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Topic Shifts: Preserving Comprehension in Conversation

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UNIVERSITÉ DE LORRAINE, IDMC

MASTER'S THESIS

Topic Shifts: Preserving Comprehension in Conversation

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*A thesis submitted in fulfilment of the requirements
for the Master's degree in Natural Language Processing*

in the

CLASP team
Department of Philosophy, Linguistics and Theory of Science
University of Gothenburg

March - August, 2022



GÖTEBORGS UNIVERSITET

To be defended on September, 1st, 2022

Declaration of Authorship

I, Amandine DECKER, declare that this thesis titled, "Topic Shifts: Preserving Comprehension in Conversation" and the work presented in it are my own. I confirm that:

- This work was done wholly or mainly while in candidature for a research degree at this University.
- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.
- Where I have consulted the published work of others, this is always clearly attributed.
- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work.
- I have acknowledged all main sources of help.
- Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself.

Signed: Amandine Decker

Date: August 23, 2022

“Wir alle sind Narren, es hat keiner das Recht, einem andern seine eigentümliche Narrheit aufzudrängen.” [We’re all fools, and not one of us has the right to impose his own foolishness on anyone else.]

— Georg Büchner, *Dantons Tod* [Danton’s death]

UNIVERSITÉ DE LORRAINE, IDMC

Abstract

University of Gothenburg
Department of Philosophy, Linguistics and Theory of Science

Master's degree in Natural Language Processing

Topic Shifts: Preserving Comprehension in Conversation

by Amandine DECKER

Topics play an important role in coherence in dialogue, as what is currently discussed constrains the possible contributions of the participants, and initiating a topic while the previous one is still under discussion may be confusing without appropriate signals. However, how to actually define the notion of topic is debated in linguistics and not sufficiently discussed in dialogue modelling.

A precise description of topics and topic shifts in conversation would contribute to understanding what it is we perceive when we judge a sequence of utterances to be coherent. In particular, having more understanding of the notion of topic is important to account for language use which does not conform to our intuitions about topical coherence, such as can be found in interactions involving for example patients with schizophrenia. In patients interaction we often see difficulties to produce a coherent speech from the ordinary listener's point of view. These difficulties can manifest at topic level where patients would use fewer markers to indicate a topic shift, or use unusual topical links such as sound similarity between two different concepts. Formalising topic transitions, and in particular more unusual ones, would thus contribute to identifying cues to support diagnosing schizophrenia.

In this thesis we analyse several pieces of conversation containing topic shifts in order to understand the different mechanisms that license topic shifts in dialogue and the way participants acknowledge them. In particular, we investigate topic shifts based on extra-linguistic content and more unconventional topic shifts where speakers take advantage of word similarities to introduce a new topic with no semantic relation with the previous one. We apply two classical discourse modelling theories to our examples, Rhetorical Structure Theory and Segmented Discourse Representation Theory, and show their limits when it comes to modelling topics and topic shifts. In particular, the unique representation for a conversation that they produce does not make it possible to precisely understand the mechanisms that lead to a disruption. Hence, we use a more complex framework, Conversation Oriented Semantics, which is based on Type Theory with Records and enables us to represent each participant's representation of the conversation, as well as different forms of context. We suggest a way to add topics to these representations and account for topic shifts, including unconventional ones.

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The last few years were far from what I pictured for myself when I started thinking about my professional dreams. But my choices regarding my studies have always been motivated by curiosity and eagerness to learn. It started years ago before high school, when I made the decision on a whim to apply for a program that emphasized subjects at the opposite of my skills. It widened my horizons, made me meet the most incredible people, and taught me that I did not have to choose between science and literature. More generally, I learned that transcending boundaries between scientific disciplines is the key to answering today's and tomorrow's big questions.

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List of Abbreviations

CDU	Complex Discourse unit
CLASP	Centre for Linguistic Theory and Studies in Probability
DGB	Dialogue Game Board
DRS	Discourse Representation Structure
DRT	Discourse Representation Theory
DU	Discourse unit
EDU	Elementary Discourse Unit
FLoV	Department of Philosophy, Linguistics and Theory of Science
KoS	Conversation Oriented Semantics
ML	Machine Learning
RFC	Right Frontier Constraint
RST	Rhetorical Structure Theory
SDRS	Segmented Discourse Representation Structure
SDRT	Segmented Discourse Representation Theory
TTR	Type Theory with Records
TTRP	Topic Transition Relevance Place

Numbering Conventions

Three types of numbering were used in this thesis to refer to:

- Linguistic examples (arabic numerals, *e.g.*, (2.1));
- Representation of record types in TTR (roman numerals, *e.g.*, (4.i));
- Update rules in TTR (letters, *e.g.*, (4.a)).

Chapter 1

Motivation and Context

- (1.1) D1: it is the technology itself when it comes to that that I am PAUSE interested in
 P2_1: yes
 P2_2: that's right PAUSE
 P2_3: technology is fun
 D3_1: this feels a bit strange to be standing here right now
 D3_2: but
 P4_1: yes
 P4_2: but I think you can stand

[Villing, 2015, P.45-46]

This piece of dialogue is an exchange between the passenger of a car (P) and the driver (D). In the scope of a research experiment, they were asked to conduct two tasks simultaneously: (1) the passenger questions the driver about their personal interests and (2) delivers navigation instructions at relevant times. The conversation in (1.1) can be divided into two parts corresponding to these two tasks. From D1 to P2_3, the participants speak about the driver's personal interests. Then they switch to the navigation topic as the driver feels uneasy with the position of the car. With this explanation of the context, the conversation seems coherent. However without it, it can be complicated to completely follow the discussion. In particular, there is no explicit transition from the first part about the driver's personal interests to the second one, where the topic is not clear without context.

This extract shows that topics play an important role in interpreting a conversation. If a participant has a wrong idea of the topic under discussion, it is very likely that their next move will be incoherent. Indeed, if a new contribution is not in the scope of what is currently discussed, the addressees can be confused if they do not acknowledge the topic shift. However identifying topic shifts is not necessarily straightforward as they are not always explicitly signalled. For example, the situational context can licence a topic shift as in (1.1), but not perceiving the relevant aspect of the situation can lead to misunderstandings.

A characterisation of topics and topic shifts, especially regarding the intra- and extra-linguistic aspects of conversation we rely on to identify them, would contribute to understanding what it is we perceive when we judge a sequence of utterances to be coherent, and what makes a topic shift reasonable at a certain point in a dialogue. In particular, increasing understanding of the notion of topic is important to account for language use which does not conform to our intuitions about topical coherence, such as can be found in interactions involving for example patients with schizophrenia. In patients' interaction we often see difficulties in producing coherent

speech from the ordinary listener's point of view. These difficulties can manifest at topic level where patients use fewer markers to indicate a topic shift, or use unusual topical links such as sound similarity between two different words. Formalising topic transitions – in particular more unusual ones – would thus contribute to identifying cues supporting diagnosis of schizophrenia. Moreover, it could benefit virtual assistants to identify relations between utterances linked by common sense reasoning but seemingly unrelated based on linguistics content only. Developing precise descriptions of topic transitions would enable virtual agents to produce smooth transitions between unrelated topics and therefore appear more natural. However, how to define the notion of topic is debated in linguistics and not sufficiently discussed in dialogue modelling.

The word *topic* can refer to several concepts in the literature. Topics are considered both at the sentence level (Bolinger, 1952; Firbas, 1964; Halliday, 1967; Givón, 1983) and at the discourse level (Schieffelin and Keenan, 1976; Brown and Yule, 1983). A *sentence topic* is an element of the sentence, usually a noun phrase, that the sentence comments on (Hockett, 1958). *Discourse topics*, on the other hand, are not necessarily explicit. They refer to what a piece of discourse is about, though the formalisation of this “aboutness” is debated. Discourse topics have been defined as based on the “question of immediate concern” (Keenan, Schieffelin, and Platt, 1983), explicitly stated or not, or as “the proposition or set of propositions that the question of immediate concern presupposes” (Schieffelin and Keenan, 1976). These definitions assume that a topic can be described in a unique way which raises several issues. Firstly, describing a topic can be done in several ways and determining the right question, proposition or set of propositions characterising a piece of dialogue would require an evaluation method (Brown and Yule, 1983, p. 72). Considering paraphrases of a representation as equivalent could solve this problem but a second issue remains. Each dialogue participant can have a different representation of what the conversation is about, which means that individual representations would be necessary to account for topics in a dialogue model.

Nevertheless, most dialogue modelling theories have a God's-eye-view of dialogue, which prevents accounting for potential mismatches between the participants' representations. They also focus on the linguistic content, while extra-linguistic information is sometimes required to recognise the links between the parts of a conversation. To overcome these limitations, we study some pieces of dialogues containing topic shifts to understand the way topics are handled in conversation. We explore different existing dialogue modelling theories for modelling topics and topic shifts.

This thesis is organised as follows. The rest of Chapter 1 introduces the research teams and organisations that played a role in this work (Section 1.1), as well as the two research projects this thesis takes its roots in (Section 1.2). In Chapter 2 we discuss different types of topics shifts in dialogue. We present two dialogue modelling theories in Chapter 3 and analyse their limitations regarding topics and topic shifts. Chapter 4 is an attempt to overcome these limitations with a more flexible framework. Eventually Chapter 5 concludes this thesis with a discussion on the future of this work and the role machine learning (ML) could play in it.

1.1 Host Organisation

This internship took place within the Department of Philosophy, Linguistics and Theory of Science at the university of Gothenburg, and in particular with members

of the Centre for Linguistic Theory and Studies in Probability (CLASP). The work described in this report follows two internships in the SEMAGRAMME team within the LORIA research lab. This internship was carried out under the supervision of Ellen Breitholtz (CLASP) and Maxime Amblard (SEMAGRAMME).

The Department of Philosophy, Linguistics and Theory of Science (FLoV) of the University of Gothenburg was founded in 2009 and is one of six departments of the Faculty of Humanities. The focus of FLoV is mainly Theoretical and Practical Philosophy, Logic, Linguistics, Computational Linguistics, Language Technology and Theory of Science. CLASP is the major research program of the department when it comes to research in Linguistics. The focus of CLASP is the analysis of natural language thanks to probabilistic and information theoretic approaches. This work is multidisciplinary and combines natural language processing, theoretical linguistics and cognitive science.

The LORIA (*Laboratoire lorrain de Recherche en Informatique et ses Applications / Lorraine Research Laboratory in Computer Science and its Applications*) is a research unit (UMR 7503) created in 1997 where CNRS, the University of Lorraine and Inria collaborate. It works mainly on fundamental and applied research in computer sciences. SEMAGRAMME is a joint team of the University of Lorraine, the CNRS, and Inria. The aim of the SEMAGRAMME project is the definition and development of logic-based models, methods and tools for the semantic analysis of natural language, and in particular utterances and discourses. The project is organised around three thematic axes: modelling the Syntax-Semantics interface, modelling of discourse dynamics, and developing basic linguistic resources.

1.2 Research Background

The research carried out during this internship is part of the dialogue analysis field. In particular, it aims at bringing new clues in the analysis of conversations involving participants with language impairments, such as schizophrenia. DRiPS (Dialogical Reasoning in Patients with Schizophrenia) and SLAM (*Schizophrénie et langage : analyse et modélisation*) are two projects in this research area. One of their common aims is to identify language impairments in patients with schizophrenia through the analysis of conversations with ordinary speakers. Both projects involve corpus data which provided new insights regarding dialogue modelling.

1.2.1 SLAM project

SLAM (Amblard, Musiol, and Rebuschi, 2012) was an multidisciplinary project combining psycho-linguistic, formal semantics and pragmatics, and philosophy. The aim of the project was to highlight and analyse the disfluencies in conversations involving patients with schizophrenia. It is divided in three axes related to (1) the creation of a corpus, (2) the analysis of the conversations, and (3) the evaluation of the results.

Regarding the corpus collection, the participants of the experiment were patients (under medication or not) on the one hand, and control participants on the other hand. They took part into a conversation with a psychologist, whose role was to maintain the interaction. Their brain activity was measured by electroencephalography and their eye-movements recorded by eye-tracking. They also fulfilled some psycho-cognitive tests. The conversations were recorded and manually transcribed,

only the content of the conversation and the noises necessary to understand the dialogue were transcribed.

Constituting a corpus of data produced by patients is challenging (Amblard, Rebuschi, and Musiol, 2019). Indeed, this type of data is sensitive and getting the authorisation to involve patients into an experiment is complex. Convincing the patients to participate is also complicated as there is no benefit for them from a medical point of view. Moreover, the patients must be able to interact with a person from outside the medical service, and focus long enough to fulfil the psycho-cognitive test. Eventually, while the transcriptions of the conversations were anonymised in terms of named entities, *i.e.*, they were replaced by placeholders, the dialogues can contain biographic elements such as temporal or geographic markers. Analysing the semantic-pragmatic level of the conversations requires to keep this context, which makes it impossible to make the transcriptions completely anonymous without losing the meaning of the conversations (Amblard, Fort, et al., 2014). Hence, the corpus cannot be made completely public.

Automatic tools were used to analyse the syntax and morpho-syntax of the conversations. Although patients' conversations contained slightly more disfluencies than the control participants, both groups were similar in terms of language variety. The semantics/pragmatics interface was then analysed through manual annotations. The portions of conversations that showed particular difficulties were identified and modelled based on a formal representation theory, *Segmented Discourse Representation Theory*, that we present in Section 3.2. These annotations highlighted different types of dialogue breakdowns for the most part in the patients' conversations. Ambiguities seemed to provoke such breakdowns, where the patients would change the interpretation of a multi-sense word without indication. Such ambiguities also emphasised the role of topics in the global coherence of a conversation. Topics are usually rather stable over time in a dialogue and all the participants should agree on the topic under discussion, and make topic shifts explicit, to prevent misunderstandings (Sacks, Schegloff, and Jefferson, 1974; Jefferson, 1984; Sacks, 1987; Schegloff, 2007).

1.2.2 DRiPS

The project Dialogic Reasoning in Patients with Schizophrenia (DRiPS) aims to investigate and model how people reason in natural language dialogue, using the notion of *topoi* – default principles of reasoning – and how this ability is different in patients with schizophrenia. Through access to a unique corpus of patients' triadic interactions DRiPS explores reasoning in patients' face-to-face dialogues. The data also includes motion capture, which makes it possible to identify and analyse verbal and nonverbal markers of social impairments during reasoning. Specifically, DRiPS addresses the question of how patients with schizophrenia differ from their healthy interlocutors (patients' partners) and how both of these groups differ from participants in dialogues without a patient, both in terms of the number of arguments used and the variety of arguments. DRiPS data shows that underpinning assumptions play a role in mutual understanding, they could also play a role when it comes to identifying the topic under discussion and to understanding the link between subsequent topics.

Chapter 2

Topics and Topic Shifts in Dialogue

In conversations, the participants exchange on different topics and the understanding of the current state of the dialogue by each participant relies on their interpretation of the topic under discussion. Usually, participants implicitly agree on the topic, but when it is unclear to any of the participants, this may cause misunderstanding leading to a breakdown of the dialogue. Reasons for this might be for example external events interfering with the dialogue (Lavia et al., 2018) or that one of the participants has a stream of consciousness style of communication (McKiernan et al., 2006; Smallwood and Schooler, 2015).

Interpreting a conversation correctly is even more complicated when the dialogue involves participants with conditions affecting language such as patients with schizophrenia (Breitholtz et al., 2021). Hence, dialogues involving such participants highlight features that play a major role in dialogue coherence and understanding since they are more challenging to model.

Coherence has been defined differently in the literature for written text and dialogue. In the case of written text, or non spontaneous speech, coherence is the property of a piece of discourse holding together as a whole (Williams and Nadel, 1989), *i.e.*, the parts it is composed of form a bigger picture which makes sense globally. As Cho et al. (2019) illustrate it, the sentences in a piece of coherent discourse add up together “the way all the pieces in a puzzle add up to the picture on the box”. On the other hand for dialogue, coherence refers to the way participants cooperate to produce a conversation that locally holds together (Schiffrin, 1985; Anderson, 1995).

Topics¹ play an important role in coherence, as the topic under discussion constrains the possible additions to the discourse, where initiating a topic while speaking about something else afterwards would confuse the addressees. In particular, for written text or non spontaneous speech, the sequence of topics should be clearly indicated in the structure of the text to improve readability. Dialogues are more flexible, as participants have the possibility to interact and clarify some points. Nevertheless speakers tend to make relevant contributions, where they are conscious of what the conversation is about and make their interventions suited to this scope (Grice, 1975). The topic under discussion in a dialogue is not fixed, several topics are usually discussed and precisely defining the scope of a topic is not straightforward. Dialogues are interactive and each intervention adds to the context, topics are thus incremental and influenced by all the participants as well as the situational context.

Formalising the participants’ representation of topics and the different ways to switch topic would help explain the characteristics of a dialogue breakdown when

¹What the conversation is about is referred to as “topic” in everyday language. We use this term with this general meaning in this thesis although it is used for different purposes in the linguistic community as we mentioned in Chapter 1.

the interaction fails at a topic level. Such a representation may highlight particularities of dialogues involving patients with schizophrenia, where this kind of breakdown is more frequent than in dialogue with non-patients, and thus provide linguistic clues supporting the diagnosis of schizophrenia. Moreover, in terms of dialogue management, a better understanding of topics and topic shifts would help having conversational tool make smoother transitions, provide ways to better understand subtle links between topics and give insights on the processes used to come back to a past topic.

Topic shifts can arise in conversation for different reasons. For example, one can be uncomfortable with a subject, the participants can consider that the current topic has been sufficiently discussed, or an urgent matter takes priority because of the context. In any case, the topic shift must be understood by all involved speakers for the conversation to continue smoothly.

This chapter aims at presenting different types of topic shifts and possible cues that make them explicit in conversation. In Section 2.1 we investigate topic shifts explicitly signalled in the language. Section 2.2 shows how changes in the situational context can initiate a topic shift. Eventually, Section 2.3 presents some cases of more ambiguous topic shifts which can create misunderstandings.

2.1 Topic Shifts with Explicit Cues in the Language

We start by investigating the least ambiguous type of topic shift, *i.e.*, the ones indicated by clear linguistic cues. Such topic shifts are easy to recognise for speakers and thus less likely to create misunderstandings. For this reason, our model should be able to account for them.

A topic shift can introduce a topic which is more or less linked to the previous one. A conversation can raise some ideas in one of the participants' mind and they could share them with the other participants. We call these small shifts *topic drifts* and discuss some explicit shifts of this type in Section 2.1.1. In contrast, a completely new topic can be initiated, in particular when the previous one is closed or when some participants want to close it, as we see in Section 2.1.2. Eventually, speakers may want to come back to a previous topic, whether it was explicitly closed or not. We call this phenomenon *topic resumption* and investigate it in Section 2.1.3.

2.1.1 Topic drifts

(2.1) LANCE: Lucky Mamie had a luxurious Day of Beauty at the Chow Bella Pet Spa, you really should bring Prozac in for some grooming.

JAINE: Are you kidding? I'm happy I made it out alive from her annual checkup. By the way, you'll never guess what happened at the vet's office today.

Adapted from [2017 Levine, Murder has nine lives [COCA]]

(2.1) is an example of unambiguous topic shift: two pet owners discuss a pet spa before one of them moves the topic to the veterinarian. The use of "by the way" makes the change explicit, where "you'll never guess what happened at the vet's office today" would have seemed rather incongruous without it (Traugott, 2020).

Indeed, "by the way" and other similar discourse markers such as "incidentally" seem to license topic shifts (Mittwoch, Huddleston, and Collins, 2002). They indicate that the speaker is likely to say something more or less unrelated to the topic under

discussion. However, to properly model this phenomenon and understand the limits of these markers, we would need to determine the maximal distance between the original topic and the new one that would keep the coherence of the conversation. In this example, Jaine mentions the veterinarian as evidence that bringing her cat to the spa is a bad idea. This leads her to change the topic to something that happened at the veterinarian: the topic is not completely unrelated and Jaine probably expects Lance to understand and accept the introduction of the new topic.

(2.2) RJ1: And the storm is still hammering New England in Long Island as you can feel out here. They're expected to get anywhere between twelve and twenty inches of snow. And we already can see a lot of it right out there you see it in Cambridge, Massachusetts.

RM2_1: Yes, yes it is a snowy day.

RM2_2: By the way, it's a very nice hat.

Adapted from [CBS The Early Show, December 27, 2010 [COCA]]

(2.2) is another example where “by the way” makes a topic shift explicit. This time two correspondents are outside in the snowy weather discussing the weather forecast, where more snow is announced, and one of them comments on the other's hat. As they are outside in the cold weather discussing the snow, mentioning a hat does not seem out of place. However this link may not be clear for everyone. In this dialogue the meaning of ‘hat’ is close to the one of ‘snow cap’, but different people could have a different definition of ‘hat’ and consider that this word is never used to refer to snow caps. If what one considers as a hat is a straw hat, this comment may seem odd or ironic without the visual context. Similarly if the journalist had commented on their colleague's t-shirt or sandals it may have been perceived as ironic or mocking because we expect some coherence in dialogue.

Although RM2_2 raises a new topic, it does not require a follow-up, as coming back to the weather forecast immediately, or potentially after some acknowledgement, would not be inappropriate. In contrast, the first example (2.1) introduces a new topic which would last for at least a few utterances, unless the other speaker, Lance, explicitly refuses this change. This indicates that topic shifts can be temporary, even only one utterance long. They can also prevent speakers from coming back to the previous topic without an explicit request.

Moreover, (2.1) and (2.2) show that some discourse markers enable to move away from the current topic without disrupting the conversation. In both examples the new topic was close to the previous one, which raises a question about the possible distance between two successive topics. Another interesting question is the influence of discourse markers: Do they licence any type of topic shift or only small ones as in the two examples we just saw? Can they be used to continue the conversation when the last topic seems closed? In the next section, we will see how a topic can be closed in a conversation and how to keep the conversation going afterwards.

