Discourse Structure Effects on the Global Coherence of Texts

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Abstract

Many theories of discourse structure rely on the idea that the segments comprising the discourse are linked through inferred relations such as causality and temporal contiguity. These theories suggest that the resulting discourse is represented hierarchically. Two experiments examine some of the implications of these hierarchical structures on the perceived coherence of texts. Experiment 1 shows that texts with more levels to their hierarchical structure are judged to be more coherent. Experiment 2 demonstrates that these effects are sensitive to the genre of the text. Specifically, narratives seem to be more affected by manipulation of the discourse structure than procedural texts.

Keywords: Coherence, Comprehension, Discourse, Discourse Relations, Genre, Global structure

Introduction

Linguistic theories of discourse comprehension often focus on the role of discourse relations¹ in the establishment of local coherence - the process of determining the manner by which two consecutive discourse segments relate to one another (e.g., Asher & Lascarides, 2003; Hobbs, 1979; Kehler, 2002; Mann and Thompson, 1988; Polanyi, van den Berg & Ahn, 2003; Sanders, Spooren & Noordman, 1992). In contrast, an increasing body of psychological literature is concerned with modeling the process underlying the establishment of a global coherence for a text or passage (e.g., Kintsch 1988, 1998; van den Broek, Rapp, & Kendeou, 2005; van den Broek, Young, Tzeng, & Linderholm, 1999; Zwaan, 1993). In this paper I will propose a framework that integrates these two approaches and suggest that the structural models of discourse used by linguists can be used to predict the ease with which the global coherence of a text can be established.

The importance of discourse relations to the local coherence of a text is easily demonstrated. As an example, consider the following discourse (1):

(1) a. John is a good chess player. b. He always beats James.

The two sentences form a complete discourse made up of two discourse units. The most intuitive and straightforward way to bind the two discourse fragments together would be to assume that sentence (1b) is a justification for the claim made in (1a). By Asher and Lascarides (2003)'s terminology this means that the two segments are linked through discourse relation they term *elaboration*².

In addition to listing the possible relations and their properties, some theories also suggest algorithmic processes that may be employed to determine the appropriate relations, given a sufficiently detailed account of the discourse. For instance, Hobbs et al. (1993) hypohtesize that the process of abduction can be used to determine the appropriateness of candidate relations. Asher & Lascarides (2003) present a different approach based on a set of constraints imposed on the discourse by each discourse relation. They propose that it is possible to infer the appropriate relation by testing these conditions.

A similar notion of discourse structure arises from some cognitive theories of discourse comprehension (van Dijk & Kintsch, 1983; Kintsch, 1998). In congruence with most linguistic theories, van Dijk and Kintsch hypothesize that the discourse is structured hierarchically, and that each level in the hierarchy acts as a summary of the content of the original discourse. However, their account of the relations between discourse segments is based on bridging inferences rather than on a catalogue of specific discourse relations³.

¹ While this paper will use the term *discourse relations*, other names have also been used in the literature for very similar concepts. These include *coherence relations* (Kehler, 2002) and *rhetorical relations* (Mann and Thompson, 1986).

² For the sake of consistency, this paper will adhere to names and definitions of discourse relations as presented in Asher and Lascarides (2003). It should be noted that while the labels used by theories for relations differ, it is often difficult to find specific relations that different theories would categorize differently.

³ van Dijk and Kintsch's hierarchy is based on three distinct hierarchy-forming processes, but those transform the discourse propositions, rather than semantically constrain or enhance them as discourse relations do.

Models such as Construction-Integration (Kintsch 1988, 1998) and Landscape (van den Broek, et al., 2005; van den Broek, et al., 1999) attempt to predict how well a given proposition will be integrated with the preceding text through a process that attempt to statistically match the content of the current proposition with an overall representation of the text that was previously processed. While the end result of such a process could be a hierarchical representation of the text, these models do not explicitly compute such hierarchies based on the logical or rhetorical relations that exist in the text. Moreover, even though such relations are frequently marked in the text through the use of connectives and other discourse markers, such explicit markers are not always required for the identification of discourse relations in the text.

