Integrating informational and intentional theories of discourse coherence

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This paper explores the ways in which insights from the two influential formal pragmatic theories of discourse coherence, namely, Question Under Discussion (QUD) and Rhetorical Relation (RR) models, can be integrated to build a more inclusive theory of discourse coherence. It proposes a simple and concrete procedure to derive the hierarchical structure of discourse from the subquestion relations between implicit QUDs reconstructed using informational structural principles (Riester 2019; Reyle & Riester 2017) and contextual entailment relations (Roberts 2012). It applies the procedure to discourse examples involving various RRs to determine subordinating and coordinating relations and to create a parsimonious feature-based inventory of RRs with formal definitions. The resulting theory shows that establishing the QUD-RR correspondence is possible, contrary to what has been claimed (Hunter & Abrusán 2017; Onea 2019; Riester 2019).
1 Introduction

The meaning of a discourse is not equal to the mere sum of all the sentences occurring in it. A discourse is meaningful because it is coherent—that is, the sentences in a discourse must hang together for the discourse to be well-formed and convey meaning. Consider an often-cited example (1) from Hobbs (1979). (1a) is not understood as merely a list of two separate facts about John, but rather as related statements: The second sentence is thematically connected to the first, providing a reason for him to go to Istanbul. In contrast, (1b) is awkward because it is not easy to see how the second sentence is possibly connected, and thus relevant, to the first.

1. a. John took the train from Paris to Istanbul. He has family there.
   b. #John took the train from Paris to Istanbul. He likes spinach.

Even in those cases where coherence relations are not explicitly marked with a conjunction or an adverbial, as in (1a) above, they are nonetheless effortlessly inferred, organizing the discourse into a systematic structure and establishing the most natural inter-clausal dependencies. Theoretically fleshing out this intuitive idea, however, turns out to be a nontrivial task. Rhetorical Relations, such as Narration, Explanation, Elaboration, etc., have been proposed as a way to explain coherence (Hobbs 1979; 1990; Mann & Thompson 1986; 1988; Kehler 2002; Asher & Lascarides 2003). In (1a), an Explanation relation can be established between the two sentences, but no apparent Rhetorical Relation can intervene between the two sentences in (1b), rendering it incoherent. It has also been argued that a coherent discourse must address a discourse topic (Question Under Discussion, or the speaker's intention) and should not digress from it (Carlson 1983; Grosz & Sidner 1986; van Kuppevelt 1995; Ginzburg 1996; 2012; Roberts 2012). (1) is about John’s trip, and the discourse participants are committed to resolving the question “What was John’s trip like?”. Whereas “Why was he going to Istanbul?” is a legitimate question in this regard, “What vegetable does he like?” obviously does not help answer the intended question at hand, explaining why (1b) sounds incoherent.

These two influential formal pragmatic theories of discourse coherence, namely, the Question Under Discussion (QUD) model and the Rhetorical Relation (RR) theories, highlight different aspects of discourse and thus have been developing largely independently from each other. RR-based theories focus on the informational aspect of discourse and are supposed to represent its interpretation, which has to be incrementally processed bottom-up (unless the discourse begins with a summary statement or the discourse goal is laid out at the outset). Strategies for resolving the QUD, on the other hand, focus on the intentional aspect and the production of discourse, mostly relying on a top-down processing. The domain/discourse goal must be set before strategies to achieve it can be devised. As a result, despite their common objective of explicating discourse coherence, only a few studies have examined a possible connection between them. Roberts (2004; 2012) informally discusses the correspondence between RRs and QUDs (e.g., Explanation
relation and “why?” QUD). Hunter & Abrusán (2017) reach a negative conclusion, namely, the impossibility of direct modeling of rhetorical structures in terms of QUDs. Following a suggestion by Hunter & Abrusán (2017), Riester (2019) abandons the subquestion requirement between implicit QUDs reconstructed from RRs, which significantly weakens the predictive power of the QUD theory. Similarly, Onea (2019) expands the notion of a subquestion by treating it as a special case of dependent or ‘potential’ questions, which are not taken to be constraints/filters on discourse coherence.

Although the intentional and informational approaches of discourse interpretation can be quite different, there seems in principle no reason why the goal-oriented perspective of QUD theories cannot be reconciled with the representational framework of RR theories. This paper proposes an account that establishes a direct correspondence between QUD and RR, which will help develop a more inclusive theory of discourse coherence that captures the inherent connection between the informational and intentional tropes of discourse. This paper proposes three simple steps to establish a correspondence between QUD and RR. First, implicit QUDs are reconstructed from a text following the Maximize Q-Anaphoricity principle (Reyle & Riester 2018; Riester 2019), assigning the narrowest focus possible to the constituent sentences. Second, a subquestion relation, if one is present, between the implicit QUDs obtained from the first step is identified using Roberts’ (2012) contextual entailment relations, incorporating information in the common ground. Third, coordinating vs. subordinating RRs are determined based on the subquestion relation established in the second step. In a nutshell, if there is a subquestion relation between the implicit QUDs, then the RR connecting the constituent sentences is subordinating; if not, then the RR is coordinating. This test will classify most RRs (Result, Explanation, Exemplification, etc.) as subordinating and Occasion, Parallel, and Contrast as coordinating. Following these steps will establish the desired mapping between QUD and RR. That is, the relations between constituent sentences connected via an RR in a text will match the subquestion relations between QUDs that are congruent with them, highlighting the strategic nature of coherence discourse and thus maintaining the theory’s predictive/explanatory power. A systematic feature-based taxonomy of RRs will emerge in the process and will be given formal definitions.

Coherence relations are linguistically interesting because they do not solely derive from extralinguistic performance factors and/or rational behaviors. Instead, they are semantic relations contributing to the logical form of a discourse and have (non-monotonic) truth-conditional semantics. As such, they are not easily defeasible or reinforceable (Mann & Thompson 1986). Recent years have seen an outpouring of experimental studies proving the effect of

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1 Adding the denial of the inference in (ib) makes the discourse incoherent.

(i) a. I’ll give you a free tour of the development. My phone number is 555–9876.
   b. But calling that phone number won’t help you to get the tour.
QUD and RR on grammatical processing and interpretation. Both off-line and on-line tasks (truth value judgment, sentence completion, self-paced reading, eye tracking, etc.) demonstrate the influence of QUD on a wide range of syntactic and semantic phenomena, such as scope ambiguity resolution, scalar implication calculation, relative clause attachment, verb semantics, exhaustivity inference in clefts, and pronoun resolution, to name a few (Clifton & Frazier 2012; Kehler & Rohde 2017; Rohde et al. 2011; Ronai & Xiang 2020; Zondervan et al. 2008; a.o.). Similarly, the semantic features involved in RRs like causality, polarity, and textual order have shown through experimental studies to be psychologically real. A large body of psycholinguistic literature (employing visual world, self-paced reading, ERP, etc.) has shown that participants differ in their acquisition, representation and processing of additive vs. causal relations (Bloom et al. 1980; Knott & Dale 1994; Knott & Sanders 1998; Sanders et al. 1992) and positive vs. adversative relations (Crible 2021; Evers-Vermeul & Sanders 2009; Köhne-Fuetterer et al. 2021; Knoepke et al. 2017). The empirical interests of discourse coherence and the significant role that QUD and RR play in meaning and grammar processing, as evidenced by these recent experimental studies, make the construction of a unified theory of discourse coherence an urgent task.

This paper is organized as follows. Section 2 briefly introduces the QUD and RR theories of discourse coherence to provide background. Section 3 discusses previous attempts to combine the QUD and RR approaches to set the stage for the current analysis, which is presented in Section 4. Section 5 concludes the paper with a summary and directions for future research.

2 Question Under Discussion and Rhetorical Relations

2.1 Question Under Discussion

The QUD model (Carlson 1983; Beaver & Clark 2008; Ginzburg 1996; Roberts 2012) has arisen as an influential framework for formal pragmatic analyses, offering a concrete and interesting (i.e., falsifiable) theory to analyze the elusive notions of discourse coherence and relevance. According to this theory, conversational goals and the strategies to achieve them are at the center of discourse organization. Goals of discourse can be viewed as questions that the interlocutors are committed to answering. The accepted question becomes the immediate topic of discussion, dubbed QUD. QUDs and their answers are partially ordered in terms of the strategic relations, with an ultimate goal of answering the big question “What is the way things are?”

Roberts (2012) develops a QUD-based theory in detail, arguing that the context includes a set of questions or issues under discussion partially ordered by contextual entailment, as illustrated by her small fragment discourse example in (2). This discourse assumes only two people, Hillary

Making the inference explicit as in (iib) is redundant, destroying the coherence of the narrative.