2.1.2 Topic termination

Topics can be more or less intricate as they follow each other in conversation. In many cases a new topic is either a subtopic of the previous one or is linked to it in a certain way. However it is possible for participants to exhaust a topic or be willing to move from it as soon as possible. The topic will hence be closed, we call this phenomenon *topic termination*.

- (2.3) B1: did Priscilla listen to it?
 M2: no I'm going to have her listen ((laugh))=
 B3: ((laugh))
 (7.2)
 M4: 'cause naturally I think our voices sound different.
 (2.6)
 B5: yeah.
 (9.7)
 M6_1: so what's new with you?
 (2.0)
 M6_2: apart from the tedium [of
 B7: oh]
 M8: Russian phonetics.

Adapted from (Howe, 1991) [translb-1]

In (2.3), two topics are discussed one after the other, the second one being completely unrelated to the first. The shift occurs in M6_1, which starts with "so". This discourse marker is a cue indicating that the topic may change but it is not the most explicit one as it is a very common word with many different uses in conversation (Raymond, 2004). However, M6_1 occurs after several long pauses in comparison to the pace of the rest of the conversation. Silences in conversation are meaningful and in this case they indicate that the first topic is coming to its end, which gives the opportunity to one of the speakers to start a new one. For this reason, M6_1 can be interpreted by speaker B as the introduction of a new topic even though it is completely unrelated to the previous one.

A speaker can also abruptly change topic to move on from a rather uncomfortable one (Jefferson, 1984). (2.4) is an extract of a conversation where troubles were discussed. Although the topic seems close to be exhausted, S4_2 interrupts it before it is properly closed. According to Harvey Sacks and Jefferson (1984), this behaviour helps moving on from a complicated topic, where properly closing a "troubles-telling" topic is likely to cause the conversation to stop.

- (2.4) G1: I mean there wasn't nuh- anything that didn't happen. that could've happened.
 S2: Right
 G3_1: 'hhh
 (0.2)
 G3_2: So,
 S4_1: I'm not surprized.
 S4_2: 'hhh Listen,
 S4_3: u-something very very: cute happened last night at the Warehouse.

Adapted from (Jefferson, 1984) [Frankel:TC:I:1:17-18]

In this section we have shown that participants can start a new topic when the previous one is closed even if they are completely unrelated. Closing a topic seems to make it less accessible for the rest of the conversation, where coming back to a closed topic probably requires it to be made explicit. We discuss this phenomenon of topic resumption in the following section.

2.1.3 Topic resumption

Some phrases enable us to explicitly come back to a previous topic. Not signalling a topic resumption could cause misunderstandings as speakers are likely to consider a topic closed once it is not discussed anymore. In particular, an explicit signal becomes all the more important when the topic a speaker wants to resume was discussed a long time ago or if the conversation has been very dense in between.

(2.5) G262_1: to go back to what you said before do you have a television? [Fr. *pour revenir à ce que vous disiez avant vous avez une télé ?*]

[SLAM Data]

(2.5) is an example where the topic resumption is signalled. “to go back to what you said before” closes the current topic and indicates that the speaker has a previous section of the conversation in mind. Identifying which part exactly may be challenging if the sentence topic is ambiguous or not clear enough. For example, in a discussion where one of the topics previously discussed was related to someone named Jimmy, and another topic was about a different Jimmy, saying “To come back to Jimmy’s story...” would not be explicit enough.

We saw several examples where topic shifts were indicated in the language. However, conversations involve many more parameters than the content of the utterances, for example face expressions, prosody, but also the external situational context. The next section presents examples of topic shifts that the context makes relevant.

2.2 Cues in the Situational Context

Context and common ground play a major role in understanding a conversation, where they enable for example presupposition resolution and anticipation of the speaker’s intention (Stalnaker, 2002; Chevalier, 2008). They also play a role in the relevance of some topic shifts, where the situational context can interrupt a conversation as we will see in Section 2.2.1. Besides, speakers can consider a change in the situational context important enough to move to a new topic while the current one is not finished as Section 2.2.2 shows. In contrast, Section 2.2.3 discusses cases where the participants just closed a topic and the situational context provides material for a new one.

2.2.1 Interruptions in the situational context

(2.5) is a piece of conversation where the participants are interrupted by an external event, *viz.*, air conditioner noises.

(2.6) G234_1: mm hmm (0.5s) do you have a cellphone? (Fr. *humhum (0,5s) vous avez un téléphone vous ?*)

R235_1: I stopped the cellphone (Fr. *j’ai arrêté le téléphone*)

G236_1: stop (Fr. *arrêter*)

R237_1: stop (Fr. *arrêter*)

G238_1: completely (Fr. *complètement*)

R239_1: complete oulac (xxx) (1s) (Fr. *complet oulac (xxx) (1s)*)
air conditioner noises

R239_2: wouallou but (0.5s) it's (Fr. *wouallou mais (0,5s) c'est (0,5s)*)

G240_1: wouallou (Fr. *wouallou*)

R241_1: it's okay it's a (1.5s) (xxx) (Fr. *c'est bon c'est un (1,5s) (xxx)*)

G242_1: (xxx)

G242_2: you see the (tech-) (Fr. *vous voyez la (tech-)*)

R243_1: an old air conditioner (Fr. *un ancien climatiseur*)

G244_1: ah (Fr. *ah*)

[SLAM Data]

Speaker R could have resumed where they stopped after R239_1 but they comment on the noises instead, which initiates a new topic.

This new topic is related to an interrupting event in the situational context, which both participants are likely to notice. As a result, the topic shift does not seem confusing to speaker G and the conversation goes on smoothly.

Although the interruption presented in (2.6) does not force the speakers to change topic, it creates an opportunity to do so, or a *topic transition relevance place* (TTRP) (Howe, 1991). Sacks, Schegloff, and Jefferson (1974) introduce the concept of *transition relevance place*, the places in dialogue where the speaker may change. Howe (1991) adapts their notion to topics. Interruptions create TTRPs, *i.e.*, they provide the possibility of a topic change, but they do not force the conversational participants to change topic, as in (2.6).

The changes in situational context we have discussed in this section are obvious enough to interrupt the conversation. Sometimes contextual events are more subtle, so that only one or few of the participants would notice them and/or consider them important enough to warrant an interruption of the current topic. This is what the following section (2.2.2) investigates.

2.2.2 Self-interruption related to situational context

If a speaker changes topic based on subtle changes in the situational context, some participants may be confused if they have not perceived the relevant event. We thus expect the speaker to indicate the context of the new topic more explicitly when it is not very clear or noticeable. For example in (2.7), speaker B could indicate the butterfly with their hand, or their gaze would give some cues on the context. Indeed, they interrupt themselves to make a comment on butterflies, which could be confusing if speaker A has not noticed the butterfly nearby.

(2.7) *Discussion in a garden.*

A1: What did you do last weekend?

B2_1: I was in Stockholm with some friends, it is a very nice city. We walked around on the different islands and hum, yeah.

A butterfly passes nearby.

B2_2: Oh I really love butterflies, especially blue ones. It's weird to think that it was still an ugly caterpillar not so long ago.

B2_3: Anyways. We saw a lot of things but one of my favourites was this tiny island in the middle of the city from which we saw the amusement park.

An interesting point in (2.7) is that speaker B interrupts themselves to make a comment. The passage of the butterfly can be seen as a TTRP, in particular because this event is limited in time and making this comment a minute later may be considered irrelevant. However, if A had interrupted B to make a comment, it could have been perceived as rude or expressing more than the will to discuss butterflies.

This example shows that all TTRPs are not necessarily available to the speakers involved in a conversation, and changing topic without a TTRP may be a strategy for implicit communication. A common example would be abruptly interrupting someone gossiping with a small talk topic to indicate that someone who should not be hearing their conversation is coming.

2.2.3 When situational context feeds into conversation

We saw in Section 2.1.2 that when a topic is closed, it gives the possibility to open a new one or resume a previous one. In particular, long pauses were an indicator of topic endings, thus they can be indicators of TTRPs. As we explained before, TTRPs do not force the speakers to change the topic of the conversation. The previous topic can still be elaborated or the conversation can simply stop. However, people may for some reason want the conversation to continue, for example because extended periods of silence are uncomfortable with strangers. In such cases TTRPs can be filled either with a follow-up of the previous topic or a different one.

Assuming that the previous topic has been exhausted, at least at this moment of the conversation, participants would have to start a new one. Depending on the type of conversation, the participants would have the possibility to discuss different topics. For example, speakers trying to agree on the answer to give to a question could debate each possible answer. Two friends who have known each other a long time would have access to topics they have discussed in previous conversations in addition to new ones they could come up with, while two people meeting for the first time would only have access to the latter. Coming up with new topics when the conversation does not provide a scope to what can be discussed implies that one participant has to propose something that the others are likely to accept. In this case, speaking about topics all participants have access to is less likely to cause discomfort or misunderstandings. The situational context provides such topics.

(2.8) shows a transition to a topic rendered salient by the situational context. The speakers have been talking about the weather for several minutes and the long pause after R3 suggests that they might have exhausted the topic. During this pause, some noises are heard, *viz.*, a child's voice in the background. Speaker M then uses this noise to start a new topic.

- (2.8) R1: we've had] seventy-five, seventy-eight degree weather already.=
 K2: yeah.
 R3: it's been just really up and down this this spring with winter and spring.
 (2.75)
 ((child's voice in background: whoa!))
 (2.91)
 M4: wonder what he's playing with, which thing=

Adapted from (Howe, 1991) [trans4b-6]

It is interesting to notice that M did not comment on the noises directly but waited for almost 3 seconds, which corresponds to a long pause compared to the

pace of the conversation. This supports the idea that the previous topic was exhausted as neither R nor K added anything to it, even though they had the opportunity.

We can also stress that M4 does not present any topic-beginning indicator, *i.e.*, no discourse marker or phrase making the topic shift explicit. A proper topic ending seems to licence a topic shift without additional signal.

All the examples we saw contained topic shifts that the language or situational context made explicit. But speakers do not always signal changes and more implicit or even ambiguous topic shifts can take place.

2.3 Implicit / More Ambiguous Topic Shifts

Not signalling a topic shift does not necessary imply that a misunderstanding will arise. Human beings are generally able to anticipate and understand other's intentions in a conversation (Sacks, Schegloff, and Jefferson, 1974; Bloch, 2011). In Section 2.3.1, we show that the ongoing task also provides some indirect cues for participants as they assume some coherence and relevance from the other speakers (Grice, 1975). However, trying to force local coherence sometimes leads to misunderstandings. Section 2.3.2 illustrates this in the case of unsignalled topic resumptions while Section 2.3.3 presents some unusual ways to shift the topic under discussion.

2.3.1 Parallel topics in a task oriented conversation

Any conversation aims at fulfilling a task. Some are very constrained and follow repetitive patterns like booking flight tickets or making a call to organise a meeting (Taboada, 2006). But even the freest conversations such as casual talks between friends have a certain structure, where digressions are welcome and participants move on from one topic to another with no need to keep a precise record of everything that is said.

The task defines the conversational goals and provides a frame to the conversation, and moving away from it can be disruptive for some participants. For example, constant digressions from an interlocutor when one tries to book an appointment is upsetting while the same behaviour when having a tea with a friend is reasonable.

In terms of topic shifts, the conversational task can help identifying the topic under discussion without explicit signals. Villing (2015) analyses dialogues between the driver and the passenger of a car, who were asked to perform in parallel a navigation task and an interview task. The passenger had to ask questions about personal interests to the driver. Simultaneously, the passenger had to deliver driving instructions to guide the driver who did not know the way. The passenger was asked to wait until one intersection ahead to give an instruction.

(2.9) is an extract of the corpus that we already introduced in Chapter 1. We can see that D1, P2_1, P2_2, and P2_3 are related to the interview while D3_1, D3_2, P4_1, and P4_2 concern the navigation. In D3_1, the driver does not signal that they are switching to the navigation but the passenger's answer shows that they understood.

(2.9) D1: it is the technology itself when it comes to that that I am PAUSE interested in

P2_1: yes

P2_2: that's right PAUSE

P2_3: technology is fun
 D3_1: this feels a bit strange to be standing here right now
 D3_2: but
 P4_1: yes
 P4_2: but I think you can stand

[Villing, 2015, P.45-46]

In this experiment, the passenger and the driver keep switching between two topics, the interview and the navigation. However knowing that there are two tasks to complete enables one to identify the right topic when the other is speaking. The participants also have a time constraints to complete the interview task and they believe that they will be questioned on the interview topics at the end. This makes them less likely to move to another topic than the interview or the navigation. Moreover, the interview is repetitive in the form. This can encourage the participants to develop efficient communication strategies (Clark and Wilkes-Gibbs, 1986; Brennan and Clark, 1996), where indicating a topic shift would be time consuming.

(2.10) shows a particularly efficient exchange where the passenger asks about the star sign of the driver in P1 with a question reduced to its minimal expression. Then the topic shifts to the navigation in D2 and goes back to the interview as soon as both participants are in agreement on the driving instructions. In P5 the passenger repeats the question to come back quickly to the interview and the driver answers in D6 also in a minimal way. None of these interventions explicitly say to which topic they refer but the participants understand each other nonetheless.

(2.10) P1: star sign
interrupting to clarify a navigation instruction
 D2: it's not this one
 P3: nope
 D4: nope
 P5: star sign
 D6: Scorpio

[Villing, 2015, P.63]

These examples show that several topics can be open in parallel in a conversation, where the speakers go from one to another without explicit signals. The task they are trying to tackle provides cues to understand the context of each intervention. In opposition to these smooth switches between topics, Section 2.3.2 discusses the case where a speaker goes back to a previous topic while the rest of the participants do not perceive the change.

2.3.2 Unsignalled topic resumption

We saw before in Section 2.1.2 that changing topic can make the previous topic less accessible to the rest of the conversation. In particular, it means that if a participant wants to come back to it later, they would have to signal it with an explicit move such as "I would like to come back to what we said before about...". Not doing this could cause disruptions because the participants are likely to expect a speaker's utterance to be relevant to what is being discussed (Grice, 1975).

- (2.11) K1092_1: I have some big responsibilities (0.5s) towards hmm (1.5s) my parents or towards myself (Fr. *j'ai quelques grosses responsabilités (0,5s) envers euh (1,5s) mes parents ou bien envers moi-même*)
- K1092_2: I have a grandmother hmm (0.5s) she is more than 90 years old (0.5s) (Fr. *j'ai une grande mère [i] euh (0,5s) elle a plus de 90 ans (0,5s)*)
- K1092_3: so (0.2s) normally (0.5s) the logic (0.5s) it is the reason why I (0.5s) ask which specialty (Fr. *donc (0,2s) normalement (0,5s) la logique (0,5s) c'est pour ça que je (0,5s) pose la question quelle spécialité*)
- P1093_1: humhum (Fr. *humhum*)
- P1093_2: she gave you (0.5s) (Fr. *elle vous a (do-) (0,5s)*)
- P1093_3: she gave you no justification then (not at all)? (Fr. *elle vous a pas donner de justification alors (rien du tout) ?*)
- K1094_1: no without hmm (0.2s) without as we say in (Ara-) in Arabic (xxx) (0.2s) without ulterior motives (Fr. *non sans euh (0,2s) sans comme on dit en on dit en (ara-) en arabe (xxx) (0,2s) sans aucune euh (1s) arrière-pensée*)
- K1094_2: it's her right (1s) and really it's her right (Fr. *c'est son droit (1s) et vraiment c'est son droit*)
- P1095_1: to the psychiatrist? (Fr. *à la psychiatre ?*)
- K1096_1: no (Fr. *non*)
- K1096_2: about the (0.2s) the (0.5s) the the when you (0.5s) you said the if you discover that she has a boyfriend (0.5s) it's her right (Fr. *concernant le (0,2s) le (0,5s) le le quand vous (0,5s) vous disiez le si vous découvert qu'elle a un copain (0,5s) c'est son droit*)
- P1097_1: ah (0.5s) (Fr. *ah (0,5s)*)

[SLAM Data]

The dialogue in (2.11) is an example of unsignalled topic resumption from the SLAM data (see Section 1.2.1). Earlier in their discussion, they discussed the reaction the psychologist would have if his sister had a new boyfriend. He explained that it would be her right and that he would not interfere while the patient thought that having a boyfriend during her studies may be a bad thing. The conversation continues with different topics until the patient explains that she wants to leave the hospital and made a request to her psychiatrist who refused. (2.11) follows this, which explains why the psychologist believes that the patient still speaks of her doctor in K1094_2 when she says “it’s her right”. Moreover, it could be a coherent elaboration of the answer she gave to the question in P1093_3. However, the patient went back to the previous topic, probably as early as in K1092_3. The absence of a signal creates a breakdown in the dialogue that the psychologist notices and aims at repairing in P1095_1.

This example shows that noticing a topic shift is very important to participate successfully in a conversation. A model of dialogue or a conversational tool should be able to determine the topic of the conversation and notice the changes even when they are not obvious. In ambiguous cases such as (2.11), being able to perceive inconsistencies and start repair moves when it is relevant seems to be a key feature for a coherent model. Section 2.3.3 discusses more ways of changing topics in unusual ways, which may be confusing to the other participants of the conversation if the topic shifts are not signalled.

2.3.3 Homonymy, synonymy and other unusual proximity factors

We saw in Section 2.1.1 that changing the topic to one that is pragmatically close is possible and does not seem to cause misunderstandings. However, this notion of proximity can be discussed. In examples (2.1) and (2.2), the new topics are close to the previous ones in terms of meaning. But we can imagine changing topic by taking advantage of the sound similarity between two words, of synonymy, or using a compound word based on a word of the last utterance.

In (2.12), correspondents are introducing the different topics they will discuss during the TV show. Doing so, they speak about dogs for a moment before one of them introduces the next topic which is the cooking sequence of the program where they will cook hot dogs. Journalists are trained to make smooth transitions between topics and in this case HS makes use of the first topic, dogs, to introduce the next one, hot dogs, even though the two sections are completely unrelated in terms of contents. They make this change more explicit thanks to “speaking about dogs”, which indicates to listeners that there is a link with what is coming and thus licences more unexpected associations.

- (2.12) HS1: good looking dogs right there, right?
 MR2: We’re going to talk about, you know, all – all their special needs because large breeds do have some. And, what made – some interesting fun facts about big breeds.
 BN3: Like the slobbering that some of them do?
 MR4: Yeah, that’s a not-so fun fact.
 HS5: Yeah.
 BN6: Harry still has some on him.
 HS7: One got me, yeah. And speaking of dogs, hot dogs, that is, our good friend, Katie Lee is cooking some of her favorite Memorial Day foods –
 BN8: Yum.
 HS9: – including chili dogs as well as coleslaw, baked beans.
 MR10: Ah, don’t start without us.
 BN11: Save some.
 KL12: So good.

Adapted from [CBS Early, May 28, 2010 [COCA]]

However, playing with word proximity with phonetics as in (2.12), or with synonyms, and changing the interpretation of a word without signalling it can be confusing. In (2.13), the relation between the word *dead* (Fr. *mort*) and the word *finished/over* (Fr. *fini*), *i.e.*, losing and being finished/dead professionally, is used to move to a new topic speaking of literal death. This link is not explicit and it is complicated to understand the intention of speaker B. A127 shows that speaker A tries to understand the interpretation of B, where they suggest an explicit link between B124 and B126 but B rejects this suggestion in B128, and their answer seems to contradict B124 and they now speak of politicians who won.

- (2.13) B124: Oh yeah (↑) and complicated (↑) and it’s really very very complicated (→) politics, it’s really something when you get into it, have to win

or else when you lose, well, you're finished (↓) (Fr. *Oh ouais* (↑) *et pis compliqué* (↓) *et c'est vraiment très très compliqué* (→) *la politique c'est quelque chose quand on s'en occupe faut être gagnant parce qu'autrement quand on est perdant c'est fini quoi* (↓))

A125: Yes (Fr. *Oui*)

B126: JCD is dead, L is dead, P is dead uh (...) (Fr. *J. C. D. est mort, L. est mort, P. est mort euh* (...))

A127: So you think they're dead because they lost (↑) (Fr. *Ils sont morts parce qu'ils ont perdu à votre avis* (↑))

B128: No they won but if they're dead, it's their disease well it's it's (→) (Fr. *Non ils gagnaient mais si ils sont morts, c'est la maladie quoi c'est c'est* (→))

[SLAM Data]

2.4 Summary and Conclusion

In this chapter we introduced the notion of topic that we will discuss in this thesis. We define it as what the conversation is about at a given time. Participants can have different interpretations of the topic under discussion and a topic is not fixed in time, it evolves with the conversation, and a conversation about the weather could involve a discussion on climate change or a debate on the best holiday location.

Conversations contain a sequence of topics and the process of moving from one topic to another follows certain rules to ensure mutual understanding. Topic shifts can be explicit thanks to the language used or because the relevant aspect of the situational context is salient enough. But they can also be implicit, which is more likely to cause the other participants to miss the change and misunderstand the conversation. Indeed, the interpretation one has of the topic under discussion influences one's understanding of the conversation, where the right context enables one to solve anaphora correctly or interpret a word with the sense intended by the speaker.

Our aim in this thesis is to understand how participants perceive topics and topic shifts, and the representation they have of them in conversations. The first step to build a model aware of topic shifts in dialogue is to account for the most explicit ones. But we also want to be able to represent implicit topic shifts or realise when the discussion does not match the expected topic in order to raise appropriate repair moves. Analysing and modelling conversations by hand is a time consuming process but no automatic tool could provide the linguistic insight necessary to the implementation of a computational model. The descriptive work carried out in this thesis aims at paving the way towards an approach combining symbolic and computational language modelling.

Chapter 3 presents existing discourse representation theories and their application to dialogue. We discuss their advantages and limitations when it comes to modelling topic shifts.

