

Inferring Inferences: Relational Propositions for Argument Mining

Andrew Potter

Computer Science & Information Systems Department
University of North Alabama
Florence, Alabama, USA
apotter1@una.edu

Abstract

Inferential reasoning is an essential feature of argumentation. Therefore, a method for mining discourse for inferential structures would be of value for argument analysis and assessment. The logic of relational propositions is a procedure for rendering texts as expressions in propositional logic directly from their rhetorical structures. From rhetorical structures, relational propositions are defined, and from these propositions, logical expressions are then generated. There are, however, unsettled issues associated with Rhetorical Structure Theory (RST), some of which are problematic for inference mining. This paper takes a deep dive into some of these issues, with the aim of elucidating the problems and providing guidance for how they may be resolved.

1 Introduction

The logic of relational propositions is a process for rendering texts as expressions in propositional logic. It is based on Rhetorical Structure Theory, as defined by Mann and Thompson (1986, 1988). From rhetorical structures, relational propositions are defined, and from relational propositions, logical expressions are constructed (Potter, 2019). Inferences contained in these expressions tend to be applicable to their respective texts as well, with little to no loss of coherence (Potter, 2021). This is significant for argument mining, as it suggests that RST can be used to identify the inferential structure of discourse. When combined with systems for automated identification of RST structures, this would provide for an end-to-end process for

discovering generalized inferential structures in free texts.

There are, however, some limitations and unsettled issues associated with this. Multiple annotation guidelines have been developed for use in performing RST analyses. The relation set for which logical generalization has been defined is the extended Mann and Thompson set.¹ Because the relational definitions provided with these guidelines focus on the intended (rhetorical) effect of the relations, they appear to be well-suited for inference mining (Potter, 2019, 2020). However, these definitions are necessarily reliant on analyst intuition, and this makes the annotation task cumbersome, particularly for large corpuses. The annotation guidelines developed by Carlson and Marcu (2001) are generally more reliant on syntactical features, and therefore more suitable for automated analysis, and yet less appropriate for inference mining. Closer to Mann and Thompson's approach are the guidelines defined by Stede et al. (2017). These provide both rhetorical and syntactic definitions, and a relation set somewhat larger than Mann and Thompson's, but much smaller than that of Carlson and Marcu. Among these sets not only are there differences in relation identification, but their definitions are sometimes inconsistent with one another. Even within the fundamentals of segmentation there are differences of opinion as to what constitutes a discourse unit.

There have been several efforts to clarify such issues (e.g., Nicholas, 1994; Stede, 2008; Wan, Kutschbach, Lüdeling, & Stede, 2019), but debate and disagreement continue unabated. Ultimately, if Rhetorical Structure Theory is to be used for inference mining, or indeed it is to continue to distinguish itself among theories of coherence relations, not only is a stable relation set needed,

¹ <https://www.sfu.ca/rst/01intro/definitions.html>

syntactically defined relations must be subsumable by their pragmatic and semantic counterparts, and their inferential characteristics must be clearly specified.

Although realization of these goals is beyond the scope of this paper, progress can be made through close examination and explication of some of the problematic relations. And this will shed light on how other issues might be approached. I have selected CIRCUMSTANCE, SOLUTIONHOOD, and ELABORATION for this analysis. While these relations are not alone in their need for attention, the issues associated with them are fundamental, not just with respect to their inferentiality, but to RST in general. CIRCUMSTANCE has been subject to various interpretations and definitions, and these have implications for when it should be used, what qualifies as a segment for these relations, and what inferences may be drawn from it. Stede et al. (2017) deprecated it in favor of the BACKGROUND relation, and similarly Carlson and Marcu (2001) classified it as a background subtype. Similarly, SOLUTIONHOOD can be difficult to distinguish from PREPARATION (Zeldes & Liu, 2020), and while defined by both Mann and Thompson and Stede, et al., it has no direct counterpart in Carlson and Marcu. ELABORATION is among the most frequently used of relations, and yet while there seems to be general agreement that its satellite will contain additional information about its nucleus, specifics as to how it should be defined diverge from there, with Mann and Thompson identifying six different ways this can occur, Stede et al., splitting the relation in two, and Carlson and Marcu subdividing it into eight separate relations.

Moreover, much has been made about the distinction between presentational (pragmatic) and subject matter (semantic) relations. This distinction was introduced somewhat tentatively by Mann and Thompson, but has been treated as gospel ever since. Claims such as those of Azar (1995, 1997, 1999) that only selected relations among the presentationals can be construed as argumentative have only served to strengthen this view. And while subject matter relations may not be interpersonal in the sense found in some of the presentational relations, this examination of CIRCUMSTANCE, SOLUTIONHOOD, and ELABORATION will show they are both inferential and instrumentally argumentative.