(ii)  
   a. I went hitchhiking in Norway. Nobody would pick me up.
   b. #It was in Norway that nobody would pick me up.
and Robin, and two food items, bagels and tofu. The interlocutors’ goal is to find out who ate what.

(2) Who ate what?

a. What did Hilary eat?
   i. Did Hilary eat bagels? Ans(ai) = no
   ii. Did Hilary eat tofu? Ans(aii) = yes

b. What did Robin eat?
   i. Did Robin eat bagels? Ans(bi) = yes
   ii. Did Robin eat tofu? Ans(bii) = no

The QUDs form a stack in which questions higher on the stack are subquestions of the lower, previously accepted questions on it. As the subquestions are answered, they pop out of the stack, revealing a bigger question. For example, when (2a_i) and (2a_ii) are answered, (2a) will be removed from the current QUD stack, but the larger QUD “Who ate what?” will remain on the stack until (2b) is fully answered. The meaning of a QUD like “What did Hillary eat?” is formalized as a set of relevant alternatives that the interlocutors are considering, called ‘q-alternatives’ (e.g., \{Hilary ate u: u \in D\} where D is the domain of discourse). Coherent discourse requires that the focus structure of an utterance be congruent with the q-alternatives for QUDs (Büring 2003; von Stechow 1991). For example, “Hilary ate \[\text{tofu}\]” is a relevant utterance in this context since the focal alternatives for “tofu” are the q-alternatives for the question “What did Hillary eat?” An utterance is relevant as long as it introduces a partial answer to the question, in the case of assertions (e.g., “Hilary ate tofu”), or is part of a strategy to answer it, in the case of questions (e.g., “What did Hillary eat?”). The notion of a strategy of inquiry relative to a QUD is defined in (3). The ordered pair which Strat yields for a given question q, \(\langle q, S \rangle\) reads “the strategy to answer q by conducting the set of subinquiries in S” (ibid.: 18). Acc stands for ‘accepted questions’.

(3) The strategy of inquiry which aims at answering q, Strat(q):

For any question \(q \in Q \cap \text{Acc}\), Strat(q) is the ordered pair \(\langle q, S \rangle\), where S is the set such that:

If there are no \(q' \in Q\) such that QUD(q’) = \(\langle \ldots q \rangle\), then \(S = \emptyset\).
Otherwise, for all \(q' \in Q\), QUD(q’) = \(\langle \ldots q \rangle\) iff Strat(q’) \(\in S\).

For (2) above, Strat yields (4):

(4) a. Strat(a_i) = \(\langle a_i, \emptyset \rangle\)
b. Strat(a_ii) = \(\langle a_ii, \emptyset \rangle\)
c. Strat(a) = \(\langle a, \{a_i, \emptyset\}, \{a_ii, \emptyset\}\rangle\)
d. Strat(b_i) = \(\langle b_i, \emptyset \rangle\)
e. Strat(b) = ⟨b, ∅⟩
f. Strat(b) = ⟨b, {⟨b, ∅⟩}, {⟨b, ∅⟩}⟩
g. Strat(2) = ⟨2, {⟨a, {⟨a, ∅⟩}, {⟨a, ∅⟩}⟩}, {⟨b, {⟨b, ∅⟩}, {⟨b, ∅⟩}⟩}⟩

(4a), (4b), (4d), and (4e) indicate that QUDs aᵢ, aᵢᵢ, bᵢ, and bᵢᵢ have no subinquiries (i.e., there are no questions higher on the QUD stack). (4c) and (4f) show that QUDs a and b are answered by conducting the subinquiries (4a), (4b), (4d), and (4e). According to (4g), the strategy to answer (2) includes two subinquiries of answering a and b. Given these relations, any question q is part of a strategy to answer q’ only if a complete answer to q contextually entails a partial answer to q’. The QUD stack is formally defined in (5).

5 The QUD stack is a function from M (the moves in the discourse) to ordered subsets of Q ∩ Acc (the set of accepted questions) such that for all m ∈ M:
   a. For all q ∈ Q ∩ Acc, q ∈ QUD(m) iff
      i. q < m (i.e., neither m nor any subsequent questions are included) and
      ii. CG(m) fails to entail an answer to q and q has not been determined to be practically unanswerable. (CG stands for common ground)
   b. QUD(m) is (totally) ordered by <.
   c. For all q, q’ ∈ QUD(m), if q < q’, then the complete answer to q’ contextually entails a partial answer to q.

Contextual entailment is defined in (6):

6 A question qᵢ contextually entails another qᵢᵢ iff answering qᵢ in a discourse context with common ground CG is such that CG ∪ Ans(qᵢ) entails a complete answer to qᵢᵢ.

Note that (4c) does not require that all questions on a QUD stack entail those higher on the stack. Roberts (2012) uses the subquestion relations in (7) to explain why.

7 a. What kinds of seafood will John eat?
   b. Isn’t John allergic to clams?

If the answer to (7b) is negative, then it does not entail John will eat clams because he might have other reasons for not eating them, e.g., he keeps kosher. Hence, (7a) does not entail (7b), i.e., the answer to (7b) does not give a partial answer to (7a). She argues that (7b), however, implicitly assumes a bridging question “What reasons would John have for not eating clams?” whose answer contextually entails a complete answer to (7b). Since an answer to the bridging question provides a partial answer to (7a), (7b) can count as a subquestion of (7a) via this question, assuming that the CG includes the proposition “One eats whatever one has no reason not to”.

The theoretical utility of QUD is that it not only helps precisely define the vague notions of discourse topic and relevance, but it can also predict how the discourse will proceed based on the
strategy of inquiry. Moreover, an important semantic distinction that was obscured in traditional semantic theories, namely, that between ‘at-issue’ content, which directly answers a QUD, and ‘not-at-issue’ content (e.g., expressive, appositive), which does not, has been made prominent in this model, generating rich literature on layers of meaning (Potts 2005; Tonhauser et al. 2013; a.o.).

2.2 Rhetorical Relations

The RR-based theories of coherence maintain that sentences in a coherent discourse must stand in some type of meaningful relations, such as Narration, Explanation, Elaboration, Parallel, and Contrast, to name a few. A simple list of open-ended and unordered relations with some intuitive taxonomy, however, falls short of being a theory (Hobbs 1979). To properly constrain the list of RRs, rather than adding them whenever a new relation is needed to describe texts (e.g., Mann & Thompson’s (1986; 1988) Rhetorical Structure Theory), Hobbs (1985; 1990; 2006), Sanders et al. (1992), and Kehler (2002; 2022) propose systematic ways to organize and characterize them. For instance, Kehler’s (2002) categorization is inspired by the philosopher Hume, who suggested three basic cognitive mechanisms for connecting ideas, namely, Resemblance, Cause-Effect, and Contiguity. The Resemblance relations are based on categorization and subsumptive reasoning within a semantic hierarchy (analogue reasoning). The Cause-Effect relations are based on inferential axioms within a knowledge base (implicational reasoning). The Contiguity (in space and time) relations depend on some scriptal knowledge about sequences of intermediate states that make up a coherent event. Kehler’s (2002) Resemblance class subsumes the RRs Parallel, Contrast, Exemplification, Generalization, Exception, and Elaboration, defined in (8), in which P and Q are predicates and a_i and b_i are arguments.

(8)  
a. Parallel: Infer P(a_1, a_2, ...) from the assertion of S_0 and P(b_1, b_2, ...) from the assertion of S_i, where for some property vector Q, Q(a_i) and Q(b_i) for all i.

b. Contrast (i): Infer P(a_1, a_2, ...) from the assertion of S_0 and ¬P(b_1, b_2, ...) from the assertion of S_i, in which for some property vector Q, Q(a_i) and ¬Q(b_i) for all i.

c. Contrast (ii): Infer P(a_1, a_2, ...) from the assertion of S_0 and P(b_1, b_2, ...) from the assertion of S_i, where for some property vector Q, Q(a_i) and ¬Q(b_i) for some i.

d. Exemplification: Infer P(a_1, a_2, ...) from the assertion of S_0 and P(b_1, b_2, ...) from the assertion of S_i, where b_i is a member or subset of a_i for some i.

e. Generalization: Infer P(a_1, a_2, ...) from the assertion of S_0 and P(b_1, b_2, ...) from the assertion of S_i, where a_i is a member or subset of b_i for some i.

f. Exception (i): Infer P(a_1, a_2, ...) from the assertion of S_0 and ¬P(b_1, b_2, ...) from the assertion of S_i, where b_i is a member or subset of a_i for some i.

g. Exception (ii): Infer P(a_1, a_2, ...) from the assertion of S_0 and ¬P(b_1, b_2, ...) from the assertion of S_i, where a_i is a member or subset of b_i for some i.

h. Elaboration: Infer P(a_1, a_2, ...) from the assertions of S_0 and S_i.
His *Cause-Effect* class includes *Result, Explanation, Violated Expectation, and Denial of Preventer*, defined in (9).