Chapter 3

Modelling Topic Shifts with Discourse Modelling Theories

Since Montague Semantics (Montague, 1973), many theories have been proposed to model the meaning of language and in particular discourse (Kamp and Uwe, 1993; Asher and Lascarides, 2003). Even though the word discourse encompasses written text, non spontaneous speech as well as dialogue, discourse modelling theories are usually imagined for written text or non spontaneous speech and leave out some specificities of dialogue. But some of them have been extended in order to take interaction into account and be more adapted to dialogue (Amblard, Musiol, and Rebuschi, 2014; Hunter et al., 2015).

This chapter introduces two theories of discourse representation. The first one (Section 3.1), Rhetorical Structure Theory (RST) is a “theory of text organization” (Mann and Thompson, 1987a) which does not attempt to represent discourse content but its structure only, *i.e.*, the relations between the segments of a text. RST was initially designed with text generation in mind (Mann and Thompson, 1987a). The understanding of the processes involved in dialogical interaction that we would gain from analysing conversations with RST could thus be helpful to improve natural language generation for dialogue systems. However, this theory was not designed for dialogue and different phenomena related to interaction are complicated to model in RST (Stent, 2000; Taboada and Mann, 2006). On the other hand, the second theory we introduce (Section 3.2), Segmented Discourse Representation Theory (SDRT) (Asher and Lascarides, 2003) has been applied to different types of dialogues in the literature (Amblard, Musiol, and Rebuschi, 2011; Asher, Hunter, et al., 2016). Like RST, SDRT aims at representing the structure of a discourse using rhetorical relations, although they are not defined in the same way as in RST. In addition, the content of the discourse is represented with a logic formalism. This makes it possible to tackle anaphora resolution, which is not the case of RST.

3.1 RST

RST (Mann and Thompson, 1987a) aims at representing text structure. We will speak of text in the two following sections instead of discourse as RST was initially designed for text analysis.

A piece of text, and of any type of discourse, can be divided into segments, which we will call discourse or dialogue units (we will refer to both as DU). Elementary units (EDUs) can be combined to form complex ones (CDUs). Their meaning is not compositional, *i.e.*, an DU expresses more than the combination of the individual parts it is composed of, *i.e.*, words. RST uses schemata and relations to describe the

hierarchical organisation of the different segments composing a text. It is a flexible theory in terms of segmentation as well as for the set of relations it uses. The segments are usually independent clauses, *i.e.*, EDUs, but larger text spans could be preferred for certain types of texts. For example with longer texts when the details are not necessary to the analysis or for languages where independent clauses are more complicated to identify (Taboada and Mann, 2006). The set of relations is open and Mann and Thompson (1987c) encourage users to define their own, depending on the type of text to analyse. The relations are defined based on the intended effect on the reader, which makes RST an interesting theory when analysing intention.

3.1.1 Description of the model

Annotating a text in RST consists in recursively linking all the segments with schemata. When several segments are linked with a schema, they form a larger segment which must also be linked to the rest of the text spans. The annotation is complete when a segment covers the entire text.

The schemata are defined with a set of relations holding between the segments involved in a schema. One of the segment in a schema can be more important than the others, where the main information is carried by this specific segment and the others could be removed without loss in meaning. For example, in the sentence “I didn’t go to the gym yesterday, I was too tired.” in a conversation where the main topic is one’s workout habits, the first clause “I didn’t go to the gym yesterday” is central and “I was too tired” provides a justification but is not necessary to understand the idea conveyed by the speaker (note that it would be the opposite if the main topic is one’s tiredness). In such a case, the central segment is called a *Nucleus* and the others are called *Satellites*. A schema can either have one nucleus and at least one satellite, or be *multi-nuclear* and have no satellite. In a multi-nuclear schema, all the segments are on the same level, *i.e.*, no segment dominates the others.

The relations are defined with four fields (Mann and Thompson, 1988):

- Constraints on the Nucleus;
- Constraints on the Satellite;
- Constraints on combination of the Nucleus and Satellite;
- Effect (desired by the writer).

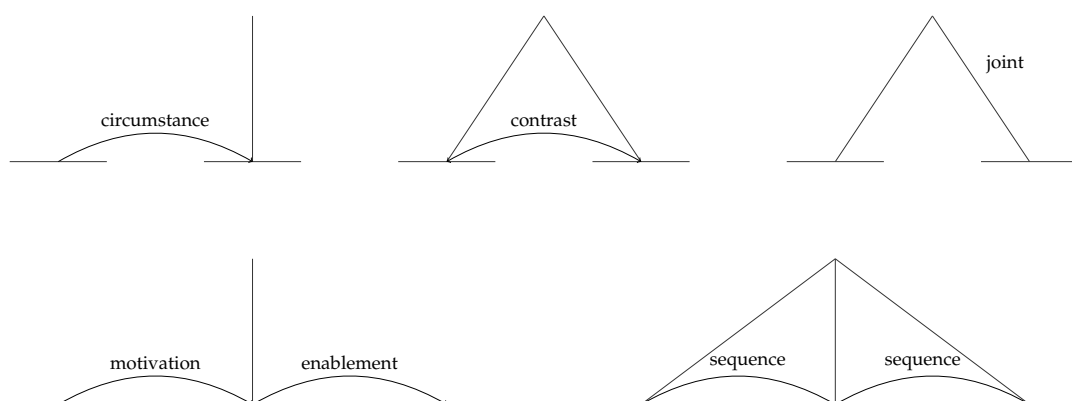


FIGURE 3.1: RST schemata (Mann and Thompson, 1988)

Mann and Thompson (1988) define 5 kinds of schemata and 24 relations. The schemata are represented on Figure 3.1 where the curves represent the relations and the vertical straight lines identify the nuclear span(s). All the relations not mentioned on the figure follow the same schema as *circumstance*, namely a single relation linking a nucleus and a satellite. *joint* has no corresponding relation, it is meant to link text spans which play the same role. For instance, several justifications could be joint and the resulting segment would be linked to the relevant nucleus with a relation *justify*.

Relation name:	<i>background</i>
Constraints on the nucleus:	the reader will not comprehend the nucleus sufficiently before reading the text of the satellite
Constraints on the satellite:	none
Constraints on the combination of the nucleus and the satellite:	the satellite increases the ability of the reader to comprehend an element in N
Effect:	the reader's ability to comprehend the nucleus increases
Relation name:	<i>justify</i>
Constraints on the nucleus:	none
Constraints on the satellite:	none
Constraints on the combination of the nucleus and the satellite:	the reader's comprehending the satellite increases their readiness to accept the writer's right to present the nucleus
Effect:	the reader's readiness to accept the writer's right to present the nucleus is increased
Relation name:	<i>contrast</i>
Constraints on the nuclei:	multi-nuclear
Constraints on the combination of nuclei:	no more than two nuclei; the situation presented in these two nuclei are (a) comprehended as the same in many respects (b) comprehended as differing in a few respects and (c) compared with respect to one or more of these differences
Effect:	the reader recognizes the comparability and the difference(s) yielded by the comparison that is being made

TABLE 3.1: Examples of RST relations (Mann and Thompson, 1988)

Table 3.1 shows three examples of rhetorical relations. *background* and *justify* follow the simplest schema with one nucleus and one satellite, while *contrast* is multi-nuclear. We can see that the way to define constraints is flexible where setting constraints on the nucleus, the satellite, and the combination of them is not mandatory. However, at least one of them must be defined as well as the effect field.

3.1.2 Modelling texts in RST

RST was designed for text analysis, where the aim of the representation is to make the intention of the writer explicit. For this reason, it is particularly suitable for modelling argumentative texts. This section presents a short example of RST analysis.

The text is an extract from a corpus of real argumentative microtexts (Stede et al., 2016). The corpus was built by asking German speaking participants to write a short text discussing a controversial issue such as “Should health insurers cover alternative medical treatments?”. The whole corpus was then professionally translated to English and annotated in RST and SDRT. We use an extract of one of the examples to illustrate the use of RST.

The topic of Figure 3.2 is labelled “EU influence on political events in Ukraine” and the writer is in favour of EU exerting influence. This model represents only the three first utterances of the text as our aim here is to briefly illustrate RST. The complete text is annotated in Appendix A.1 (Figure A.1). To improve readability, the nuclei are no more indicated by a straight line. Instead, the arrow representing the relations point toward the nucleus (there is no multi-nuclear relation in this example).

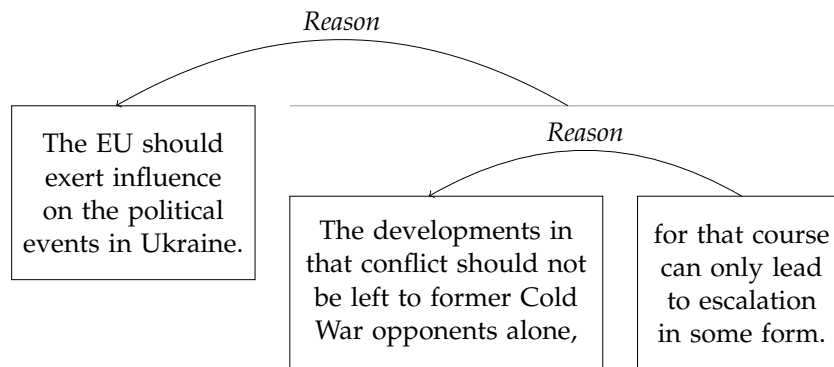


FIGURE 3.2: Example of RST analysis, example from Stede et al. (2016)

The text can be read in the right order from left to right. We can see that the last EDU provides a reason for the second one, and that together they justify the first one. This example reproduces the annotations of Stede et al. (2016) who do not give the definitions of their relations, but the relation Reason seems to have the same meaning as the Justify one presented in Table 3.1 (Mann and Thompson, 1988).

This example shows that RST is simple to apply because there is no formalisation of the content. However this can also be a drawback as this model is unable to identify inconsistencies such as logical incoherences. Moreover, a coherent text is defined as one which can be annotated but Danlos (2005) shows that RST is too restrictive and fails to account for some valid texts. Eventually, it was designed for written text and in particular monologues, which makes this theory ill-suited for dialogue. Some extensions (Stent, 2000) have been proposed but dialogue presents numerous phenomenon RST is unable to model. The following section investigates the limits of RST for dialogue and specifically topic shifts in dialogue.

3.1.3 Applying RST to topic shifts in dialogue

In dialogue, each contribution is meaningful. For example they can give new information, request a clarification or provide feedback to the previous speaker. In any

case, speakers have intentions (Morgan, Cohen, and Pollack, 1990), and in many cases these intentions must be recognised in order to fully understand a conversation. As RST aims at making intentions explicit, it seems like an interesting framework to analyse dialogue. However, it was originally designed for monological texts.

Nevertheless Mann and Thompson (1987c) define the set of relations of RST as an open set, which should be adapted to each type of text. Thus extending the theory to dialogue seems possible. Very few attempts have been done in this direction, an example is Stent (2000) who proposes an annotation scheme for task oriented dialogues.

In this section, we try to model some of the examples presented in Chapter 2 in RST. We show that while this theory could be adapted to model some simple topic shifts, it is unable to account for numerous phenomena of dialogue, in particular when it comes to more implicit topic shifts.

Figure 3.3 is a proposition of representation in RST of the example (2.1) of topic drift presented in Section 2.1.1. The example is rewritten here and segmented in EDUs. The two colours on the model represent the two speakers. In this example, the first speaker, L, mentions a pet spa and suggests in L1_2 that J should bring their cat. L1_1 was a supporting argument for this point. Then J shows that she completely disagree with this idea, where J2_1 is the central idea, supported by J2_2. She could have stopped there but she continues in J2_3 with an anecdote which happened at the vet's, which will most likely support her claim in J2_2. For this reason, J2_2 and J2_3 form a span supporting J2_1. We can imagine that the conversation would continue on this anecdote, which would create a larger span including J2_3. It would play the role of J2_3 in the representation.

L1_1: Lucky Mamie had a luxurious Day of Beauty at the Chow Bella Pet Spa
 L1_2: you really should bring Prozac in for some grooming
 J2_1: Are you kidding?
 J2_2: I'm happy I made it out alive from her annual checkup.
 J2_3: By the way, you'll never guess what happened at the vet's office today.

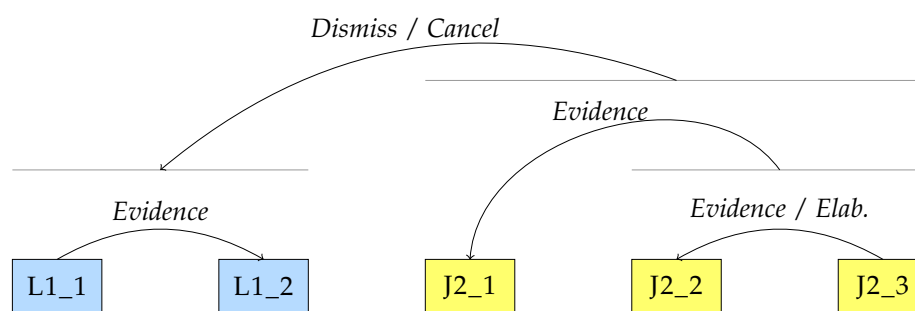


FIGURE 3.3: Example of RST analysis for dialogue, example (2.1) rewritten and segmented here

This example shows that RST can, at least in certain cases, account for topic drifts in dialogue. A similar example, that we introduced in Section 2.1.1, is presented in Appendix A.2. We can imagine a long sequence of topic drifts which would all be embedded in the previous topic like Matryoshka dolls. While this representation could make sense for a sequence of sub-topics, which all fit under a larger umbrella topic (*pets* > *dogs* > *corgis*), the representation would omit much information for a

sequence of topics linked two by two but not all together (*pets – euthanasia – illness of elderly people* (Howe, 1991)).

Another example of explicit topic shift RST may account for with some adaptations is topic termination, that we introduced in Section 2.1.2. A schema, similar *Joint*, could link several successive topics without any links between them as we can see on Figure 3.4 (the unabridged RST representation is available in Appendix A.3). This example was presented in Section 2.1.2. M6_1 introduces a new topic unrelated to the previous one. The long pauses before and after B5 as well as “yeah” indicated that the previous topic could be closed. The RST representation we suggest links the two topics with a schema labelled *topic sequence*, which is similar to *Joint*. The issue with this representation is that *topic sequence* would be at the same level as all the other relations, while two unrelated topics form two independent blocks in terms of coherence. The relation *topic sequence* thus has a different purpose than the usual RST relations. Moreover, the relation *Sequence* suggested by Mann and Thompson (1988) in the original set of relations indicates a “succession relationship between the situations” presented in the nuclei, which is not the case for the relation *topic sequence* we suggest. Our relation indicates successive topics in a conversation, not successive events denoted by different topics.

- B1: did Priscilla listen to it?
 M2: no I'm going to have her listen
 ((laugh))=
 B3: ((laugh))
 (7.2)
 M4: 'cause naturally I think our voices
 sound different.
 (2.6)
 B5: yeah.
 (9.7)
 M6_1: **so what's new with you?**
 (2.0)
 M6_2: apart from the tedium [of
 B7: oh]
 M8: Russian phonetics.

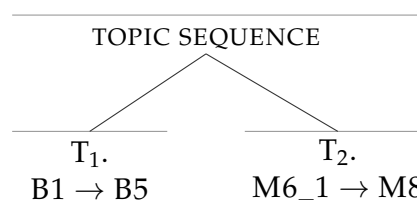


FIGURE 3.4: Suggestion of RST analysis for a sequence of unrelated topics, example (2.3) adapted from Howe (1991) [translb-1]

Eventually topic resumptions are the last type of topic shifts we presented in Chapter 2 with explicit cues in the language. For both topic drifts and topic terminations, RST seemed suitable only to a certain extent, where we showed that some information about the topics and the links between them was lost. Indeed, a DU cannot belong to two spans of text of the same depth. It means that if a DU makes a link between two topics, either one topic must be represented as embedded in the other as in Figure 3.3 so that the DU can belong to both topics, or the DU must be linked to only one topic and both topics linked by the multi-nuclear relation like the one we suggested. The limits of RST appear even more clearly with topic resumptions. Indeed accounting for them requires to go back to a previous section of the dialogue which would break the continuity of the representation. Mann and Thompson (1987b) define a text span as “an uninterrupted linear interval of text”,

which forces the annotator to link a text spans in a continuous way. Afantenos et al. (2015) considered RST unsuitable to model multi-party dialogues (*i.e.*, involving more than two participants) because of this constraint, as it did “not allow structures with crossing dependencies”. We showed with topic resumptions that such issues could also arise in dialogues involving only two participants.

We could decide to account for topic resumptions in a similar way as complete shifts after a topic termination, with a sequence schema labelled *topic resumption* for instance. However, this representation would conceal the topic the speakers is going back to, which is a major loss of information as it should shape the context of the conversation.

To conclude, accounting for the most explicit topic shifts in dialogue raised issues in RST. Even though some adaptations can be suggested, a part of the information is lost. Moreover, RST focuses on the text, which means that the situational context cannot be represented and interactions based on it may be considered incoherent with this theory. However, making the structure of a text explicit thanks to rhetorical relations can be useful when analysing interaction. Other theories use similar relations. In particular, SDRT models both the content and the structure of texts based on a logical formalism and rhetorical relations.

3.2 SDRT

Montague semantics (Montague, 1973) was the first attempt at formalising the meaning of natural language. Chomsky (1969) introduced formal methods into syntax but his theory did not dive into the analysis of linguistic meaning. Montague, however, suggests an homomorphism between syntax and semantics, accounting for the idea that syntax and semantics develop in parallel. Nevertheless, his theory focuses on isolated sentences and is unable to account for the context or cope with dynamic phenomena as present in *Donkey sentences* (Geach, 1962).

Discourse Representation Theory (DRT) was introduced by Kamp and Uwe (1993), which extends Montague semantics and takes context into account¹ (Geurts, Beaver, and Maier, 2020). The main idea is to consider a sentence as a *context modifying function* instead of a logic predicate. Every new sentence raises the possibility to update the current representation of the discourse, or *mental state* of it.

As opposed to RST, DRT makes it possible to model the content of each utterance and potentially identify incoherences at a syntactic level. However, the structure of dialogue, which helps assessing its coherence (Lascarides and Asher, 2007; Feng, Lin, and Hirst, 2014), is not accounted for.

SDRT (Asher and Lascarides, 2003) supplements DRT with rhetorical relations explaining the structure of discourse. It corresponds to the core idea of RST, though the implementation differs. Stede et al. (2016) investigated the similarities between RST and SDRT and in particular built a corpus of argumentative microtexts annotated with both formalism.

3.2.1 Discourse Representation Theory

DRT models discourse with *Discourse Representation Structures* (DRSs), boxes containing a logical representation of the content of the discourse. Each new utterance

¹A similar idea was developed independently by Irene Heim (Heim, 2002) in her File Change Semantics.

is modelled as a DRS and then merged with the current representation, which corresponds to an update of the context. The update method we present here is a simple one which ignores issues such as matching the discourse referent with the right antecedent in anaphora resolution. Our aim is to introduce DRT, a more in depth description can be found in Kamp and Uwe (1993).

A DRS is a pair $\langle U, CON \rangle$ where U is the set of discourse referents and CON the set of DRS-conditions. DRS-conditions use First-Order Logic, where the set of all possible DRS-conditions is defined recursively as follows:

- If P is a (n -place) predicate and $x_1, \dots, x_n \in U$ then $P(x_1, \dots, x_n) \in CON$;
- If $x, y \in U$ then $x = y \in CON$;
- If K and K' are DRSs then $K \vee K', K \Rightarrow K', \neg K \in CON$.

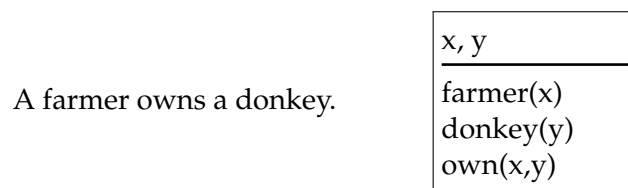


FIGURE 3.5: DRS example

Figure 3.5 is a DRS representing the sentence “A farmer owns a donkey” where $U = \{x, y\}$ and $CON = \{farmer(x), donkey(x), own(x, y)\}$. DRT would require additional DRS-conditions constraining the genre of x and y . These conditions would be used when solving pronominal anaphoras. As our aim is only to provide an introduction to this formalism, we use a simpler version of the representation.

As mentioned before, DRT is meant for discourse, it is thus possible to update the representation on Figure 3.5 with a subsequent sentence. To add a clause to the representation, we first build the related DRS and then merge it with the previous representation.

Figure 3.6 is a DRS representing the piece of discourse “A farmer owns a donkey. He beats it.”. The second sentence does not contain any explicit discourse referent, we thus introduce a and b but no DRS-condition to explicit their roles. We then merge the two DRS by adding a and b to the first set of discourse referents and $beat(a, b)$ to the DRS-conditions. We add two new DRS-conditions $a = x$ and $b = y$ to link a and b to their corresponding explicit discourse referents. Eventually, a and b become redundant and we can get rid of them as well without losing information as $a = x$ and $b = y$.

Note. For a DRS $\langle U, CON \rangle$, all the DRS-conditions in CON are considered conjoint, there is thus no need to use conjunction when defining DRS-conditions. There is no distinction between the representation of two conjunct clauses A and B and the representation of the concatenation of A and B . For example, “A farmer owns a donkey. He beats it.” and “A farmer owns a donkey and he beats it” would both be represented by Figure 3.6.

