The X-Bar grammar for stories: Story grammar revisited*

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Abstract

The Story Grammar (S-G = Story Grammar) approach suggests a model based on the generative framework for representing both story structure and comprehension (cf., for example, Rumelhart, 1975, 1977; Mandler and Johnson, 1977; Stein and Glenn, 1979; Thorndyke, 1975). The present paper is an attempt to develop the S-G model in two ways: 1. It suggests a radical revision of the S-G model replacing it with an X-Bar story grammar (XBSG), which incorporates the notion of the X-Bar grammar as developed in sentence level grammar (cf. Jackendoff, 1977). I will argue that several fundamental shortcomings of the S-G (among which are the lack of 'descriptive' and 'observational' adequacy) can be overcome by a grammar based on the X-Bar model. 2. Of greater importance, it attempts to fill in the most significant deficiency of the traditional story grammars, namely, the lack of parsing procedures. Based on causal relations between propositions, the parsing procedures which are proposed take as their input propositions of the story and produce the tree diagram of that story as their output. Some empirical evidence, based on summary experiments, is introduced in support of the XBSG and the parsing procedures.

Introduction

The Story Grammar approach has suggested a model based on the generative framework for representing both the structure and the comprehension of stories (cf., for example, Rumelhart, 1975, 1977; Mandler and Johnson, 1977; Stein and Glenn, 1979; Thorndyke 1975). The central aim of this paper is to suggest a radical revision of the S-G model (S-G = Story Grammar), replacing it with a grammar based on the *X-Bar model* (this was initially developed in Shen, 1988).

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The organization of this paper is as follows. Section 1 will consider certain fundamental shortcomings of the S-G model, both as a grammar for stories and as a theory of story comprehension. The discussion of each of these shortcomings (especially the first one) will be accompanied by an (initial) presentation of some key features of the X-Bar model and the solution it suggests for dealing with these shortcomings.

The X-Bar Story Grammar (XBSG) is developed in sections 2 and 3, which present its two main components: the syntactic component in section 2, the parser in section 3. Section 4 will provide some empirical evidence, based on summary experiments, for the XBSG model's ability to explain aspects of narrative processing.

Motivations for the X-Bar Story Grammar

1.1 Basic assumptions of the standard Story Grammar model

In order to set the background for the presentation of the XBSG, let us start by briefly considering the conceptual framework underlying the 'Story Grammar' model. This framework consists of two components: the generative model taken from a linguistic theory, and the action structure. The two systems are combined as follows: a story structure is generated by a set of context-free phrase-structure rules, which correspond to the 'syntactic' rules of sentence level grammars; these rules use categories adopted from action theory such as EPISODE, PROBLEM, TRY, and OUTCOME (cf. Rumelhart, 1977). The structural (i.e. 'syntactic') relations between these categories have a 'semantic' interpretation which consists of action relations, for example Cause, Enable, and Motivate. This grammar operates on propositions as the minimal units of analysis at the story level, corresponding to words (or morphemes) as the minimal units in the analysis of sentences.

Let me illustrate these characteristics of the standard S-G model with the analysis of the Czar story which was suggested by Rumelhart, 1977. (An alternative analysis to this story based on the XBSG model will be presented in section 2.)

The Czar story is presented in Table 1. Rumelhart's grammar is introduced in Table 1-1, and the tree diagram of the story generated by this grammar appears in Figure 1. (The propositions in the story are identical to those used by Rumelhart, save for the fact that I have included the inferred propositions in the proposition list. These propositions are enclosed in brackets with their numbers prefixed by 'i' [an abbreviation for 'inferred'].)[1]

Table 1: *Rumelhart's 1977 version of the Czar Story*

1.	There was once a king who had three lovely daughters.
2.	One day, the daughters went walking in the woods.
3.	They were enjoying themselves so much that
[i1.	they stayed in the woods.]
4.	they forgot the time
5.	and stayed too long.
[i2.	They are in the woods.]
i3.	The dragon chooses to kidnap the girls.]
i4.	A dragon desires to have the girls.]
6.	A dragon kidnapped the three daughters.
[i5.	the dragon has the daughters.]
7.	they called for help.
8.	Three heroes heard the cries
[i6.	They desire the daughters to be free and safe.]
[i7.	The heroes decide to rescue the girls from the dragon.]
[i8.	The heroes select the method of going to the daughters' location.]
9.	and set off to rescue the daughters.
10.	The heroes came
[i9.	The heroes are at the dragon's location.]
11.	and fought the dragon.
12.	and they killed the dragon
13.	and rescued the maidens
14.	The heroes then returned the daughters safely to their palace.
15.	When the Czar heard of the rescue,
16.	he rewarded the heroes handsomely.

Table 1-1: *Rumelhart's rules*

STORY	→ SETTING–EPISODE
EPISODE	→ CAUSE–PROBLEM–TRY–OUTCOME
TRY	→ SELECT (the method)–TRY–DO–CONSEQUENCE
CAUSE	→ EPISODE

Three points should be emphasized with respect to this analysis:

1. The minimal units of analysis are the propositions whose numbers are represented as the terminal nodes of the tree. The propositions correspond to words (or morphemes) in the analysis of sentences. It will be recalled that not all the propositions are explicitly stated in the story; some must be inferred.
2. The non-terminal nodes represent action categories, such as CAUSE, DESIRE, TRY, OUTCOME etc. These categories (directly or indirectly) dominate the propositions of the story.

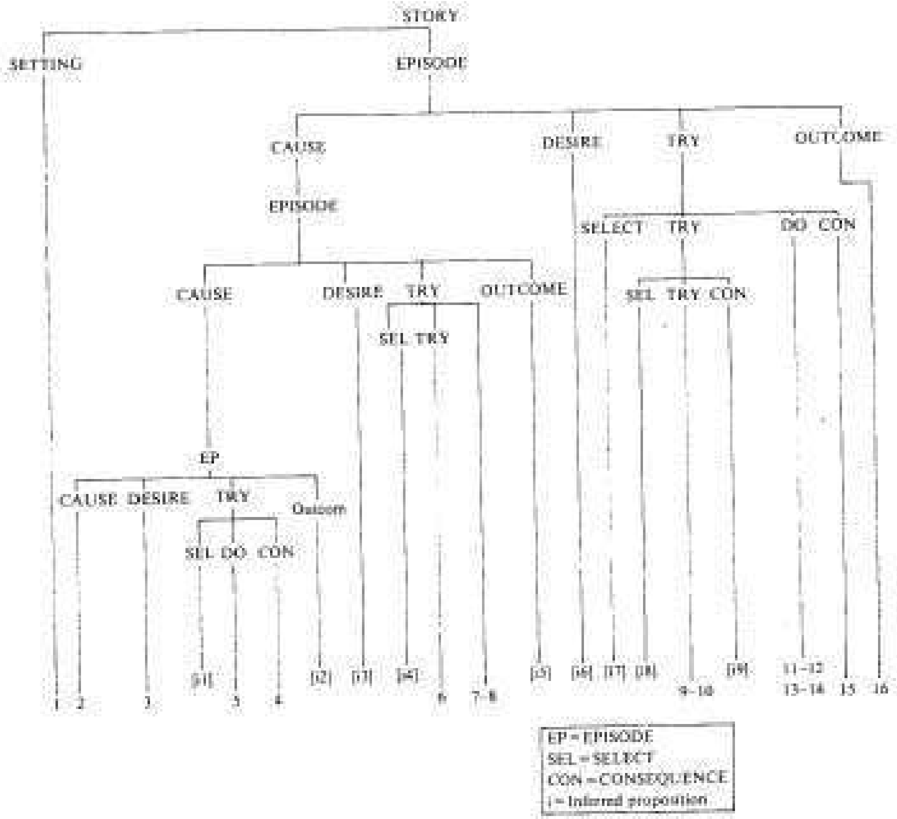


Figure 1: *Rumelhart's analysis of the Czar Story*

3. The entire tree is generated by the four rewrite rules presented in Table 1-1. These allow for a certain recursiveness, resulting in the grammar's ability to generate an infinite number of stories. Thus, a 'CAUSE' node dominated by an EPISODE node may itself dominate another EPISODE node.

1.2. *Motivations for the X-Bar Story Grammar*

The above framework represents the standard Story Grammar approach. Although I accept two of its central features, i.e., the appeal to generative grammar and the use of action categories, there still remain several fundamental shortcomings with this grammar. In this section I will suggest that these shortcomings be resolved by a grammar based on the X-Bar Model. Four shortcomings of the S-G approach will be discussed:

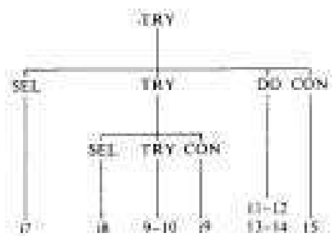
1. The lack of descriptive adequacy. 2. The lack of observational adequacy. 3. The lack of 'psychological reality'. 4. The lack of parsing procedures.

1. The first shortcoming of the S-G is its lack of what might, roughly, be called 'descriptive adequacy', i.e. its inadequacy in assigning a 'correct' structural description to the stories it analyzes. More specifically, my claim is that the standard tree diagram of the standard S-G model fails to account for a central aspect of the internal structure of each of its constituents — at each level of the tree — namely, the fact that readers intuitively distinguish between those propositions which represent the 'essential and irreducible' core (i.e., the 'most important' information) of the entire unit, and those which merely 'expand on' or 'elaborate' this core.

