, new entities are (weakly) introduced with every eventuality that is talked about, with the potential to be strengthened, to remain in the background, or even to be dropped.

4 Related Approaches

4.1 Implicit Arguments as A-definites (Koenig and Mauner, 1999)

Important work on the discourse status of non-expressed event participants was presented by Koenig and Mauner (1999), who build upon results of psycholinguistic experiments concerning implicit verbal arguments. Reading times of sentences like (10) following one of the sentences in (9-a) were compared in an experiment carried out by Mauner *et al.* (1995)

(9)   a.   A ship was sunk
      b.   A ship sank
      c.   A ship was sunk by someone

(10)   ... to collect settlement money from the insurance company.

Subjects take longer to process rationale clauses like (10) when they follow intransitive sentences like (9-b) than when they follow short passives (9-a) or agentive passives (9-c). Thus it seems that verbs like "sink" in (9-a) include an implicit actor argument as part of the representation of the lexical item, and the implicit anaphoric (PRO) subject of "collect" in (10) can be anchored more easily in the discourse model. Koenig and Mauner (1999) claim that implicit arguments, as well as words like the French subject clitic "on", the German "man", and indefinite uses of English "they" (*a-definites* in their terminology), cannot serve as antecedents of anaphora and do not introduce any discourse referent at all. Their DRT representation for sentence (9-a) is (11):

(11) $$\boxed{\begin{array}{c} y \\ \hline ship(y), sink(x,y) \end{array}}$$

In this representation, it remains unclear how the apparently free variable x, representing the actor, is model-theoretically interpreted. Moreover, as noted in their paper, bridging references to implicit arguments *are* indeed possible, e.g. consider example (12).

(12)   a.   They killed the president.
      b.   The terrorists were merciless.

Koenig and Mauner (1999) do not give any details on how such an inference can be drawn according to their theory. The interpretational apparatus of DRT (Kamp and Reyle, 1993) would have to be changed in order to allow uninstantiated variables in final DRSs. Such an attempt is made by Farkas and Swart (2003). Here, we want to refrain from a major modification of truth conditions in DRT.

4.2 Bridging as Coercive Accommodation (Bos *et al.*, 1995)

Bos *et al.* (1995) presented an approach that is indeed very close to our proposal. Basically, they combine an extension of van der Sandt (1992)'s theory of presupposition with

the *Generative Lexicon* (Pustejovsky, 1995), comparing bridging with Pustejovsky's *coercion*. This approach is based on a convincing formal definition of an extension of DRT. However, the treatment of bridging as a lexical phenomenon is not unproblematic. It is limited to lexically induced bridging inferences. Bos *et al.* (1995) show example (13) as a limitation case of their approach.

(13)   Probably, if Jane takes a bath, Bill will be annoyed that there is no more hot water.

Interpreting this short discourse involves the inference that taking a bath involves using a hot water reservoir. This inference is difficult to explain in Bos *et al.* (1995)'s framework. Regarding FrameNet, in the present state of English FrameNet it is unclear whether phrasal verbs are lexical units and how they evoke frames, e.g. whether "take a bath" counts as a lexical unit, or just "take". However, in other versions of FrameNet, such knowledge is encoded; an equivalent sentence in Spanish using the verb "bañarse" (to take a bath) is analyzable in FrameNet terms[7]. There, it evokes the frame *Cause_to_be_wet* with a core frame element *Liquid*, which can be instantiated by "hot water". Still better is a suggestion made by the developers of Polish FrameNet[8], according to which both "wziąć kąpiel" (like in English) and "wykapać się" (like in Spanish) evoke the frame *Grooming*, where an *Agent* engages in personal body care. An *Instrument* can be used in this process as well as a *Medium*. Thus, if "take a bath" is treated as a lexical unit, we can draw the inference that the water in the second clause is used for the bath in the first clause.

(14)   Yesterday, Chomsky analyzed a sentence on the blackboard, but I couldn't see the tree.

Moreover, as Piwek and Krahmer (2000) note, not all implied antecedents are lexical entailments; sometimes, non-lexical background knowledge is needed, as in (14). To correctly understand this utterance, the hearer has to rely on specific background knowledge, in particular on the knowledge that a generative syntactic analysis typically involves a tree-like representation of the sentence. It is questionable whether highly context-sensitive information of this kind is part of the lexicon. In any case, FrameNet provides us with additional secondary information which surely is beyond the lexicon but still has an influence on resolving bridging anaphora.

5   Conclusion

We have sketched how SDRT's account of bridging can be extended in order to cover reference to eventualities. SDRT and FrameNet are combined by assuming a neo-Davidsonian event representation and distinguishing two types of discourse referents. We could indicate that the meta-principles assumed for bridging can be put down to more general constraints to be obeyed in discourse interpretation. We have spelled out

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[7]see http://gemini.uab.es/
[8]Magdalena Zawisławska, p.c.; see http://www.ramki.uw.edu.pl/

how world knowledge, represented in frames, contributes to the interpretation process, both for establishing discourse relations and for resolving indirect anaphora.

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