DRT provides a framework to model the content of a discourse. However, it does not account for the relations between the utterances and is thus unable to model the structure of a dialogue. Indeed, a coherent dialogue is more than a sequence of well formed utterances, they have to be linked with each other and each participant has

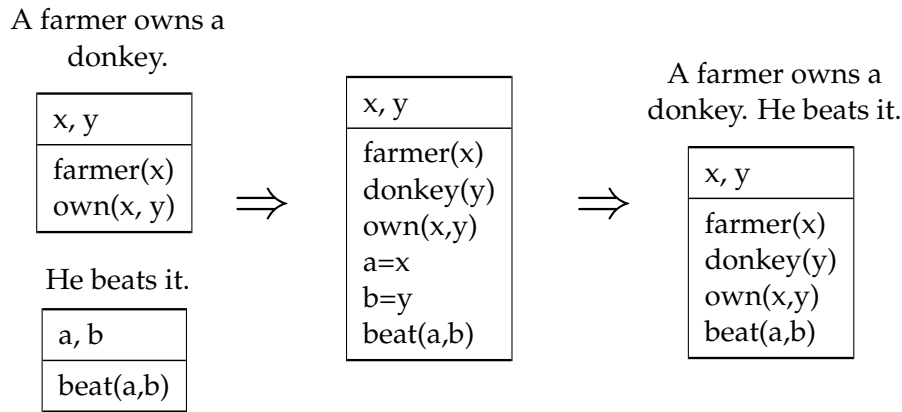


FIGURE 3.6: DRS merging process and pronominal anaphora resolution

to take the current context into account as well as the last move to make a coherent intervention. Therefore, DRT is insufficient to model dialogue and in particular topics and topic shifts, which are linked to the global coherence of a dialogue.

3.2.2 Segmented Discourse Representation Theory

SDRT is a theory for discourse interpretation developed by Asher and Lascarides (2003) since the 1990s. It accounts for the structure of a discourse and its global coherence (Schlöder, 2019). It is an extension of DRT where rhetorical relations explain the links between segments of discourse.

The main idea underlying this theory is that listeners have a mental representation of the discourse which is updated after each intervention (Kamp and Uwe, 1993). The discourse leads to misunderstanding if the full structure is not coherent. One of the main constraints for coherence is the *Right frontier constraint* which is discussed later at the end of Section 3.2.2.

SDRT follows the same modelling process as DRT but with rhetorical relations linking the different DRSs. In other words, we model a DU as a DRS and associate a label to it. We then use a rhetorical relation to explicit the relation between two DUs by linking the two corresponding labels. The *Segmented Discourse Representation Structures* (SDRSs) are thus macro-structures describing the coherence relations between many DRSs, which represent the content of the discourse.

Formally, a SDRS is a tuple $\langle \Pi, F, L \rangle$ where Π is a set of labels, F is a function associating a DRS or a rhetorical relation to the labels in Π , and $L \in \Pi$ is the last label. L is useful when determining which labels are accessible when we update the representation.

There are two types of rhetorical relations: coordinating and subordinating. Two DUs are linked by a coordinating relation if they are on the same level and none dominates the other. In a graph representation, the segments would be linked by an horizontal edge. If one DU dominates the other, they are linked by a subordinating relation and the graph representation uses a vertical edge.

Figure 3.7a is a representation as a SDRS of the piece of discourse “A farmer owns a donkey. He beats it.”. The two EDUs π_1 : “A farmer owns a donkey.” and π_2 : “He beats it.” are modelled as DRSs and labelled respectively K_{π_1} and K_{π_2} . These DRSs are conditions in the SDRS representing our piece of discourse (where K_{π_1} verifies π_1 and K_{π_2} verifies π_2). In this example, π_2 brings additional information to π_1 , it is

thus an *Elaboration* of π_1 . It is the third relation in our SDRS. This SDRS is labelled π_0 so that it could be used in another relation if the discourse were to be updated.

Figure 3.7b is a graph representation of this piece of discourse. We use the labels π_1 and π_2 instead of the corresponding representations for readability. We can see that π_2 is linked to π_1 by a vertical edge, *Elaboration* is a subordinating relation where the first EDU dominates the second. In this thesis we will use this graph representation when we consider the logical content unnecessary to the point we illustrate.

Note. In SDRT, a DU can only be linked to a previous one, though not necessarily the one right before it. The temporal progression is carried by the rhetorical relations. For instance, the piece of discourse “John fell. Marie pushed him.” could be modelled with the relation *Explanation*, while *Result* would be used for “Marie pushed John. He fell.”.

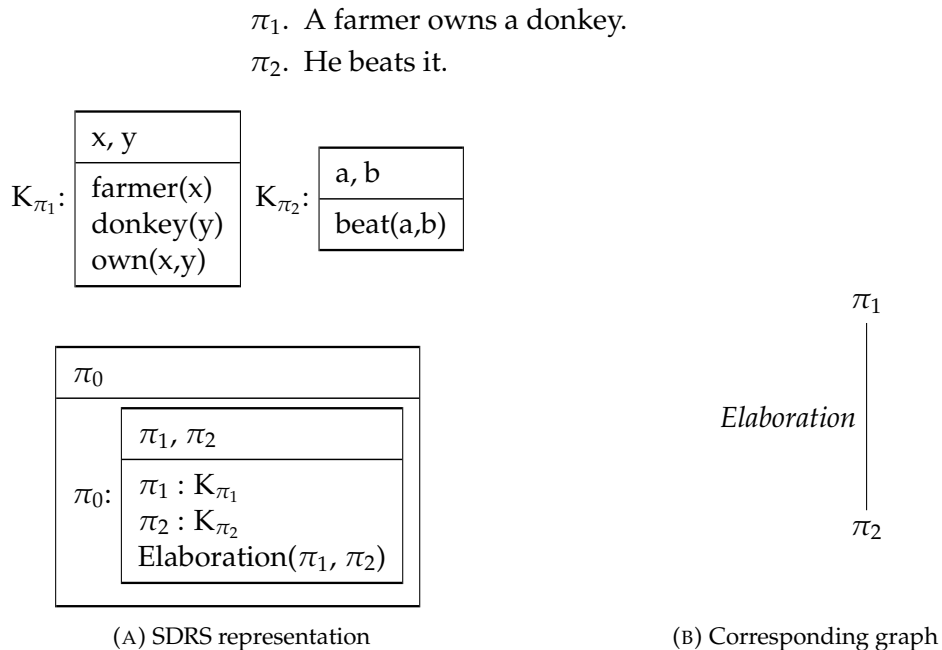


FIGURE 3.7: SDRS example

Right Frontier Constraint. The SDRT proposes a constraint for the attachment of a new utterance: the *right frontier constraint* (RFC) (Polanyi, 1988; Asher, 1993; Asher and Lascarides, 2003). It states that a new DU must be attached on the right frontier of the representation of the ongoing discourse. This constraint can be broken if the utterance explicitly indicates the attachment point, as it prevents incoherences.

This constraint reflects the fact that some referents become unavailable when the discourse goes on. For example, after the piece of discourse “John had a great dinner last night, then he watched some TV.”, “the dinner” is no more available. Adding “It was delicious.” seems odd as the only referent, “TV”, is not usually used with “delicious”. However, after “John had a great dinner last night, he ate lasagna.”, “the dinner” is available and “It was delicious.” is coherent.

The difference between these two pieces of discourse is the type of relation linking the two DUs they are composed of, “John had a great dinner last night” being the first DU in both cases. These relations are represented on Figure 3.8. In the first case,

both DUs are on the same level, thus the relation is coordinating, *i.e.*, represented as a horizontal edge (Figure 3.8a). In the second case, the first DU dominates the second, which corresponds to a subordinating relation, *i.e.*, a vertical edge (Figure 3.8b). Hence the RFC authorises an attachment to “John had a great dinner last night” only in the second case, since a coordinating relation blocks the first DU, which is consistent with intuition.

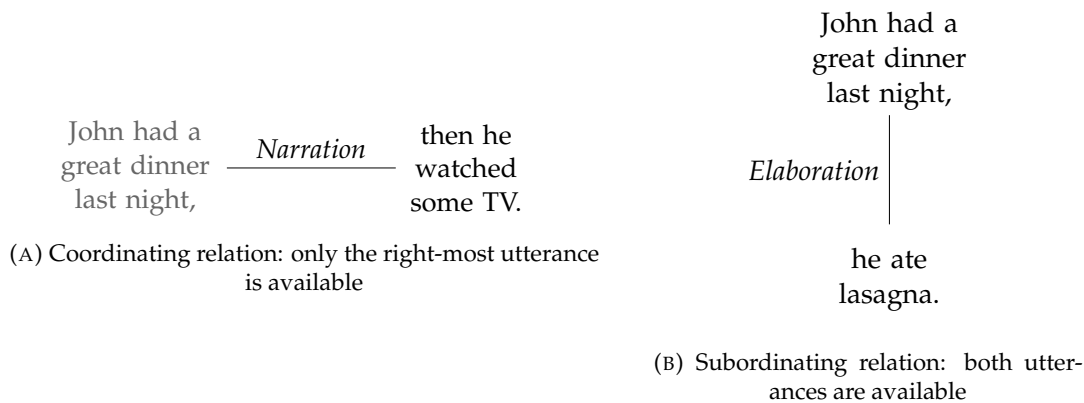


FIGURE 3.8: Illustration of the *Right Frontier Constraint*

However this constraint is not always adapted to dialogue, where a dialogue could break the RFC and still be completely coherent in the sense that none of the dialogue participants has any problem understanding and participating in the conversation. Indeed speakers can discuss several topics in parallel, correct a previous utterance or simply speak at the same time. Many dialogue phenomena would require the RFC to be violated unless the set of relations has been redefined to perfectly fit the given dialogue, at the risk of having a completely *ad hoc* view of SDRT and completely loosing the function of the RFC. Hunter et al. (2015) suggest an adaptation of the RFC to multi-party dialogues, where they propose to wait for a CDU to be complete before it is attached to the current representation, and to consider the last utterance of each speaker as the starting point for the right frontier. Figure 3.9 illustrates these multiple starting points. The example we use is an extract of chat conversation from Hunter et al. (2015) between players of *The Settlers of Catan*. We see on Figure 3.9a that WM3 cannot be attached to LJ1, the question it answers to, because another participant already answered it before. With the adapted right frontier, LJ1 remains available until speaker LJ speaks again, which enables the expected attachments as we can see on Figure 3.9b.

Nevertheless some phenomena are still not accounted for by this version of RFC as mentioned by Hunter et al. (2015). For example, multi-tasking can still break the RFC as the different topics run in parallel while the representation would project them all at the same level. Speakers can also violate the RFC inside a turn by correcting or elaborating on a DU of the turn theoretically already made inaccessible by other DUs. An example could be correcting an earlier element of a shopping list as in the following piece of discourse: “Could you get me four eggs? And some milk. Oh wait, six eggs.”

3.2.3 SDRT and topic shifts in dialogue

We saw that SDRT is not completely adapted to dialogue. However, the issues we mentioned in Section 3.2.2 are related to particular cases of multi-party dialogues and due to the RFC. Despite these limitations, Afantenos et al. (2015) used SDRT to

LJ1. anyone want sheep for clay?
 GW2_1. got none, sorry :(
 GW2_2. so how do people know about the league?
 WM3. no

Extract from [Hunter et al. (2015, p.6)]

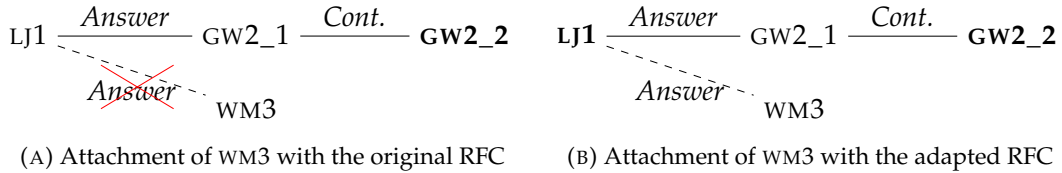


FIGURE 3.9: Illustration of the RFC adapted to multi-party dialogues: the bold font indicates the available attachment points for WM3

build a discourse parsing model for multi-party chat dialogue and got results “close to or better than the current state of the art for discourse parsing on monologue”. This shows that SDRT, with an appropriate definition of the RFC, can be used to model dialogue.

Moreover, the representation proposed by SDRT combines a logical formalism, which makes it possible to represent the discourse content, as well as rhetorical relations to model its structure. Hence, SDRT presents the same advantages as RST but overtakes some of the limits we described in Section 3.1.3. Indeed, with an appropriate set of rhetorical relations, any text that RST can model can be modelled in SDRT as well, since the continuity principle in RST ensures that the attachments are always done on the right frontier.

However SDRT does not follow the continuity principle, which means that a DU can be attached to any earlier DU and not only the first previous one. This enables to model topic resumptions for example, where the discourse part coming back to a topic could be linked to this topic and the discourse would be incoherent in case the RFC is broken, *i.e.*, if the resumption is not explicit, which follows intuition.

Additionally, the logical formalism used in SDRT provides a way to account for the context. While it was designed to represent the content of the discourse, we can imagine adding the situation context in the representation when it is relevant. Figure 3.10 suggests a representation for the example (2.6), where air conditioner noises interrupt the conversation. There are two topics in this piece of dialogue, firstly the participants speak about cellphones ($T_{cellphone}$) and secondly they comment the air conditioner ($T_{air_conditioner}$). This second topic, represented as π_2 , interrupts $T_{cellphone}$ because of the noises. Hence, the relation *Interruption* links π_1 and the entity π_4 formed by the noises (π_2) and the new topic (π_3). Inside π_4 , the noises (π_2) are linked to the air conditioner topic (π_3) by the relation *Comment*. Note that *Interruption* is not a relation of the same type as comment. It does not carry the information of a rhetorical relation as its purpose is to indicate that two DUs are unrelated rhetorically because an external event interrupted the flow of the conversation. Comparatively, some types of events could be integrated to the dialogue with usual rhetorical relations if they are related to the interaction. For example, when playing a game like The Settlers of Catan (Hunter et al., 2015), a player could ask the others if they have clay. Showing a card to this player would constitute an answer even though the event is extra-linguistic, and a regular rhetorical relation could be used in this case.

- G234_1: mm hmm (0.5s) do you have a cellphone? (Fr. *humhum (0,5s) vous avez un téléphone vous ?*)
 R235_1: I stopped the cellphone (Fr. *j'ai arrêté le téléphone*)
 G236_1: stop (Fr. *arrêter*)
 R237_1: stop (Fr. *arrêter*)
 G238_1: completely (Fr. *complètement*)
 R239_1: complete oulac (xxx) (1s) (Fr. *complet oulac (xxx) (1s)*)
air conditioner noises
 R239_2: wouallou but (0.5s) it's (Fr. *wouallou mais (0,5s) c'est (0,5s)*)
 G240_1: wouallou (Fr. *wouallou*)
 R241_1: it's okay it's a (1.5s) (xxx) (Fr. *c'est bon c'est un (1,5s) (xxx)*)
 G242_1: (xxx)
 G242_2: you see the (tech-) (Fr. *vous voyez la (tech-)*)
 R243_1: an old air conditioner (Fr. *un ancien climatiseur*)
 G244_1: ah (Fr. *ah*)

$K_{\pi_1}: T_{cellphone} (G234_1 \rightarrow R239_1)$

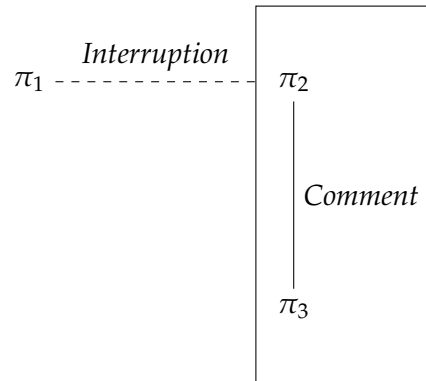
$K_{\pi_2}: \begin{array}{|c|} \hline x \\ \hline air_conditioner_noises(x) \\ \hline \end{array}$

$K_{\pi_3}: T_{air_conditioner} (G239_2 \rightarrow R244_1)$

$K_{\pi_4}: \begin{array}{|c|} \hline \pi_4 \\ \hline \pi_2 : K_{\pi_2} \\ \pi_3 : K_{\pi_3} \\ Comment(\pi_2, \pi_3) \\ \hline \end{array}$

$\pi_0: \begin{array}{|c|} \hline \pi_0 \\ \hline \begin{array}{|c|} \hline \pi_1, \pi_4 \\ \hline \pi_1 : K_{\pi_1} \\ \pi_3 : K_{\pi_4} \\ Interruption(\pi_1, \pi_4) \\ \hline \end{array} \\ \hline \end{array}$

(A) SDRS representation



(B) Corresponding graph

FIGURE 3.10: Suggested model of a topic shift induced by the situational context

The two other examples we saw in Section 2.2 are similar, where the situational context works as the relevant attachment point for the utterance starting a new topic. This shows that SDRT can be extended to account for topic shifts based on the situational context. However, in cases where there are no explicit cues, neither linguistic nor extra-linguistic, there would be no attachment point and the representation would lack some information. Moreover, a dialogue model in SDRT presents only one point of view on the dialogue which reflects the interpretation of the annotator.

But dialogue is an interactive process where each participant can have a different understanding of the conversation. In particular, when the situational context is the explicit cue to explain a topic shift, and thus is used as attachment point, it presupposes that the cue was perceived by all the participants. But it is not necessarily the case and a model should be able to account for these different looks on the situation, as discrepancies would explain potential clarifications. To solve this issue, Rebuschi, Amblard, and Musiol (2013) propose to build one representation per speaker.

Ultimately we saw that SDRT is more expressive than RST, as it accounts for the same phenomena as well as additional ones thanks to the logical formalism it contains. Nevertheless, SDRT requires some adaptations to be better suited to dialogue. Firstly, the set of rhetorical relations must be extended as the original set was designed for discourse. Conversation is not organised in the same way and is interactive by definition, which creates additional pragmatic relations between utterances. Secondly, the RFC must be modified to take into account, among other things, parallel threads of discussion, which is even more common in multi-party conversations (Hunter et al., 2015). Additionally, this theory is applied at the level of the utterances, which means that there is no representation of a more global view on the conversation. Eventually, while the logical formalism allows the representation of the situation context, a new type of relations is required to link it to related utterances.

3.3 Summary and Conclusion

In this chapter, we presented two discourse modelling theories and applied them to different dialogues containing topic shifts. Although we were able to suggest a representation of some pieces of dialogues containing a topic shift, neither RST nor SDRT provided the right level of representation to keep track of topics and topic shifts. The way participants make a link between two topics cannot be made explicit on these representations. These theories can be suitable to model dialogue at a local level and to model extensive discourses that are more organised than free conversation. However, our aim is to characterise interaction at a topic level, which requires a way to represent the transitions between topics and the reason behind these transitions. Hence, being able to represent the conversational context is crucial.

Moreover, both RST and SDRT produce a unique representation of a conversation. However, each participant in a dialogue can have a different representation of the relations between the different parts of the conversation and of what the conversation is about. This means that one representation per participant would be necessary to account for topics in a dialogue model, and analysing the differences between each participant's take on the conversation would help understand the way a disruption appeared in a conversation.

In the next chapter, we present *Type Theory with Records* (TTR) introduced by Cooper (2005). This framework is more flexible than RST and SDRT but can also be more detailed. Indeed, each move in the conversation is described by a set of fields, each accounting for one aspect of the move. New fields can be imagined to represent the rhetorical relations between the utterances, as in RST and SDRT, and the topical links in the dialogue. TTR is a tool that makes it possible to represent the dialogue itself, as RST and SDRT, but also different types of context which are required to fully understand conversation. We apply it following *Conversation Oriented Semantics* (KoS) (Ginzburg, 2012). It proposes an implementation of TTR for dialogue taking context and interaction into account.

Chapter 4

Contextualisation of Conversation

In Chapter 2, we saw that there are different ways to link two subsequent utterances at a topical level, some more straightforward than others, and these links play a role in the global coherence of a dialogue. In the absence of a topical link, speakers have to be more explicit on their intentions to prevent misunderstandings. Moreover, the situational context can influence the conversation. As it is extra-linguistic, a model of conversation must account for it separately from the linguistic content in order to evaluate the coherence of the dialogue. In Chapter 3, we presented two discourse modelling theories that show limitations when attempting to model topic shifts. Ignoring topic-related phenomena in dialogue reduces the scope of these theories. Nevertheless, explaining the structure of a dialogue helps analyse its coherence and the relations used both in RST and SDRT fulfil this aim in most cases. In addition, a logic based approach similar to the one used in SDRT can produce a very fined-grained representation of the content, which can be used to understand topical links or the influence of situational context.

In this chapter, we will return to some of the examples presented in Chapter 2 and discuss their representations in *Type Theory with Records* (TTR). This framework is more flexible than RST and SDRT because it allows us to account for different dialogue phenomena by enriching the formalism. In particular, it provides us with adapted tools to model different types of conversational context such as situational context or agents' intentions. We start by introducing TTR and the way it can be applied to dialogue. Then in Section 4.2, we suggest some additions to TTR that enable us to account for the situational context as well as topical links in dialogue. Eventually, we apply these new features to two conversations involving patients in Section 4.3.

4.1 Introduction to the Framework

TTR is a formal semantics framework presented by Robin Cooper (Cooper, 2005; Cooper, 2014; Cooper, 2022). It aims at representing situations with *record types*, i.e., structured types that consist of a set of fields of the form *label : type*. This framework combines the advantages of different linguistic theories we are interested in when modelling dialogue (Cooper, 2005). Based on the formalism of TTR, Ginzburg (2012) suggested Conversation Oriented Semantics (KoS) to model more specifically dialogue context and interaction. Conversation is viewed as a game where the information state of each participant is described by a *Dialogue Gameboard* (DGB). Every move in the conversation causes the DGBs to be updated based on a set of rules. This representation enables us to keep track of the understanding each participant has of the conversation, as well as the moves they are planning and what licenses these moves. Comparing the participant's DGBs can help us understand the mechanism that led to a dialogue breakdown.

In this section we start by introducing the formalism of TTR and KoS (Section 4.1.1). Then we explain the notion of *topos* that Breitholtz (2021) introduced on the DGB as *topoi* play a role in the introduction of new topics in a conversation.