Within the S-G framework, the only structural means available for capturing the different structural roles fulfilled by these two sets of propositions is through the height of the proposition(s) in the tree diagram. The standard claim made by several story grammarians (for example Rumelhart, 1979) is that within a given unit it is the higher proposition(s) that represent the 'essential core' whereas the lower ones represent the 'elaborating information' (what has been termed the 'level effect', cf. for example Mandler, 1984). However, this 'level effect' is not a sufficient predictor even of Rumelhart's own findings obtained in summary experiments (this will be discussed when considering the S-G's third shortcoming).

Consider, for example, Rumelhart's analysis of the TRY unit which consists of propositions i^7–15 in the Czar story, repeated in Figure 1-1. (In order to facilitate the identification of inferred propositions, I have included them in the list of propositions as i^7, i^8, i^9, assigning them superscripted numbers.)

The main shortcoming of this analysis (typical of analyses suggested by the standard S-G model) is that it fails to account for the fact that within



[i7. The heroes select to rescue the girls from the dragon]
[i8. The heroes select the method of going to the daughters' place]
9. and set off to rescue the daughters.
10. the heroes came
[i9. The heroes are at the dragon place]
11. and fought the dragon.
12. and they killed the dragon
13. and rescued the maidens
14. The heroes then returned the daughters safely to their palace.
15. When the Czar heard of the rescue,

Figure 1-1: *Rumelhart's analysis of the TRY unit* these ten propositions a distinction can be drawn between those representing the 'essential core' of the entire TRY unit (i.e. the rescuing of the girls by the heroes) — propositions 11, 12 and 13 — and those which merely expand on or elaborate this essential core, i.e., those describing the coming of the heroes to the dragon's location (i[7], i[8], 9 and 10 and i[9]) and the events that follow the rescue (propositions 14, 15). This analysis is supported by Rumelhart's own findings (Rumelhart, 1977) in summary experiments of this story, according to which the probability of occurrence of propositions 11, 12 and 13 is higher than that of the other propositions within this unit. Clearly, this fact cannot be accounted for by assuming the 'level effect', since the 'essential core' propositions (11–13) are dominated by a node which is a 'sister node' of the nodes dominating propositions i[7] and 15 (i.e., they are nodes of the same level). Moreover, proposition 14 belonging to the 'elaborating' propositions, is dominated by the same DO node dominating the 'core' propositions. (I will return to this point in discussing the third shortcoming of the S-G model.)

Examining a large set of stories will lead us to the conclusion that the above phenomena are not limited to the Czar story, but rather represent frequent and widespread phenomena in narrative discourse that should be accounted for in any theory of narrative structure.

The point, of course, is that these phenomena cannot in principle be reflected in the standard S-G structural description, since all standard Story grammars without exception (e.g. Rumelhart, 1975, 1977; Mandler and Johnson, 1977; Stein and Glenn, 1979; Thorndyke, 1975) lack an adequate notion of phrase structure. Since precisely this kind of adequacy is at the heart of the X-Bar grammar underlying the story grammar to be developed in this study, let me briefly introduce two basic ideas underlying the X-Bar model which are highly pertinent to all three of the shortcomings to be discussed here. (The reader who is acquainted with the basic notions of X-Bar grammar may skip over the following paragraphs.)

The X-Bar grammar developed in syntax (for example by Jackendoff, 1977; Chomsky, 1986) is a type of phrase structure grammar; that is, it is a grammar consisting of two types of categories: 'lexical categories' such as VERB and NOUN (to use sentence level examples), and 'phrasal categories' such as VERB-PHRASE and NOUN-PHRASE. A central feature of phrasal categories in this framework is that each such category consists (by definition) of a lexical category of the same type and an expansion of the lexical category. Consider, for example, the following phrase 'little boys', which is analyzed in Figure 2-1 below.

This phrase is a NOUN PHRASE, i.e., a phrasal category of the 'NOUN' type, which consists of two constituents: the lexical category NOUN (dominating the lexical item 'boys'), which is of the same category type as

Figure 2-1: *The phrase structure of 'little boys'*

the dominating NP (i.e. of the 'NOUN' type), and another lexical category ADJECTIVE, (dominating 'little') which expands on the NOUN. In terms of the X-BAR system, a phrasal category which dominates a corresponding category of the same type is called 'a bar projection' of the latter; thus in our example the NP is a bar projection of the dominated NOUN. In this notation the dominating NP is called an N' (where the ''' applies to the number of bars) — i.e. a NOUN with one bar expansion (similarly, N''=NOUN with 2 bar expansions etc.). The dominated category which is of the same type is called the HEAD of the phrase, while the other category dominated by N' (i.e. the ADJECTIVE) is the MODIFIER of this HEAD. In this framework there are two types of MODIFIERs, i.e., SPECIFIERs and COMPLEMENTs (which will be discussed later in this paper in section 2).

For now it will be sufficient to point out that in English, and in many other languages, SPECIFIERS precede their HEADs and COMPLEMENTs follow it.

In such a grammar, then, a given phrasal category in general, X', X-PHRASE, (for example, NOUN-PHRASE in the present example) consists of an obligatory category, the 'HEAD' category (a category of the 'X' type, for example, a NOUN), and an (optional) 'MODIFIER' category. The internal structure of all phrasal categories used by such a grammar conforms to the template presented in Figure 2-2 below.

Another key feature of this X-Bar system is that a given lexical category

Figure 2-2: *The 'x-Bar template'*

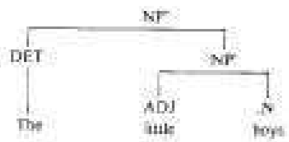


Figure 2-3: *The phrase structure of 'The little boys'*

may have more than one bar projection. Thus, the preceding phrase ('little boys') can be extended by adding the DETERMINER 'the', as in: 'The little boys' which is (in X-BAR terms) an N'' (i.e., a NOUN with two bars), as presented in Figure 2-3.

The maximal number of bars a given category may receive, i.e. the maximal 'projection' of that category, is determined by the constraints imposed by the specific (linguistic or non-linguistic) system which is being analyzed in terms of the X-BAR model.

Thus at the sentence level the maximal projection of each category (i.e. the maximal number of bars for each category type) is limited to three (+/−1), (Jackendoff, 1977). This number may vary for other systems (as described, for example, in Gil, 1985).

The above characteristics of X-BAR grammar result in a restricted form of grammar which imposes the constraint that all generative rules must be of the following form:

$X^n \rightarrow$(SPECIFIER)–$X^{<n-1>}$–(COMPLEMENT).

('n' = the number of bars.)
('X' = each category in the grammar.

This basic scheme (or rule format) of the X-BAR model is to be read as follows: The immediate constituents of X^n (i.e. category of the type X with N bars) are $X^{<n-1>}$ (i.e. the same category type–X– with $^{<n-1>}$ bars), which is an obligatory constituent, and a SPECIFIER and/or COMPLEMENT, which are optional.

Turning now to the story level, incorporating the ideas of the X-Bar model yields the following form for phrasal categories. Starting with the categories comprising such a grammar, a distinction should be made between 'propositional' categories, analogous to lexical categories in sentence level grammar, for example, TRY, OUTCOME, and phrasal categories, for example, TRY-PHRASE, OUTCOME-PHRASE, again as in sentence grammars.

Before formulating the entire system of X-Bar rules (to be developed in section 2) let us consider how this basic distinction between HEAD and MODIFIER can enable us to solve the shortcoming of the standard S-G model discussed above.

Incorporating this distinction enables the grammar to adequately represent the notion that a given category which dominates more than one proposition is a complex 'phrasal' category consisting of a constituent representing the 'essential' core, or 'HEAD', and a constituent(s) which optionally expands that core, i.e. the MODIFIER. Thus, in such a grammar the proposition i^7–15 above, can be assigned the structure in Figure 3 below (the precise rules generating this structure will be given in section 2):

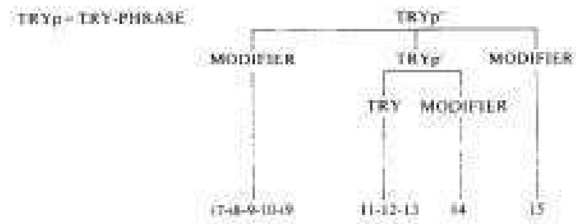


Figure 3: *The X-Bar analysis of propositions i^7–15*

In Figure 3, propositions 11–13 represent the 'HEAD' category, since they are of the same type (the TRY type) as the dominating category (the TRY-PHRASE), whereas propositions i^7–i^9, 14 and 15 represent the 'MODIFIER' category.

Observe, Figure 3 also illustrates the idea that the maximal projection of a given category may exceed one bar (i.e. may have more than one phrasal extension), in that the highest projection category of the TRY is identified as a TRY''.

The tree captures another feature of the entire TRY unit, namely the intuition that proposition 14 (which describes the heroes returning the daughters to their palace) is 'more related' to the attempt to rescue the girls than is the fact that the Czar hears about it. (This intuition is supported by the fact that proposition 14 shares its agent [i.e. the heroes] with propositions 11–13, whereas proposition 15 does not.) This is reflected in figure 3, since proposition 15 modifies the entire TRY' constituent (consisting of propositions 11–14) while proposition 14 modifies only the TRY node (dominating propositions 11–13). Thus, although both 14 and 15 are MODIFIERs of the HEAD propositions (11–13), only proposition 14 modifies it 'directly' while proposition 15 is an 'indirect' MODIFIER.

2. A second related limitation of the standard S-G model may by now be formulated: its lack of observational adequacy. The main reason for this lack (to be immediately illustrated) is that the S-G model is based on an unconstrained grammar which does not impose any constraints on the form of its 'syntactic' rules. Consequently this unconstrained grammar does not exclude the generation of unacceptable sequences.