(9)  

a. **Result**: Infer \( p \) from the assertion of \( S_0 \) and \( q \) from the assertion of \( S_1 \) where normally \( p \rightarrow q \).

b. **Explanation**: Infer \( p \) from the assertion of \( S_0 \) and \( q \) from the assertion of \( S_1 \) where normally \( q \rightarrow p \).

c. **Violated Expectation**: Infer \( p \) from the assertion of \( S_0 \) and \( q \) from the assertion of \( S_1 \) where normally \( p \rightarrow \neg q \).

d. **Denial of Preventer**: Infer \( p \) from the assertion of \( S_0 \) and \( q \) from the assertion of \( S_1 \) where normally \( q \rightarrow \neg p \).


(10)  

a. **Occasion** (i): Infer a change of state for a system of entities from \( S_{0'} \), inferring the final state for this system from \( S_1 \).

b. **Occasion** (ii): Infer a change of state for a system of entities from \( S_1 \), inferring the initial state for this system from \( S_{0'} \).

RR also figures prominently in Asher & Lascarides’ (2003) Segmented Discourse Representation Theory (SDRT). SDRT requires that new information be attached to the speech act discourse referent of the last clause in the preceding discourse with a particular RR. To illustrate, in the Segmented Discourse Representation Structure (SDRS) in (11), the speech act discourse referent associated with the event of John pushing Max, \( \pi_2 \), is connected to the speech act discourse referent for the event of Max falling, \( \pi_1 \), with the RR *Explanation*.

(11)  

Max fell. John pushed him.

\[
\begin{array}{|c|}
\hline
x, y, e_{\pi_1}, e_{\pi_2} \\
\hline
Max(x) \\
fall(e_{\pi_1}, x) \\
e_{\pi_1} < n \\
John(y) \\
push(e_{\pi_2}, y, x) \\
e_{\pi_2} < n \\
Explanation(\pi_1, \pi_2) \\
\hline
\end{array}
\]

The operating RR is inferred via commonsense reasoning with domain knowledge, which is calculated in a separate pragmatic system called ‘the glue logic’. These are based on Gricean-style pragmatic maxims and world knowledge, i.e., they are defeasible laws which are assumed to form part of the hearer’s knowledge basis. For example, *Explanation*(\( \pi_1, \pi_2 \)) is inferred when there is evidence in the discourse that the event described by \( \pi_2 \) caused the event of \( \pi_1 \), i.e., *Cause*\(_{hs}(\pi_2, \pi_1)\).
SDRT is attractive in that its empirical coverage is not confined to individual utterances or a simple question-answer adjacency pair but extends to longer stretches of discourse. As a result, long-distance dependencies, such as pronoun resolution, which is often affected by RR, find a natural explanation in this theory. Consider Asher & Lascarides' (2003) favorite example in (12), in which the anaphoric link between “salmon” in (12c) and “it” in (12f) is impossible despite the fact that no blocking expressions such as “every” or “not” intervene between (12c) and (12f).

(12)  
  a. John had a lovely evening.  
  b. He had a great meal.  
  c. He ate salmon.  
  d. He devoured lots of cheese.  
  e. He won a dancing competition.  
  f. #It was a beautiful pink.

Figure 1 shows the discourse structure of (12) in a graphic form. Elaboration connects two clauses in a subordination relation, whereas Narration builds a coordination structure, with the resulting structure affecting anaphora resolutions.

<table>
<thead>
<tr>
<th>Elaboration</th>
<th>Narration</th>
</tr>
</thead>
<tbody>
<tr>
<td>He had a great meal</td>
<td>He won a dancing competition</td>
</tr>
<tr>
<td>Elaboration</td>
<td>Narration</td>
</tr>
<tr>
<td>He ate salmon</td>
<td>He devoured lots of cheese</td>
</tr>
</tbody>
</table>

Figure 1: The discourse graph of (12).

Many scholars postulate the right frontier constraint (Asher & Lascarides 2003; Hobbs 1990; Grosz & Sidner 1986; Polanyi 1985; 2001; a.o.), which requires a new clause to attach either to the last node entered to the graph or one of the nodes that dominate the last node. Since the last node is usually located on the right of the structure, the nodes to which a new clause can attach are on the right frontier of the discourse graph or SDRS. In Figure 1, (12a) and (12e) are in the right frontier. This constraint blocks the pronoun in (12f) from binding to its antecedent in (12c) since (12c) is not on the right frontier when (12f) is introduced. The possible ways of continuing the discourse in (12) are thus constrained by the overall discourse structure: The possibilities are limited to elaborating on the dancing competition or to introducing a new event parallel to either John having a lovely evening or him winning the dancing competition. As such, like the QUD model, RR theories like SDRT offer a logical method of not only describing coherent discourse but also predicting possible continuations of it.
3 Theories on the relationship between RR and QUD in the literature

3.1 Roberts (2004)

Assuming that all discourses address implicit questions, Roberts (2004) points out that RR-based theories of discourse coherence such as SDRT do not make connections between intentions and questions, nor between RRs and strategies of inquiry. She informally sketches a possible connection between them using examples from Mann & Thompson (1986), who assign the Solution-hood relation between the two utterances in (13). According to Roberts (2004), (13a) triggers a domain goal, which in this case is satisfying the speaker's hunger. Therefore, the implicit QUD would be “How can the speaker’s hunger be satisfied?”. (13b) suggests an answer to that question, namely, going to eat at a specific restaurant.

(13)  
a. I’m hungry.  
b. Let’s go to the Fuji Gardens.

Mann & Thompson (1986) use Contrast to establish coherence between (14a) and (14b). Roberts (2004) points out that this RR by itself is an insufficient characterization of (14) since it cannot predict the types of context that allows utterances like it. Here, the QUD is “What do the interlocutors want?” and the answers to this question in (14a) and (14b) not only participate in a Contrast relation but are predicted to be felicitous in this context by the QUD account, given relevance.

(14)  
a. We don’t want orange juice.  
b. We want apple juice.

Mann & Thompson (1986) call the RR connecting (15a) and (15b) Elaboration. Roberts’ (2004) QUD is “What are your hobbies?” The elaboration in (15b) is felicitous because it is part of a larger strategy to find out about the speaker, including her general likes and dislikes. According to Roberts (2004: 213), (15b) is relevant in the sense that it helps answer this big question, which is “what the query is really after,” rather than minimally answering the immediate question.

(15)  
a. I love to collect classic automobiles.  
b. My favorite car is my 1899 Duryea.

In sum, Roberts (2004) suggests that RRs can be seen as strategies for accomplishing (domain) goals in discourse. In a separate article, Roberts (2012: 62) also briefly discusses the connection between her QUD model and RRs, where she contends that the goal of discourse is not limited to offering more information but also includes deriving a consensus regarding the “value” of the information offered. A primary function of some RRs, she argues, is to convince the addressee that the information contributed is worth adding to the CG. One way of achieving this is by
demonstrating how the new information explains or follows from already existing information in the CG.

3.2 Hunter & Abrusán (2017)

Hunter & Abrusán (2017) test two hypotheses regarding possible connections between RRs and QUDs. They reject the first obvious hypothesis that RRs directly correspond to QUDs (the R-QUD hypothesis). The main reason why a simple one-to-one correspondence between RRs and QUDs cannot be maintained, they argue, is that individual discourse units, not RRs, are ordered by constraints such as the right frontier in SDRT, while a QUD stack orders questions, not answers. As a result, the stack derived from the right frontier of a discourse would not necessarily be ordered by the subquestion relation. (16) illustrates their point.

(16) a. We had so much fun in London! (π₁) We got to see the Lion King! (π₂) I’ve been wanting to go for a really long time (π₃) and my mom finally gave me tickets for my birthday! (π₄) We also got to ride on the big Ferris wheel (π₅) ...

b. Elaboration(π₁, π₂), Background(π₂, [π₃, π₄]), Continuation(π₃, π₄), Elaboration(π₁, π₃), Continuation(π₃, π₄).

c. (q₁) What did you do? (q₂) What makes that so exciting?