Trabasso and his colleagues (Trabasso and Sperry, 1985; Trabasso and van den Broek, 1985) suggest a model of discourse representation that is based on the construction of *causal networks*. According to their model, readers construct a network of causal relations among different propositions in the text. This network forms the underlying representation from which higher level representations of the text, such as plot lines, can be derived. Interestingly, while this model explicitly represents causal hierarchies it does not derive non-causal relationships that might exist among the propositions of the discourse. Furthermore, these networks, and the measures of comprehension derived from them, are largely irrespective of the position a specific node within the text, only its relationship to other nodes.

In contrast, Giora (1997) proposes a definition of global coherence that relies on an increase in the specificity of the discourse's topic as the text progresses. That is, Giora argues that on average each additional proposition should serve as additional information that further specifies the topic of the discourse and that together with the previous propositions should narrow the possible scope of the text. This view suggests that the topic of a maximally globally coherent text is such that each proposition serves to elucidate and specify its topic. As a result, the order in which the propositions appear could influence how globally coherent a text is. For instance, if one discourse segment describes the scene while another pertains to the specifics of an event that occurred within the scene, a text would be less globally coherent if the description of the scene followed the description of the event because the description of the scene would then overlap with some information that is already known and therefore contribute less to the overall topic.

This property of global coherence can be generalized such that a discourse hierarchy that is more focused on a single branch (i.e., more recursive) will on average be more coherent than a similarly sized but broader hierarchy (see Figure 1). This difference is the result of the fact that the broader discourse hierarchy in essence contains two subtopics which are more equally developed whereas the in more recursive hierarchy only one topic is developed. As a result, the topic of a broader hierarchy will generally be

less specific than that of a more recursive hierarchy comprised of a similar number of propositions. Experiment 1 tests this prediction by comparing the coherence of Wall-Street Journal articles of similar lengths but different degrees of recursion.

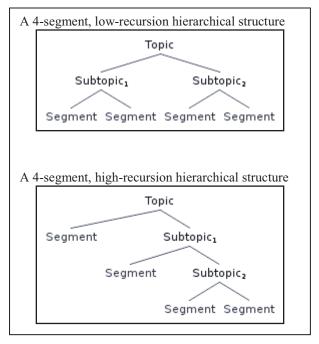


Figure 1 - Low- and High- recursion hierarchies

Experiment 1

Methods

Participants Fifteen undergraduate students enrolled at Northwestern University participated in this experiment in partial fulfillment of course requirements.

Materials Twelve texts were selected from part of the Wall-Street Journal corpus that was analyzed by Carlson, Marcu, and Okurowski (2001). These texts were between 15 and 23 discourse segments long and their RST discourse trees had either 7 or 9 levels of recursion. The length of these texts was between 116 and 193 words with a median of 183.

To better control for the number of segments, 6 of the texts were designated as "Short" (15 to 18 discourse segments) and the other 6 were designated as "Long" (20 to 22 discourse segments). Within each of these groups 3 texts were part of the "High-recursion" group (9 levels) and 3 texts were part of the "Low-recursion" group (7 levels).

Five additional texts of various lengths and recursion levels from the same corpus were used as training materials. Appendix A presents the two of the stories used in the experiment.

Procedure Participants were presented with the 17 texts in a paper packet. The front page of the packet consisted of instructions, and asked participants to read the texts (which were presented as Wall Street Journal Articles) and rate them on two 9-point scales: Difficulty ("How difficult was the article to understand?") and Memorability ("How much of the article do you think you will be able to recall tomorrow?"). Each text appeared on its own page with the two scales at the bottom of the page and the order of presentation of the experimental texts was randomly determined for each participant.

Results

Since different participants use different parts of the scale, the ratings were transformed into ranks individually for each participant and scale prior to the analysis. ⁴ Table 1 shows the average ratings and ranks.