According to the S-G analysis, the terminal nodes of the tree diagram of a given story consist of explicit propositions (i.e. those which are explicitly stated in the story) and implicit propositions (which are not stated but rather inferred from the story; these were marked above with the prefix 'i', for example i_1 etc.). Note further that the grammar does not specify which of the non-terminal nodes should be explicitly represented by a certain proposition in the story.

Aside from the fact that neither Rumelhart's grammar nor other story grammars specify explicit and formal procedures for inferring such (implicit) propositions, this analysis is flawed in a more serious respect: as the grammar does not require any of the constituents in the story to be explicitly stated, unacceptable structures may be generated. Thus, given that each terminal node might be 'empty' and considering the tree in Figure 1 above, one of the stories that might be generated is [1].

[1]*

1. There was once a king who had three lovely daughters.
2. One day, the daughters went walking in the woods.
3. They were enjoying themselves so much that
4. they forgot the time
5. and stayed too long.
6. A dragon kidnapped the three daughters.
7. They called for help.
8. Three heroes heard the cries
9. and decided to rescue the daughters.
10. The heroes came.
11. The heroes then returned the daughters safely to their palace.
12. and then, When the Czar heard of the rescue,
13. he rewarded the heroes handsomely.

Note that this sequence is identical to the original Czar story save for the fact that propositions 11, 12, 13 of the original story (which were dominated by the DO node) have been deleted from the present version. Let us further assume that these missing propositions may be inferred from [1]; consequently, Rumelhart's (hypothetical) analysis of these propositions will assign them the following structural description as in Figure 3-1 below, where ix, iy, iz stand for inferred propositions (the figure only presents the tree diagram of the relevant TRY node).

Note that the 'missing' propositions (ix, iy, iz) are dominated by the DO node in the same way as were propositions 11, 12, and 13 of the original story (see Figure 1). Nothing blocks this structure, since ix, iy, and iz are analogous to the inferred ix, iy and iz in Rumelhart's tree.

Figure 3-1, then, reflects the fact that unacceptable sequences (as in [1] above) may be generated by Rumelhart's grammar, due to the fact that this grammar imposes no constraint on the generation of 'lexically empty' (i.e. inferred) nodes.

This is a serious flaw of the S-G model, since inferred propositions which are not explicitly represented in a given story might (and in fact do) occur in almost every story, while every story also contains propositions which must be explicitly stated in the story, that is, propositions which are not deletable (i.e. inferable) without producing an unacceptable sequence(s). A crucial requirement for any story grammar is the specification of which (non-terminal) nodes in the structure are required to be explicitly represented in the story tree.

It is my claim that such a constraint is imposed by the X-Bar Story Grammar. In the X-Bar grammar a given phrasal category (for example, a TRY PHRASE) obligatorily includes a proposition(s) which represent(s) its 'HEAD'. In less technical terms, it can be argued that in analogy to sentence level grammars which block the generation of a 'NOUN PHRASE' with a lexically empty N (i.e. without a lexical item which represents the NOUN), in the story grammar there cannot be, for example, a TRY PHRASE which does not contain a lexically realized proposition(s) dominated by the HEAD TRY. This can be illustrated by considering Figure 3, which represents the X-Bar analysis of the TRY unit dominating propositions 11–13 of the original version; these propositions cannot be dispensed with in the sequence representing the highest TRY-PHRASE (dominating propositions i7–15) because that they represent the 'HEAD' of the entire unit, being dominated by the lowest TRY branching from the highest TRY PHRASE. (The exact description of the way this analysis results from the X-Bar grammar will be described in section 2, in which I will present the entire grammar.)

3. The third problem with the standard S-G model is a lack of 'psychological reality', i.e. the inadequacy of its standard tree diagram to account for the cognitive representation of a given story in memory as manifested in recall and summary experiments. More specifically, the issue addressed here is what was previously mentioned as the 'level effect' (cf. Mandler, 1984), namely the alleged correlation (suggested by most Story Grammars) between the height of a given proposition in the tree diagram and

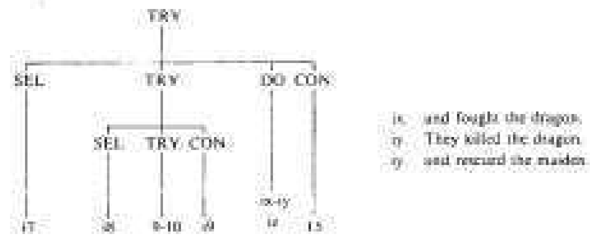


Figure 3-1: *Rumelhart's (hypothetical) analysis of the TRY unit in [1]*

its 'importance', where this 'importance' is reflected in the probability of that proposition appearing in the subjects' protocols.

The following empirical as well as logical objections to this 'level effect' can be raised.

I. An analysis of results which were obtained in experiments performed by S-G researchers themselves suggest that the above correlation does not always hold. A case in point is the above Czar story. According to Rumelhart's analysis, it is proposition 16 which is the most 'important' proposition in the story, since it is dominated by the highest node in the tree (the 'OUTCOME'), while (for example) proposition 13 (which describes the release of the Czar's daughters by the three heroes) is located at a lower level. However, the results of the summary experiments conducted by Rumelhart himself suggest the reverse order of 'importance'. There is a significant difference between propositions 13 and 16's probability of occurrence: 100 percent vs. 60 percent, respectively (which reflects their relative 'importance').

This is hardly an incidental result, but rather a representative example of a more basic problem with the standard Story Grammar model. (The issue was discussed extensively in Shen, 1984 and 1985.)

II. Rather than reflecting its importance, the height of a node dominating a given proposition in the tree is dependent mainly (though not solely) on the number of the phrasal extensions of its dominating category. Thus, given a phrasal category — X-PHRASE — dominating a set of propositions, if we extend it by adding another proposition to it, the height of the original proposition will be changed without any change in its relative 'importance'.

We may conclude, then, that the height of a proposition in the tree cannot be a successful predictor of its 'importance'. Instead, I suggest that the basic parameter for predicting 'importance' is the 'structural role' of the proposition, i.e. the category dominating the proposition in the tree diagram of the story. To use, again, terms taken from the X-BAR model, what is suggested here is that, given any phrasal category (for example 'TRY PHRASE') dominating a set of propositions, the 'important' proposition(s) in the set is the one dominated by the HEAD category while the less 'important' are those dominated by the MODIFIER, (all other things being equal). (In the above example this would be the lowest 'TRY' dominated by the 'TRY PHRASE', i.e. 11–12–13.)

The relation between the notion of 'importance' and the 'Bar structure' of a given category accounts perfectly for the above counterexample to Rumelhart's analysis. According to the X-Bar analysis of the story (to be presented in detail in the next section), it is proposition 13 which represents the 'Head' of the story's 'Central Episode' (a notion also to be explained in section 4), whereas proposition 16 is dominated (together with propositions 14–15) by a 'MODIFIER' of this 'HEAD'. (This will be elaborated upon in section 4 together with empirical support for the XBSG.) Thus, the X-Bar system accounts for psychological phenomena as reflected in summary and recall experiments far better than the standard S-G.

4. The fourth drawback of the S-G model (and of most theories working within the domain of Discourse Analysis) is perhaps the most crucial one: the lack of parsing procedures. The problem may be formulated as follows. Given that the very idea of any Story Grammar is based on assigning a structural description to the propositions of a given story, or (to put it differently) on the mapping of the propositions which constitute the 'actual story text' onto its underlying structure, it is evident that an indispensable component of such a theory must be a parser of some sort, i.e. a set of procedures which will assign the required structural description to the propositions of the story. Thus, for example, such a parser is necessary in order to 'determine' that proposition 2 is to be attached to a 'CAUSE' node, proposition 3 to a 'DESIRE' node, etc.

Crucial as it is, however, this problem is perhaps the most neglected area among workers within the domain of Story-Grammar. The point is made by Garnham (1985: 175):

> The first (difficulty with the story grammars — Y.S.) arises from the fact that the units of story structure are propositions. The proposition corresponds to the word or morpheme in the analysis of sentences, but propositions and words differ in one crucial respect. The lexical category of a word is stored in the mental lexicon, so there is no problem in deciding under which nodes (e.g. N, V, DET) a lexical item can be inserted into a phrase marker. The set of propositions, unlike the set of words, is indefinitely large. There can be no list of propositions and their categories, corresponding to the lexicon, and no story grammarian has described how the category of a proposition should be computed. A story grammar tree can be forced onto a story by assuming that the propositions of the story are members of the required categories but, if story grammars are to have explanatory power, there must be independent evidence about the categories to which propositions belong. (See also Garnham 1983).

The present X-Bar Story Grammar aims at resolving this problem by constructing such a required 'parser' (to be fully elaborated in section 3).

Having described some of the motivations for adopting the X-Bar framework and some of its main properties, we are in a position to develop the XBSG which is based upon this framework. The XBSG, then, will be introduced in the following two sections (2 and 3). Finally, in the Conclusion of the paper I will return to the above shortcomings of the standard S-G model, and consider how they are accounted for by the XBSG.

2. The X-Bar Story Grammar's syntactic rules

The syntactic rules are presented in Table 2. As previously explained the XBSG is based upon concepts taken from two frameworks: the first is the *Action (or Problem-solving) structure* (see also Black and Bower, 1980, or the notion of Plan schemata used in Brewer and Lichtenstein, 1980, 1981), which provides the syntactic categories summarized in Table 3; the second is the *X-Bar system*, which provides the compositional framework for the representation of those categories.

To illustrate the rules, I will re-analyze the same Czar story which has been extensively studied by various story grammarians (cf. Rumelhart, 1977; Mandler and Johnson, 1977 inter alia).