The paper is organized as follows. The next section provides a brief review of related research.

This is followed by an overview of the theoretical background for this study. Next, I examine the selected RST relations and their associated issues from the perspective of the logic of relational propositions with the aim of clarifying their inferential features. The paper closes with a discussion and summary of the results.

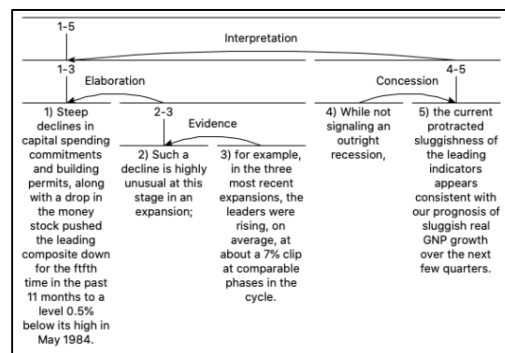


Figure 1: Nested RST Structures (Mann & Thompson, 2000)

2 Related work

Studies in the relationship between RST and argumentation are numerous (e.g., Abelen, Redeker, & Thompson, 1993; Azar, 1995, 1997; Doronkina, 2017; Galitsky, Ilvovsky, & Kuznetsov, 2018; Garcia-Villalba & Saint-Dizier, 2012; Green, 2010; Imaz & Iruskieta, 2017; Mitrović, O'Reilly, Mladenović, & Handschuh, 2017; Musi, Ghosh, & Muresan, 2018; Peldszus, 2016; Peldszus & Stede, 2013; Rocci, 2021; Stede, 2020; Wyner & Schneider, 2012), but without focus on the inferential characteristics of rhetorical relations.

On the other hand, the relationship between coherence relations and logic has also been the subject of extensive study (e.g., Asher & Lascarides, 2003; Danlos, 2008; González & Ribas, 2008; Groenendijk, 2009; Hobbs, 1979, 1985; Marcu, 2000; Potter, 2019, 2020, 2021; Sanders, Spooren, & Noordman, 1992; Wong, 1986). Inevitably, the question arises: Why not Segmented Discourse Representation Theory? SDRT builds on the perspective of discourse as a dynamic phenomenon in which context is modified with each successive segment (Asher & Lascarides, 2003), and discourse structure is viewed as a systematic extension of truth-conditional semantics, whereas intentionality is fundamental to the RST perspective. That this intentionality lends

itself to argumentative, interpretation is apparent (Potter, 2007, 2008a, 2008b, 2009, 2010, 2019, 2020, 2021), and as such is of interest to argument mining. So far as I know, other than these studies, there have been no attempts to establish a specific alignment between RST and propositional logic.

3 Theoretical Background

The fundamental bases for this work are Rhetorical Structure Theory (RST), relational propositions, and the logic of relational propositions. Rhetorical Structure Theory (RST) is a theory of text organization (Mann & Thompson, 1988). It is used for analyzing texts in terms of the relations that hold among its discourse units. A relation consists of three parts: a satellite, a nucleus, and a relation. Figure 1 shows an RST analysis containing five discourse units related by the ELABORATION, EVIDENCE, CONCESSION, and INTERPRETATION relations. The distinction between satellite and nucleus arises as a result of the asymmetry of the relations. Within a relation, the nucleus is more central to the writer’s purpose than the satellite. Thus unit 3 is the satellite of 2, and span [2-3] is the satellite of 1. Unit 4 is the satellite of 5, and [4-5] is the satellite of [1-3]. A defining characteristic of RST relations is their intended effects. Each relation has a defined effect, representing the writer’s intention for the relation, as determined by the RST analyst. For example the intended effect of the EVIDENCE relation is *acceptance* of the situation presented in the nucleus. This effects field is what makes RST *rhetorical*.

Relational propositions provide a propositional analog to RST structures, with relations being expressed as propositions. These propositions are implicit assertions occurring between clauses in a text and are essential to the effective functioning of the text (Mann & Thompson, 1986). A relational proposition consists of a relation (or predicate) and two variables, one of which corresponds to the RST satellite and the other to the nucleus. Complex relational propositions can be expressed using a predicate notation defined by Potter (2019). This supports the representation of complex RST structures in compact functional form. However, conceptualizing RST analyses as relational propositions provides more than a space-saving alternative to RST diagrams. Relational propositions provide a means for exploring texts as inferential structures, and this in turn sheds light on the nature of nuclearity and its role in discourse

coherence—and as a side-effect, it exposes some issues in RST, hence providing motivation for the investigation that led to the writing of this paper.