Table 1: Mean ratings and ranks in Experiment 1

	Recursion	Difficulty		Memorability	
Length	level	Rating	Rank	Rating	Rank
Long	High	2.64	5.07	4	8.1
	Low	3	5.57	3.07	7.04
Short	High	3.38	6.73	2.6	5.78
	Low	4.16	8.63	2.24	5.08

Overall, 12 of the 15 participants judged the texts in the high-recursion condition as easier to understand than the low-recursion ones. Similarly, 12 of the 15 participants (albeit a different 12) judged the texts in the high-recursion condition as more memorable than the low-recursion ones. Paired-sample t-tests confirmed this result for both difficulty (t(14) = 4.17, p < .001) and memorability (t(14) = 5.20, p < .001). However, while the same trends exist for each of the two text lengths these trends are only statistically significant for difficulty rankings of short texts (t(14) = 2.58, p < .05).

Interestingly, short stories were rated as more difficult (t(14) = 4.17, p < .001) and less memorable (t(14) = 5.20, p < .001). Because Wall-Street Journal articles are generally terse and difficult to follow, it is possible that this difference is because the shorter stories tend to be less comprehensible due to their terseness.

Experiment 2

The differences observed in the ratings of the Wall-Street Journal texts are consistent with my hypothesis. Participants found texts with a higher level of recursion to be both easier to understand and remember. While this

⁴ It should be noted that similar results (in both trends and significance levels) are achieved even when the untransformed ratings are used. However, these untransformed ratings tend to follow a bimodal distribution.

result suggests a relationship between the hierarchical structure of texts and their global coherence, it is possible that the texts used in the two conditions varied in other important ways.

In order to control for such possible variability Experiment 2 uses a different set of texts. These texts were constructed such that it is possible to modify their overall discourse structure without any substantial effect on their content. As a result, these texts make it possible to directly examine the hypothesis that the overall structure of the discourse has an effect on its comprehension.

Moreover, many of the theories of discourse representations are specifically formulated to deal with narratives and similar texts. However, there is evidence that discourse comprehension is also sensitive to the perceived genre of the text (Geiger and Millis, 2005; Zwaan 1994). Furthermore, Sagi (2006) presents some evidence that the processing of discourse relations is affected by their context. It would therefore be of interest to examine whether the effects of discourse structure vary according to the genre and context of the text. Experiment 2 manipulates this variable by presenting the same general content as either a narrative describing the actions of an agent or a text containing the instructions of performing the same actions.

Methods

Participants Ninety-four undergraduate students enrolled at Northwestern University participated in this experiment in partial fulfillment of course requirements (46 in the Narrative condition and 48 in the Procedural condition).

Materials Six texts were specifically designed for the purposes of this experiment. Each text described the performance of a single arcane ritual that was comprised of 7 distinct and unrelated steps. The performance of each step was described with a single sentence. In addition, the mystical rationale behind one of these steps (the "elaborative step") was explained using three sentences that immediately followed it. There were two versions of each text. In the "early" version of the text, the elaborative step was presented 2nd whereas in the "late" version of the text it was incorporated as the 6th step in the ritual. Each text also had a "narrative" version, in which a named agent was described as performing the ritual and a "procedural" version, in which a named agent was described as explaining how to perform the ritual. Appendix B presents the four versions of a sample ritual from the experiment.

Procedure Participants were presented with the 6 texts in a paper packet. The front page of the packet consisted of instructions, and asked participants to read the texts (which were referred to as "passages") and answer the questions that followed each passage. Each text appeared on its own page together with 5 questions. The first question asked the participants to judge the purpose of the ritual and was intended to make sure that the participants read the

passage. The other 4 questions asked participant to rate different aspects of the text's coherence using 9-point scales. The order in which the texts were presented and which texts were incorporated the elaborative step early which incorporated it late were counterbalanced between participants. The genre of the texts was manipulated between participants (each participant read six texts of the same genre).