The analysis of the story into propositions is presented in Table 4,

Table 2: *The syntactic rules*

1. STORY	→	SETTING–EPISODE [OUTCOMEn, (where n = / > 0)]
2. Xn	→	(SPECIFIER)-Xn-1-(COMPLEMENT)
3. SPECIFIER	→	Xn or a proposition.
4. COMPLEMENT	→	OUTCOMEn or a proposition.

Notes:
1. X stands for the categories used by the XBSG, i.e., PROBLEM, TRY and OUTCOME.
2. the 'n' stands for the number of bars (i.e. phrasal extensions) of a given category X.

Table 3: *The Action Categories*

EPISODE:	the basic action unit, assigned to an 'agent' who attempts to solve a PROBLEM. This attempt results in an OUTCOME. The EPISODE thus consists of three components: the PROBLEM, the TRY, and the OUTCOME.
PROBLEM:	a mental state which motivates the agent's TRY (attempt) to solve it.
TRY:	an action (or several actions) performed by the agent in order to solve the PROBLEM.
OUTCOME:	a state or an event or an action caused or enabled by the TRY
Cause:	X Causes Y if X is the sufficient or the necessary and sufficient condition to Y.
Enable:	X Enables Y if X is an external (i.e. not mental) event which is a necessary condition to Y.
Motivate:	X Motivates Y if X is a mental state which is a necessary condition o Y.

Table 4: *The Czar story*

1. There was once a king who had three lovely daughters.
2. One day, the daughters went walking in the woods.
3. They were enjoying themselves so much that
4. they forgot the time
5. and stayed too long.
6. A dragon kidnapped the three daughters.
7. As they were being dragged off they called for help.
8. Three heroes heard the cries.
9. and decided to rescue the daughters.
10. The heroes came
11. and fought the dragon.
12. They killed the dragon
13. and rescued the maidens.
14. The heroes then returned the daughters safely to their palace.
15. When the Czar heard of the rescue,
16. he rewarded the heroes handsomely.

while Figure 4 presents the tree diagram of the structure of this story as generated by the XBSG syntactic rules.

In what follows I will discuss the syntactic rules as illustrated by the Czar story.

Rule 1 expands the highest Category in the grammar, i.e. the STORY. It consists of the SETTING (the description of the spatial and temporal background of the events to follow and, usually, the introduction of the protagonist of the story) and an O″ (i.e. an EP = EPISODE). Note that the Episode, which was traditionally used as the basic unit of analyzing stories, is being represented within the XBSG as a projection category of the 'OUTCOME' (i.e. a category of the same type as the OUTCOME), consisting of at least one bar expansion (this point will be discussed below).

The highest level of the tree diagram of the Czar story illustrates Rule 1; thus, the highest node (The STORY) is broken down to the SETTING (represented by proposition 1 which introduces the main characters of the story and the spatio-temporal background for the following events) and an OUTCOME″ which is a (complex) Episode dominating the remainder of the STORY (i.e. propositions 2–16).

It is crucial to understand clearly how the Episode is conceived of within the XBSG. As has already been said, the EPISODE category is taken as a bar projection of the OUTCOME category; this implies that the HEAD of each EPISODE is also its OUTCOME, while the EPISODE's other constituents (the TRY and the PROBLEM) are conceived of as MODIFIERs of the HEAD. Since the 'Story' in its narrow sense (i.e.

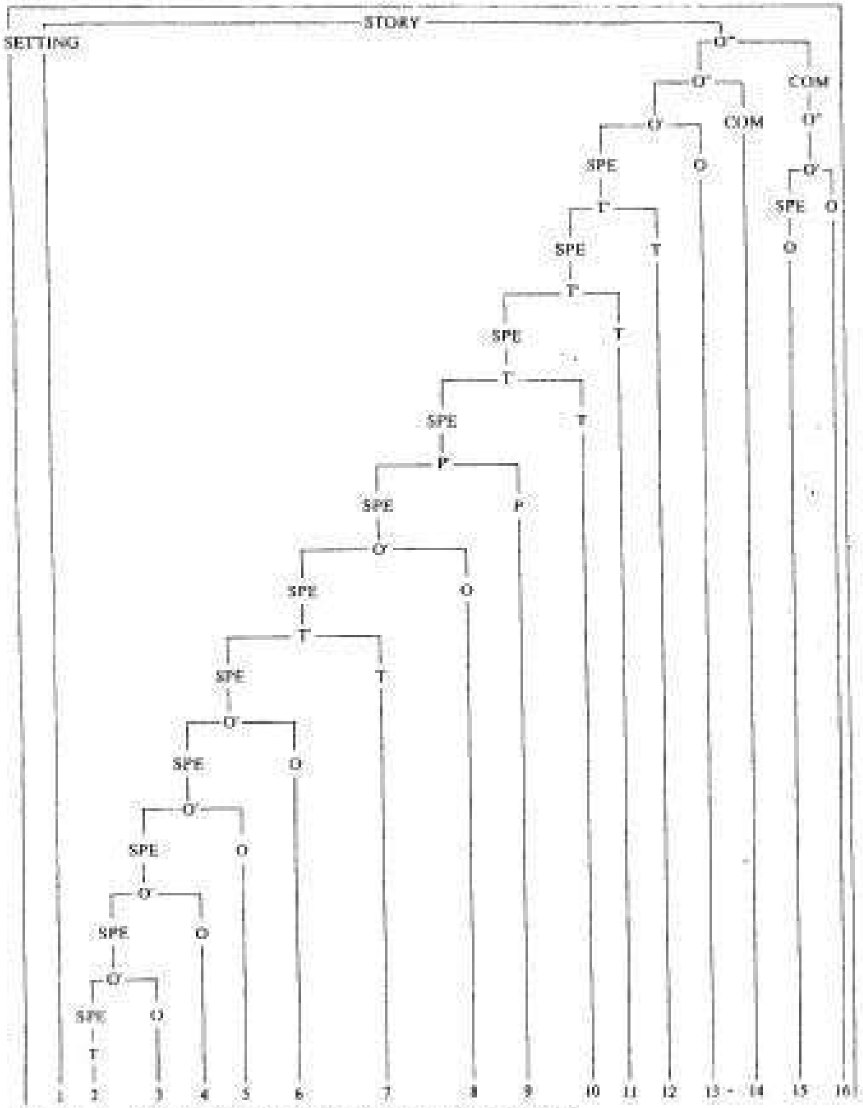


Figure 4: *Analysis of the Czar story according to the XBSG*

excluding the SETTING) consists of a (usually complex) EPISODE, the above implies that the HEAD proposition(s) of the entire 'story' (the SETTING excluded) is the proposition dominated by the OUTCOME node whose highest projection category is the Highest OUTCOME.

The Czar story, for example, consists of a complex episode dominating

a series of four linearly ordered 'simple' Episodes. Propositions 2–6 constitute the first Episode, which describes the dragon's kidnapping the girls who were enjoying themselves in the woods; in the second episode, consisting of propositions 7–8, the three heroes hear the girls call for help; the third Episode describes the actions leading up to the rescue of the girls (propositions 9–14); and the fourth Episode (propositions 15–16) describes the heroes being rewarded by the Czar. Note that the boundary of a given Episode is marked by the introduction of a new (explicitly stated or inferred) Problem (which can be described also as a goal). Thus the first Episode begins with the girls' (inferred) goal to enjoy their walking in the wood and ends with the dragon kidnapping them;[2] the second Episode begins with the girls' Problem of how to be released from the dragon, and ends with the heroes hearing the girls call for help; the third one also starts with a Problem, i.e., the heroes' Problem of how to release the girls, and ends with the rescue; while the fourth starts with the Czar's hearing about the rescue and his intending to reward the heroes (an inferred Problem), and ends with the actual reward.

Each of these Episodes is viewed here as a projection category of its Outcome. Thus, for example, the entire first Episode (propositions 2–6) is represented as a projection category of proposition 6, which represents the Outcome. Note further that these four 'simple' Episodes together comprise a complex Episode — the 'Central Episode' (to be discussed in section 3.2.2.), whose Head is proposition 13.

Rule 2 is the central rule of the XBSG model, since it presents the basic sheme of the X-bar model. As this rule has already been discussed, the following two brief illustrations may suffice. Consider first the highest EPISODE, i.e. the O''' dominating propositions 2–16, that is, the propositions which describe the events beginning with the girls walking in the woods and ending with the heroes being rewarded by the Czar for rescuing his daughters. The internal structure of this O''', as generated by rule 2, consists of an O'' (i.e. an O with^{n-1} extensions) comprising of propositions 2–14 and describing the rescue of the daughters by the heroes and all the events leading up to it, and a COMPLEMENT consisting of propositions 15–16, which describe the reward given to the heroes by the Czar.

Moving down two levels in the tree, we may now consider the internal structure of the O' which dominates propositions 2–13. According to rule 2, this node dominates a SPECIFIER (props. 2–12) which describes the events leading up to and including the attempt of the heroes to fight the dragon and rescue the girls, and an O (dominating proposition 13) which describes the achievement of the heroes' goal in rescuing the girls. Note that this latter O functions as HEAD of the entire O' dominating it (and in fact of the highest EPISODE [the O''' dominating proposition 2–16]).

Consider the highest EPISODE, i.e. the O″ dominating propositions 2–16, that is the propositions which describe the events beginning with the girls walking in the woods and ending with the heroes being rewarded by the Czar for rescuing his daughters. The internal structure of this O″ is generated by rule 2, in that it consists of an O′ (i.e. an O with n-1 extensions) composed of propositions 2–14 describing the rescuing of the daughters by the heroes and all the events that have lead up to it, and a COMPLEMENT consisting of propositions 15–16 which describe the reward given to the heroes by the Czar.