(16c) lists two QUDs corresponding to the first two RRs, Elaboration and Background. They are stacked in such a way that q₂, the more recent question, is on top of q₁. Elaboration(π₁, π₂) and Continuation(π₃, π₄) in subsequent discourse indicate that q₁ has not completely resolved and thus is still on the stack of open questions when π₃ and π₄ are introduced. The problem is that q₂ is not a subquestion of q₁, leaving unanswered why π₃ and π₄ are still coherent and relevant.

As an alternative, Hunter & Abrusán (2017) suggest that QUDs may be associated with Complex Discourse Units (CDUs) since a CDU and the RR connecting its members have the potential to yield the desired planning structure (the CDU-QUD hypothesis). That is, the content CDUs, which reveal a topical cohesion, can be analyzed as complex answers to implicit QUDs, since the set of CDUs in a discourse will naturally give rise to a partial order based on a subset relation. If a CDU π includes a CDU π', the set of members of π will be a proper subset of the set of members of π'. From these premises, they explore the possibility that if a CDU π₂ is a member of another CDU π₁ then QUD(π₂) is a subquestion of QUD(π₁). To illustrate this, they analyze the SDRT’s classic example in (12) above, repeated in (17a).

(17) a. John had a lovely evening (π₁). He had a great meal (π₂). He ate salmon (π₃). He devoured lots of cheese (π₄). Then he won a dancing competition (π₅).

b. Elaboration(π₁, π₂, π₃, π₄), Narration(π₂, π₅), Elaboration(π₁, π₅), Continuation(π₃, π₅), Narration(π₃, π₄)

c. (q₁) What was John’s evening like? (q₂) What did he do? (q₃) What did he eat?
In (17), $\pi_{1-5}$ is associated with $q_1$, $\pi_{2-5}$ is associated with $q_2$, and $\pi_{3-4}$ is associated with $q_3$. Note that $\pi_{2-5}$ is included in $\pi_{1}$ and $\pi_{3-4}$ is included in $\pi_{2-5}$ because the former is related to the latter in terms of an Elaboration relation. These RRs naturally generate a set of questions ordered by the subquestion relation, i.e., $q_3 < q_2 < q_1$.

Hunter & Abrusán (2017) point out that this neat subquestion relation, however, breaks down for CDUs related in terms of other subordinating RRs, citing the example in (18).

(18) a. Yesterday John and his wife went to the fanciest restaurant in Paris ($\pi_1$). It was John’s birthday ($\pi_2$), and his wife wanted to spoil him ($\pi_3$).
   b. Explanation($\pi_1$, $\pi_{2-3}$), Result($\pi_2$, $\pi_3$)
   c. ($q_1$) What did John do yesterday? ($q_2$) Why did he do this?

Two CDUs are built out of (18): $\pi_{1-3}$ and $\pi_{2-3}$. Although $\pi_{2-3}$ is a subset of $\pi_{1-3}$, the question associated with the latter, $q_2$, is not a subquestion of the question associated with the former, $q_1$. Therefore, CDU-QUD correspondence is only applicable when the CDU $\pi_2$ attaches to the top node of the prior CDU $\pi_1$ with a relation that entails sub-eventhood, like Elaboration. This means that CDUs are no longer able to form a plan or strategy to achieve a discourse goal. Hunter & Abrusán (2017) suggest that one way to salvage the idea of a CDU-QUD correspondence is to relax the requirement that QUDs be ordered by the subquestion relation, instead allowing strategies for achieving discourse goals that are more multifaceted and complex.

3.3 Riester (2019)

The suggestion by Hunter & Abrusán (2017) is taken up by Riester (2019), who abandons the subquestion requirement between implicit QUDs reconstructed from RRs, thus deviating significantly from Roberts (2012). Such constraint, he asserts, is neither necessary to maintain coherence nor realistic when actual discourse is considered. In (19), which is a slight modification of (12) above, the “what-about” question is not a sub-question of the “what” question, but the discourse is still coherent. As previously discussed, this point has been driven home by Hunter & Abrusán (2017), as well.

(19) (What did John do?) John had a lovely evening. He had a great meal. (What about the meal?) It was cooked by a famous chef and it was rather expensive. He won a dancing competition.

As long as a new utterance has some topical connection to an immediately preceding utterance, Riester (2019) contends, it needs not address a question that is already in the QUD stack. To theoretically flesh out this idea, he proposes the ‘compact QUD-tree format’ in Figure 2, in which topically connected (or anaphorically dependent) questions appear to the right of their antecedents and thus need not be entailed. This format also has the advantage of separating questions and assertions by restricting the former to the non-terminal nodes, and the latter to the terminal nodes.
Assuming this more flexible tree structure, Riester (2019) argues that subordinating discourse relations can be directly replaced by questions (e.g., Explanation by a “why” question and Elaboration by a “what-about” question), contra Hunter & Abrusán (2017). The coordinating discourse relations, e.g., Narration, are replaced by a series of parallel questions about different times “What happened at \( t_i \)?”, à la von Stutterheim & Klein (1989).

To constrain the implicit QUDs, whose number can be as many as the number of constituents in a sentence taken out of context, Riester (2019) suggests the pragmatic principle in (20). This general principle corresponds to ‘Avoid-F’ (Schwarzschild 1999) or ‘Maximize-Anaphoricity’ (Büring 2008) in the previous literature on focus.

(20) **Maximize-Q-Anaphoricity**: Implicit QUDs should contain as much given (or salient) material as possible.

He illustrates how (20) prevents overgeneration and offers a deterministic procedure of the QUD reconstruction. He cites the example in (21), which can be an answer to any of the questions in (22).

(21) He literally suffocated.

(22) a. What happened?
    b. What about him?
    c. Who literally suffocated?

Only when (21) is embedded in a discourse context, as in (23), can we rule out some potential QUDs, namely, (22c).

(23) And all I can say is that his condition was extremely bad during his last years (\( \pi_1 \)). He literally suffocated (\( \pi_2 \)).

Maximize-Q-Anaphoricity further eliminates (22a), selecting (22b) as the QUD for (21).
3.4 Onea (2019)

Onea’s (2019) theory is inspired by Wisniewski’s (1995) erotetic inference system, in which questions can serve the role of conclusions. An erotetic inference is a process where one arrives at a question on the basis of some previously accepted declaratives and/or a previously raised question. The criteria of validity for the inferences between questions are precisely defined in this system. A question is sound if at least one possible answer to it is true. For example, the question in (24c) is a conclusion following from the assertions in (24a) and (24b).

(24)  
   a. The theory of ideas is presented in the writings of Plato.  
   b. If the theory of ideas is presented in the writings of Plato, then it was invented by either Plato or Socrates.  
   c. Who invented the theory of ideas: Plato or Socrates?

A question can follow from another question, as illustrated in (25).

(25)  
   a. Was Plato a pupil of Socrates and a teacher of Aristotle?  
   b. Was Plato a pupil of Socrates?

Wisniewski’s (1995) definitions of erotetic implication explicate the relevant notions of question raising/evocation.

Onea (2016; 2019) refers to questions that are evoked based on valid erotetic inference as ‘potential questions’. He observes that in the process of addressing a question, an auxiliary question is often raised which is not a subquestion in a strict sense but still is necessary for answering the original question. That is, assertions are not only answers to QUDs, but also lead to potential questions or PQs, defined in (26).²

(26) Potential questions (Onea 2019: 158)  
   If a question q has a supposition p and some assertion π in discourse makes p significantly more probable, then π licenses q as a potential question.

A supposition is defined as a kind of general, weak pragmatic presupposition. For example, in (27), the supposition that someone might be in the house is made more probable by A’s assertion that the lights are on. Therefore, A’s utterance licenses B’s question as a PQ.

(27)  
   A: Look, the lights are on.  
   B: I wonder who might be in the house?

He treats the erotetic structure (Wisniewski 1995) and rhetorical structure of discourse as two levels of analysis of the same phenomenon, albeit with the latter being deemed a higher level of

² Onea’s (2016; 2019) PQs can be seen as a more formalized version of van Kuppevelt’s (1995) subquestion-hood (or sub-topic), which applies when an answer to a question is not fully satisfactory, leading to another question to resolve the same issue.
abstraction than the former. He derives subordinating and coordinating RRs from his PQs, as his definitions in (28) show.

(28)  a. If the question $q$ answered by $\pi_2$ is licensed by $\pi_1$ as a PQ, the relation between $\pi_1$ and $\pi_2$ is subordinating.

b. If $\pi_1$ answers $q_1$ and $\pi_2$ answers $q_2$ and both $q_1$ and $q_2$ are licensed by a node $\pi_0$ as PQs, the relation between $\pi_1$ and $\pi_2$ is coordinating.