As developed by Potter (2019, 2021), each of the RST relations supports a logical interpretation, and most of these interpretations are not only inferential, and but tautological as well, which is to say, they implement a valid rule of inference. This can best be explained by way of example. The relational proposition for the EVIDENCE relation shown in Figure 1 is *evidence(3,2)*. The intended effect is that the satellite, unit 3, provides evidence in support of 2. In the analysts’ estimation, the reader might not believe 2 without the supporting evidence provided by 3 So 3 gives credence to 2, leading to acceptance of 2. Thus the logical form of *evidence(s, n)* is realized as modus ponens, $((s \rightarrow n) \wedge s) \rightarrow n$. The relation is not merely conditional, since *s* is asserted. Further, in the example, the relational proposition, *evidence(3,2)*, is positioned as the satellite to unit 1, resulting in the relational proposition *elaboration(evidence(3,2),1)*. As argued below in Section 6, *elaboration* is inferential insofar as the satellite supports the reader’s comprehension of the nucleus by providing additional information. Like *evidence*, the logical form of *elaboration* is modus ponens, $((s \rightarrow n) \wedge s) \rightarrow n$. A couple of important things are happening here. The first is that the *evidence* modus ponens has been nested within the *elaboration* modus ponens, functioning as its satellite, and as a premise in the *elaboration* argument. So there is an inferential dependency of one upon the other, such that if fully realized, we have one valid argument as premise to another, i.e., a tautology within a tautology:

$$\begin{aligned} & (((((3 \rightarrow 2) \wedge 3) \rightarrow 2) \rightarrow 1) \wedge \\ & ((3 \rightarrow 2) \wedge 3) \rightarrow 2)) \rightarrow 1) \end{aligned}$$

The second point has to do with the integration of the Boolean domains of these tautologies. As thus far analyzed, the text consists of one argument that establishes acceptance, and this acceptance is then used in a second argument to establish comprehension. This relational proposition, *elaboration(evidence(3,2),1)*, is then used as the nucleus of an *interpretation* predicate. Like *elaboration*, the *interpretation* predicate supports comprehension, yet not by extending the subject matter, but rather by introducing an additional conceptual framework, taking the subject matter to

another level. So the polarity of inference is reversed. As INTERPRETATION is defined, its nucleus is leveraged to support the satellite: $((n \rightarrow s) \wedge n) \rightarrow s$. At this point, things begin to get a little more interesting. The s of the interpretation is also the n of a *concession*. With *concession*, the writer acknowledges the situation presented in the satellite but asserts that, although there might seem to be an incompatibility between the satellite and the nucleus, the satellite and nucleus are compatible. The writer holds the nucleus in positive regard, and by indicating a lack of incompatibility with the satellite, seeks to increase the reader's positive regard for the nucleus (Potter, 2019; Thompson & Mann, 1986). In other words, while the satellite might seem to indicate rejection of the nucleus, it does not do so, and recognition of their compatibility increases acceptance of the nucleus. In other words, since the satellite does not imply the negation of the nucleus, the nucleus holds:

$$(((\neg(s \rightarrow \neg n) \rightarrow n) \wedge \neg(s \rightarrow \neg n)) \rightarrow n)$$

This is the logical structure of the nucleus of the *interpretation* relational proposition. It may seem a bit complicated, but it is actually just an odd modus ponens. So the full relational proposition of the text under examination is

$$\text{interpretation}(\text{concession}(4,5), \\ \text{elaboration}(\text{evidence}(3,2),1))$$

which expands to the logical expression:

$$(((((((3 \rightarrow 2) \wedge 3) \rightarrow 2) \rightarrow 1) \wedge ((3 \rightarrow 2) \wedge 3) \rightarrow 2)) \rightarrow 1) \rightarrow (((\neg(4 \rightarrow \neg 5) \rightarrow 5) \wedge \neg(4 \rightarrow \neg 5)) \rightarrow 5)) \wedge ((((((3 \rightarrow 2) \wedge 3) \rightarrow 2) \rightarrow 1) \wedge ((3 \rightarrow 2) \wedge 3) \rightarrow 2)) \rightarrow 1)) \rightarrow (((\neg(4 \rightarrow \neg 5) \rightarrow 5) \wedge \neg(4 \rightarrow \neg 5)) \rightarrow 5))$$

The *evidence* and *concession* predicates specify a Boolean domain of acceptance, *elaboration* of clarification, *interpretation* of illumination or insight, and the overarching logic is one of coherence rather than truth. Thus the logic of discursive coherence subsumes the Boolean domains of rhetorical relations. For each of the relations examined here, identification of the Boolean domain plays an important role.