4.1.1 Introduction to TTR and KoS

Type Theory with Records (TTR) is a rich type theory, *i.e.*, it goes beyond Montague's basic types by providing, for example, types for categories of objects or situations. The theory was inspired from the type theory of Martin-Löf (1984) and situation semantics (Barwise and Perry, 1983). TTR's core idea is that agents make *judgements* about the world as they perceive and understand it, classifying objects and situations as belonging to a certain type. Judging that an object a is of type T is denoted by $T : a$. The basic type Ind is used to describe humans, animals, and things. A human being could thus be denoted as $x : Ind$ in TTR. By applying a *predicate* to one or more individuals, we can represent events and states. They are denoted by *ptypes*, *i.e.*, a predicate and its arguments such as $spa(y)$ for " y is a spa". Ptypes create *constraints* on the individuals. Eventually a situation can be translated into a set of individuals and constraints on them, that we represent with *record types*, *i.e.*, a set of pairs of labels and types, where a type can be a basic type, a ptype or a record type. For example, a situation where an agent has a day of beauty at a spa involves an individual and a spa where the agent would have this day of beauty. This could be represented with the following record type in TTR:

$$(4.i) \left[\begin{array}{l} x : Ind \\ y : Loc \\ c_{spa} : spa(y) \\ e : have_day_of_beauty(x) \\ c_{loc} : be_at(e,y) \end{array} \right]$$

The labels x and y respectively define an individual and a location, where y must be a spa as stated by the constraint c_{spa} . These labels are then reused in the event e and the constraint c_{loc} that state that the individual x is having a day of beauty in the location y .

(4.i) describes a type of situation. But we also want to be able to represent the situation itself. In TTR we would use a *record* to do it. A record is a set of pairs of labels and *objects* rather than types. We separate the label and the object with an equal sign rather than a column. A record r is of a certain type T if it contains fields with the same labels as T and the objects the labels are associated to are of the right type according to T . For example, (4.ii) is a record of the type denoted in (4.i) if a is of type Ind , b of type Loc , s_1 of type $spa(b)$, s_2 of type $have_day_of_beauty(a)$ and s_3 of type $be_at(s_2, b)$.

$$(4.ii) \left[\begin{array}{l} x = a \\ y = b \\ c_{spa} = s_1 \\ e = s_2 \\ c_{loc} = s_3 \end{array} \right]$$

Records represent the situations themselves. Hence, a record denoting an agent's take on a conversation at a certain point would be infinitely complex. However, we are able to suggest a representation of the type of this record. For this reason, in the following, we will only represent record types when we speak of a situation or an agent's state of information.

(4.i) represents the type of a very general situation. If we want to talk about a more specific type of situation, with a particular agent and spa as in “Lucky Mamie had a luxurious Day of Beauty at the Chow Bella Pet Spa”, we can use *manifest* fields, where labels are associated with a value as well as a type. The utterance we use as example is also more specific than the first record type we presented as the day of beauty is “luxurious”. This precision can be added in TTR as a new constraint on e :

$$(4.iii) \left[\begin{array}{l} x = \text{LuckyMamie} : \text{Ind} \\ y = \text{ChowBellaPetSpa} : \text{Loc} \\ c_{spa} : \text{spa}(y) \\ e : \text{have_day_of_beauty}(x) \\ c_{loc} : \text{be_at}(e,y) \\ c_{adj} : \text{luxurious}(e) \end{array} \right]$$

This new record presents all the fields of (4.ii) as well as more information thanks to two manifest fields and an additional constraint. (4.iii) is thus as *subtype* of (4.ii). A type T_1 is a subtype of a type T_2 ($T_1 \sqsubseteq T_2$) if T_1 is more specific, *i.e.*, T_1 presents at least all the fields of T_2 . A label-type pair of T_2 can be a manifest field in T_1 but not the opposite. For a detailed presentation of TTR, see Cooper (2022).

The piece of text we used to introduce TTR was taken from one of the dialogues we studied in Chapter 2, it is rewritten below in (4.1). However the representation we just built does not show that it is part of a conversation: a more structured record type would be required to account for dialogue related phenomena.

Conversation Oriented Semantics (KoS) is a framework based on TTR that aims at representing dialogue and in particular interaction and context. KoS suggests a representation of dialogue as a game, modelled with *Dialogue Game Boards* (DGBs) accounting for the conversational context. The information state is represented on a separate game board for each participant and all the DGBs are dynamically updated as the dialogue unfolds. (4.iv) is a representation of speaker L’s information state after L1_1 has been said.

- (4.1) L1_1: Lucky Mamie had a luxurious Day of Beauty at the Chow Bella Pet Spa,
 L1_2: you really should bring Prozac in for some grooming.
 J2_1: Are you kidding?
 J2_2: I’m happy I made it out alive from her annual checkup.
 J2_3: By the way, you’ll never guess what happened at the vet’s office today.

Adapted from [2017 Levine, Murder has nine lives [COCA]]

$$(4.iv) \text{ DGB: } \left[\begin{array}{l} \text{pr} : [\text{agenda} = [T_{spa}] : \text{list}(\text{RecType})] \\ \text{sh} : \left[\begin{array}{l} \text{l-m} : \left[\begin{array}{l} \text{prev} : \text{Rec} \\ \text{curr} : \left[\begin{array}{l} \text{spkr} = \text{L} : \text{Ind} \\ \text{addr} = [J] : \text{list}(\text{Ind}) \\ \text{cntnt} = \left[\begin{array}{l} x = \text{LuckyMamie} : \text{Ind} \\ \dots \end{array} \right] : \text{RecType} \end{array} \right] \end{array} \right] \\ \text{l-T} : \left[\begin{array}{l} \text{prev} : \text{RecType} \\ \text{curr} = T_{spa} : \text{RecType} \end{array} \right] \end{array} \right] \end{array} \right]$$

The DGB is split between information that the agent considers shared (sh) between all participants and the ones they consider private (pr). The latest moves (l-m)

and latest topics (l-T) in the conversation are shared between the participants as they represent the content of the dialogue itself. The previous utterances and topics are embedded in the field 'prev' of 'l-m' and 'l-T' respectively, *i.e.*, when a new move or topic is brought in the conversation, the fields 'l-m' and 'l-T' are copied into their field 'prev' and the new move/topic is written in 'curr'. The current utterance 'curr' is represented with its speaker 'spkr', the addressees 'addr' and the actual content of the utterance. The addressees are represented as a list of individuals as a dialogue can involve more than two people, although it is not the case here. This representation is convenient in our case as all the dialogues we will model in this chapter involve two people. However, depending on the context, other representations could be more adapted. In a multi-party conversation, a set would put all the addresses on the same level. On the other hand, a partially ordered set would be more adapted if some participants were considered more important than others. The content is modelled with a record type representing the situation depicted in the utterance. It is incomplete in (4.iv) to improve readability but (4.ii) would be a suitable record type. In the private part of the DGB, we represented the agenda of the participant, *i.e.*, their intentions for the next utterances in the form of topics. Topics are represented as record types, and we want to be able to represent more than one planned topic; the agenda is thus modelled as a list of record types. In the dialogue we are analysing, it seems reasonable to consider that speaker L is planning to advise J to bring their own pet to the spa. Hence, the topic "spa" is still on their agenda. Again the use of a list to represent the agenda can be discussed as it implies that the next topics the participants want to raise are ordered in their mind, which is not necessarily the case. One could be willing to discuss a few different topics at some point in the conversation without having a precise order in mind, and a planned topic can be more or less salient at different moments depending on the content of the dialogue. Similarly, the representation we use for the latest moves (resp. latest topics) contain all the past moves (topics) of the dialogue nested into each other. Indeed, the field 'prev' contains the previous 'l-m' ('l-T'), which in turns contains a field 'prev'. This representation does not reflect what actually happens from a cognitive point of view, for participants in a conversation do not necessarily remember in details everything that has been said. Moreover, not all the previous moves (topics) are accessible to the discussion as we saw in Section 3.2.2. The availability of the past moves (topics) in the representation should thus take these constraints into account.

The types associated with the shared and private parts of the DGB can contain other fields than the ones we just presented. However the latest moves are central in a conversation as they represent the dialogue itself. Similarly, the agenda represents the intentions of the participants. Although making it explicit is not always possible, it remains a core feature of a conversation. Representing the latest topics as well is a contribution of this thesis. We chose a simple representation, homologous to the representation of the latest moves, to show how topics could be integrated to the DGB. However, we will see that separating them from the moves raises an issue regarding the analysis of the coherence of a piece of conversation.

We used the beginning of the dialogue (4.1) to introduce the most basic features of a DGB. In the following, we will focus more on the topic drift in this conversation to introduce *topoi* and their role in topic shifts in dialogue. We will use the representation proposed by Breitholtz (2021) to include them on the DGB.

4.1.2 Introducing topoi and their representation on the DGB

At the end of the dialogue in (4.1), speaker J introduces a new topic with “By the way, you’ll never guess what happened at the vet’s office today.” However, this topic is not completely unrelated to the previous utterances. The participants were discussing a pet spa and speaker J explained in J2_1 that it would not be suitable for their pet. They continue in J2_2 with an utterance we interpret as a reason for J2_1 even though the link between (a) “not bringing one’s pet to the spa” and (b) “one being happy they made it out alive from the pet’s annual checkup” is not direct. A possible interpretation of this link is that (b) means that the pet is fierce and that bringing such a pet to the spa is a bad idea. This type of link between a suggestion (J2_1 goes against the suggestion in L1_2 and thus functions as a suggestion as well, supporting the opposite idea) and an assertion supporting the suggestion is referred to as *topos* (Ducrot, 1988; Anscombe, 1995). Topoi are usually used in the context of argumentation as they explain how a statement supports another one. We argue that they can also be used to justify some topic shifts as it is the case in (4.1) when speaker J introduces the vet’s office.

Indeed, the vet’s office is a link between (b) “one being happy they made it out alive from the pet’s annual checkup” and (c) “something happened at the vet’s office”. The idea that a pet’s annual checkup takes place at a vet’s office is common knowledge in a community where regular visits to a veterinarian is usual for pet owners. A topos $\tau_{loc_checkup_is_vets_office}$ carrying this information can thus explain the transition between J2_2 and J2_3 and in particular the topical link between them. $\tau_{loc_checkup_is_vets_office}$ becomes salient in speaker J’s mind when the checkup is mentioned and they make use of it to introduce their anecdote. In TTR, the evolution of one’s state of information is licensed by *update rules*, i.e., functions from one type of situation to another. If an update rule is available to an agent and can be applied to their state of information then the agent is allowed to update their state of information so that its type becomes the one the function produces. In practice it corresponds to *asymmetrically merging* the type of the information state with the type produced by the function. The asymmetric merge of two types T_1 and T_2 , which we denote as $T_1 \wedge T_2$, roughly corresponds to creating a type T_3 containing all the fields with a label unique to T_1 or T_2 , and the fields of T_2 where the label is shared with T_1 . In other words, it corresponds to the unification of two feature structures. For more details, see Cooper (2022).

This evolution process is based on the cognition of the agent, and the nature of this process is an empirical question. Our aim is to suggest a model that is consistent with the data. In our example, it seems credible that the topic $T_{checkup}$ reminded speaker J of their anecdote at the vet’s office because the topos $\tau_{loc_checkup_is_vets_office}$, which is related to both $T_{checkup}$ and T_{vets_office} , exists in their long-term memory and enabled them to make a link between the two ideas by transitivity. We thus need an update function that allows J to add this topos and the topic it raised to their DGB. This function should take an information state as input, where the latest move made a topos and a related topic more salient in the dialogue participant’s mind. This cognitive process is available only if the agent has a relevant topic in their long term memory, which we refer to as *background resources*, and if they have something to say that this topos is licensed. This function, that we refer to as $f_{topos_licenses_topic}$, can be seen in (4.a) (and in Appendix B.1.1).

$$\begin{aligned}
f_{topos_licenses_topic} = \lambda r : & \left[\begin{array}{l} \text{pr} : \left[\begin{array}{l} \text{topoi} : \text{list}(\text{Topos}) \\ \text{agenda} : \text{list}(\text{RecType}) \end{array} \right] \\ \text{sh} : \left[\text{l-m} : \left[\text{curr} : \text{RecType} \right] \right] \end{array} \right] \cdot \\
\lambda e : & \left[\begin{array}{l} \text{t} : \text{Topos} \\ \text{c}_1 : \text{in_bkgd_resources}(\text{t}) \\ \text{c}_2 : \text{relevant_to}(\text{t}, r.\text{sh}.\text{l-m}.\text{curr}) \\ \text{T} : \text{RecType} \\ \text{c}_3 : \text{in_comm_project}(\text{T}) \\ \text{c}_4 : \text{relevant_to}(\text{t}, \text{T}) \end{array} \right] \cdot \quad (4.a) \\
& \left[\text{pr} : \left[\begin{array}{l} \text{topoi} = [e.\text{t} \mid r.\text{pr}.\text{topoi}] : \text{list}(\text{Topos}) \\ \text{agenda} = [e.\text{T} \mid r.\text{pr}.\text{agenda}] : \text{list}(\text{RecType}) \end{array} \right] \right]
\end{aligned}$$

$f_{topos_licenses_topic}$ can be applied to a state of information whose type is such that the latest move is related to a topos that exist in the agent's background resources, and the agent has a topic T, relevant to the topos, in their communicative project, *i.e.*, they have something to say on this topic. Retrieving a topos from one's long-term memory and a related topic from one's communication project is a cognitive event, which is the reason why it is denoted by a e in the function. The function produces a type where the topos is added at the beginning of the private list of topoi (we represent this operation with the operator $|$), and the topic is placed on the agenda. This function modifies only the content of the private field, which is the reason why the shared field does not appear. If an agent uses this function, they would apply it to their state of information with a relevant event and then merge the type of their state of information with the result of the function, which would modify only the relevant fields and preserve the other ones.

We can apply $f_{topos_licenses_topic}$ to the actual state of information of J after J2_2. Indeed, $\tau_{loc_checkup_is_vets_office}$ is relevant to the last move $T_{checkup}$ and to T_{vets_office} , the new topic that J would like to start. We assume that $\tau_{loc_checkup_is_vets_office}$ exists in J's background resources as this topos licenses their next move. J's state of information can thus be updated according to $f_{topos_licenses_topic}$ by asymmetrically merging its type with the type produced by $f_{topos_licenses_topic}$. (4.b) shows the computation of the new type of J's state of information. The current state of information appears twice in the computation but not in the same form. Indeed, update functions must be applied to records rather than record types. Hence, $f_{topos_licenses_topic}$ must be applied to a record \mathcal{R}_{ini} and to the cognitive event \mathcal{E} of types that are coherent with the function (which is denoted by ':') to obtain the type of the agent's state of information after the update. On the other hand, the type of this record, \mathcal{T}_{ini} , must be asymmetrically merged with the result of the function to obtain the updated state of information.

$$\begin{aligned}
\mathcal{R}_{ini} : \mathcal{T}_{ini} &= \left[\begin{array}{l} \text{pr} : \left[\begin{array}{l} \text{topoi} = [] : \text{list}(\text{Topos}) \\ \text{agenda} = [] : \text{list}(\text{RecType}) \end{array} \right] \\ \text{sh} : \left[\text{l-T} : \left[\begin{array}{l} \text{prev} = \text{T}_{no_grooming} : \text{RecType} \\ \text{curr} = \text{T}_{checkup} : \text{RecType} \end{array} \right] \right] \end{array} \right] \\
\mathcal{E} : \left[\begin{array}{l} \text{t} = \tau_{loc_checkup_is_vets_office} : \text{Topos} \\ \text{c}_1 : \text{in_bkgd_resources}(\text{t}) \\ \text{c}_2 : \text{relevant_to}(\text{t}, r.\text{sh}.\text{l-m}.\text{curr}) \\ \text{T} = \text{T}_{vets_office} : \text{RecType} \\ \text{c}_3 : \text{in_comm_project}(\text{T}) \\ \text{c}_4 : \text{relevant_to}(\text{t}, \text{T}) \end{array} \right] & \tag{4.b}
\end{aligned}$$

$$\begin{aligned}
\mathcal{T}_{goal} &= \mathcal{T}_{ini} \wedge (f_{topos_licenses_topic} \cdot \mathcal{R}_{ini} \cdot \mathcal{E}) \\
&\longrightarrow_{\beta} \mathcal{T}_{ini} \wedge \left[\text{pr} : \left[\begin{array}{l} \text{topoi} = [\tau_{loc_checkup_is_vets_office}] : \text{list}(\text{Topos}) \\ \text{agenda} = [\text{T}_{vets_office}] : \text{list}(\text{RecType}) \end{array} \right] \right] \\
&= \left[\begin{array}{l} \text{pr} : \left[\begin{array}{l} \text{topoi} = [\tau_{loc_checkup_is_vets_office}] : \text{list}(\text{Topos}) \\ \text{agenda} = [\text{T}_{vets_office}] : \text{list}(\text{RecType}) \end{array} \right] \\ \text{sh} : \left[\begin{array}{l} \text{l-m} : \left[\begin{array}{l} \text{prev} : \text{RecType} \\ \text{curr} = \text{J2_2} : \text{RecType} \end{array} \right] \\ \text{l-T} : \left[\begin{array}{l} \text{prev} : \text{RecType} \\ \text{curr} = \text{T}_{checkup} : \text{RecType} \end{array} \right] \end{array} \right]
\end{array} \right]
\end{aligned}$$

(4.v) represents the content of J's DGB after the update, *i.e.*, after J2_2 has made $\tau_{loc_checkup_is_vets_office}$ and T_{vets_office} more salient in J's mind. They can now carry out their next move, *i.e.*, pronounce an utterance that realises T_{vets_office} . We consider that T_{vets_office} is the only topic on their agenda because we are interested in a small portion of their conversation. If the full dialogue was to be modelled, J would most likely have more topics on their agenda.

$$(4.v) \quad \mathcal{T}_{goal} = \left[\begin{array}{l} \text{pr} : \left[\begin{array}{l} \text{topoi} = [\tau_{loc_checkup_is_vets_office}] : \text{list}(\text{Topos}) \\ \text{agenda} = [\text{T}_{vets_office}] : \text{list}(\text{RecType}) \end{array} \right] \\ \text{sh} : \left[\begin{array}{l} \text{l-m} : \left[\begin{array}{l} \text{prev} : \text{RecType} \\ \text{curr} = \text{J2_2} : \text{RecType} \end{array} \right] \\ \text{l-T} : \left[\begin{array}{l} \text{prev} : \text{RecType} \\ \text{curr} = \text{T}_{checkup} : \text{RecType} \end{array} \right] \end{array} \right]
\end{array} \right]$$

When an agent pronounces an utterance related to a topos to realise their agenda, they most likely assume that the addressees will acknowledge this topos and thus understand how the utterance is linked to the conversation. In our example, speaker J introduces the topic of the vet's office by mentioning that they have an anecdote about it in J2_3, which starts with "by the way". This discourse marker seems to indicate to the addressee that the new utterance is in some way linked to the previous one, which supports the idea that the speaker expects the addressee to understand the link. We thus need an update rule to move the topos from the private to the shared part of the DGB when the agenda is realised. Such a function, that we call f_{use_topos} can be seen in (4.c) (and in Appendix B.1.2).

$$\begin{aligned}
f_{use_topos} = \lambda r : & \left[\begin{array}{l} \text{pr} : \left[\begin{array}{l} \text{topoi} : \text{list}(\text{Topos}) \\ \text{agenda} : \text{list}(\text{RecType}) \end{array} \right] \\ \text{sh} : \left[\begin{array}{l} \text{topoi} : \text{list}(\text{Topos}) \\ \text{l-m} : \text{RecType} \\ \text{l-T} : \text{RecType} \end{array} \right] \end{array} \right] \cdot \\
\lambda e : & \left[\begin{array}{l} \text{u} : \text{RecType} \\ \text{t} : \text{Topos} \\ \text{c}_1 : \text{in}(\text{t}, r.\text{pr}.\text{topoi}) \\ \text{c}_2 : \text{relevant_to}(\text{t}, \text{u}) \\ \text{c}_3 : \text{realisation_of}(\text{fst}(r.\text{pr}.\text{agenda}), \text{u}) \end{array} \right] \cdot \quad (4.c) \\
\left[\begin{array}{l} \text{sh} : \left[\begin{array}{l} \text{topoi} = [\text{fst}(r.\text{pr}.\text{topoi}) \mid r.\text{sh}.\text{topoi}] : \text{list}(\text{Topos}) \\ \text{l-m} : \left[\begin{array}{l} \text{prev} = r.\text{l-m} : \text{RecType} \\ \text{curr} = e.\text{u} : \text{RecType} \end{array} \right] \\ \text{l-T} : \left[\begin{array}{l} \text{prev} = r.\text{l-T} : \text{RecType} \\ \text{curr} = \text{fst}(r.\text{pr}.\text{agenda}) : \text{RecType} \end{array} \right] \end{array} \right] \end{array} \right]
\end{aligned}$$

f_{use_topos} can be applied when an utterance u is pronounced, to a state of information whose type contains a private topos related to this utterance, and if the utterance realises the agenda of the state of information. It produces a type where the utterance becomes the current latest move, the previous latest move being updated accordingly, and the topos is now shared. Note that the agenda is not updated by this function. We could consider that once the topic realised in the conversation, it is popped out of the agenda. However, a topic usually lasts longer than one utterance and we can imagine that when a speaker introduces a new topic, they expect to be able to discuss it more. Popping a topic out of the agenda would thus be handled by another function. Yet, understanding when agents actually consider that a topic will no more be discussed would require more extensive research and experiments rather than solely analysing conversations. For this reason, we will not formally discuss the functions responsible for popping topics out of the agenda in this thesis.

f_{use_topos} can be applied to our example with speaker J's state of information (4.v) where they are planning a move T_{vets_office} based on the topos $\tau_{loc_checkup_is_vets_office}$. For the previous update, we showed the formal computation of the result, but to improve readability we will now use a more compact representation, *i.e.*, prooftrees where the premises are the function and its arguments and the result is the updated state of information. When an utterance is needed in the event required by the update function, we denote by U_x a record of the type corresponding to the update rule if x is a relevant utterance. The asymmetrical merging does not appear. Figure 4.1 illustrates the application of f_{use_topos} to J's state of information.