Onea (2019), however, emphasizes that PQs are by no means a filter for valid/coherent discourse moves. For instance, B’s question in (29) is not a licit PQ but still constitutes a perfectly acceptable discourse continuation.

(29)  A: Mary kissed John.
       B: Who else kissed John?

According to Onea (2016; 2019), the notion of subquestion is only a very special case of dependent questions where the speaker knows the answer but addresses all subquestions in order not to miss any alternative. A more common situation, he argues, is when there is lack of complete information. He asserts that discourse is only partially strategic, as it is also driven by reactions to new information introduced by the interlocutors. The idea of ‘loosely strategic discourse’, he assumes, complements the idea of Roberts (2012): PQs are basically discourse devices for deviating from strictly strategic discourse while preserving Roberts’ basic idea that discourse is goal-oriented, and that discourse goals can be best understood as questions.3

4 A new integrated analysis

Removing or even relaxing the requirement that QUDs be ordered by the subquestion relation, which was suggested by Hunter & Abrusán (2017) and executed in Riester (2019) and Onea (2019), sacrifices much of the explanatory and predictive power of the original QUD model. Riester (2019: 174) states,

“It is sometimes suggested that QUDs ‘arise’ or ‘follow’ from the previous context and then ‘guide’ the way how the subsequent discourse is going to evolve. Nothing could be more wrong than that. In fact, the only rule that speakers or writers must observe when formulating

3 Other notable proposals to amend QUD include Rojas-Esponda (2013; 2014), who incorporate presuppositions to Roberts’ QUD. She points out that the presupposition in a superquestion may be lacking in subquestions (e.g., “Who ate what?” presupposes that each person in a contextually relevant set ate something, while “What did Hillary eat?” only has a weaker presupposition that Hillary ate something and “Did Hillary eat tofu?” has no presupposition). To be able to track presuppositions, she relaxes the definition of questions so that they can be a partition on a subset of the world set (rather than the entire set of worlds, cf. Groenendijk & Stokhof 1984). Her main concern is restricted to tracking presuppositions, which differs from our goal of integrating QUD and RR theories and therefore her ideas are not discussed in detail.
their next move is to think about some topical connection to whatever was said before, but in all other respects they are free to formulate their own continuation of the plot.”

It is unclear, however, how “some topical connection” can be clarified. As observed in (1b) above (“John took the train from Paris to Istanbul. He likes spinach.”), sharing the same topic entity is not sufficient for discourse coherence. Onea’s (2019) PQs are more constrained, but they too are not taken to serve as filters on discourse coherence. This section will develop a theory that maintains the QUD-RR correspondence meeting both descriptive and explanatory adequacy. To keep this correspondence, a mapping must be established between the subquestion relation among implicit QUDs and the hierarchical discourse structure comprised of coordinating and subordinating RRs. The mapping will be achieved in the following steps.

(30) Step 1. Derive an implicit QUD from each sentence πᵢ in discourse observing Maximize-Q-Anaphoricity in (20) above, favoring the narrowest scope possible.
Step 2. Establish a subquestion relation between the reconstructed QUDs using the definition of contextual entailment in (6) above.
Step 3. Determine the hierarchical structure of discourse using the subquestion relation.
Case 1: If QUD(π₁) is a subquestion of QUD(π₂) or vice versa, then Subord(π₁, π₂).
Case 2: If there is no subquestion relation between QUD(π₁) and QUD(π₂), and QUD(π₁) and QUD(π₂) are subquestions of QUD(π₀), where π₀ is a summary and abstraction of π₁ and π₂, then Coord(π₁, π₂).
(Subord = subordinating; Coord = coordinating).

Before using examples to illustrate how taking these steps will solve our problem, let us first elaborate a bit more on each of them. Step 1 offers a systematic method for reconstructing implicit QUDs from a discourse. As pointed out by Riester (2019), the number of implicit QUDs can be as limitless as the number of constituents in isolated sentences taken out of context, leading to a problem of overgeneration of QUDs. Following Riester (2019) and Reyle & Riester (2016), we assume that the QUD reconstruction procedure obeys the pragmatic principle Maximize Q-anaphoricity! defined in (20) above, repeated here. This principle favors the narrowest focus possible.

(20) Maximize-Q-Anaphoricity: Implicit QUDs should contain as much given (or salient) material as possible.

In the case of Step 2, we will not attempt to reconstruct the main QUD from the entire CDUs first (cf. Hunter & Abrusán 2017) because there seems to be no objective method for doing so. Instead, a QUD will be reconstructed from each elementary discourse unit (EDU) using the Maximize Q-anaphoricity! principle, and then a subquestion relation between them, if any, will be calculated using Roberts’ (2012) definition of contextual entailment defined in (6) above, repeated here.
(6) A question $q_1$ contextually entails another $q_2$ iff answering $q_1$ in a discourse context with common ground CG is such that $CG \cup \text{Ans}(q_1)$ entails a complete answer to $q_2$.

The higher/at-issue QUD and its congruent main assertion of a CDU will be identified as a result of this procedure. Regarding Step 3, although a consensus exists that discourse is not merely a linear sequence of sentences but has a hierarchical structure, there is no agreement on the actual classifications of RRs into coordinating and subordinating relations (Asher & Lascarides 2003; Hobbs 1985; 1990; Polanyi 1985; 2001; a.o.) and some have even given up the idea that the division is categorical (e.g., Asher & Vieu 2005). The lack of consensus is mostly due to the absence of agreed-upon operational tests that consistently distinguish between the two classes of relations. Although most previous studies derive QUDs from RRs, e.g., a “why” question from Explanation, we argue that the direction of derivation should be reversed. The QUD model with its subquestion relations can help determine the two classes of RRs, following Step 3.

We are now ready to apply the steps introduced in (30) to actual examples in order to demonstrate that following this procedure yields the desired QUD-RR mapping. Causality-based RRs are subdivided into four relations, as illustrated by the minimal quadruple in (31).

\begin{enumerate}
\item Donald Trump is by far the least experienced in government of all the presidential candidates ($\pi_2$). He will probably not win the election ($\pi_1$). \textbf{[Result]}
\item Donald Trump will probably not win the election ($\pi_1$). He is by far the least experienced in government of all the presidential candidates ($\pi_2$). \textbf{[Explanation]}
\item Donald Trump is by far the least experienced in government of all the presidential candidates ($\pi_2$), but \textbf{he will probably win the election} ($\pi_1$). \textbf{[Violated Expectation]}
\item Donald Trump will probably win the election ($\pi_1$), even though he is by far the least experienced in government of all the presidential candidates ($\pi_2$). \textbf{[Denial of Preventer]}
\end{enumerate}

Following Step 1, two QUDs are reconstructed from the discourses in (31) (because Trump and the election are given information, ruling out questions like “Who will lose the election?” or “What will Trump lose?”):
(32) a. QUD₁ (from π₁): Will Trump win the election?
   b. QUD₂ (from π₂): How much experience does Trump have in government?

In executing Step 2, inferential axioms presupposed by RRs play an important role. For example, discourses in (31) make salient the following (defeasible) inferential axiom:

(33) If x is a presidential candidate and has the least experience in government, x will not win the election.⁷

Assuming that this proposition is part of the CG, answering QUD₂ will provide a partial answer to QUD₁. If the answer to QUD₂ is “the least experience”, as in these examples, then the answer to QUD₁ will be negative, assuming that (33) is upheld. However, if the answer to QUD₂ were “a lot of experience”, it would not guarantee a positive answer to QUD₁ because Trump may be lacking in other important qualifications. Following Roberts’ reasoning in (7) above, QUD₁, even in this case, can contextually entail QUD₂ via a bridging QUD in (34b), which is a superquestion of QUD₂ and also provides a partial answer to QUD₁.

(34) a. QUD₁ (from π₁): Will Trump win the election?
   b. QUDbridging: What factors determine Trump’s chances of winning the election?
   c. QUD₂ (from π₂): How much experience does Trump have in government?

Finally, Step 3 allows us to identify QUD₁ as a higher/at-issue question and the congruent EDU π₁ (underlined in (31)) as the main assertion of the CDU. This in turn makes QUD₂ as a subquestion or strategy and the congruent EDU π₂ as the subordinating assertion of the CDU.