4 Circumscribing CIRCUMSTANCE

In CIRCUMSTANCE, as defined by Mann and Thompson (1988), the satellite sets a framework for the subject matter within which the reader is intended to interpret the nucleus. Carlson and Marcu (2001) and Stede et al. (2017) concur in this definition. The inferentiality of CIRCUMSTANCE is supported in part by its affinity with the BACKGROUND relation. Stede et al. (2017) argued that the BACKGROUND relation should usually be preferred over CIRCUMSTANCE, because in their view, BACKGROUND is more informative. Potter (2019) defined CIRCUMSTANCE as a causal relation, with possible presentational features. Carlson and Marcu (2001) recognized the similarity between CIRCUMSTANCE and BACKGROUND, but noted that CIRCUMSTANCE tends to be more clearly delimited, and as such is stronger than BACKGROUND. As a pragmatic relation, the inferentiality of BACKGROUND, with a Boolean domain of comprehensibility, is well substantiated. To the extent that CIRCUMSTANCE presents as a special case of BACKGROUND, it too can be expected to be inferential. But I believe the case for inferentiality for CIRCUMSTANCE can stand on its own.

CIRCUMSTANCE is categorized as a subject matter or semantic relation. That a relation might be designated as semantic indicates that since reader acceptance is presumed, this might seem to suggest no inferential activity would obtain. And yet the asymmetry of semantic relations indicates otherwise: these are not merely conjunctions. That their intended effect may be realized without persuasion does not eliminate the necessity for reasoning. The intended effect of each of the semantic relations is predicated on a Boolean domain, albeit more subtle than one of truth and falsity. In CIRCUMSTANCE, the inferential feature, while subtle, is more pronounced than in some others. Its Boolean domain is a delimitation of context. The satellite circumscribes the universe of discourse within which the nucleus holds. In some cases, the strength of the circumscription may be sufficient that the designation of argumentative would be warranted. Figure 2 shows an example of CIRCUMSTANCE. The text is from US President Ronald Reagan's first inaugural address. The nucleus is perhaps one of his most famous quotations. Giving it some context should be helpful both in clarifying what he really said and in explicating the CIRCUMSTANCE relation. The crisis

Reagan had in mind is described in some detail earlier in the address, that inflation is the worst in American history, that unemployment is high, that taxes and the deficit are too high, that personal freedoms have been curtailed, and in general things are tough all over. These are the circumstances under which we are asked to accept that government is not the solution to our problems, that government is the problem.

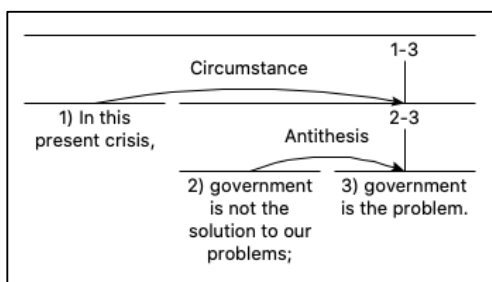


Figure 2: CIRCUMSTANCE as Delimiting

The satellite of CIRCUMSTANCE circumscribes the conditions under which the nucleus holds. In this sense it is similar to CONDITION relation, except that the CONDITION satellite expresses a hypothetical, future, or otherwise unrealized situation, whereas with CIRCUMSTANCE the satellite is not unrealized. Thus while CONDITION is $(s \rightarrow n)$, CIRCUMSTANCE is $((s \rightarrow n) \wedge s) \rightarrow n$, or *modus ponens*. Note that this differs from Potter's (2019) description of the logic of CIRCUMSTANCE as subject matter implicative: $(s \wedge (n \wedge (s \rightarrow n)))$. That definition was intended to account for the relation as a semantic rather pragmatic, property of the relation. However, this is unnecessary and redundant and moreover an inaccurate rendering of the relation. The Boolean domain of CIRCUMSTANCE is one of contextual enablement. Anything outside the circumscribed universe of discourse cannot be presumed to hold. If the crisis Reagan alluded to no longer persists, then the role of government in solving problems may be in good stead. And a logical analysis of the text bears this out. The relational proposition for the RST analysis shown in Figure 2 is *circumstance(1,antithesis(2,3))*. With *antithesis*, the intended effect is to increase the reader's positive regard for the situation presented in the nucleus. The satellite is incompatible with the nucleus, such that the reader cannot have positive regard for both the nucleus and the satellite: ...*government is not the solution to our problems;*