Rules 3 and 4 generate the internal structure of the MODIFIERs — the SPECIFIER and the COMPLEMENT.

Rule 3 states simply that the SPECIFIER of a given phrasal category can dominate either another phrasal category or a proposition(s) (i.e. a terminal node).

The T′ which dominates propositions 2–12 clearly illustrates this rule, in that it is dominated by a SPECIFIER node; that is, the sequence of events described by propositions 2–12 is conceived of as the SPECIFIER of the O dominating proposition 13 (which, as was explained, is the HEAD of the O′ dominating both).

Rule 4 states that the COMPLEMENT of a given phrasal category can dominate either an OUTCOME PHRASE, or a proposition(s) (i.e. a terminal node). The reason that the COMPLEMENT cannot dominate categories other than the OUTCOME, has to do with the nature of causal chain of events. Thus, a COMPLEMENT represents a proposition which is a 'Dead End', that is, a proposition which is caused (or enabled) by its antecedents but does not cause (or enable or motivate) the subsequent propositions (this notion will be developed later on). Since the PROBLEM and the TRY PHRASEs are, by definition, causes of subsequent events (The PROBLEM motivates the TRY which in itself causes or enables the OUTCOME) it directly follows that the COMPLEMENT (which represents only Dead End's propositions, cannot dominate either the PROBLEM or the TRY categories.

A case in point is the COMPLEMENT dominating props. 15–16 in the tree. As can clearly be seen, the node dominated by this COMPLEMENT node is an O′ which describes the reward given to the heroes.

These four rules constitute the syntactic component of the XBSG model.

The analysis of another extensively used story, the Farmer story (taken from Rumelhart, 1977) will serve as a further illustration of the XBSG. (Due to space limitation I will not discuss this analysis; the reader is referred to appendix 1.)

3. The X-Bar Story Grammar: The parser

3.1. *An introduction*

The preceding description of the syntactic component of the XBSG still leaves a basic question unanswered. How, according to this grammar, are the propositions of a given story to be mapped onto its underlying structure? In other words, how does a reader of a given story assign a structural description to (i.e. identifies the category structure of) the propositions of that story? As has already been pointed out (in describing the shortcomings of the standard S-G model), this is a crucial problem for any attempt to construct a theory of discourse processing.

According to the view common to many structural theories of discourse processing, processing a discourse involves the construction of structural categories out of the textual units (the latter representing propositions which in turn are represented in the discourse clauses and sentences). In spite of the centrality of this problem, however, neither theories working within the Story Grammar paradigm nor related theories of narrative processing have suggested a 'parser' or procedures for it.

There are, however, a few exceptions, such as the proposals made by for example Omanson, 1979, van Dijk, 1975, which I consider to be deficient in various respects. Due to space limitations I will not elaborate on these proposals or their drawbacks. The main difficulty in formulating such a parser can be elucidated by comparing story level (i.e. discourse) to sentence level grammars.

Within the generative framework, sentence grammars contain as part of their syntactic component the lexicon, which defines for each lexical item (i.e. each terminal node in the tree diagram) its syntactic category. On the other hand, the story grammar cannot in principle contain a similar predetermined and fixed lexicon of terminal nodes. The counterparts of the lexical items within sentence grammars are here propositions which can neither be listed in such a lexicon nor be determined by any straightforward and automatic procedure. Furthermore, the process of identifying the category of a given proposition is context dependent: the same proposition can be identified as part of a 'TRY PHRASE' in one context and as part of 'an OUTCOME PHRASE' in another. (This was elaborated elsewhere, see Shen, 1985).

A second related problem is that of the construction of the tree. The problem is how, according to this parsing model, the parser is supposed to attach the propositions and categories to the nodes in the tree, i.e., in terms of the X-Bar model, how the 'Bar structure' is to be assigned to the propositions and categories at all levels of the tree.

The proposed parsing procedures aim at solving both of the above problems. Corresponding to these two problems two types of procedures are distinguished:

1. *Category identification procedures*; these are responsible for the identification of the narrative categories which the propositions constitute.
2. *Node construction procedures*; these are responsible for the construction of the tree.

Before formulating these procedures, a key feature of the present model should be emphasized, concerning the processing assumptions which the procedures must meet. Processing a (narrative) discourse is a linear process in which adjacent units (in our case the propositions) are comprehended step by step, on the basis of their local relations, i.e. the causal relations.

Thus it is assumed that processing a story takes the following form: The parser conceives of proposition a', and then proposition b'. He then examines which causal relation holds between these propositions, if any. Only at this stage is he able to identify a's category (on the basis of the Category identification procedures), and to 'insert' it under its node in the tree (on the basis of the Node Construction procedures). The importance of this characterization is that it enables the parser to meet a fundamental requirement of any theory which aims at psychological reality, i.e., the requirement that only a limited number of information units be held in Short Term Memory (=STM) at any stage of the parsing of a given unit.

Note that the two procedure-types parse a given story by operating in tandem on each successive proposition. That is, it is not the case that the category identification procedures first assign all category nodes in the entire story, then the node construction procedures build the tree; rather, both procedures operate together to parse first one proposition, then the next, etc. Thus the tree is built up stage-wise, node by node. However, it is not clear at this point whether the procedures are being applied simultaneously or in sequence.

3.2. *The parser*

Let us introduce, then, the procedures for parsing a given story. As previously explained, a distinction is made between two types of procedures, i.e. the category identification and the node construction procedures (which are presented in Tables 5-1 and 5-2, and discussed in the sections 3.2.1 and 3.2.2, respectively). In order to illustrate how this parser analyzes a given story, I will again use the Czar story. The story is presented again in Table 4; its tree diagram according to the X-Bar Story Grammar is presented in Figure 4; while Table 5-3 presents the various stages of parsing of the entire story, according to the XBSG's parser.

As can be seen, Table 5-3 consists of two main parts, namely, the 'Category Identification' process, represented on the left half of the Table, and the 'Construction of the Tree' process on the right.

A note on terminology: When two propositions are causally related

Table 5-1: *The Category Identification Procedures*

Procedure I. Given: proposition a' encauses proposition b'.
Rule 1:
If a' is an intentional mental state, identify a' as the PROBLEM (i.e. write all projections of a' as PROBLEM)
Rule 2:
a' is the TRY if a' is an intentional action and-
I. a' is performed intentionally in order to accomplish b', or
II a' is intended to create the necessary preconditions for solving a PROBLEM that was identified in an earlier proposition (x) in the text (where x can be inferred or explicitly stated).
Rule 3:
If b' is neither a PROBLEM nor a TRY, identify it as the OUTCOME.

Procedure II. If a' does not encause b', move to c' and
Rule 4:
If both a' and b' encause c', then a' and b' form a conjoined proposition, analyzed by rules 1–3.
Rule 5:
If only b' encauses c', then b' starts a new Category in the diagram, to which Rules 1–3 above apply (and a' is conjoined to the preceding category).
P-held Rule
hold P until T (TRY) is completed

Table 5-2: *The Node Construction procedures*

NC1.
If a given node X encauses Y and Y is not a Dead End, attach X and Y to (a projection category) Y + 1 (or: insert X to the tree as a SPECIFIER of a projection of Y.
NC2.
If X encauses Y and Y is a Dead End, attach X and Y to <a projection category> X + 1.
NC3.
If neither (1) nor (2) holds, start a new unit.
NC4.
If a given OUTCOME node meets the conditions of the 'CENTRAL EPISODE', attach the following nodes to (a projection category of) that OUTCOME.

Table 5-3 *The processing of the Czar story*

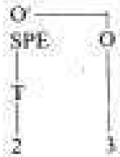
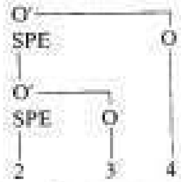
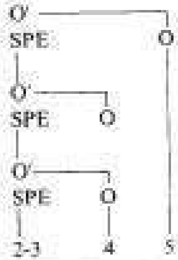
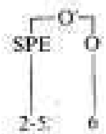
Category Identification		of the Tree		The Construction	
Pr. held in STM rel. = released inf. = inferred	Pr. processed & relations → = encause , = does not encause	Rules used R = rule pr. = procedure	Result	NC (Node constructions) Rules	Result
P inf.	2→3	R2	2 = T		
rel. P	3→4	R3	3 = O	NC1	
	4→5	R3	4 = O	NC1	
	5→6	R3	5 = O	NC1	
	5→7	R3	6 = O	NC1	

Table 5-3 *(continued)*

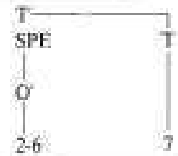
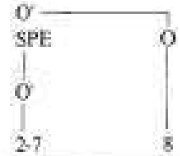
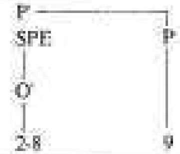
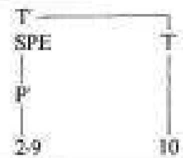
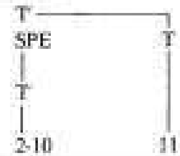
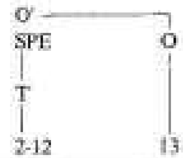
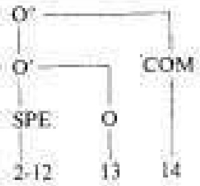
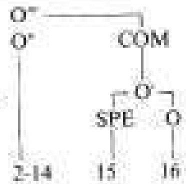
(a new) P inf.	7→8	R2	7 = T	NC1	
rel. P	8→9	R3	8 = O	NC1	
	9→10	R2	9 = P	NC1	
pr. 9	10→11	R2	10 = T	NC1	
pr. 9	11→12	R2	11 = T	NC1	
pr. 9	12→13	R2	12 = T	NC1	
pr. 9	13→14	R3	13 = O	NC1	

Table 5-3 *(continued)*

rel. 9	14,15	pr.II	move to 16		
(a new) P inf.	15→16	R3&5	14=O	NC2	
		R3	15=O (15 starts a new unit)		
rel. P		R3	16=O (16 is the last prop.)		
	15→16			NC1	
				NC4 (Since the O' dominating 2-14 meets the criteria of the 'Central Ep')	

either by 'cause' or by 'enable' relations (previously defined; see Table 3). I will use the cover term 'encause' to apply to both these types of causal relations. (The 'motivation' relation is included in 'enablement', as argued in Shen, 1985, where the causal relations are discussed in a more detailed manner.) Thus a given proposition a' encauses proposition b' iff a' 'causes' or 'enables' b'.