Since a subquestion relation has been established between the implicit QUDs reconstructed from the EDUs (Case 1 in (30)), the causality-based RRs, namely, Result, Explanation, Violated Expectation, and Denial of Preventor, are subordinating RRs.⁸

The differences among the examples in (30) derive from the differences in textual order and (in)consistency of the presupposed implication. (30a) and (30c) presents the answer to the

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⁷ This kind of inference is based on Aristotelian notions of enthymemes and topoi, which have been incorporated in dialogue model by Breitholtz (2021). She focuses on a much narrower range of RRs (mainly Explanation) since her goal is to incorporate arguments/rhetorical reasoning-based contextual knowledge into conversation. Her QUD, on the one hand, and enthymemes and topoi, on the other, are listed as separate fields; these do not seem to interact with each other in the framework she uses, Type Theory with Records (TTR, Cooper 2016; Ginzburg 2012), which is a completely different computational approach than SDRT or QUD (Onea & Zimmermann 2019).

⁸ This conclusion differs from Asher & Vieu (2005), who claim that Result is ambiguous. Onea (2019) argues that this relation is unambiguously subordinating when the preceding assertion licenses a PQ about its result. Another difference is that the result clause is sometimes subordinate to the cause clause in the previous accounts (e.g., Asher & Vieu 2005), whereas the cause clause is subordinate to the result clause in the proposed analysis. The current analysis seems to line up better with the cognitive processes in which the origin (cause) and the target (result) of the force in causal situations can be fairly easily identified, after which the goal bias (Do et al. 2019; Stefanowitsch & Rohde 2004) selects the target (result) as the focus of attention.
subquestion first and then the answer to the main QUD, i.e., the at-issue content. (30b) and (30d) reverse the presentation of information, putting forward the at-issue content first, and then explains it or denies a preventer. Since the former encodes the default presentation from the premise to the conclusion in the implicational relation in (33) (deductive), it will be treated as basic order. The latter encodes the presentation from the conclusion to the premise (inductive), displaying a non-basic order. (31a) and (31b) are consistent with the defeasible inferential axiom (33), whereas (31c) and (31d) are not, i.e., the inference is defeated. Hence, the former is positive, and the latter, a negative relation. In the negative RRs, although the answer to the subquestion is “the least experience”, it does not automatically lead to a negative answer to the main QUD (as in (31c) and (31d)) because there are other factors that can affect the election outcome. In this case, a different subquestion like (35c) to the bridging QUD in (35b) may be raised, making salient a (competing) defeasible axiom (36) in the CG.

(35)  
a. Will Trump win the election?  
b. What factors determine Trump’s chances of winning the election?,  
c. Does Trump appeal to populism?  

(36) If x is a presidential candidate and x appeals to populism, x will win the election.

Intuitively, the local discourses in (31) are embedded in the larger discourse with the big QUD “Who will win the election?”. Hence, the discourse is predicted to continue with a discussion most likely on qualifications of different candidates and their prospects at winning the election.

So-called ‘contiguity’-based RRs include Occasion in (37) and Elaboration in (38). These relations are not causal in a strict sense but still involve situations where two eventualities affect each other in the world. For example, in (37), traveling to Vietnam creates a condition for which Trump can meet Kim.

(37) Trump traveled to Vietnam ($\pi_1$). He met with the leader of North Korea, Kim Jong-un ($\pi_2$). [Occasion (or Narration)]

(38) A young aspiring politician was arrested in Texas today ($\pi_1$). John Smith, 34, was nabbed in a Houston law firm while attempting to embezzle funds for his campaign ($\pi_2$). [Elaboration]

The implicit QUDs reconstructed from (37) following Step 1 are listed in (39b) and (39c):

(39)  
a. QUD$_1$ (from $\pi_1 + \pi_2$): What did Trump do?  
b. QUD$_2$ (from $\pi_1$): Where did Trump go?  
c. QUD$_3$ (from $\pi_2$): Whom did Trump meet?

According to Step 2, QUD$_1$ and QUD$_2$ do not stand in a subquestion relation because the answer to QUD$_1$ does not provide a partial answer to QUD$_2$ and vice versa. Rather, they are both subquestions of a higher question, namely, QUD$_0$ in (39a). This question is answered by a
summary and abstraction of \( \pi_1 \) and \( \pi_2 \), “Trump met Kim in Vietnam”. Taking Step 3 leads to the conclusion that Occasion is a coordinating RR (Case 2 in (30)). Applying the steps in (30) to the Elaboration relation in (38), on the other hand, we discover that the main QUD in (40a) is the same as the QUD of \( \pi_1 \) and that the sub-questions in (40b-d) are answered by \( \pi_2 \). This means that \( \pi_1 \) is dominant, serving as the main assertion of (38) (thus underlined).

(40)  
a. QUD\(_1\) (from \( \pi_1 \)): What happened in Texas today?  
b. QUD\(_2\) (from \( \pi_2 \)): Who was arrested?  
c. QUD\(_2\) (from \( \pi_2 \)): Where did it happen?  
d. QUD\(_2\) (from \( \pi_2 \)): When did it happen?

Although previous studies treat Elaboration as a sub-type of Parallel (Hobbs 1985) or a broader Resemblance relation (Kehler 2002), the QUD-based approach in this paper classifies it as a subordinating RR. Occasion and Elaboration are distinguished in terms of temporal sequence and inclusion relations. Let us treat the temporal sequential relation as the basic/default order and inclusion relation as non-basic order, since by default each EDU describes a new eventuality (to be informative). Polarity is irrelevant here because no causal/implicational relation is presupposed that can be observed (positive) or violated (negative).

Calculating the assertion of segments standing in Kehler’s (2002) Resemblance category involves abstracting over the similar arguments and/or properties, as Hobbs (1985) originally proposed. (41) contains a minimal pair of Parallel and Contrast.

(41)  
a. Nancy Pelosi admires Biden (\( \pi_1 \)), and Chuck Schumer looks up to him (\( \pi_2 \)).  

[Parallel]

b. Nancy Pelosi admires Biden (\( \pi_1 \)), but Trump loathes him (\( \pi_2 \)).  

[Contrast]

(41a) and (41b) share the same QUD\(_0\) given in (42a). In (41a), Nancy Pelosi and Chuck Schumer are similar in that both are high-ranking democratic politicians. The parallel predicates here are “admire” and “look up to”, which can be interpreted as the same predicate meaning “like”. The subquestions are presented in (42b) and (42c), which are congruent with the information structure of \( \pi_1 \) and \( \pi_2 \), respectively.

(42)  
a. QUD\(_1\): Who likes Biden?  
b. QUD\(_1\) (from \( \pi_1 \) of (41a)): Does Nancy Pelosi like Biden?  
c. QUD\(_1\) (from \( \pi_1 \) of (41a)): Does Chuck Schumer like Biden?  
d. QUD\(_2\) (from \( \pi_2 \) of (41b)): Does Trump like Biden?

In (41b), Nancy Pelosi and Trump are similar in that both are well-known politicians but different in that they are from opposing parties. The contrasting predicates are “admires” and “loathes”. \( \pi_1 \) in (41b) provides a positive answer to the subquestion (42b) and \( \pi_2 \) provides a negative answer to the subquestion (42d). Since no subquestion relation holds between the EDUs in them, Parallel
and *Contrast* are coordinating RRs (Case 2 in (30)). These RRs are symmetric, i.e., the two EDUs stand in equal footing, contributing equally to the CDU, so basic vs. non-basic order cannot be distinguished. Polarity, however, is relevant: *Parallel* is positive, and *Contrast* is negative.