After completing the rating task participants were presented with a packet containing recall questions about the texts. There were 4 questions associated with each text and to answer each of these questions participants were required to recall a specific detail from a single step of the ritual (each question targeted a different step).

Results

The 4 ratings for each story were combined into a single rating score and transformed into ranks as in experiment 1. Furthermore, the recall questions were scored for each participant as correct, incorrect, or unanswered (participants were judged to have left a question unanswered if they left it empty or wrote "I don't remember" or "I don't know"). The overall average ratings and ranks for each condition are given in table 2 and the number of correctly answered and unanswered recall questions are given in table 3.

Table 2: Mean ratings and ranks in Experiment 2

	Elaborated	Coherence	
Genre	Step	Rating	Rank
Narrative	Early	4.82	3.27
Narrauve	Late	4.95	3.73
Procedural	Early	4.55	3.56
Frocedurar	Late	4.53	3.44

Table 3: Mean Recall scores in Experiment 2

Elaborated		Recall Questions		
Genre	Step	# Correct	# Empty	
Narrative	Early	1.12	0.77	
Narrative	Late	1.11	0.75	
Procedural	Early	1.67	0.99	
Procedurar	Late	1.59	1.12	

In the narrative condition participants rated the "Late" version as more coherent for 5 out of the 6 texts whereas in the procedural condition participants rated the "Early" version as more coherent for 4 out of the 6 texts. This interaction was statistically significant for both subjects (F(1,92)=4.14, p < .05) and items (F(1,5)=7.13, p < .05). Planned contrasts revealed a marginally significant effect of discourse structure for the narrative texts (Participant analysis: t(45)=1.84, p=.073; Item analysis: t(5)=2.96, p < .05). The effect of discourse structure was not statistically significant for the procedural texts (Participant analysis: t(47)=.85, p>.1; Item analysis: t(5)=.778, p>.1).

Participants who read the procedural texts answered the recall questions more accurately than those who read the narrative texts (t(92) = 3.90, p < .001). Moreover, participants who read the procedural text also left more questions unanswered than those who read the narrative ones (t(92) = 1.90, p < .05). Taken together these two results suggest that participant who read the procedural versions of the texts not only exhibited better recall of the texts, but were also more selective in the questions they answered showing a better ability to identify what questions they knew the answer to.

This finding consistent with the results reported by Geiger and Millis (2004) where participants' recall of texts was improved when they read texts with the explicit goal of performing the actions described in them. However, Geiger and Millis did not find any statistically significant differences in recall between the procedural and descriptive versions of their texts (although the texts they used differed substantially in content and coherence across the two versions). Alternatively, it is possible that this effect is due to a difference in the representations of narrative and procedural texts. If participants represent series of procedural instructions in a more precise and verbatim way but allow themselves more interpretive freedom in the representation of stories such as narratives then this would lead them to recall more inaccurate details about narratives than about procedural texts.

Surprisingly, no statistically significant differences in recall were observed between the "Early" and "Late" versions of the texts. Nevertheless, a comparison between the first 3 texts read and the last 3 texts read revealed a statistically significant order effect in the number of questions that were left unanswered for the narrative texts (F(1,32)=5.94, p < .05). A consequent analysis revealed that, consistent with the original hypothesis, participants left more questions unanswered in the last block when they read the "early" version of the text (M=0.89) than when they read the "late" version (M=0.62; paired t-test, t(32)=2.11, p < .05). Such an order effect is consistent with the findings presented in Sagi (2006, Experiment 2) where participants were found to adjust their reading strategy across the course of the experiment.

While it is surprising that there was no effect of discourse structure on recall, it is possible that the recall method used in this experiment was not sensitive enough. Perhaps using more elaborate questions or a free recall paradigm might result in a stronger effect. Alternatively, it is possible that the introduction of a delay between the time the participants read the texts and the time they are presented with the recall question might also serve to strengthen the effect.