Let us consider first the Category Identification component.

3.2.1. *Category identification procedures*

As was said, these procedures comprise the four left columns of Table 5-3. The first column represents the proposition (represented as pr.) held in STM (Short Term Memory) at each stage. This column is necessary because of the 'PROBLEM-held' rule, according to which, at each stage, the parser is required to hold the PROBLEM which motivates the TRY of the given stage. All the propositions under this column have already been identified (at a previous or a given stage) as the (explicit or inferred) PROBLEM.

The procedures for category identification are presented in Table 5-1 below.

These procedures are divided into two types:

I. Procedures which apply to propositions a', b' if a'→b'(→=encauses); see parsing rules 1–3 below.
II. Procedures which apply to a', b' if a' does not encause b'; see parsing rules 4–5 below.

Let us briefly discuss each rule separately. Illustrations for the rules will be taken from the parsing analysis of the Czar story as presented in Table 5-3.

Rule 1 is used in order to identify the PROBLEM. The rule imposes two conditions that a given proposition(s) must meet in order to be identified as a PROBLEM:

The first condition might be called the 'contextual condition', that is, the requirement (shared by all three parsing rules 1–3 comprising Procedure I) that the proposition which is identified as a PROBLEM should encause the following propositions. This condition reflects the assumption, previously explained, that the identification of the category of a given proposition is context dependent. Thus the context here is the (immediate) subsequent proposition(s).

The second condition imposes a constraint on the semantic content of the proposition in question, namely that it represent an intentional mental state, (for example 'want', 'decide' etc.). This semantic constraint distinguishes the PROBLEM category from the TRY and OUTCOME. Consider, for example, proposition 9, which illustrates the above Rule.

9. and decided to rescue the daughters.
10. The heroes came

Proposition 9 meets the above two conditions and therefore is identified as a PROBLEM: 1) It encauses proposition 10 (the heroes' coming is motivated by their decision to rescue the girls); 2) It represents a mental state. According to rule 1, then, proposition 9 is identified as a PROBLEM.

The second rule, i.e. the TRY identification rule, also imposes both 'contextual' and 'semantic' constraints on the proposition to be identified as a TRy.

Two points are worth emphasizing with respect to this rule.

1. The 'constant' contextual condition (shared by all the rules in procedure I), requires that the proposition to be identified as belonging to the TRY category should encause the following proposition(s). Over and above this condition, Rule 2.II requires that the preceding proposition(s) must also be taken into account (provided that Rule 2.I does not hold); that is, the parser is assumed to identify an earlier (explicitly stated or inferred) PROBLEM.

2. As for the 'semantic' constraint, note that what distinguishes propositions to be identified as a TRY from those to be identified as a PROBLEM is that the former represent an intentional action whereas the latter represent an Intentional state.

In order to illustrate this rule, let us consider the parsing of proposition 11; the relevant row of Table 5-3 is, presented below in Table 6-1, represents the parsing of proposition 11 (which is also presented below in addition to proposition 12).

11. and fought the dragon.
12. They killed the dragon.

According to the above fragment of Table 5-3, we examine proposition 11 to determine whether it encauses the next proposition (i.e. proposition 12), and find that it does; this is represented by an arrow in the second column connecting propositions 11 and 12. The next step is to identify which rule (from among rules 1–3) is to be applied to this proposition.

Rule 1 is rejected as it requires the proposition to be a mental state. Rule 2.I is then selected, as this proposition is indeed an intentional action performed in order to accomplish proposition 12. Since Rule 2 identifies a given proposition as a TRY, we accordingly conclude by assigning the label TRY to proposition 11. These parsing steps are presented in the third and fourth columns of Table 5-3.

Table 6-1: *The category identification of proposition 11*

Category Identification			
Pr. held in STM rel. = released inf. = inferred	Pr. processed & relations → = encause , = does not encause	Rules used R = rule pr. = procedure	Result
pr. 9	11→12	R2	11=T

Rule 3 is straightforward and needs no further comment. An illustration of this rule is to be found in the parsing of proposition 6.

6. A dragon kidnapped the three daughters.
7. As they were being dragged off they called for help.

This proposition encauses the next proposition (proposition 7) and thus falls within the domain of rules 1–3. After checking, whether the first two rules can be applied to this proposition, the parser rejects both. Proposition 6 does not represent a mental state (and therefore rule 1 is rejected) nor does it meet the conditions of either Rule 2.I or 2.II: it is not performed in order to accomplish the following proposition which describes the girls calling for help, and it is not intended to create the necessary conditions for solving the current PROBLEM, since, in fact, it solves this very PROBLEM (that is, it obtains this very goal). Hence, neither rule 1 nor rule 2 applies, resulting in the application of Rule 3, according to which proposition 6 is identified as an OUTCOME.

Related to the above, we must take special note of the procedure for identifying the last proposition of a given story. Clearly, neither rules 1–3 nor rules 4–5 can be applied to the last proposition of the story since, by definition, this proposition is not followed by any other proposition, which is a prerequisite of applying any one of rules 1–5. Since the last proposition of the story must nevertheless be assigned some structural category, the Outcome category has been chosen as the most natural candidate — for, unlike the Problem and Try categories, the notion of Outcome emphasizes the fact that some final state has been reached. To put it differently, unlike the Problem and Try categories, which indicate than an action(s) is (to be) taking place that will lead to some final state, the Outcome category represents this final state.

Rules 4 and 5 are used throughout for parsing propositions which are not causally related. Rule 4 will not be discussed here, since it is not applied to any of the parsing stages of the Czar story. (It is, however, relevant for other stories which are discussed elsewhere; cf. Shen, 1985).

Rule 5 applies to those cases where there is a 'gap' in the continuity of the causal chain of events. As the rule states, given that two propositions a' and b' are not causally related, where only b' encauses the following proposition(s), then a new unit started by b' is constructed, while a' is conjoined to the preceding category. A case in point is propositions 14 and 15 to which rule 5 applies. The reader is referred to the relevant row in Table 5-3.

13. and rescued the maidens
14. The heroes then returned the daughters to their palace.

15. When the Czar heard of the rescue,
16. he rewarded the heroes handsomely.

First the parser determines that propositions 14 and 15 are not causally related, since the fact that the Czar heard of his daughters' rescue (proposition 15) is not encaused by the returning of the daughters to the palace (proposition 14). (He might hear of it, for example, by somebody delivering the message to him, or otherwise.) This is reflected in Table 5-3, where 14 and 15 are connected by the sign "," which means that they are not causally related. Hence the parser must invoke Procedure II, according to which it moves to proposition 16 and tries to determine which of the two rules subsumed under procedure II, (parsing rule 4 or 5), can be applied. Since it is only proposition 15 (i.e. the fact that the Czar heard about the rescue) that causes the Czar to reward the heroes (i.e. proposition 16) and not the conjunction of propositions 14 and 15, rule 5 applies (see the third column of the relevant row of Table 5-3). According to this rule proposition 15 starts a new EPISODE, whereas proposition 14 is conjoined to the preceding category, and is identified according to rule 3 as an OUTCOME (see the fourth column).

The last rule, which applies to both procedures I and II, is the 'PROBLEM-held' rule. The use of this rule is represented in the left-most column of Table 5-3. As can be seen, each time a TRY is identified, the last PROBLEM is released only when this TRY has been closed and a new unit (always an OUTCOME) begun. An example can be seen in the parsing of propositions 10–13.

10. the heroes came
11. and fought the dragon.
12. They killed the dragon
13. and rescued the maidens

Starting with proposition 10, the parser applies rule 2.II since it is an intentional action intended to create the necessary precondition for solving the PROBLEM presented in proposition 9 (i.e., in order for the heroes to rescue the daughters, they have to come to the place where they are held).

Moving on to the next proposition (i.e. proposition 11), the parser still holds proposition 9 in STM (according to the P-held rule), and identifies proposition 11 as the same TRY category, since 11 is intended to create another precondition for solving the (yet unsolved) PROBLEM stated in 9. This P-held rule is further applied to the parsing of proposition 12 (which is also identified as a TRY). However, when arriving at proposition 14, the TRY unit is completed (14 is identified as an OUTCOME), allowing proposition 9 to be released, according to the P-held rule.

As a further illustration, the reader is referred to Appendix 2, where the parsing procedures to be followed in analyzing the Farmer story are presented in detail (due to space limitation I will not discuss this analysis).

3.2.2. *Node construction (NC) procedures*

The stage-by-stage construction of the tree is presented in the right half of Table 5-3,, and consists of two main parts represented in the fifth and sixth columns respectively: the node construction (=NC) procedures (see Table 5-2), which apply to each proposition at a given parsing stage, and the result of applying the procedures, i.e. (sub) tree that is constructed.