The *Resemblance* category also includes asymmetric RRs, in which a membership or a subset relation between arguments typically holds, making one utterance more dominant. These RRs are further subdivided into four relations, as illustrated in the minimal quadruple in (43).

\[(43)\]
\[
\begin{align*}
&\text{a. Young aspiring politicians often support their party’s presidential candidate} \\
&\quad (\pi_1). \text{For instance, Pete Buttigieg campaigned hard for Biden in 2020} (\pi_2). \quad [\text{Exemplification}] \\
&\text{b. Pete Buttigieg campaigned hard for Biden in 2000} (\pi_2). \text{Young aspiring politicians often support their party’s presidential candidate} (\pi_1). \quad [\text{Generalization}] \\
&\text{c. Young aspiring politicians often support their party’s presidential candidate} (\pi_1). \text{However, Jeff Van Drew supported Trump in 2020} (\pi_2). \quad [\text{Exceptional Example}] \\
&\text{d. Jeff Van Drew supported Trump in 2020} (\pi_2). \text{Nonetheless, young aspiring politicians often support their party’s presidential candidate} (\pi_1). \quad [\text{Exceptional Generalization}]
\end{align*}
\]

The discourses in (43) share the same main QUD, in (44a) reconstructed from $\pi_1$, with sub-questions in (44b) and (44c) obtained from $\pi_2$ following Step 1 and 2 from (30).

\[(44)\]
\[
\begin{align*}
&\text{a. QUD}_1 (\text{from } \pi_1): \text{Who do young aspiring politicians support?} \\
&\text{b. QUD}_2 (\text{from } \pi_2 \text{ of (43a,b)}): \text{Who did Pete Buttigieg support?} \\
&\text{c. QUD}_2 (\text{from } \pi_2 \text{ of (43c,d)}): \text{Who did Jeff Van Drew support?}
\end{align*}
\]

The main assertion of the CDUs in (43) is the same as the assertion of the more general statement, underlined in the examples. This means that *Exemplification*, *Generalization*, *Exceptional Example*, and *Exceptional Generalization* are subordinating RRs (Case 1 in Step 3 in (30)). Like the minimal quadruple in (31) above, different RRs in (43) are distinguished in terms of order and polarity. (43a) and (43c) have the basic order (inferring a specific example based on a general principle, i.e., deductive) whereas (43b) and (43d) have the non-basic order (inferring a general principle from a specific example, i.e., inductive). (43) also equally invokes the defeasible inferential axiom in (45)

\[(45)\]
\[
\text{If } x \text{ is a young aspiring politician, } x \text{ (typically) supports } x \text{’s party’s presidential candidate.}
\]

(43a) and (43b) are consistent with this axiom (positive), whereas (43c) and (43d) are inconsistent with it (negative). In sum, the subquestion-hood test we applied has revealed that only *Parallel*, *Contrast* and *Occasion* are coordinating RRs and that most RRs are subordinating. This analysis gains empirical support from Mann & Thompson’s (1988) corpus studies, which found that the observed relations were mostly asymmetric. This observation led them to make an important
Theoretical distinction between 'nucleus' and 'satellite' in their Rhetorical Structure Theory (RST). They characterize nuclei as the most important and central parts of text, and satellites as only contributing to the nuclei and thus being secondary. This intuitive distinction is made precise in the proposed account by delineating a process of obtaining the coordinating and subordinating RRs from reconstructed QUDs and their subquestion relations.

The preceding discussions naturally generate a more systematic feature-based inventory of RRs presented in Figure 3. Following Sanders et al. (1992), RRs are defined in such a way that they are not theoretical primitives but decomposed into clusters of binary features from a feature hierarchy. Using a feature hierarchy makes significant generalizations holding across different RRs, and it results in a more restricted and well-defined set of relations. This hierarchy does not presuppose any preconceived organizing principles (cf. Kehler's (2002) classification of Resemblance, Cause-Effect, and Contiguity based on Hume's three basic cognitive mechanisms for connecting ideas).

![Figure 3: A feature-based inventory of RRs.](image)

The most basic relational types concern the dynamic vs. static relations, distinguished by the presence or absence of the highest feature \([\pm \text{dynamic}]\) in the feature hierarchy. The dynamic relation includes Kehler's (2002) higher categories Cause-Effect and Contiguity, the latter of which only includes a single RR, namely, Occasion. Note that Cause-Effect and Contiguity have something in common. Causing an event or creating a condition for it are conceptually similar in that both...
situations describe how events typically occur together in the world. Hence, they are placed under the dynamic relation. In a dynamic relation, the described states of affairs are asserted to exert force or influence each other in the world. In a non-dynamic or static relation, they are simply juxtaposed for a comparison, whose similarities or differences lead to coherence inferences. Within [+dynamic] RRs, a more specific feature [+causal] distinguishes Result from Occasion, the latter of which is defined as a dynamic non-causal RR instead of a weak relation of being merely additive (cf. Sanders et al. 1992). A dynamic causal relation obtains when an eventuality directly or indirectly causes another eventuality to occur. A dynamic non-causal relation holds when an eventuality provides a condition for which another eventuality occurs, or the second eventuality occurs as a response to the first. Static RRs, on the other hand, are divided into two groups depending on whether the relation is symmetric or not (±symmetric). Since eventualities are not asserted to exert force or influence one another in the world in a static relation, causality does not play a role. A symmetric relation (in static RRs) holds between two utterances that contribute to the discourse equally. An asymmetric relation holds when one utterance dominates the other. Lower in the feature hierarchy, polarity and order are the two important parameters, which are also treated as features, namely, ±positive and ±basic (order). A positive relation holds when the presupposed implicational relation is observed, whereas a negative relation holds when it is violated. This feature, however, is irrelevant for dynamic non-causal RRs because no implicational relation is presupposed that can be upheld (positive) or defeated (negative). Lastly, basic order encodes the default presentation pattern, from a premise to a conclusion in implicational relation (deductive) or the temporal sequence relation (for Occasion). Non-basic order encodes the reverse presentation from a conclusion to a premise in implicational relation (inductive) or the temporal inclusion relation (for Elaboration).

Table 1. The defeasible inference in the CG is treated as presuppositions because both positive and negative relations imply the same propositions. In these definitions, all relations are uniformly represented in the first-order predicate calculus specifying the internal predicate-argument structure of asserted and presupposed propositions (cf. Kehler’s (2002) three higher-order categories have different types of input and inference patterns, as observed in (8)–(10) above). The inference processes used are simple, that of modus ponens/deduction or making generalizations/induction. \( p \implies q \) is a non-monotonic implication, meaning “\( p \) then typically \( q \),” < is a temporal precedence relation and \( \supset \) is a temporal inclusion relation.

Mann & Thompson (1986) claim that RRs (which they call ‘relational predicates’) are not presuppositions because the former are inherently combinatorial while the latter are not. This does not seem irrefutable evidence and we assume that RRs trigger combinatorial presuppositions. They also argue that the diversity of relational predicates cannot be explained by the existing theories of presupposition. In the proposed definitions, only the background axioms are presupposed, not the relations themselves.
<table>
<thead>
<tr>
<th>RR</th>
<th>Assertion</th>
<th>Presupposition</th>
</tr>
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<tbody>
<tr>
<td>Result</td>
<td>$P(a)$ expressed by $\pi_1$ and $Q(a)$ expressed by $\pi_2$</td>
<td>$\forall x (P(x) \sim Q(x))$</td>
</tr>
<tr>
<td>Explanation</td>
<td>$Q(a)$ expressed by $\pi_2$ and $P(a)$ expressed by $\pi_1$</td>
<td>$\forall x (P(x) \sim Q(x))$</td>
</tr>
<tr>
<td>Violated Expectation</td>
<td>$P(a)$ expressed by $\pi_1$ and $\neg Q(a)$ expressed by $\pi_2$</td>
<td>$\forall x (P(x) \sim Q(x))$</td>
</tr>
<tr>
<td>Denial of Preventer</td>
<td>$\neg Q(a)$ expressed by $\pi_2$ and $P(a)$ described by $\pi_1$</td>
<td>$\forall x (P(x) \sim Q(x))$</td>
</tr>
<tr>
<td>Occasion</td>
<td>$P(a)$ expressed by $\pi_1$ and $Q(a)$ expressed by $\pi_2$</td>
<td>$P(a) &lt; Q(a)$</td>
</tr>
<tr>
<td>Elaboration</td>
<td>$P(a)$ expressed by $\pi_1$ and $Q(a)$ expressed by $\pi_2$</td>
<td>$P(a) \supseteq Q(a)$</td>
</tr>
<tr>
<td>Parallel</td>
<td>$P(a)$ expressed by $\pi_1$ and $P(b)$ expressed by $\pi_2$</td>
<td>$a$ and $b$ share a property $Q$, i.e., $a, b \in {x \mid Q(x)}$</td>
</tr>
<tr>
<td>Contrast</td>
<td>$P(a)$ expressed by $\pi_1$ and $\neg P(b)$ expressed by $\pi_2$</td>
<td>$a$ and $b$ share a property $Q$, i.e., $a, b \in {x \mid Q(x)}$</td>
</tr>
<tr>
<td>Exemplification</td>
<td>$\forall x (P(x) \sim Q(x))$ expressed in $\pi_1$ and $Q(a)$ expressed in $\pi_2$</td>
<td>$P(a)$</td>
</tr>
<tr>
<td>Generalization</td>
<td>$Q(a)$ expressed in $\pi_2$ and $\forall x (P(x) \sim Q(x))$ expressed in $\pi_1$</td>
<td>$P(a)$</td>
</tr>
<tr>
<td>Exceptional Exemplification</td>
<td>$\forall x (P(x) \sim Q(x))$ expressed in $\pi_1$ and $\neg Q(a)$ expressed in $\pi_2$</td>
<td>$P(a)$</td>
</tr>
<tr>
<td>Exceptional Generalization</td>
<td>$\neg Q(a)$ expressed in $\pi_2$ and $\forall x (P(x) \sim Q(x))$ expressed in $\pi_1$</td>
<td>$P(a)$</td>
</tr>
</tbody>
</table>

Table 1: Formal definitions of RRs.