[on the contrary,] *government is the problem*. This incompatibility increases the reader's positive regard for the nucleus. The satellite of the CIRCUMSTANCE relation identifies an enabling context through which the situation identified in the nuclear proposition is realized. Its logical analog as this nested *modus ponens*:

$$(((1 \rightarrow ((2 \vee 3) \wedge \neg 2) \rightarrow 3)) \wedge 1) \rightarrow ((2 \vee 3) \wedge \neg 2) \rightarrow 3))$$

Lest there be any doubt as to the implicativeness of the relation between the CIRCUMSTANCE satellite and the disjunctive syllogism, consider the effect of eliminating the satellite. The relational proposition is then *antithesis(2,3)*, or $((2 \vee 3) \wedge \neg 2) \rightarrow 3$, with the corresponding text making a general claim about the inefficacy of government. This is not what Reagan said. In specifying an enabling context, the CIRCUMSTANCE relation delimits the scope of the situation identified by the nucleus. Anything beyond that scope is unspecified. Taking the nucleus out if its circumstantial context is to remove support for writer's claim.

As a valid argument within a valid argument, the logical expression is a tautology, that is to say, the expression $((1 \rightarrow ((2 \vee 3) \wedge \neg 2) \rightarrow 3)) \wedge 1) \rightarrow ((2 \vee 3) \wedge \neg 2) \rightarrow 3))$ is true for all possible values of 1, 2, and 3. That these expressions are tautologies should be of no concern so long as it is the coherence of the text that is of interest. That is, the logical definitions are based on a presumed realization of the writer's intended effect. While this is consistent with the expectation of coherence, for critical assessment, the presumed realization of intended effect amounts to begging the question. It is the soundness of the expression that is of interest. For an examination of soundness, it is the premises, and not what may be inferred from them, that is of interest. The premises of the argument are found, as expected, in the left hand side (LHS) of the logical expression, to the left of the outermost implication. Restating the logical expression,

$$(((1 \rightarrow ((2 \vee 3) \wedge \neg 2) \rightarrow 3)) \wedge 1) \rightarrow ((2 \vee 3) \wedge \neg 2) \rightarrow 3))$$

using only the LHS for each relation reduces to

$$((1 \rightarrow ((2 \vee 3) \wedge \neg 2)) \wedge 1)$$

Although negation of the LHS will not necessarily negate the RHS, an LHS once negated deprives the discourse of its intended effect. Since the burden of persuasion is on the LHS, negation is sufficient for rejection of the RHS. More specifically, negation of the CIRCUMSTANCE satellite is sufficient to imply negation of the LHS of the expression, such that $(\neg 1 \rightarrow \neg((1 \rightarrow ((2 \vee 3) \wedge \neg 2)) \wedge 1))$ is a valid argument. Thus one might challenge the claim that there was any crisis, e.g., arguing that the claim of crisis was a politically motivated fabrication, and this would suffice to weaken the generalization that government is the problem. Of further interest is the possibility of inferring 3 directly from 1. As it happens, $((1 \rightarrow ((2 \vee 3) \wedge \neg 2)) \wedge 1) \rightarrow (1 \rightarrow 3)$ and $((1 \rightarrow ((2 \vee 3) \wedge \neg 2)) \wedge 1) \rightarrow 3$ are both valid. This shows that the satellite of the CIRCUMSTANCE relation enjoys a transitive relationship with the nucleus of the ANTITHESIS relation. That is to say, the reduced text

- 1) *In this present crisis,*
- 3) *government is the problem.*

is both logical and plausibly coherent. That this abridgement of the inferential path is readable, despite the loss of rhetorical force, lends support to the inferential interpretation of the CIRCUMSTANCE relation.

5 SOLUTIONHOOD and its subtypes

SOLUTIONHOOD as defined by Mann and Thompson the satellite presents a problem and the nucleus constitutes a solution. *Problem* as used

here is broadly defined, and may be presented as a question, a request, a description of a desire or goal, or any one of a variety of other similar situations. The use of the interrogative in discourse, when the writer raises the question and follows it with a response, is quite different from raising a question and leaving it for the reader to answer. In this respect SOLUTIONHOOD is akin to the PREPARATION relation, but more focused. The satellite provides the setup or prompt for presenting the nucleus. The question or problem can be treated as a propositional function, or specification of a query (Hintikka, 2007). Solutions and answers provide the information needed to resolve the problem. From the query, the solution is instantiated (Potter, 2019). It is in this sense that the nucleus is inferred from the satellite, or that the answer follows coherently from the question.