U_{J2_3} is a record of a type such as required by f_{use_topos} where $J2_3$ is an utterance relevant to the topos $\tau_{loc_checkup_is_vets_office}$ which is in J's state of information, and which realises their agenda T_{vets_office} . Their state of information is thus updated accordingly, as can be seen in (4.vi).

When an information is shared, a participant considers that all the others have access to it and can thus rely on it to understand the conversation. If speaker J had not considered the topos shared, they would most likely have made the link between $J2_2$ and $J2_3$ more explicit as the addressee would not have understood otherwise. For the addressees, adding a topos to their DGB would be referred to as a process of *accommodation* (Stalnaker, 1974; Karttunen, 1974; Lewis, 1979). This process was

$$\begin{array}{c}
(4.v) \wedge (f_{use_topos} \cdot r \cdot e) \qquad r: (4.v) \qquad e: U_{J2_3} \\
\hline
(4.vi) \text{ DGB: } \left[\begin{array}{l}
\text{pr : } \left[\begin{array}{l} \text{topoi : list(Topos)} \\ \text{agenda : list(RecType)} \end{array} \right] \\
\text{sh : } \left[\begin{array}{l}
\text{topoi} = [\tau_{loc_checkup_is_vets_office}] : \text{list(Topos)} \\
\text{l-m : } \left[\begin{array}{l} \text{prev} = \left[\begin{array}{l} \text{prev : RecType} \\ \text{curr} = J2_2 : \text{RecType} \end{array} \right] : \text{RecType} \\ \text{curr} = J2_3 : \text{RecType} \end{array} \right] \\
\text{l-T : } \left[\begin{array}{l} \text{prev} = \left[\begin{array}{l} \text{prev : RecType} \\ \text{curr} = T_{checkup} : \text{RecType} \end{array} \right] : \text{RecType} \\ \text{curr} = T_{vets_office} : \text{RecType} \end{array} \right]
\end{array} \right]
\end{array} \right]
\end{array}$$

FIGURE 4.1: Update of speaker J's state of information when J2_3 is uttered

originally discussed regarding presuppositions but it can also apply to topoi (Breitholtz, 2021). The corresponding update rule would be a function $f_{accommodate_topos}$ (see Appendix B.1.3) such that if an agent has a topos in their background resources which is related to the previous and current move of their state of information, then they can add it to their private and shared list of topoi.

Regarding the update of the current topic of the conversation when an other agent utters something, we already mentioned that the way agents actually perceive topic in dialogue is still an open question. Organising experiments would be required to suggest a representation of topics and the way they are updated on the DGB that would be coherent with the actual perception have of them. However for this thesis, we suggest a simple update rule $f_{accommodate_topics}$ (see Appendix B.4) that allows an agent to change the current latest topic of their state of information to a new topic when an other participant has uttered something. If the current latest topic is not relevant to the current latest move and the agent has a topic T in their background resources that is relevant to the latest move, they can update the current latest topic to T.

The update rules we described enable the participants of a conversation to update their state of information when one of them produces a new move. Ideally, participants use the right rules so that their representations of the conversation, *i.e.*, the shared part of their DGB, are coherent with one another. Nevertheless, it is possible for participants to understand the link between two utterances differently and thus use different update rules. Hence, they can have a different representation of the shared state of information, which could lead to misunderstandings. For example, when using a topos to change the topic, the more uncommon the topos the more likely it is that the addressees will miss the link, or misunderstand it. Similarly, when introducing a new topic using the situational context can be misleading for some participants if they did not notice the relevant aspect of the situational context. In Section 4.2, where we suggest new fields on the DGB to account for situational and background context, we will discuss conflicting representations between conversation participants.

4.2 Additions to TTR

In the beginning of this chapter we have presented TTR and a way it can be used to model dialogue with KoS. However, only the content of the utterances and topoi that could link utterances are represented on the DGB yet. We saw in Chapter 2 that

a new topic can be introduced by drawing on several sources, linguistic or extra-linguistic. The situational context provides potential conversation topics, and based on their background knowledge, an agent can link two topics that they consider close, based on semantic similarity for instance. We will thus suggest new fields and update rules that would enable us to account for situational and background context respectively in Section 4.2.1 and Section 4.2.2.

4.2.1 Situational context

Our senses perceive more things than we are conscious of and it seems impossible to represent everything we sense on a model. Nevertheless, not everything we consciously notice or pay attention to comes into the conversation. A possible representation of the situational context in TTR could thus have several layers. A field could represent sensory input and another one the portion of it that the agent pays attention to, which corresponds to the situational context for the agent, as the rest of the sensory input would not be salient. The sensory input would be continuously updated while the situational context would change with attention, where paying attention to something corresponds to copying it from the sensory input to the situational context. An agent could then draw on the situational context in their dialogue moves. The sensory input would be private all the time while the situational context can be both private and shared, with possible overlaps. However this representation is complex and the constant flux of sensory input does not seem necessary in our take on dialogue analysis yet. Thus, we chose to represent only the situational context on the DGB.

(4.2) is one of the examples we presented in Chapter 2 where a newly introduced topic is related to the situational context. In (4.vii) we suggest a representation in TTR of the content of B's DGB before B2_2 when they see the butterfly flapping nearby. Since they are paying attention to it and planning a dialogue move based on it, it appears in the situational context. A rule very similar to $f_{topos_licenses_move}$ but for situational context instead of $topoi$ can denote the update that make the situational context and the dialogue move appear on the DGB. This rule, $f_{SitC_licenses_move}$, can be seen in Appendix B.2.1.

(4.2) *Discussion in a garden.*

A1: What did you do last weekend?

B2_1: I was in Stockholm with some friends, it is a very nice city. We walked around on the different islands and hum, yeah.

A butterfly passes nearby.

B2_2: Oh I really love butterflies, especially blue ones. It's weird to think that it was still an ugly caterpillar not so long ago.

$$(4.vii) \left[\begin{array}{l} \text{pr :} \\ \text{sh :} \end{array} \left[\begin{array}{l} \text{SitC :} \\ \text{agenda = [T}_{butterflies} \text{] : list(RecType)} \\ \text{SitC = } \emptyset \text{ : RecType} \\ \text{l-m :} \\ \text{l-T :} \end{array} \right] \right]$$

Detailed description of the nested list structure in (4.vii):
 - The outermost list has two elements: 'pr :' and 'sh :'.
 - The 'pr :' element points to a list containing:
 - 'SitC :' followed by a list of three items: 'x : Ind', 'c1 : butterfly(x)', and 'c2 : flapping_by(x)'.
 - 'agenda = [T_{butterflies}] : list(RecType)'.
 - The 'sh :' element points to a list containing:
 - 'SitC = ∅ : RecType'.
 - 'l-m :' followed by a list of two items: 'prev : RecType' and 'curr = B2_2 : RecType'.
 - 'l-T :' followed by a list of two items: 'prev : RecType' and 'curr = T_{Stockholm} : RecType'.

$$\begin{array}{c}
(4.vii) \wedge (f_{use_SitC} \cdot r \cdot e) \qquad r : (4.vii) \qquad e : U_{B2_2} \\
\hline
(4.viii) \left[\begin{array}{l}
pr : \left[\begin{array}{l}
SitC : \left[\begin{array}{l}
x : Ind \\
c_1 : butterfly(x) \\
c_2 : flapping_by(x)
\end{array} \right] \\
agenda = [T_{butterflies}] : list(RecType)
\end{array} \right] \\
sh : \left[\begin{array}{l}
prev : RecType \\
l-m : \left[\begin{array}{l}
spkr = B : Ind \\
addr = [A] : list(Ind) \\
curr : \left[\begin{array}{l}
x : Ind \\
c_1 : butterfly(x) \\
c_2 : like(sp,x)
\end{array} \right]
\end{array} \right]
\end{array} \right]
\end{array} \right]
\end{array}$$

FIGURE 4.2: Update of speaker B's state of information when B2_2 is uttered

When realising $T_{love_butterfly}$ with B2_2, speaker B most likely expects A to have seen the butterfly as introducing this new topic would seem odd otherwise. In this sense, using the situational context to introduce a new topic works in a similar way as using a topos, where planning a certain move related to the situational context, and realising it with an utterance pushes the situational context to the shared part of the speaker's DGB. The type of the function f_{use_SitC} that denotes this evolution is thus analogous to the function f_{use_topos} as can be seen in (4.d) (and in Appendix B.2.2).

$$\begin{aligned}
f_{use_SitC} = \lambda r : & \left[\begin{array}{l}
pr : \left[\begin{array}{l}
SitC : RecType \\
agenda : list(RecType)
\end{array} \right] \\
sh : \left[\begin{array}{l}
l-m : RecType \\
l-T : RecType
\end{array} \right]
\end{array} \right] . \\
\lambda e : & \left[\begin{array}{l}
u : RecType \\
c_1 : is_about(u, r.pr.SitC) \\
c_2 : realisation_of(u, fst(r.pr.agenda))
\end{array} \right] . \qquad (4.d) \\
sh : & \left[\begin{array}{l}
SitC = r.sh.SitC \wedge r.pr.SitC : RecType \\
l-m : \left[\begin{array}{l}
prev = r.l-m : RecType \\
curr = e.u : RecType
\end{array} \right] \\
l-T : \left[\begin{array}{l}
prev = r.l-T : RecType \\
curr = fst(r.pr.agenda) : RecType
\end{array} \right]
\end{array} \right]
\end{aligned}$$

We can apply this function in our example as speaker B plans a move $T_{love_butterfly}$ related to their situational context and then realise it with B2_2. The update of their state of information is represented in Figure 4.2.

The situational context is now shared in (4.viii), *i.e.*, the representation of B's DGB after B2_2. However, it is possible that A has not seen the butterfly and thus has a different state of information. (4.ix) is a representation of the DGB after B2_2 for *both* A and B. The shared situational context has not been represented as it is the part on which A and B could have different point of views. In Table 4.1 we propose three possible scenarios from this moment in the conversation. In every case, we first

show the take of A and B on the shared situational context, which we refer to with the label DGB.sh.SitC as one would do in TTR to refer to a label in another type. For B the representation is always the same, as not giving additional linguistic signals to make the topic shift explicit indicates that they consider it explicit enough. However there are several possibilities for the interpretation of A.

$$(4.ix) \text{ DGB: } \left[\text{sh: } \left[\text{l-m: } \left[\text{curr: } \left[\begin{array}{l} \text{spkr} = \text{B} : \text{Ind} \\ \text{addr} = [\text{A}] : \text{list}(\text{Ind}) \\ \text{cntnt: } \left[\begin{array}{l} \text{x} : \text{Ind} \\ \text{c}_1 : \text{butterfly}(\text{x}) \\ \text{c}_2 : \text{like}(\text{sp}, \text{x}) \end{array} \right] \end{array} \right] \right] \right] \right]$$

State	A	B
B2_2	DGB.sh.SitC : $\left[\begin{array}{l} \text{x} : \text{Ind} \\ \text{c}_1 : \text{butterfly}(\text{x}) \\ \text{c}_2 : \text{flapping_by}(\text{x}) \end{array} \right]$	DGB.sh.SitC : $\left[\begin{array}{l} \text{x} : \text{Ind} \\ \text{c}_1 : \text{butterfly}(\text{x}) \\ \text{c}_2 : \text{flapping_by}(\text{x}) \end{array} \right]$

(A) Both participants saw the butterfly.

State	A	B
B2_2	DGB.sh.SitC : $\left[\begin{array}{l} \cancel{\text{x}} : \text{Ind} \\ \text{c}_1 : \text{butterfly}(\text{x}) \\ \text{c}_2 : \text{flapping_by}(\text{x}) \end{array} \right]$	DGB.sh.SitC : $\left[\begin{array}{l} \text{x} : \text{Ind} \\ \text{c}_1 : \text{butterfly}(\text{x}) \\ \text{c}_2 : \text{flapping_by}(\text{x}) \end{array} \right]$

(A3) $Q_{\text{where_butterfly}}$

	DGB.sh.SitC : $\left[\begin{array}{l} \text{x} : \text{Ind} \\ \text{c}_1 : \text{butterfly}(\text{x}) \\ \text{c}_2 : \text{flapping_by}(\text{x}) \end{array} \right]$	DGB.sh.SitC : $\left[\begin{array}{l} \text{x} : \text{Ind} \\ \text{c}_1 : \text{butterfly}(\text{x}) \\ \text{c}_2 : \text{flapping_by}(\text{x}) \end{array} \right]$
--	--	--

(B) The addressee did not see the butterfly but infers that the speaker saw one.

State	A	B
B2_2	DGB.sh.SitC : $\left[\begin{array}{l} \cancel{\text{x}} : \text{Ind} \\ \text{c}_1 : \text{butterfly}(\text{x}) \\ \text{c}_2 : \text{flapping_by}(\text{x}) \end{array} \right]$	DGB.sh.SitC : $\left[\begin{array}{l} \text{x} : \text{Ind} \\ \text{c}_1 : \text{butterfly}(\text{x}) \\ \text{c}_2 : \text{flapping_by}(\text{x}) \end{array} \right]$

A3 *Repair*

(C) The addressee did not see the butterfly and does not understand the speaker's topic shift.

TABLE 4.1: Three possible reactions of the addressee when the topic shifts to butterflies

In the first case, represented in Table 4.1a, A has noticed the butterfly as well, it thus appeared in their private situational context before B2_2 and is shared afterwards. It can be drawn on to explain the topic shift.

A second possibility would be that A has not seen the butterfly, as modelled in Table 4.1b, but understands that B2_2 was said because B saw one. A can thus try to accommodate by either looking for the butterfly by following B's gaze for instance,

by asking about it, or even by simply assuming that there was one that licensed the introduction of a new topic.

Eventually, A could be disturbed by this sudden topic shift and not understand the reason why B mentions butterflies. In this case, starting a repair move, as in Table 4.1c, would help them not to lose track of the conversation. However it is also possible to ignore the disruption and keep going with the conversation. In this case, further misunderstandings could arise later as the other participant would not be aware of the first issue.

We just suggested a way to represent situational context on the DGB and thus to model conversations where it licenses the introduction of a new topics. However, we saw in Chapter 2 that some links are more implicit, where they are based on the proximity of words at a phonetic or semantic level for instance. In the next section, we suggest a way to account for these more unusual topic shifts.

4.2.2 Background context

We saw in Section 4.1.2 that a new topic can be introduced thanks to an implicit link to the previous one or to the last utterance. Topoi can explain such links, where the speaker relies on what they consider common knowledge or reasonable assumptions to go from one topic to another. Topoi are extra-linguistic: they are related to reasoning and are based on life experience and the way we perceive the world. However, it is also possible to use implicit *linguistic* links as words and phrases are linked to each other by their meaning and sound similarity for example. In this section we will come back to an example of Chapter 2 where a new topic is introduced thanks to an implicit linguistic link. We suggest using a field labelled “background context” (BkgdC) to account for the knowledge required to explain this link.

The following example, (4.3), is a conversation involving several television hosts presenting the outline of their TV show. They are speaking about dogs when one of them changes the topic in HS7_2 to hot dogs, which is the recipe they will discuss later in the show.

- (4.3) HS1: good looking dogs right there, right?
 MR2: We’re going to talk about, you know, all – all their special needs because large breeds do have some. And, what made – some interesting fun facts about big breeds.
 BN3: Like the slobbering that some of them do?
 MR4: Yeah, that’s a not-so fun fact.
 HS5: Yeah.
 BN6: Harry still has some on him.
 HS7_1: One got me, yeah.
 HS7_2: And speaking of dogs, hot dogs, that is,
 HS7_3: our good friend, Katie Lee is cooking some of her favorite Memorial Day foods –

Adapted from [CBS Early, May 28, 2010 [COCA]]

By using “And speaking of dogs” to introduce this new topic, they make it explicit that there is a connection with the previous utterances. In this case the link lies in the construction of the compound word “hot dog” which is based on “dog”, even

though both words are unrelated in terms of meaning. Someone following the conversation through a translator would not understand this transition in most cases as all the information explaining it is carried by the phonetics of the words.

We thus need an update rule that would allow an agent to add a move of their communication project to their agenda if the move is linked phonetically to the latest move on the DGB. We suggest the rule f_{phon_link} in (4.e) (and in Appendix B.3.1).

$$\begin{aligned}
 f_{phon_link} = \lambda r : & \left[\begin{array}{l} \text{pr} : \left[\begin{array}{l} \text{agenda} : \text{list}(\text{RecType}) \\ \text{BkgdC} : \text{RecType} \end{array} \right] \\ \text{sh} : \left[\begin{array}{l} \text{l-m} : \left[\begin{array}{l} \text{prev} : \text{RecType} \\ \text{curr} : \text{RecType} \end{array} \right] \\ \text{l-T} : \left[\begin{array}{l} \text{prev} : \text{RecType} \\ \text{curr} : \text{RecType} \end{array} \right] \end{array} \right] \end{array} \right] . \\
 \lambda e : & \left[\begin{array}{l} \text{T} : \text{RecType} \\ \text{c}_1 : \text{in_comm_project}(\text{T}) \\ \text{phon}_1 : \text{Rec} \\ \text{c}_2 : \text{is_related_to}(\text{T}, \text{phon}_1) \\ \text{phon}_2 : \text{Rec} \\ \text{c}_3 : \text{contains}(r.\text{sh}.\text{l-m}.\text{curr}, \text{phon}_2) \\ \text{c}_4 : \text{is_subtype}(\text{phon}_1, \text{phon}_2) \\ \text{c}_5 : \text{in_bkbd_resources}(\text{c}_4) \end{array} \right] . \tag{4.e} \\
 \left[\text{pr} : \left[\begin{array}{l} \text{agenda} = [e.\text{T} \mid r.\text{pr}.\text{agenda}] : \text{list}(\text{RecType}) \\ \text{BkgdC} = r.\text{pr}.\text{BkgdC} \wedge \left[\begin{array}{l} e.\text{phon}_1 \\ e.\text{phon}_2 \end{array} \right] : \text{RecType} \end{array} \right] \right]
 \end{aligned}$$

This rule can be applied to a state of information whose type is such that a unit of the current latest move is contained in terms of phonetics by an other unit, which is related to a topic of the agent’s communication project. The agent must also be aware of this phonetic inclusion, *i.e.*, it must be in their background resources. Indeed, some words can so different from each other in terms of meaning that the association would be very complicated to make. For example, based on spelling only, “fun” is included in “funeral”, but these words are unrelated both etymologically and semantically.

In our example, the latest move is HS7_1. This utterance contains “dogs”, which is included in “hot dogs”. This licenses the topics T_{hot_dogs} based on f_{phon_link} . (4.x) shows the state of information of HS after the update licensed by f_{phon_link} .

$$\begin{aligned}
 \text{(4.x) DGB:} & \left[\begin{array}{l} \text{pr} : \left[\begin{array}{l} \text{agenda} = [T_{hot_dogs}] : \text{list}(\text{RecType}) \\ \text{BkgdC} = \left[\begin{array}{l} \text{phon}_{dogs} : \left[\begin{array}{l} \text{phon}_{dog} : \backslash \text{dog} \backslash \\ \text{phon}_{plural} : \backslash s \backslash \end{array} \right] \\ \text{phon}_{hot_dogs} : \left[\begin{array}{l} \text{phon}_{hot} : \backslash \text{hot} \backslash \\ \text{phon}_{dog} : \backslash \text{dog} \backslash \\ \text{phon}_{plural} : \backslash s \backslash \end{array} \right] \end{array} \right] : \text{RecType} \end{array} \right] \\ \text{sh} : \left[\begin{array}{l} \text{l-m} : \left[\begin{array}{l} \text{prev} : \text{RecType} \\ \text{curr} = \text{HS7_1} : \text{RecType} \end{array} \right] \\ \text{l-T} : \left[\begin{array}{l} \text{prev} : \text{RecType} \\ \text{curr} = T_{dogs} : \text{RecType} \end{array} \right] \end{array} \right] \end{array} \right]
 \end{aligned}$$

(4.xi) would be a representation of speaker HS’s state of information at this point. Note that we defined the rule such that a unit of the latest move must be included in

a unit related to the new topic as it was coherent with our example. However, the relation could be the opposite one, which would correspond to going from “hot dogs” to “dogs” with our example. Determining what way is the easiest is an empirical question which would be interesting to investigate to learn more about the way we rank such unconventional links.

They can now realise T_{hot_dogs} with an utterance. Similarly to $topoi$ and situational context, if an agent uses their background context to link an utterance to the conversation then they consider that the addressees will acknowledge this link, which means that the background context becomes shared. A function f_{use_BkgdC} , described in Appendix B.3.3, similar to f_{use_topos} and f_{use_SitC} allows HS to update their DGB when they utter HS7_2. The content of the resulting DGB is represented in (4.xi).

$$(4.xi) \quad \left[\begin{array}{l} pr : \left[\begin{array}{l} agenda = [T_{hot_dogs}] : list(RecType) \\ BkgdC : RecType \end{array} \right] \\ \\ sh : \left[\begin{array}{l} BkgdC = \left[\begin{array}{l} phon_{dogs} : \left[\begin{array}{l} phon_{dog} : \backslash dog \backslash \\ phon_{plural} : \backslash s \backslash \end{array} \right] \\ phon_{hot_dogs} : \left[\begin{array}{l} phon_{hot} : \backslash hot \backslash \\ phon_{dog} : \backslash dog \backslash \\ phon_{plural} : \backslash s \backslash \end{array} \right] \end{array} \right] : RecType \\ \\ l-m : \left[\begin{array}{l} prev : RecType \\ curr = HS7_2 : RecType \end{array} \right] \\ \\ l-T : \left[\begin{array}{l} prev = \left[\begin{array}{l} prev : RecType \\ curr = T_{dogs} : RecType \end{array} \right] : RecType \\ curr = T_{hot_dogs} : RecType \end{array} \right] \end{array} \right] \end{array} \right]$$

The representation we suggested to link topics based on the proximity of the words they contain enable us to account for more unusual topic shifts that rely on word similarities. Phonetics was at the core of our example but we can imagine extending this representation to more intricate relations between the characters of the words, or to semantics with word senses.