These definitions characterize dynamic RRs as contributing to the defeasible inferential presuppositions, rather than assertions. What is asserted in these relations is simply the truth of the two EDUs.\(^{10}\) Static RRs, on the other hand, require more world knowledge or presupposition accommodation (e.g., in (43) above, even if the addressee doesn’t know who Pete Buttigieg is, she will accommodate the presupposition that he is a young aspiring democratic politician).

\(^{10}\) Using these definitions, the denotation/lexical entry of an implicit RR like Result can be given (a colon introduces a presupposition and a dot, an assertion, Heim & Kratzer 1998): $[\text{Result}] = \lambda f \in D_{\alpha x}. [\lambda g \in D_{\alpha y}. \lambda x. \text{for all } x, f(x) \sim g(x). [\lambda y. f(y) \& g(y)]]$. Applying this function to the EDUs of (31a), for example, its meaning is calculated as follows: $[\text{Result}][\text{[has the least experience in government] \& [will not win the election]}][\text{[Trump]}] = \text{For all } x, x \text{ has the least experience in government } \sim x \text{ will not win the election. Trump has the least experience in government } \& \text{ Trump will not win the election.
The proposed taxonomy of RRs and QUD-based analysis preserve a crucial feature of RR-based theories, namely, the right frontier constraint, which requires a new clause to attach either to the last node entered to the tree or to one of the nodes that dominate the last node. To show how this constraint is observed, consider (12) above, repeated below.

(12) John had a lovely evening (π₁). He had a great meal (π₂). He ate salmon (π₃). He devoured lots of cheese (π₄). He won a dancing competition (π₅). #It was a beautiful pink (π₆).

The QUD stack for (12) is presented in (46). The subquestion relation correctly predicts that Elaboration is a subordinating RR and Occasion is a coordinating RR. The pronoun “it” in π₆ fails to refer back to “salmon” in π₃ because QUD₃ has been answered, which means it was removed from the QUD stack by the time QUD₅ is added.

(46) QUD₁ (from π₁): What was John’s evening like?
QUD₂ (from π₂): What did he eat?
QUD₃ (from π₃): Did he eat salmon?
QUD₄ (from π₄): Did he eat cheese?
QUD₅ (from π₅): What did he win?

Before concluding this paper, let us go back to Hunter & Abrusán’s counterexamples to their R/CDU-QUD congruence hypotheses in (16) and (18) above to see if the proposed analysis can explain these. (16) is repeated below:

(16) a. We had so much fun in London! (π₁) We got to see the Lion King! (π₂) I’ve been wanting to go for a really long time (π₃) and my mom finally gave me tickets for my birthday! (π₄) We also got to ride on the big Ferris wheel (π₅) ...
b. Elaboration(π₁, π₂), Background(π₂, [π₃, π₄]), Continuation(π₃, π₄), Elaboration(π₁, π₅), Continuation(π₅, π₆).
c. (q₁) What did you do? (q₂) What makes that so exciting?

Applying Step 1, the QUD for π₁ should be (47a) for which the answer including an evaluative predicate “fun” becomes felicitous. As an anonymous reviewer pointed out, uttering π₁ out of blue is awkward, when the addressee doesn’t know about the speaker’s trip to London. This intuition follows directly from the Maximize Q-Anaphoricity. The remaining implicit QUDs reconstructed observing the principle are listed in (47b) and (47d). Regarding the QUD in (47d), the same reviewer pointed out that π₃ and π₄ are not simply background to π₂ but instead serve as an explanation of why Lion King was so much fun. Following Step 2, QUD₂ and QUD₅ become subquestions of QUD₁ (i.e., π₂ and π₅ are partial answers to QUD₁). The RR is Elaboration, which is subordinating. A subquestion relation can also be established between (47b) and (47d) via the bridging question in (47c). The defeasible axiom in (48) makes π₃ and π₄ relevant. The RR is Explanation, which is subordinating.
(47)  a. QUD$_1$ (from $\pi_1$): What was your trip to London like? Was it fun?
   b. QUD$_{2,5}$ (from $\pi_{2,5}$): What fun things did you do?
   c. QUD$_{bridging}$: What makes an activity (during a trip) fun?
   d. QUD$_{3,4}$ (from $\pi_{3,4}$): What makes seeing the Lion King fun?

(48)  If $x$ is a gratification of a long-term desire (facilitated by a loving family member), $x$ is (usually) fun/exciting.

Turning to (18), repeated below, this example also does not seem significantly different from the Explanation example analyzed in (31b) above.

(18)  a. Yesterday John and his wife went to the fanciest restaurant in Paris ($\pi_1$). It was John’s birthday ($\pi_2$), and his wife wanted to spoil him ($\pi_3$).
   b. Explanation($\pi_1$, $\pi_{2,3}$), Result($\pi_2$, $\pi_3$)
   c. ($q_1$) What did John do yesterday? ($q_2$) Why did he do this?

Part of Hunter & Abrusán’s difficulty is that their QUDs ($q_1$ and $q_2$ in (17c)) are not sufficiently constrained. It is also unclear how they came up with $q_1$ for the entire discourse (to test the CDU-QUD correspondence hypothesis). It appears to have been obtained from the broad VP focus structure of $\pi_1$ alone. Applying the Maximize Q-Anaphoricity! principle in Step 1 of (30), the QUDs reconstructed from (18a) are given in (49a), (49c) and (49d). In addition, a contextually-given bridging QUD in (49b) intervenes, which serves as a higher question of QUD$_2$ and QUD$_3$ and whose answer provides a partial answer to QUD$_1$.

(49)  a. QUD$_1$ (from $\pi_1$): What (kind of) restaurant John and his wife go to yesterday?
   b. QUD$_{bridging}$: What do John and his wife consider when choosing a restaurant?
   c. QUD$_2$ (from $\pi_2$): Was it a special occasion?
   d. QUD$_3$ (from $\pi_3$): Did John’s wife want to do something special for him?

In this setup, QUD$_2$ and QUD$_3$ can reasonably count as subquestions or strategies to answer the main QUD$_1$ with the help of a contextually-given defeasible axiom like (50).

(50)  If $x$ has a special occasion (like birthdays), $x$ (usually) goes to a fancy (not a cheap) restaurant.

This confirms that Explanation builds a subordinating relation with the result EDU ($\pi_1$ in (18a)) as the main assertion.

5 Conclusion

This paper proposed an inclusive theory of discourse coherence by integrating the QUD and RR theories. It provided a simple and concrete procedure to derive the hierarchical structure of discourse from the subquestion relations between implicit QUDs reconstructed using informational
structural principles and contextual entailment relations. It then applied the procedure to discourse examples involving various RRs to determine subordinating and coordinating RRs and to build a parsimonious feature-based inventory of RRs with formal definitions. The resulting theory shows that establishing the QUD-RR correspondence is possible and that coherent discourse is strategic, capturing the inherent connection between the informational and intentional tropes of discourse. This analysis can be viewed as spelling out Roberts’ (2004) idea that specific types of RRs are building blocks of strategies of inquiry.

The empirical scope of the paper was rather narrow, focusing mostly on two-sentence sequences involving a single speaker (and a potential interlocutor). Analyzing participants’ situated utterances, non-verbal actions, cognitive states, or interactions between two or more parties was outside the scope of the paper. As such, repair, self-correction, evasion, etc. were not dealt with in the paper, which focused on narrative-style discourse (not conversational discourse). As pointed out by an anonymous reviewer, much progress has been made in formal theories of dialogue/conversation involving multiple speakers and their separate discourse representations (Breitholtz 2021; Ginzburg 2012; Ginzburg & Cooper 2015; Schlangen 2015; a.o.). Modeling the complexity of conversational discourse, however, does not by itself solve the problem of integrating QUD and RR theories, which was the main goal of this paper. Future research will need to determine if and how the current proposal can be extended to longer and more complex discourse and multi-party conversational data. A formal implementation of the descriptive rules in (30) in discourse-level semantic framework like (S)DRT will help make precise the elusive notion of ‘discourse topic’.
Competing interests
The author has no competing interests to declare.

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