Instantiations of SOLUTIONHOOD may be simple, e.g., *I'm hungry. Let's go to the Fuji Gardens*, where the speaker's announcement of hunger is given as sufficient reason for dinner at a Japanese restaurant. Or they may be complex. Figure 3 shows the satellite of a SOLUTIONHOOD relation in use as the setup for an extended argument. The argument is from Gilbert Ryle's philosophical treatise, *The Concept of Mind*. Through multiple layers of EVIDENCE, the writer positions the argument as a response to the question posed in the satellite, but in going beyond simply satisfying the question, it seeks to affirm an assumption implicit in the question, that people are strongly drawn to believe the thesis of mind-body dualism. A case of complex question perhaps? Ryle could have begun with an assertion rather than a

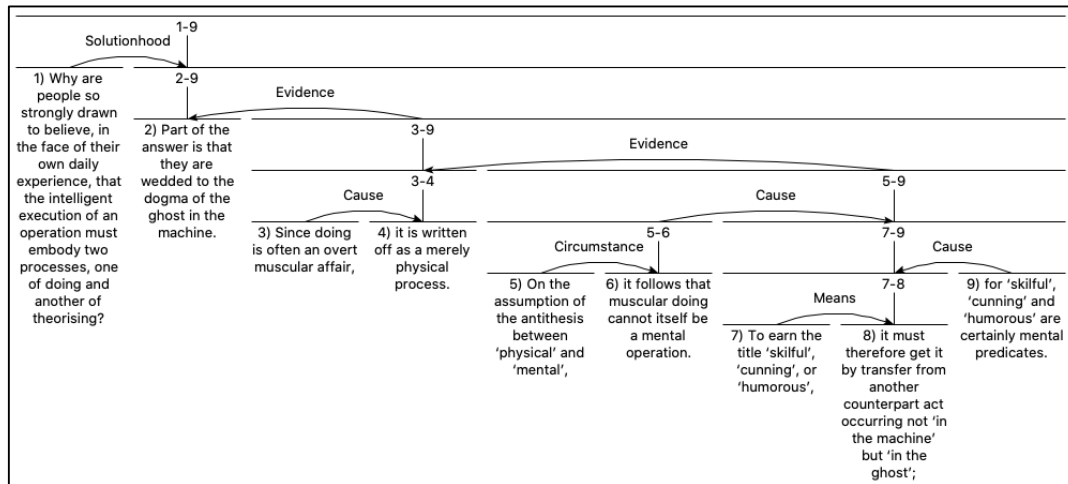


Figure 3: SOLUTIONHOOD as Setup for an Extended Argument (Ryle, 1949)

question (e.g., “People are strongly drawn to believe...”) followed by the support provided in span 2-9. But this would have shifted the locus of effect from segment 2 to segment 1. That is not the claim he sought to establish. That people ascribe to the dogma of the ghost in the machine is a core thesis of his critique of René Descartes. SOLUTIONHOOD is used as a maneuver to position the claim and its supporting argument. As structured, the locus of intended effect (segment 2), follows logically from the argument:

```

solutionhood(
  1,
  evidence(
    evidence(
      cause(
        circumstance(
          5,6),
          cause(
            9,
            means(
              7,8))),
          cause(
            3,4)),
        2))

```

Carlson and Marcu (2001) do not define a SOLUTIONHOOD relation *per se*, but rather specify an array of more finely-grained solution-oriented relations. Of particular concern are PROBLEM-SOLUTION, QUESTION-ANSWER, and STATEMENT-RESPONSE. For each of these, there are three subtypes. This, according to Carlson and Marcu, is necessary because sometimes the problem will be more important than the solution, sometimes the solution will be more important than the problem, and sometimes they will be of equal importance. Similar subtypes are specified for CONSEQUENCE, EVALUATION, and INTERPRETATION. That there should be such subtypes is not without precedent. Mann and Thompson used similar pairings for causal relations (VOLITIONAL-CAUSE, NON-VOLITIONAL CAUSE, and VOLITIONAL-RESULT, NON-VOLITIONAL RESULT). More recently, Stede et al. (2017) specified satellite and nuclear subtypes for the EVALUATION relation.

In SOLUTIONHOOD, the essence of the relation is that one part provides a solution to a problem presented by the second part (Mann & Thompson, 1986). The reader recognizes that the nucleus is a solution to the problem presented in the satellite.