NC1
If a given node X encauses Y and Y is not a dead end, attach X and Y to (a projection category) Y+1 (or: insert X in the tree as a SPECIFIER or a projection of Y).

In addition to the notion of a 'projection category' (which has already been explained in Section 2) the first procedure involves another important notion, namely, Dead End. This notion represents a central phenomenon in narrative texts. Its definition is given in [2].

[2]: *DEAD END*:
A proposition b' in a sequence a', b', c', is a dead-end if b' is encaused by a' and b' does not encause c'.

This notion applies to a case where a given proposition is encaused by the preceding proposition but in itself does not encause the following propositions(s). The concept is similar to what researchers like Schank (1975) have likewise called a 'dead end', that is, a unit (in our case a proposition) which marks a dead-end in the narrative sequence of events in that it does not encause the following events. An example case in point is proposition 14:

13. and rescued the maidens
14. The heroes then returned the daughters safely to their palace.
15. When the Czar heard of the rescue,

Proposition 14 is encaused by proposition 13 (the rescue of the maidens enables their returning safely to their home), but does not encause proposition 15: the daughters returning to the palace is neither a necessary nor sufficient condition for the Czar to hear of his daughters' rescue. Proposition 14, then, counts as a dead-end.

With the above two definitions out of the way, we may turn to an illustration of the way the parsing rule NC1 is applied. Consider, for example, the parsing of propositions 2-3-4 of our story, as presented in the relevant rows of Table 5-3.

2. One day, the daughters went walking in the woods.
3. They were enjoying themselves so much that
4. they forgot the time

Once proposition 2 is identified as belonging to the ('basic') category TRY, and proposition 3 as a ('basic') OUTCOME (by using the category identifying procedures), the next parsing stage is the construction of a node to dominate both these nodes.

Using NC1, the parser begins by determining that these two nodes are indeed causally related (the daughters' walking in the woods enabled their enjoyment). It then determines that the OUTCOME node (dominating proposition 3) is not a dead-end (since it encauses proposition 4). Given the above, it attaches the TRY node to a (projection category) OUTCOME'; that is, the node dominating T and O is O'.

The above illustration reflects a major advantage of the proposed parser (previously mentioned in section 3.1). In order to parse two given nodes X and Y, the user of this parser must hold in his STM buffer only the nodes in question and the following proposition. (The need to hold the following proposition is implied by the [sub]condition according to which Y is not a dead-end, since in order to determine whether a given proposition is a dead-end the parser must check whether or not it encauses the following proposition.) Thus, in parsing any two adjacent nodes, the STM only has to hold on to a (relatively) small amount of information.

This feature of the parser meets a crucial requirement for any psychologically valid theory, that is, given that STM has a limited capacity, the parser requires the STM to hold only a limited number of information units at any given stage of the on-line processing of the unit.

As was previously explained (in section 3.1), this crucial requirement is met by both the Node construction procedures and the Category identification procedures.

NC2
If X encauses Y and Y is a Dead End, attach X and Y to (a projection category) X + 1.

The second procedure applies to the case where the two nodes to be parsed, X and Y, are causally related but Y is a dead-end, that is, Y does not encause the following proposition. In this case the application of NC2 results in attaching Y to a projection category of X plus one bar (in the former case where Y was not a dead-end, it was X that was attached to Y + 1).

An example is the parsing of proposition 14.

13. and rescued the maidens
14. The heroes then returned the daughters safely to their palace.
15. When the Czar heard of the rescue,

At this point the parser has already identified the unit dominating propositions 2–13 as an O' (an OUTCOME') (see the relevant row in Table 5-3). Moving towards proposition 14 (which describes the returning of the daughters to their palace) it identifies 14 as a dead-end, since it does not encause proposition 15 (as explained previously).

Given that proposition 14 is a dead-end, the parser applies NC2, which results in attaching proposition 14 to a higher level node — O'' (a projection category of the preceding O' dominating 2–13), as its COMPLEMENT.

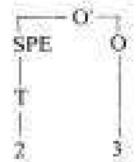
NC3 will not be addressed here, mainly because the Czar story does not involve its application anywhere (I have elaborated on this point in Shen, 1985).

It should be emphasized that during the node construction procedures, the parser is assumed to hold in STM the subtree (that is, the root node of that subtree) which has already been processed at the preceding stage of the tree construction. Consider, for example, the processing of propositions 3 and 4. The relevant row of Table 5-3 is presented below in Table 6-2.

2. One day, the daughters went walking in the woods.
3. They were enjoying themselves so much that
4. they forgot the time

When the parser reaches these two propositions he is assumed to be holding in STM the (previously) inferred PROBLEM (which is: 'The girls wanted to enjoy their walking in the wood'). He then identifies the category of proposition 3 on the basis of its causal relations with proposition 4. At this stage, proposition (2) has been released from the STM buffer and transferred to Long Term Memory, where it represents the node dominating whatever portion of the story that has been processed so far; note, however, that it is only after the 'construction of the tree' stage that proposition 2 is finally released from STM, since only at this stage is it assigned on the basis of its causal relations with proposition 3 to the structural position of a SPECIFIER of the OUTCOME dominating this latter proposition. (Note that what is actually maintained in STM is not merely a proposition [in the above example,

Table 6-2: *The parsing of proposition 3*

Category Identification				The Construction of the Tree	
Pr. held in STM	Pr. processed & relations	Rules used	Result	Node Construction rules	Result
rel. P	3→4	R3	3→O	NC1	

proposition 2] but rather the last node that has been processed up to the given stage).

In sum, the construction of the tree always presupposes that the parser holds in STM the previously processed node (in addition to the proposition representing the current PROBLEM).

NC4
If a given OUTCOME node meets the conditions of the 'Central EPISODE', attach the following nodes to (a projection category of) that OUTCOME as its COMPLEMENT.

The definition of the notion of 'the CENTRAL EPISODE' is presented in [3-1] below:

[3-1]
The **CENTRAL EPISODE** is the first EPISODE in the story which meets the following three conditions:

1. Its Problem is that of the Protagonist. Note that no formal definition of the notion of Protagonist is given here, since basically the Protagonist is identified on the basis of pragmatic considerations; usually, however, the protagonist is presented at the beginning of the story, typically in the Setting. Moreover, there can be more than one character fulfilling the role of protagonist, as in the Czar story, in which both the three girls and the three heroes fulfill that role: the girls, introduced in the Setting, are such due to the fact of their kidnapping by the dragon which initiates the series of events in this story; the heroes due to the fact that they carry on the attempt to rescue the maidens.

2. The Problem of that Episode is not a sub-Problem of a higher-level Problem, that is, it is not a Problem whose solution enables the solution of a Problem of another Episode.

3. The EPISODE does not encause any other EPISODE which meets the first two conditions.

The 'CENTRAL EPISODE', then, is the last encausing EPISODE in the story performed by the protagonist, and whose PROBLEM is not embedded within a higher level PROBLEM. (The formulations of these definition were discussed in a detailed manner in Shen, 1985.) Note that this procedure can be viewed as the only exception to the first procedure, in that it postulates that, given two causally related nodes X and Y, where X is a CENTRAL EPISODE node, it is node Y which is to be attached to a projection category of the X, rather than the contrary (as procedure 1 would suggest). This sole exception to procedure 4 pertains, however, only to the highest level EPISODE in a given story.

As can be seen in Table 5-3, the O" dominating propositions 2–14 (whose HEAD is a proposition 13 which describes the rescue of the daughters from the dragon by the three heroes) is identified as the 'CENTRAL EPISODE'; and therefore procedure 4 is applied, which results in attaching the following unit (the O' dominating propositions 15–16) to a projection category of this O" as its COMPLEMENT. Let me briefly explain how this O" meets the conditions presented.

1. The first condition in [3-1], states that the central EPISODE's PROBLEM will be assigned to the protagonist. The O" dominating propositions 2–14 meets this requirement, since, as previously explained, are identified as protagonists.
2. The second condition is met in that the PROBLEM of the heroes is not included in a higher-level PROBLEM (such as the attempt to gain a reward from the Czar or the like).
3. The third condition is also met by this EPISODE. Although this EPISODE does encause the last EPISODE of the story (the O' dominating propositions 15–16), the latter does not meet the second condition, since its PROBLEM is that of the Czar who is not the protagonist of the story. Hence the O" dominating propositions 2–14 meets the third condition of [3-1].

As no other EPISODE in the story meets these three conditions, the above O" is identified as the CENTRAL EPISODE, and the following O' (propositions 15–16) is attached to its projection category as a COMPLEMENT.

As a further illustration of the use of these Node construction procedures (as well as the Category identification procedures), the reader is referred to Appendix 2 where the step-by-step parsing of the (previously analysed) Farmer story is presented.

4. Some empirical evidence for the XBSG

The preceding sections have presented the main characteristics of the XBSG model as a formalism for representing the structure of stories. As was previously explained, the XBSG model also claims to be an adequate formalism for representing (some aspects of) the processing and storage of narrative text.

The main point to be emphasized regarding information processing is that processing and storage of information in long-term memory involves the reorganization of that information into a hierarchical structure at whose top is an 'entry' under which the information is stored. This informational structure is reflected in recall and summary experiments, in which the information units are not equally well remembered: some units (or 'entries') are recalled better than others. In other words, some information units are more 'important' than others. (This point is elaborated in Shen, 1985 and Shen, 1988.)