Discussion

This paper presented data from two experiments in support of the hypothesis that the representation underlying discourse is based on a hierarchy of logical relations. Experiment 1 demonstrated that texts conforming to different structural hierarchies are associated with different ratings of coherence. Experiment 2 demonstrated that the scope these structural effects differ according to the genre of the text. Interestingly, it appears that the coherence of a narrative is more dependent on its overall discourse structure than the coherence of a procedural text.

One possible interpretation of this result is that readers have stronger expectations about the structure of a narrative story than they do about procedural texts. Another interpretation might be that the critical difference between the two texts presented to participants was that of perspective - in the narrative condition the actions are presented in the 3rd person (i.e., the protagonist is performing them) whereas in the procedural condition the actions are given in the 2nd person (i.e., the protagonist is describing how the actions should be performed by the reader). Importantly, this manipulation of perspective is inherent to the difference between the genres as it manifests itself through the goals of the reader. However, whether the effect described in the paper is due to differences in the representation of the genre, the goals of the reader, or the perspective of the text is an important research question that future research will hopefully address.

Regardless, the fact that narratives and procedural texts are processed differently poses a problem to the generalizability of most current models of discourse processing as these models tend to assume that readers approach all texts similarly and that genre differences are due to the content of the text and not its processing.

Nevertheless, it is possible to adapt some of these models to account for differences based on genre and logical structure. For instance, the Landscape model incorporates a top-down process with the express purpose of guiding the process of achieving coherence. In most current instantiations of the model, this top-down process is generally only concerned with the standard of coherence that the model attempts to achieve. However, it should not be difficult to modify this model by adding specific assumptions about positions at which topic shifts are more likely to occur. Such positions correspond to the ends of one subtopic and the beginning of another. Likewise, it might be feasible to incorporate a more structured, logical, mechanism such as the one suggested by Asher and Lascarides (2003) to the bottom-up portion of the Landscape model so that it would be capable of constructing local logical relations and relating discourse segments to one another.

However, before embarking on such an endeavor it is important to better understand how the genre differences demonstrated in Experiment 2 inform and interact with the discourse comprehension process. For example, it might be the case that once the genre of the text is identified specific schemas and expectations regarding the logical structure are triggered. On the other hand, because genre is a fairly fluid concept where a text of one genre might incorporate various parts which are better defined in terms of another genre (cf. Smith, 2003) it could be that there is not explicit

representation of genre. Rather, it is conceivable that an implicit mechanism constantly adjusts the reader's expectations as to the upcoming structure of the discourse. In either case, the global coherence of a text is maximal when this expectations or predictions of the discourse comprehension process are met resulting in a text that is easier to read not because it is somehow better written but because it conforms with the reader's prior conceptualization of it. Understanding where these conceptualizations come from and the how they are brought to bear on a particular text might eventually enable us to generate texts that are easier to read, process, and remember.

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Appendix A – Sample text from Experiment 1

Wall Street Journal Article #1188 Short (17 discourse segments) / Deep story (9 levels)

Directors of Bergen Bank and Den Norske Creditbank, two of Norway's leading banks, announced they had agreed to the formal merger of the banks.

The merger would create Scandinavia's seventh largest bank, with combined assets of 210 billion Norwegian kroner (\$30.3 billion).

The banks said an application for a concession to merge into one entity to be called Den Norske Bank AS was sent Monday to the Finance Ministry.

The two boards said in a joint statement that the proposed merger agreement was considered in separate board meetings in Oslo Monday.

They said the agreement will be submitted to their respective supervisory boards next Wednesday. Extraordinary general meetings, to be held Nov. 28, will decide the share exchange ratio.

The merger requires the approval of Norwegian authorities.

Wall Street Journal Article #1194 Short (16 discourse segments) / Shallow story (7 levels)

International Business Machines Corp. agreed to acquire a 15% stake in Paxus Corp., an Australian computer-software and information-services concern, for 20 million Australian dollars (US\$17 million).

The investment will be made through IBM Australia Ltd., a unit of IBM, the two companies said yesterday.

IBM can raise its stake in Paxus to 20% over three years, but agreed to not go beyond 20% in that time.