Nothing is stipulated as to the importance of one part over the other. In Carlson and Marcu’s PROBLEM-SOLUTION, one part presents a problem, the other presents a solution. They do stipulate that one part might be more important than the other, and that this will determine the relation. *Importance* here has to do with how salient or essential each part is. So if the problem is deemed more important, it is coded as the nucleus, and if the solution is more important, then it is coded as the nucleus. This exemplifies a fundamental difference between Mann and Thompson’s vision for what RST is and Carlson and Marcu’s approach. For Mann and Thompson the nuclearity of a relation is determined by specific constraints on the spans. For SOLUTIONHOOD this means that one part must present a problem and the other must be a solution to the problem. From this the satellite and nucleus are determined. Any determination of importance, salience, or essentiality follows as a consequence of conformance to the defined constraints. For Carlson and Marcu, the nuclearity of a relation is determined by a identification of the relative importance, salience, or essentiality of the spans. This amounts to saying that the nuclearity of the spans is determined by the nuclearity of the spans. The difficulty presented by this circular reasoning is not merely hypothetical. Determining relational salience on the basis of something other than functional constraints adds a subjective feature to the analysis. In their example of PROBLEM-SOLUTION-S, because the problem is deemed more important than the solution, Carlson and Marcu assigned the role of nucleus to the problem and satellite to the solution. Here is the text:

- 1) *Despite the drop in prices for thoroughbreds, owning one still isn't cheap. At the low end, investors can spend \$15,000 or more to own a racehorse in partnership with others. At a yearling sale, a buyer can go solo and get a horse for a few thousand dollars. But that means paying the horse's maintenance; on average, it costs \$25,000 a year to raise a horse.*
- 2) *For those looking for something between a minority stake and total ownership, the owners' group is considering a special sale where established horse breeders would sell a 50% stake in horses to newcomers.*

Clearly, the first span is the problem and the second span is the solution. So by definition, the relation is SOLUTIONHOOD, or some sort of PROBLEM-SOLUTION. But it is unclear how this perception, that the satellite as more salient than the nucleus arises. On the contrary, the context in which this text is drawn suggests otherwise. The second span is the concluding paragraph from a *Wall Street Journal* article entitled *Racehorse Breeders Bet the Average Joe Would Pay for a Piece of Thoroughbred*. In my view, allowing the relational intentionality to determine the salience, and hence the relation, rather than an arbitrary designation of salience determining the relation, is the preferred approach for discovering rhetorical structure.

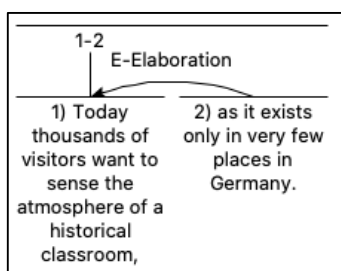


Figure 4: Example of E-ELABORATION, as defined by (Stede, Taboada, & Das, 2017).

While subtyping SOLUTIONHOOD in terms of salience seems questionable, even if accepted, the inferentiality of its relational propositions remains consistent. Within the Boolean domain of problem-solution matchups, the solution follows from the problem, not the other way on. Although it makes sense to say

I'm hungry.
THEREFORE, let's go to the Fuji Gardens

the coherence of

The owners' group is considering a special sale.
THEREFORE, owning one still isn't cheap.

is questionable at best, except perhaps from a cynical perspective unsupported by the text. If the writer's intent is that the solution is less than adequate, its relation to the problem may not be SOLUTIONHOOD at all, but possibly ELABORATION or even a causal relation. The bottom line then is that if the relation is SOLUTIONHOOD or any of its variants, then inferentiality flows from problem to solution, irrespective of nuclearity.