With the different additions to the DGB we suggested, we are now able to account for various types of topic shifts, including less straightforward ones and those that rely on extra-linguistic information. Hence, we can try to use our extended framework to model conversations involving patients with schizophrenia that contain a topic shift. Ideally, our model would be able to indicate and explain the disfluencies in a conversation.

4.3 Patient Conversations

In the previous sections we have introduced KoS, a framework based on TTR to represent the state of information of each participant in a dialogue on DGBs. We discussed different fields and update rules that enable us to account for topic shifts in conversation. However one of the aims of this thesis is to better characterise disfluencies in dialogue at a topical level, in particular when the conversation involves a patient with schizophrenia. In this section, we will apply KoS to two extracts of patients conversation we introduced in Chapter 2 to show how our model accounts for the topic shift they contain. The piece of conversation in Section 4.3.1 does not contain any misunderstanding but the topic shift is due to a change in the situational context, which was complicated to model in RST and SDRT as we saw previously. On the other hand, the example in Section 4.3.2 shows a misunderstanding

between the patient and the psychologist that is not straightforward to explain. For both example we suggest a representation that helps understand the interaction and highlights the reason for the misunderstanding in the second example.

4.3.1 Example with no problem

(4.4) contains a topic interruption due to air conditioner noises. This dialogue extract thus has two parts separated by the noises. Up to R239_1 the patient (speaker R) and the psychologist (speaker G) speak about technology and in particular about having a cellphone. Then, from R239_2, they discuss the air conditioning system. We will first imagine several scenarios after the interruption, regardless of the actual continuation of the conversation.

- (4.4) G234_1: mm hmm (0.5s) do you have a cellphone? (Fr. *humhum (0,5s) vous avez un téléphone vous ?*)
 R235_1: I stopped the cellphone (Fr. *j'ai arrêté le téléphone*)
 G236_1: stop (Fr. *arrêter*)
 R237_1: stop (Fr. *arrêter*)
 G238_1: completely (Fr. *complètement*)
 R239_1: complete oulac (xxx) (1s) (Fr. *complet oulac (xxx) (1s)*)
air conditioner noises
 R239_2: wouallou but (0.5s) it's (Fr. *wouallou mais (0,5s) c'est (0,5s)*)
 G240_1: wouallou (Fr. *wouallou*)
 R241_1: it's okay it's a (1.5s) (xxx) (Fr. *c'est bon c'est un (1,5s) (xxx)*)
 G242_1: (xxx)
 G242_2: you see the (tech-) (Fr. *vous voyez la (tech-)*)
 R243_1: an old air conditioner (Fr. *un ancien climatiseur*)
 G244_1: ah (Fr. *ah*)

[SLAM Data]

(4.xii) shows the general state of information before the air conditioner noises. The latest moves are related to the “cellphone” topic and there is no indication that this topic is closed. But the noises interrupt the conversation, which could have several possible consequences that we represent in (4.xiii).

$$(4.xii) \text{ DGB: } \left[\begin{array}{l} \text{pr : } \left[\begin{array}{l} \text{SitC : } RecType \\ \text{agenda : } list(RecType) \end{array} \right] \\ \text{sh : } \left[\begin{array}{l} \text{SitC : } RecType \\ \text{l-T : } \left[\begin{array}{l} \text{prev : } RecType \\ \text{curr = } T_{cellphone} : RecType \end{array} \right] \end{array} \right] \end{array} \right]$$

The first possible scenario, represented in (4.xiii.a), would be for both participants to ignore the noises or wait for them to end without interrupting their topic. In this case the noises would not appear in the situational context as we chose to represent only the aspects of it that are relevant to the conversation. The noises would have been included in the sensory inputs if we had chosen a more complex model such as the one we discussed at the beginning of Section 4.2.1. The topic “cellphone” appears in the agenda as it is still the topic under discussion.

(4.xiii.b) shows another possible scenario, where the participants temporarily change the topic to the air conditioning system without completely abandoning the cellphone one. $T_{air_conditioner}$ is thus the first topic in the agenda but $T_{cellphone}$ is kept in the agenda, which makes it easy to come back to it later in the conversation.

Eventually (4.xiii.c) represents a scenario where the cellphone topic is completely dropped and thus does not appear in the agenda anymore. Choosing this model as an annotator would require some cues in the conversation indicating that the participants do not plan to come back to the topic later. Indeed, the air conditioning topic was introduced based on a sudden interruption, as opposed to a new topic introduced because the previous one was exhausted. It is possible that the participants do not wish to pursue the cellphone topic in the future but without evidences in the dialogue, the scenario in (4.xiii.b) is less constraining. A possibility to consider would be using an additional field to store the possible topics. This field would mimic the memory of the participants, where a topic such as the cellphone one would be stored for a certain amount of time and made less and less accessible over time, unless a related topic appeared in the conversation. In this case, $T_{cellphone}$ would not appear in the agenda in (4.xiii.b) but in this memory field instead, and it would be copied to the agenda if a participant planned to come back to it.

(4.xiii) a. The air conditioner noises do not interrupt the conversation:

$$\left[\text{pr} : \left[\begin{array}{l} \text{SitC} : \text{RecType} \\ \text{agenda} = [T_{cellphone}] : \text{list}(\text{RecType}) \end{array} \right] \right]$$

b. The cellphone topic is temporarily dropped in favour of the air conditioner:

$$\left[\text{pr} : \left[\begin{array}{l} \text{SitC} : \left[\begin{array}{l} x : \text{Ind} \\ c_1 : \text{air_conditioner}(x) \\ c_2 : \text{noisy}(x) \end{array} \right] \\ \text{agenda} = [T_{air_conditioner}, T_{cellphone}] : \text{list}(\text{RecType}) \end{array} \right] \right]$$

c. The cellphone topic is dropped in favour of the air conditioner without intentions to come back to it:

$$\left[\text{pr} : \left[\begin{array}{l} \text{SitC} : \left[\begin{array}{l} x : \text{Ind} \\ c_1 : \text{air_conditioner}(x) \\ c_2 : \text{noisy}(x) \end{array} \right] \\ \text{agenda} = [T_{air_conditioner}] : \text{list}(\text{RecType}) \end{array} \right] \right]$$

In our example, the patient used the noises to start a new topic. As there are no explicit cues to indicate that they definitely closed the cellphone topic, the representation we consider is (4.xiii.b). As they make use of the situational context to start a new topic, the update rule f_{use_SitC} we introduced in Section 4.2.1 is suitable to model the evolution of their state of information, *i.e.*, (4.xi) \wedge (4.xiii.b), when they utter R239_2. R's state of information after R239_2 thus becomes (4.xiv) as denoted in Figure 4.3.

The noises now appear in the shared situational context. We do not know if the psychologist would have chosen a similar move if the patient had not discussed the noises, which means that their agenda is unknown right after the noises. However, they immediately acknowledge the topic change, which shows that the noises also appear in their shared situational context.

This example of topic shift in a conversation involving a patient with schizophrenia was interesting to analyse with KoS because we saw that it raised some questions with other formalism such as SDRT. With the framework we presented here, we were able to use the situational context to introduce a new topic while the previous one

$$\begin{array}{c}
 \underbrace{((4.xiii) \wedge (4.xiii.b)) \wedge (f_{use_SitC} \cdot r \cdot e) \quad r : (4.xiii) \wedge (4.xiii.b) \quad e : R239_2} \\
 (4.xiv) \left[\begin{array}{l}
 pr : \left[\begin{array}{l}
 SitC : RecType \\
 agenda : list(RecType)
 \end{array} \right] \\
 sh : \left[\begin{array}{l}
 SitC : \left[\begin{array}{l}
 x : Ind \\
 c_1 : air_conditioner(x) \\
 c_2 : noisy(x)
 \end{array} \right] \\
 l-T : \left[\begin{array}{l}
 prev = T_{cellphone} : RecType \\
 curr = T_{air_conditioner} : RecType
 \end{array} \right]
 \end{array} \right]
 \end{array}
 \right]
 \end{array}$$

FIGURE 4.3: Update of speaker R's state of information when R239_2 is uttered

remained available in the communication project for a future move. Modifying the way the agenda and communication project work, with a more flexible structure such as a partially ordered set, or with the addition of a topical memory field on the DGB could make this framework more precise when characterising more or less acceptable topic shifts.

Moreover, we can account for the understanding of the conversation separately for each participant, and the differences in the shared part of the DGB are an indicator of misunderstandings. In the next section, we will analyse another piece of conversation from the SLAM data, where the psychologist does not understand some of the intervention of the patient and thus has a different view on the conversation.

4.3.2 Example with misunderstanding

In the following example, (4.5), introduced previously in Section 2.3.3, a misunderstanding arises as the link between two utterances of a speaker is unclear. In particular, the patient speaks of politics in B124 and says that losing in politics implies one's political end (Fr. *fini*). They continue in B126 by citing several dead politicians. The psychologist tries to interpret the link between B124 and B126 and suggests in A127 that losing was responsible for their death, which could be a topos according to which dying professionally/being done professionally can lead someone to death. However, it was not the patient's reasoning and we see in B128 that B126 was not related to B124 in terms of meaning. Indeed, the patient now speaks of politicians who were winning.

- (4.5) B124: Oh yeah (↑) and complicated (↑) and it's really very very complicated (→) politics, it's really something when you get into it, have to win or else when you lose, well, you're finished (↓) (Fr. *Oh ouais (↑) et pis compliqué (↓) et c'est vraiment très très compliqué (→) la politique c'est quelque chose quand on s'en occupe faut être gagnant parce qu'autrement quand on est perdant c'est fini quoi (↓)*)
- A125: Yes (Fr. *Oui*)
- B126: JCD is dead, L is dead, P is dead uh (...) (Fr. *J. C. D. est mort, L. est mort, P. est mort euh (...)*)
- A127: So you think they're dead because they lost (↑) (Fr. *Ils sont morts parce qu'ils ont perdu à votre avis (↑)*)
- B128: No they were winning but if they're dead, it's their disease well it's it's (→) (Fr. *Non ils gagnaient mais si ils sont morts, c'est la maladie quoi c'est c'est (→)*)

[SLAM Data]

We suggest that the patient made use of the relation between “dead” and the sense of “finished”/“over” (Fr. *fini*) in B124, *i.e.*, being discredited, professionally dead, to introduce the idea of actual death in B126. This link is similar to the phonetic link we discussed in Section 4.2.2, where one aspect of the words is used to link two utterances, otherwise unrelated. The sense of “finished”/“over” being related to a certain sense of “dead” allowed the patient to continue the conversation with an other sense of “dead”. This transition could have been made explicit if they had said something like “And speaking of politically dead people, other politics are actually dead.”, but the absence of explicit signal leaves the interpretation up to the psychologist. Since this type of link is unusual, the psychologist comes up with a different interpretation of the transition, that they explicit in A127. By linking B124 and B126 with a topos, the psychologist preserves a pragmatic relation between the utterances and B126 is still seen as relevant to the topic of competitiveness in politics. Hence, the psychologist expects B124 and B126 to form a coherent unit, and a future utterance linked to B126 would have to be coherent with B124 as well. On the other hand, the patient’s transition does not keep any pragmatic link between B124 and B126. B126 can be seen as the introduction of a new topic about dead politicians, which was licensed by the link between B124 and B126. Since B124 is not part of this new topic, continuing with an utterance that contradicts it is not a problem.

Formally, it means that the patient used a function f_{sense_link} (see Appendix B.3.2), similar to f_{phon_link} that we introduced in (4.e) in Section 4.2.2, to license their move and realised it with f_{use_BkgdC} . This function updated what they consider as the shared latest topic. The psychologist however used a function based on a topos to integrate this move on his DGB. Since B126 can be seen as relevant to the topic of competitiveness in politics, they do not update what they consider as the shared latest topic. In consequence, the shared part of the DGB of both participants, represented in (4.xv) for the psychologist and (4.xvi) for the patient, presents a mismatch after B126. The psychologist has access to a shared topos but no background context, while the patient is in the opposite situation, and they have a different idea of the current topic under discussion, *i.e.*, the current latest topic.

$$(4.xv) \text{ DGB}_A: \left[\begin{array}{l} \text{pr} : \text{Rec} \\ \text{sh} : \left[\begin{array}{l} \text{topoi} = [\tau_{\text{professional_death_can_lead_to_death}}]: \text{list}(\text{Topos}) \\ \text{BkgdC} : \text{RecType} \\ \text{l-m} : \left[\begin{array}{l} \text{prev} : \text{RecType} \\ \text{curr} = \text{B126} : \text{RecType} \end{array} \right] \\ \text{l-T} : \left[\begin{array}{l} \text{prev} : \text{RecType} \\ \text{curr} = \text{T}_{\text{competitiveness_in_politics}} : \text{RecType} \end{array} \right] \end{array} \right] \end{array} \right]$$

$$(4.xvi) \text{ DGB}_B: \left[\begin{array}{l} \text{pr} : \text{Rec} \\ \text{sh} : \left[\begin{array}{l} \text{topoi} : \text{list}(\text{Topos}) \\ \text{BkgdC} = \left[\begin{array}{l} \text{sense}_{\text{fini_abstr}} : \text{“being discredited,} \\ \text{professionally dead”} \end{array} \right] : \text{RecType} \\ \text{l-m} : \left[\begin{array}{l} \text{prev} : \text{RecType} \\ \text{curr} = \text{B126} : \text{RecType} \end{array} \right] \\ \text{l-T} : \left[\begin{array}{l} \text{prev} : \text{RecType} \\ \text{curr} = \text{T}_{\text{dead_politicians}} : \text{RecType} \end{array} \right] \end{array} \right] \end{array} \right]$$

The role of topics in the coherence of a conversation is not accounted for by our framework. Modelling this example would require a way to represent the link between a topic and the utterances it is related to. With this additional information, the next move of the patient, B128, would be coherent with the patient's state of information, as only B126 is related to the current topic and not B124. On the other hand, it would be incoherent for the psychologist as what they consider to be the current topic is related to both B126 and B124. Thus producing B128, which is incoherent with B124 would create a dialogue breakdown.

4.4 Summary and Conclusion

In this chapter, we suggested to use TTR and KoS to model topics and topic shifts in conversation. We used *topoi*, introduced on the DGB by Breitholtz (2021), to explain some implicit links between topics. We also proposed a representation in TTR of situational context and background context to account for topic shifts. We applied the extended framework to two pieces of conversations involving patients with schizophrenia and saw that the commonness of the types of links used to produce coherent portions of dialogue influences the way addressees understand the conversation. Without an explicit signal, using an event of the background context that clearly interrupted the conversation to start a new topic is less likely to create misunderstandings than a more subtle event. Similarly, more common *topoi* are more likely to be shared and thus understood by the addressees. Less common links based on phonology or word proximity are most likely less accessible to the participants of a conversation when accommodating a move. Hence, if a relevant *topos* is available, they may use it to interpret the link between two utterances while the speaker does not have an argumentative take on this link, which can create misunderstandings.

When it comes to topic resumptions, the way we model the latest topics influences the accessibility of the past topics. Indeed, some parts of the conversation are easier to come back to than others. We saw in Section 3.2.2 that SDRT partially accounts for this with the RFC, but these rules do not capture all the phenomena related to topic resumption. In particular, how well a participant remembers the previous moves of a dialogue is not taken into account.

The way we represent the situational context could also be discussed. Indeed, the representation we chose is simple and well suited to the examples we studied but perception involves many cognitive processes that are not straightforward to explain.

In conclusion, modelling topics and topic shifts still requires a lot of investigation both on how they work in conversation and on the cognitive processes involved, and on the way to model them. TTR is flexible thanks to the possibility to add more fields and thus more levels of representations. However, this flexibility can make the models very complex and unsuitable for the analysis of long dialogues. A lead to investigate to alleviate the annotation work could be ML. Indeed, some of the topic related processes we discussed in this chapter seem to be gradient: *topoi* are more or less common and dialogue moves become less accessible with time unless more attention is given to them. Combining the current symbolic approach with ML could help us gain in efficiency (Shavlik, 1994).

Chapter 5

Conclusion and Discussion

In this thesis we have investigated topics and topic shifts in dialogue. In particular, we aimed at characterising topic shifts in conversations involving patients with schizophrenia, a mental pathology that induces language impairments. To understand the specificities of such interactions, we first took a step back and worked with different types of dialogues, where most of them did not involve patients. This enabled us to highlight different ways to change the topic of a conversation and to compare topic shifts which were understood and misunderstood in dialogues involving patients. As topics and topic shifts are not much discussed in dialogue modelling, we applied existing theories to some of our examples to understand their advantages and limits when it comes to analysing the coherence of a conversation. We chose RST because it focuses on the coherence of a text and its simplicity enables one to model extensive conversations. However, RST was initially designed for text analysis. Hence, it does not handle interaction, which is central in dialogue. Some adaptations have been suggested such as ignoring some contributions if they are abandoned by the speakers, but it implies a loss of information. Moreover, dialogue is organised differently from text and non spontaneous speech. Trying to model a conversation as a coherent and continuous can be complicated as speakers can correct their past moves and discuss unrelated ideas one after the other for example. For this reason, a more flexible structure is necessary to model conversation, such as that proposed by SDRT. The logical formalism it contains makes it possible to represent extra-linguistic content on top of the dialogue itself. However in some cases the extra-linguistic content is out of the scope of the rhetorical relations used in SDRT to model a discourse structure. Additionally, neither RST nor SDRT make it possible to represent the point of views of all the participants taking part in a conversation. Being able to compare them is however crucial to understand the way dialogue breakdowns happen.

Eventually we chose to work with TTR and KoS as they allow us to represent the point of view of each participant and different forms of context of the conversation. We suggested several additions to TTR that enable the representation of topic shifts, including unusual ones such as those that can be found in conversations involving patients with schizophrenia. Enriching this work with a hierarchy of the different ways to link utterances and change the topic of the conversation could contribute to the cues supporting the diagnosis of schizophrenia. In TTR it would correspond to proposing a hierarchy of the update rules. Indeed, using unusual update rules without giving any clue on the type of rule used can confuse the addresses, who would use the update rule that they consider the most likely used in a situation. What an agent considers to be a fitting update rule in a situation is influenced by their experience. Hence, there is no unique hierarchy of the update rules. However, a statistical approach could make it possible to predict the behaviour of an agent with a certain probability.

Nevertheless, TTR is a complex framework, which makes it less suitable for the annotation of long dialogues. Moreover, TTR manipulates record types, *i.e.*, object types, rather than records, *i.e.*, the objects themselves. Indeed, records represent the actual state of information of an agent, which is infinitely complex, while determining the type of their state of information regarding a conversation at a certain point can be done based on the conversation and its context. The information state update, on the other hand, requires manipulating objects, *i.e.*, update rules must be applied to records in order to produce the future type of the record. As explained in Maraev et al. (2018), such update rules raise an issue because they produce record types but require records as input. Hence, a record must be reconstructed based on the output of the function to be used as input for the next function. This can be a problem when proposing an implementation of TTR as record types are not necessarily fully specified, *i.e.*, they can present fields whose value is not specified. When constructing a record corresponding to such types, “hypothetical objects” must be constructed for each underspecified field. Maraev et al. (2018) suggests to use well-typed functions that output records so that a function could be applied directly to the output of an other function.

Using a symbolic approach to model dialogue is a time consuming process even with a more simple theory such as RST. Producing quality annotations requires the development of an annotation guide and several annotators to compare their agreement. In spite of this, this thesis provides a manual analysis of some conversations to better understand topics and topic shifts in dialogue and paves the way towards the development of an annotation framework for topic-level interactions. In Section 5.1 we give a few reasons motivating our choice to start with a symbolic approach rather than a ML based one. We discuss future leads to investigate in Section 5.2 and conclude this thesis in Section 5.3.

5.1 Why not Machine Learning?

Existing work on the language produced by patients with schizophrenia showed that ML techniques can be used to help identify language features associated with this disease. Howes et al. (2012) showed that high-level dialogue features, such as backchannels (*e.g.*, “yeah”, “hmmm”, ...), overlap and the proportion of talk of each participant are related to patients’ symptom levels. Amblard, Braud, et al. (2020) and Li et al. (2021) used classification algorithm to identify language features that would help identify patients with symptoms of schizophrenia. They also highlighted potential bias at the lexical level in the corpus. The data collection process encourages some topics of conversation and thus influences the lexical field used by the participants. Moreover, the difficulty to include patients in an experiment makes the data very sparse, which makes the use of ML alone more complicated.

On top of these limitations induced by our task, the lack of explainability of ML approaches makes them less suitable than symbolic approaches. We are interested in the process involved in producing dialogical interactions. Analysing conversations involving patients with schizophrenia makes it possible to highlight linguistic features indicative of this disease, but also to better understand how successful interactions are constructed. The results of this research could thus be applied to different domains. On the other hand, ML could provide ways to automatically detect language features associated with schizophrenia but the models would not provide explanations on the dialogical interactions. Moreover, diagnosing mental diseases

is a sensitive matter and being able to justify the results of our model is a central concern.

5.2 Future Work

Our work in this thesis provided more insight on topic shifts than topic themselves. Accounting for the inner coherence of a topic, and understanding the way participants perceive and remember the sequence of topics in a conversation would make our model of topic-level interaction more complete. Applying a structure similar to the one proposed in SDRT, with coordinating and subordinating relations, to the topics in a dialogue could be a first lead to investigate as it would provide some rules to evaluate the accessibility of previous topics.