Paxus said in a statement it has several "well developed product and services relationships" with the U.S. computer company, and plans to expand these links.

The company earns about half its revenue overseas and plans further expansion.

A majority stake in Paxus currently held by NZI Corp. will be diluted to slightly less than 50% after IBM acquires its interest.

The agreement requires approval from Australia's Foreign Investment Review Board and National Companies and Securities Commission, and from shareholders of Paxus.

Appendix B – Sample text from Experiment 2

Narrative / Early elaboration

Gary is an apprentice wizard with the mystical order of Aber Tau Magus. Yesterday he tried out a ritual he discovered in arcane book.

- 1. First he drew an elaborate pentagram on the floor.
 - Then he took an agate out of a pouch and rubbed it with a counter-clockwise circular motion. Traditionally rubbing an agate is intended to ward off evil spirits. This warding was first suggested by a long-forgotten arch-mage by the name of Dervalis. During the middle ages many mages found this idea appealing and incorporated it into their rituals.
- Next he lit a stick of cherry incense and let the smoke fill the room.
- 4. He then waved an ebony wand in the air as if batting at invisible insects.
- 5. He proceeded by calling out "Oh great Pazuzu grant me your strength" five times.
- 6. Then he plucked a hair off his forearm and let it drop.
- 7. Finally he sat down and meditated for 15 minutes.

Narrative / Late elaboration

Gary is an apprentice wizard with the mystical order of Aber Tau Magus. Yesterday he tried out a ritual he discovered in arcane book.

- 1. First he drew an elaborate pentagram on the floor
- 2. Then he plucked a hair off his forearm and let it drop.
- Next he lit a stick of cherry incense and let the smoke fill the room.
- 4. He then waved an ebony wand in the air as if batting at invisible insects.
- 5. He proceeded by calling out "Oh great Pazuzu grant me your strength" five times
- Then he took an agate out of a pouch and rubbed it with a counter-clockwise circular motion. Traditionally rubbing an agate is intended to ward off evil spirits. This warding was first suggested by a long-forgotten arch-mage by the name of Dervalis. During the middle ages many mages found this idea appealing and incorporated it into their rituals.
- 7. Finally he sat down and meditated for 15 minutes.

Procedural / Early elaboration

Gary is an apprentice wizard with the mystical order of Aber Tau Magus. Yesterday he described a ritual he discovered in an arcane book:

- 1. First you draw an elaborate pentagram on the floor.
- 2. Then you take an agate out of a pouch and rub it with a counter-clockwise circular motion. Traditionally rubbing an agate is intended to ward off evil spirits. This warding was first suggested by a long-forgotten arch-mage by the name of Dervalis. During the middle ages many mages found this idea appealing and incorporated it into their rituals.
- 3. Next you light a stick of cherry incense and let the smoke fill the room.
- 4. You then wave an ebony wand in the air as if batting at invisible insects.
- 5. You proceed by calling out "Oh great Pazuzu grant me your strength" five times.
- 6. Then you pluck a hair off your forearm and let it drop.
- 7. Finally you sit down and meditate for 15 minutes.

Procedural / Late elaboration

Gary is an apprentice wizard with the mystical order of Aber Tau Magus. Yesterday he described a ritual he discovered in an arcane book:

- 1. First you draw an elaborate pentagram on the floor.
- 2. Then you pluck a hair off your forearm and let it drop.
- Next you light a stick of cherry incense and let the smoke fill the room.
- 4. You then wave an ebony wand in the air as if batting at invisible insects.
- 5. You proceed by calling out "Oh great Pazuzu grant me your strength" five times.
- 6. Then you take an agate out of a pouch and rub it with a counter-clockwise circular motion. Traditionally rubbing an agate is intended to ward off evil spirits. This warding was first suggested by a long-forgotten arch-mage by the name of Dervalis. During the middle ages many mages found this idea appealing and incorporated it into their rituals.
- 7. Finally you sit down and meditate for 15 minutes.

Elaborated step

Elaborated step