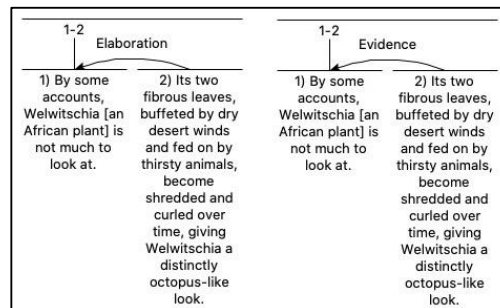


Figure 5: ELABORATION and/or EVIDENCE

6 Inferential ELABORATION

ELABORATION is among the most frequently used relations (Cardoso, Taboada, & Pardo, 2013; Carlson & Marcu, 2001). It has also been the subject of controversy. Knott, Oberlander, O'Donnell, and Mellish (2001) have sometimes been cited as advocating that ELABORATION should be removed from the RST relations set (e.g., Louis & Nenkova, 2010; Marcu & Echihiabi, 2002; Prévot, Vieu, & Asher, 2009; Taboada & Mann, 2006); however, their concern was more limited than that. Their objection was to one particular ELABORATION subtype: *Object-Attribute*. They considered this relation to be idiosyncratic. The distinctive characteristic of this subtype is that, from their perspective, it is not really a relation among discourse units, but rather a relation between a clause and an element within another clause. Stede et al. (2017) addressed this objection at least in part by defining two types of elaboration. In the first type, called ELABORATION, the satellite provides details or more information on the state of a affairs described in the nucleus. The second type, called E-ELABORATION, the satellite may refer not to the situation presented in the nucleus but to some element or entity mentioned in the nucleus (Stede et al., 2017), as illustrated in Figure 4. This appears consistent with the definition provided by Mann and Thompson, with the exception that the Object-Attribute subtype is set apart as its own relation. Carlson and Marcu treat ELABORATION as a general class, rather than a relation, subclassing it into eight separate relations. Although these are sufficiently distinct to be useful by an analyst or parser, from a rhetorical standpoint, they all accomplish the same thing – the assertion of the satellite is intended to increase the likelihood the reader will understand the nucleus. In this respect

these relations are similar to BACKGROUND, and have the same logical generalization—similar, but not identical. One obvious difference is that the BACKGROUND satellite usually precedes the nucleus, and thus anticipates the need for supportive information (in this way BACKGROUND is similar to PREPARATION, except its domain is *comprehension* rather than *interest*). A more fundamental difference is that BACKGROUND is more general than ELABORATION.

Considered rhetorically we tend to reach one type of definition, based on writer intent, but considered solely from the perspective semantics, we arrive at something else. If in ELABORATION the satellite presents additional detail about the situation or some element presented in the nucleus, the question remains as to what the writer might hope to accomplish when employing the relation. We cannot look to Mann and Thompson, Stede, or Carlson for guidance there.

Unfortunately, the definition provided in one of my earlier papers (Potter, 2019) is also less than helpful. There, the relation is said to include an inference between the nucleus and the satellite, ($n \rightarrow s$). The inference of s from n was due to the specification that the satellite be inferentially accessible in the nucleus, as originally defined by Mann and Thompson (1988). And since ELABORATION is a subject matter relation, neither n nor s are controversial, so both were treated as asserted, such that the definition given is ($s \wedge n \wedge (n \rightarrow s)$). So there are a couple of problems here. First, regarding the inferential accessibility, this merely establishes *relevance*, not *intended effect*, and second, even the definition were discursively representative, it would be logically redundant, since anytime ($s \wedge n$), it will follow that ($n \rightarrow s$). But more to the point, this definition is *not* discursively representative.

As Hobbs (1979) observed, an elaboration enhances the reader's understanding by providing additional information. Thus for RST, the Boolean domain of ELABORATION should be seen as one of clarification, and the inferential path is from satellite to nucleus, not nucleus to satellite. This is the case for all forms of ELABORATION. One way or another, the satellite supports the nucleus, making it more informative. That is its Boolean domain. Its logic is therefore *modus ponens*, ($((s \rightarrow n) \wedge s) \rightarrow n$). It is not always easy to determine whether an elaboration should be read semantically or pragmatically. The example shown in Figure 5,

concerning the appearance of the African plant, *Welwitschia*, can be analyzed as *elaboration(2,1)*, and this also may help resolve any doubts the reader might have as to the plant's ugliness, hence *evidence(2,1)*. Either way, the logic is the same.

7 Conclusion

The possibility that relational propositions might support an alignment of discourse with propositional logic appears to have occurred to Mann and Thompson in their development of RST. While refraining from commitment to this conceptualization, they hint at its possibility in their early publications on relational propositions (Mann & Thompson, 1983, 1986). However, the logic of relational propositions maps readily from their original vision. The abstraction of RST analyses as logical expressions provides a means for mapping argumentative inference with high granularity, and with traceability back to the text. A key enabler for this process is the alignment of Boolean domains with writer intentionality. While this multiplicity of Boolean domains is, so far as I know, a novel concept for argument mining, applications of Boolean logic beyond truth functional domains are by no means new, having an extensive history in circuit design, set theory, digital logic, and database query languages.

The inspirational notion here is of an interactive inference mining browser that would perform automated RST analysis of free texts, restate the RST analysis as a nested relational proposition, and generate a logical expression representing the inferential processes in the text. This could be integrated with other tools for identification of argumentative structures. There remain fundamental issues to be addressed. Problems with relation definition, such as those examined in this paper need to be resolved. As things stand, there are several *de facto* standards for RST analysis, none of them fully adequate and yet all seemingly frozen in time. Tall monuments cast long shadows. Hopefully what I have presented here will be useful, and if not in fully solving any problems then in at least in taking steps toward their solution.

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