The analysis of a bigger corpus would be needed to better understand the way participants perceive topics and acknowledge topic shifts in dialogue. Comparing a manual annotation of topics with the result of an automatic topic modelling approaches, such as Latent Dirichlet Allocation (Blei, Ng, and Jordan, 2003), would be interesting to see if statistical approaches match human intuition. However, topic modelling approaches do not account for the links between topic or their internal coherence, while understanding and formalising these links is the core of our approach. The result of our research could help implementing better models that keep track of topics and thus produce more coherent contributions.

Eventually, none the three formalism we used in this thesis, *i.e.*, RST, SDRT, and TTR, make it possible to represent different layers in conversation. The relations between utterances are different from the relations between topics, and meta conversation, *i.e.*, conversation about the conversation, also forms another layer. We can imagine adapting TTR so that different layers would be created. For example, creating a type Topic constructed over the utterances could be a step in this direction. However, TTR as we used it in this thesis is already very complex and does not make it possible to have a global view on the conversation. Developing a new framework, inspired the ones presented in this thesis, and accounting for the different layers of interaction in dialogue would be of great help when analysing coherence in conversation and dialogue breakdowns, in particular for long conversations involving patients with schizophrenia. It would indeed help understand the dialogue mechanisms underlying the language impairments induced by schizophrenia.

5.3 Final Words

This thesis presents a descriptive work on topics and topic shifts in conversation. Topics are not often taken into account by dialogue modelling theories and providing some linguistic insights on their influence in conversation paves the way towards more complete theories.

We also introduced topics to the TTR/KoS formalism, which complements the notion of genres discussed by Ginzburg (Ginzburg, 2001; Ginzburg, 2012) and opens up for better implementations of TTR.

This internship was the occasion to apply different theories of dialogue modelling to a real research problem. While RST and SDRT had been studied during the year, TTR was new. However, the different courses about logic, formal languages, and computational semantics provided good basis to understand this new framework.

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Appendix A

Complete models in RST

A.1 Example of an argumentative text

Figure A.1 presents the full example introduced in Section 3.1.2 (Figure 3.2. Stede et al. (2016) present their RST annotations as trees while Figure A.1 follows the representation of Mann and Thompson (1987a). All the relations are the same except for the sequence schema. Stede et al. (2016) link the three spans together and label the relation *list*.

- $\pi 1$. The EU should exert influence on the political events in Ukraine.
- $\pi 2$. The developments in that conflict should not be left to former Cold War opponents alone,
- $\pi 3$. for that course can only lead to escalation in some form.
- $\pi 4$. Furthermore, Ukraine is culturally and geographically much closer than other countries that the EU (used to) get involved with.
- $\pi 5$. Indeed one could argue that a country has to deal with internal political changes itself,
- $\pi 6$. but political power also brings about political responsibility,
- $\pi 7$. in this case the responsibility to protect the Ukrainian people from the rather strong interests of the two Great Powers.

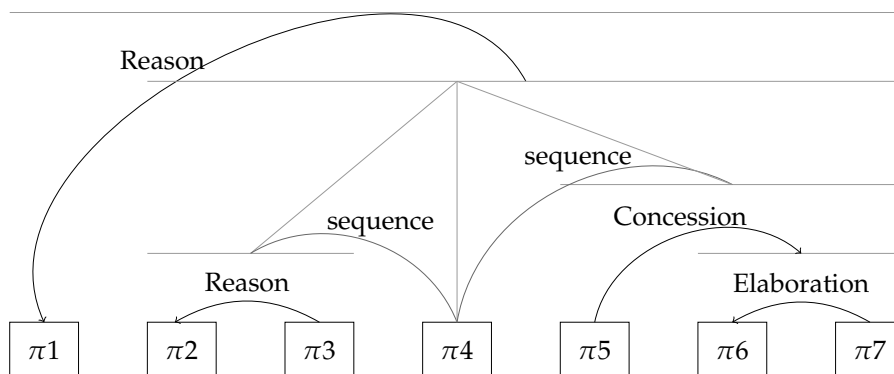


FIGURE A.1: Example of RST analysis for dialogue, example (2.1) rewritten and segmented here

A.2 Including topic drifts in a representation in RST

Figure A.2 is a representation in RST of an example of topic drift introduced in Section 2.1.1. The topic drift happens in RM2_2. This utterance can be seen as a comment on RM2_1, while RM2_1 summarises the intervention of the other speaker. However, this representation groups RM2_1 and RM2_2 under one span, which would raise issues if the conversation continued on the topic of hats.

RJ1_1: And the storm is still hammering New England in Long Island as you can feel out here.

RJ1_2: They're expected to get anywhere between twelve and twenty inches of snow.

RJ1_3: And we already can see a lot of it right out there you see it in Cambridge, Massachusetts.

RM2_1: Yes, yes it is a snowy day.

RM2_2: By the way, it's a very nice hat.

Adapted from [CBS The Early Show, December 27, 2010 [COCA]]

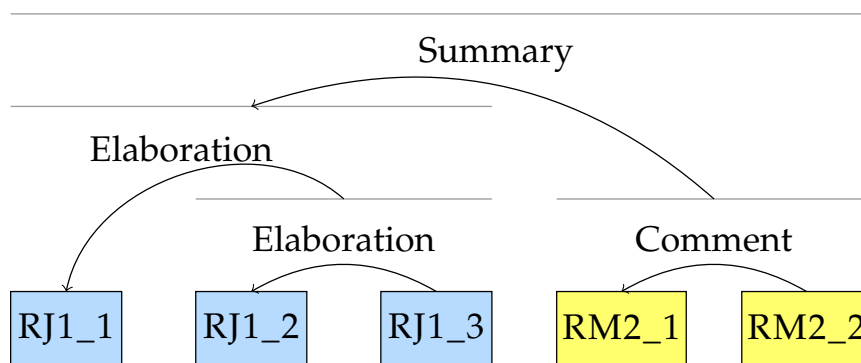


FIGURE A.2: Example of RST analysis for dialogue, example (2.1) rewritten and segmented here

A.3 Modelling topic termination with RST

Figure A.3 is the unabridged representation of Figure 3.4. We use a new relation, topic sequence, to model two subsequent unrelated topic. The main issue of this modelling choice is that RST's continuity principle would make it impossible to link a future part of the conversation to the first topic if it were mentioned again.

B1: did Priscilla listen to it?

M2: no I'm going to have her listen ((laugh))=

B3: ((laugh))

(7.2)

M4: 'cause naturally I think our voices sound different.

(2.6)

B5: yeah.

(9.7)

M6_1: so what's new with you?

(2.0)

M6_2: apart from the tedium [of

B7: oh]

M8: Russian phonetics.

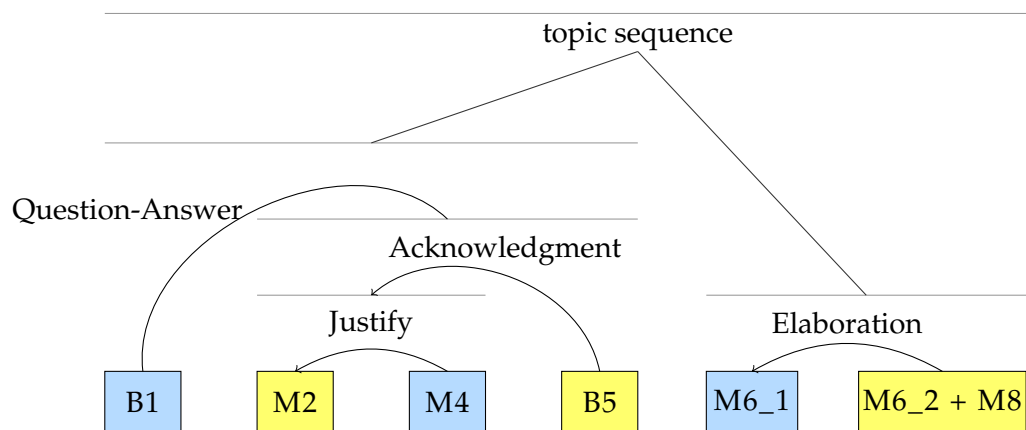


FIGURE A.3: Suggestion of RST analysis for a sequence of unrelated topics, example (2.3) adapted from Howe (1991) [translb-1]

Appendix B

Update rules for TTR

B.1 Topoi

B.1.1 A topos licenses a new topic

$$\begin{aligned}
 f_{\text{topos_licenses_topic}} = \lambda r : & \left[\text{pr} : \left[\begin{array}{l} \text{topoi} : \text{list}(\text{Topos}) \\ \text{agenda} : \text{list}(\text{RecType}) \end{array} \right] \right] \cdot \\
 & \lambda e : \left[\begin{array}{l} \text{t} : \text{Topos} \\ \text{c}_1 : \text{in_bkgd_resources}(\text{t}) \\ \text{c}_2 : \text{relevant_to}(\text{t}, r.\text{sh.l-m.curr}) \\ \text{T} : \text{RecType} \\ \text{c}_3 : \text{in_comm_project}(\text{T}) \\ \text{c}_4 : \text{relevant_to}(\text{t}, \text{T}) \end{array} \right] \cdot \\
 & \left[\text{pr} : \left[\begin{array}{l} \text{topoi} = [e.\text{t} \mid r.\text{pr.topoi}] : \text{list}(\text{Topos}) \\ \text{agenda} = [e.\text{T} \mid r.\text{pr.agenda}] : \text{list}(\text{RecType}) \end{array} \right] \right]
 \end{aligned}$$

B.1.2 Realising a topic on the agenda licensed by a topos

$$\begin{aligned}
 f_{\text{use_topos}} = \lambda r : & \left[\text{pr} : \left[\begin{array}{l} \text{topoi} : \text{list}(\text{Topos}) \\ \text{agenda} : \text{list}(\text{RecType}) \end{array} \right] \right] \cdot \\
 & \left[\text{sh} : \left[\begin{array}{l} \text{topoi} : \text{list}(\text{Topos}) \\ \text{l-m} : \text{RecType} \\ \text{l-T} : \text{RecType} \end{array} \right] \right] \cdot \\
 & \lambda e : \left[\begin{array}{l} \text{u} : \text{RecType} \\ \text{t} : \text{Topos} \\ \text{c}_1 : \text{in}(\text{t}, r.\text{pr.topoi}) \\ \text{c}_2 : \text{relevant_to}(\text{t}, \text{u}) \\ \text{c}_3 : \text{realisation_of}(\text{fst}(r.\text{pr.agenda}), \text{u}) \end{array} \right] \cdot \\
 & \left[\text{sh} : \left[\begin{array}{l} \text{topoi} = [\text{fst}(r.\text{pr.topoi}) \mid r.\text{sh.topoi}] : \text{list}(\text{Topos}) \\ \text{l-m} : \left[\begin{array}{l} \text{prev} = r.\text{l-m} : \text{Rec} \\ \text{curr} = e.\text{u} : \text{RecType} \end{array} \right] \\ \text{l-T} : \left[\begin{array}{l} \text{prev} = r.\text{l-T} : \text{Rec} \\ \text{curr} = \text{fst}(r.\text{pr.agenda}) : \text{RecType} \end{array} \right] \end{array} \right]
 \end{aligned}$$

B.1.3 Accommodating a topos

$$\begin{aligned}
 f_{\text{accommodate_topos}} = \lambda r : & \left[\begin{array}{l} \text{pr} : [\text{topoi} : \text{list}(\text{Topos})] \\ \text{sh} : \left[\begin{array}{l} \text{topoi} : \text{list}(\text{Topos}) \\ \text{l-m} : \left[\begin{array}{l} \text{prev} : [\text{prev} : \text{Rec} \\ \text{curr} : \text{RecType}] \end{array} \right] \\ \text{curr} : \text{RecType} \end{array} \right] \end{array} \right] \\
 \lambda e : & \left[\begin{array}{l} \text{t} : \text{Topos} \\ \text{c}_1 : \text{in_bkgd_resources}(\text{t}) \\ \text{c}_2 : \text{relevant_to}(\text{t}, r.\text{sh}.\text{l-m}.\text{prev}.\text{curr}) \\ \text{c}_3 : \text{relevant_to}(\text{t}, r.\text{sh}.\text{l-m}.\text{curr}) \end{array} \right] \\
 & \left[\begin{array}{l} \text{pr} : [\text{topoi} = [e.\text{t} \mid r.\text{pr}.\text{topoi}] : \text{list}(\text{Topos})] \\ \text{sh} : [\text{topoi} = [\text{t} \mid r.\text{sh}.\text{topoi}] : \text{list}(\text{Topos})] \end{array} \right]
 \end{aligned}$$

B.2 Situational context

B.2.1 The situational context licenses a topic

$$\begin{aligned}
 f_{\text{SitC_licenses_topic}} = \lambda r : & \left[\begin{array}{l} \text{pr} : \left[\begin{array}{l} \text{SitC} : \text{RecType} \\ \text{agenda} : \text{list}(\text{RecType}) \end{array} \right] \\ \text{sh} : \left[\begin{array}{l} \text{SitC} : \text{RecType} \\ \text{l-T} : \text{RecType} \end{array} \right] \end{array} \right] \\
 \lambda e : & \left[\begin{array}{l} \text{SitC} : \text{RecType} \\ \text{T} : \text{RecType} \\ \text{c}_1 : \text{in_comm_project}(\text{T}) \\ \text{c}_2 : \text{relevant_to}(\text{T}, \text{SitC}) \end{array} \right] \\
 & \left[\begin{array}{l} \text{pr} : [\text{SitC} = r.\text{pr}.\text{SitC} \wedge e.\text{SitC} : \text{RecType}] \\ \text{agenda} = [e.\text{T} \mid r.\text{pr}.\text{agenda}] : \text{list}(\text{RecType}) \end{array} \right]
 \end{aligned}$$

B.2.2 Realising a topic of the agenda licensed by the situational context

$$\begin{aligned}
 f_{\text{use_SitC}} = \lambda r : & \left[\begin{array}{l} \text{pr} : \left[\begin{array}{l} \text{SitC} : \text{RecType} \\ \text{agenda} : \text{list}(\text{RecType}) \end{array} \right] \\ \text{sh} : \left[\begin{array}{l} \text{SitC} : \text{RecType} \\ \text{l-m} : \text{RecType} \\ \text{l-T} : \text{RecType} \end{array} \right] \end{array} \right] \\
 \lambda e : & \left[\begin{array}{l} \text{u} : \text{RecType} \\ \text{c}_1 : \text{is_about}(\text{u}, r.\text{pr}.\text{SitC}) \\ \text{c}_2 : \text{realisation_of}(\text{u}, \text{fst}(r.\text{pr}.\text{agenda})) \end{array} \right] \\
 & \left[\begin{array}{l} \text{SitC} = r.\text{sh}.\text{SitC} \wedge r.\text{pr}.\text{SitC} : \text{RecType} \\ \text{sh} : \left[\begin{array}{l} \text{l-m} : \left[\begin{array}{l} \text{prev} = r.\text{l-m} : \text{Rec} \\ \text{curr} = e.\text{u} : \text{RecType} \end{array} \right] \\ \text{l-T} : \left[\begin{array}{l} \text{prev} = r.\text{l-T} : \text{Rec} \\ \text{curr} = \text{fst}(r.\text{pr}.\text{agenda}) : \text{RecType} \end{array} \right] \end{array} \right] \end{array} \right]
 \end{aligned}$$

B.3 Background Context

B.3.1 Phonetic link

$$\begin{aligned}
 f_{phon_link} = \lambda r : & \left[\begin{array}{l} \text{pr} : \left[\begin{array}{l} \text{agenda} : \text{list}(\text{RecType}) \\ \text{BkgdC} : \text{RecType} \end{array} \right] \\ \text{sh} : \left[\begin{array}{l} \text{l-m} : \left[\begin{array}{l} \text{prev} : \text{Rec} \\ \text{curr} : \text{RecType} \end{array} \right] \\ \text{l-T} : \left[\begin{array}{l} \text{prev} : \text{Rec} \\ \text{curr} : \text{RecType} \end{array} \right] \end{array} \right] \end{array} \right] \cdot \\
 \lambda e : & \left[\begin{array}{l} \text{T} : \text{RecType} \\ \text{c}_1 : \text{in_comm_project}(\text{T}) \\ \text{phon}_1 : \text{Rec} \\ \text{c}_2 : \text{is_related_to}(\text{T}, \text{phon}_1) \\ \text{phon}_2 : \text{Rec} \\ \text{c}_3 : \text{contains}(r.\text{sh}.\text{l-m}.\text{curr}, \text{phon}_2) \\ \text{c}_4 : \text{is_subtype}(\text{phon}_1, \text{phon}_2) \\ \text{c}_5 : \text{in_kbd_resources}(\text{c}_4) \end{array} \right] \cdot \\
 \left[\text{pr} : \left[\begin{array}{l} \text{agenda} = [e.\text{T} \mid r.\text{pr}.\text{agenda}] : \text{list}(\text{RecType}) \\ \text{BkgdC} = r.\text{pr}.\text{BkgdC} \wedge \left[\begin{array}{l} e.\text{phon}_1 \\ e.\text{phon}_2 \end{array} \right] : \text{RecType} \end{array} \right] \right]
 \end{aligned}$$

B.3.2 Sense link

$$\begin{aligned}
 f_{sense_link} = \lambda r : & \left[\begin{array}{l} \text{pr} : \left[\begin{array}{l} \text{agenda} : \text{list}(\text{RecType}) \\ \text{BkgdC} : \text{RecType} \end{array} \right] \\ \text{sh} : \left[\begin{array}{l} \text{l-m} : \left[\begin{array}{l} \text{prev} : \text{Rec} \\ \text{curr} : \text{RecType} \end{array} \right] \\ \text{l-T} : \left[\begin{array}{l} \text{prev} : \text{Rec} \\ \text{curr} : \text{RecType} \end{array} \right] \end{array} \right] \end{array} \right] \cdot \\
 \lambda e : & \left[\begin{array}{l} \text{T} : \text{RecType} \\ \text{c}_1 : \text{in_comm_project}(\text{T}) \\ \text{concept} : \text{Rec} \\ \text{c}_2 : \text{is_related_to}(\text{T}, \text{concept}) \\ \text{sense} : \text{Rec} \\ \text{c}_3 : \text{is_related_to}(r.\text{sh}.\text{l-m}.\text{curr}, \text{sense}) \\ \text{c}_4 : \text{is_related_to}(\text{sense}, \text{concept}) \end{array} \right] \cdot \\
 \left[\text{pr} : \left[\begin{array}{l} \text{agenda} = [e.\text{T} \mid r.\text{pr}.\text{agenda}] : \text{list}(\text{RecType}) \\ \text{BkgdC} = r.\text{pr}.\text{BkgdC} \wedge [e.\text{sense}] : \text{RecType} \end{array} \right] \right]
 \end{aligned}$$

B.3.3 Realising a topic of the agenda licensed by the background context

$$\begin{aligned}
 f_{use_BkgdC} = \lambda r : & \left[\begin{array}{l} \text{pr} : \left[\begin{array}{l} \text{BkgdC} : \text{RecType} \\ \text{agenda} : \text{list}(\text{RecType}) \end{array} \right] \\ \text{sh} : \left[\begin{array}{l} \text{BkgdC} : \text{RecType} \\ \text{l-m} : \text{RecType} \\ \text{l-T} : \text{RecType} \end{array} \right] \end{array} \right] . \\
 \lambda e : & \left[\begin{array}{l} \text{u} : \text{RecType} \\ \text{c}_1 : \text{is_about}(r.\text{pr}.\text{BkgdC}, \text{u}) \\ \text{c}_2 : \text{realisation_of}(\text{fst}(r.\text{pr}.\text{agenda}), \text{u}) \end{array} \right] . \\
 \left[\text{sh} : \left[\begin{array}{l} \text{BkgdC} = r.\text{sh}.\text{BkgdC} \wedge r.\text{pr}.\text{BkgdC} : \text{RecType} \\ \text{l-m} : \left[\begin{array}{l} \text{prev} = r.\text{l-m} : \text{Rec} \\ \text{curr} = e.\text{u} : \text{RecType} \end{array} \right] \\ \text{l-T} : \left[\begin{array}{l} \text{prev} = r.\text{l-T} : \text{Rec} \\ \text{curr} = \text{fst}(r.\text{pr}.\text{agenda}) : \text{RecType} \end{array} \right] \end{array} \right] \right]
 \end{aligned}$$

B.4 Accommodate Topic

$$\begin{aligned}
 f_{accommodate_topic} = \lambda r : & \left[\begin{array}{l} \text{pr} : \left[\begin{array}{l} \text{topoi} : \text{list}(\text{Topos}) \\ \text{topoi} : \text{list}(\text{Topos}) \end{array} \right] \\ \text{sh} : \left[\begin{array}{l} \text{l-m} : \left[\begin{array}{l} \text{prev} : \text{Rec} \\ \text{curr} : \text{RecType} \end{array} \right] \\ \text{l-T} : \left[\begin{array}{l} \text{prev} : \text{Rec} \\ \text{curr} : \text{RecType} \end{array} \right] \end{array} \right] \end{array} \right] . \\
 \lambda e : & \left[\begin{array}{l} \text{c}_1 : \neg \text{relevant_to}(r.\text{sh}.\text{l-T}.\text{curr}, r.\text{sh}.\text{l-m}.\text{curr}) \\ \text{T} : \text{RecType} \\ \text{c}_2 : \text{in_bkgd_resources}(\text{T}) \\ \text{c}_3 : \text{relevant_to}(\text{T}, r.\text{sh}.\text{l-m}.\text{curr}) \end{array} \right] . \\
 \left[\text{sh} : \left[\text{l-T} : \left[\begin{array}{l} \text{prev} = r.\text{sh}.\text{l-T} : \text{RecType} \\ \text{curr} = e.\text{T} : \text{RecType} \end{array} \right] \right] \right]
 \end{aligned}$$