In order to provide some initial support for the XBSG model's ability to formalize this central aspect of the information processing of narratives, the results of summary experiments conducted by the present author as well as by Rumelhart (Rumelhart, 1977) were analyzed. The materials used in my own experiments were three stories (two of which were taken from the 'Decameron', and the third from a collection of short stories written by the Israeli author Shai Agnon), while Rumelhart's experiments used the Czar story (analyzed above) and the Farmer story analyzed in Appendix 1. In both experiments the subjects' task was to summarize three stories which they had read.

Here only the latter data (i.e. those obtained in Rumelhart's experiments) will be addressed, for two reasons:

First, it is good methodology to show that the XBSG can account for experimental findings other than my own.

Second, the space limitations imposed by a brief paper must be taken into account. Not only are Rumelhart's two stories shorter than those I used, they have already been analyzed in this paper (see Figures 4 and 5); thus, it will be convenient to use them again. (For more information regarding the data obtained in my own experiments, see Shen, 1985.)[3]

The general purpose of our analysis has been to examine the connection between the 'Importance degree' of a given proposition, as reflected in the subjects' protocols, and its structural position in the tree diagram generated by this grammar. Recall that the basic unit of the story is the Episode, which is defined as O^n (where ^{n} is greater than 0); a new Episode begins whenever a new Problem is introduced. In the case of the Czar story we postulated four linearly ordered Episodes: the first consists of propositions 2–6, which describe the dragon's kidnapping the girls who were enjoying themselves in the woods); the second consists of propositions 7–8, describing the three heroes hearing the girls call for help; the third describes the actions leading up to the rescue of the girls (propositions 9–14); and the fourth (propositions 15–16) describes the heroes being rewarded by the Czar. These four 'linear' Episodes are dominated by a complex Episode which is the 'Central Episode' of the story (consisting of propositions 2–16).

From this observation, together with the principle that the most important proposition for any given unit is its Head proposition one can derive a grouping of the story propositions into three levels (or degrees) of 'Importance'. These levels are represented in Table 7, which specifies the grouping of the propositions for both the Czar and the Farmer story. According to Table 7, the story consists of the following levels of importance:

1. The highest level of 'Importance' consists of the HEAD proposition of the 'Central Episode' of the story. In the Czar story this is proposition 13 (which describes the rescue of the girls by the heroes); in the Farmer story

Table 7: *The distribution of propositions according to their 'Importance' degree*

The Czar's story:			
degree of	Level 1	Level 2	Level 3
Number of proposition	13	6, 8, 12, 16	1, 2, 3, 4, 5, 7, 9, 10, 11, 14, 15
The Farmer story:			
degree of 'Importance'	Level 1	Level 2	Level 3
Number of proposition	15	1, 3, 4, 8, 10, 11, 14	2, 5, 6, 7, 9, 12, 13,

it is proposition 15 (which describes the failure of the farmer's attempt to make peace with the serpent).

2. The second level of 'Importance' consists of the Head propositions of the 'simple' Episodes dominated by the complex central episode; in addition to these, this level also includes the Head proposition of the Try unit of the Central Episode. In the Czar story this level includes props. 6, 8, 12 and 16; in the Farmer story it consists of props. 1, 3, 4, 8, 10, 11 and 14.

3. The lowest level of 'Importance' consists of the rest of the propositions, that is, those propositions which do not represent the Head of the Central Episode or any of the other Episodes of the story (or of the Central Episode's 'TRY' unit). The propositions included in this group are 1, 2, 3, 4, 5, 7, 9, 10, 11, 14 and 15 in the Czar story, and 2, 5, 6, 7, 9, 12 and 13, in the Farmer story.

The following hypothesis was tested. It was hypothesized that for each subject, the probability of occurrence of a given proposition in subject test protocols correlates with its level in the above 'Importance' scale, across stories and across subjects. Thus, propositions of the first degree have the highest probability of occurrence, followed by those of the second degree, while the third group has the lowest probability. Recall that the task that Rumelhart's subjects had to perform was a summarization task. In this experiment, 10 subjects (students of psychology and linguistics) were asked to read each story and then summarize it with no time limitations. (The protocols are presented in Rumelhart, 1977.)

As explained, these protocols were analyzed within the XBSG framework. This has been done as follows. The sentences comprising each protocol were divided into three levels of Importance as presented in Table 7. The decision as to whether a given sentence matches in fact the corresponding proposition has been determined according to the presence or absence of the Predicate: a sentence which contained the corresponding predicate was considered as representing the corresponding proposition. In order to check on the reliability of my judgments as to the presence or absence of a given proposition from the protocols, I presented a sample of 5 protocols to another judge who was asked to mark the story propositions represented in each protocol. The agreement between the other judge's determinations and mine was around 90 percent (most of the disagreements were resolved through discussion).

The relative frequency of each set of proposition belonging to a given importance level was examined, but without any variance analysis (no

Table 8: *Mean square*

	Story 1	Story 2
Level 1	100%	100%
Level 2	48%	53%
Level 3	5%	11%

such analysis had been performed in Rumelhart's paper, either, on the ground that ... 'traditional modes of analysis are difficult to apply ...' [p.283]). The results are presented in Table 8.

Since no parametric analyses have been performed on these data, the data presented in Table 8 represent the mean square (percentage) of the three levels of importance in each one of the stories. As can be seen, the main result is that the percentage increases in correspondence with the level of importance. Thus, each one of the 20 summaries (10 summaries for each story) revealed the pattern that was predicted by the XBSG, with no exception: Proposition(s) belonging to the first level would occur more frequently than those belonging to the second level which, in turn, will occur more frequently than those belonging to the third level.

These data (as well as the data obtained in my own experiments) provide some support for the hypothesis that the probability of occurrence of a given group of propositions does indeed increase as a function of its 'Importance'.

Conclusion

Having described the general framework of the XBSG, we may conclude by pointing out, briefly, the advantages of the XBSG over the Story Grammar model, with regard to the shortcomings of the latter model, as described in section 1.

Firstly, the 'HEAD-MODIFIER' distinction, a basic feature of the XBSG, enables this model to meet the descriptive adequacy condition better. The structural description it assigns to the stories it analyzes better reflects readers' intuitions as to the structural roles fulfilled by the propositions of these stories — i.e. the distinction between propositions which represent the 'essential and unreducible' core (i.e. the 'most important' information) of the entire unit, and those which merely 'expand on' or 'elaborate on' this core.

Secondly, the XBSG is observationally more adequate than the S-G, in that it prevents the generation of unacceptable structures which may be generated by the S-G model. As was previously argued (see section 1), any story grammar must contain a mechanism which will specify which (non-terminal) nodes in the structure are required to be explicitly represented in the story. Such a mechanism is needed in order to account for the fact that every story contains both inferred propositions (which are dispensible in the story) and propositions which must be explicitly present if the generation of unacceptable structures are to be avoided.

No such mechanism appears to be part of, or suggested by the standard S-G model, and hence unacceptable structures may, in principle, be generated by the S-G mode. This PROBLEM, however, is solved by the XBSG, by imposing the constraint that a given phrasal category (for example a TRY PHRASE) consists obligatorily of a proposition(s) which represent(s) its 'HEAD' (i.e. a proposition which is dominated by a category of the same type).

Thirdly, the XBSG accounts better than the S-G model for psychological data collected from recall and summary experiments, including those collected by S-G researchers, (as explained in the case of the Czar story). This is mainly due to the fact that of the two suggested predictors of 'Importance' — the one proposed by the XBSG (namely, the 'structural role' of a given proposition [i.e. whether it is dominated by a 'HEAD' or a 'MODIFIER']) works better than the one suggested by most story grammarians (that is, the height of the proposition in the tree), in explaining a proposition's probability of being recalled in the experiments.

The fourth advantage of the X-BAR model lies in its being a more restricted form of grammar when compared to the standard S-G model. As explained, this is due to the fact that the XBSG imposes the constraint that all structures generated by the grammar, (except at the highest level of the tree) must conform to the basic X-Bar rule [i.e., $\mathbf{X^n \rightarrow (SPECIFIER) - X^{<n-1>} - (COMPLEMENT)}$].

The fifth advantage of the XBSG is that it suggests a formal and explicit procedure for the crucial problem of mapping the textual units onto the tree diagram of a given story — that is, it incorporates a parser. Furthermore, this parser meets the constraint regarding the limited capacity of memory.

Finally, in addition to these basic advantages of the X-BAR model over the S-G's, there is an important methodological advantage. The X-BAR system has been accepted by most syntacticians working within the

generative framework as part of linguistic competence. Therefore, there is no theoretical price to pay in assuming that the X-BAR competence is also involved in the generation of linguistic phenomena larger than the sentence — the narrative discourse.

Thus, while retaining the generative framework and action categories of standard Story grammars, the XBSG gains important advantages over the standard S-G model both by radically revising its representational formalism and by proposing explicit parsing procedures.

Comparison to other models

In addition to the detailed comparison of the XBSG to the standard story grammar approach, it will also be instructive to consider the relationship between the XBSG and other theories of story comprehension. Several theories of story structure and understanding have recently been developed, (for example, Black and Bower, 1980; Brewer and Lichtenstein, 1980, 1981; van Dijk, 1977; Lehnert, 1981; Omanson, 1982; Schank and Abelson, 1977 inter alia), which represent story structure and knowledge structure involved in processing stories, by other means than grammars. Due to space limitation I will consider only three representative theories: Schank and Abelson's 1977, Black and Bower's 1980, and Trabasso and van-den Broek's 1985. Some of the following considerations will hold, however, for the other above-mentioned theories as well. (Since the differences between the story grammar approach and other theories of story comprehension, as well as the former's advantages over the latter, have already been thoroughly discussed [cf. Mandler, 1980, 1982; Rumelhart 1975, 1977, 1980; Frisch and Perlis, 1981, inter alia], I will focus on the specific advantages of the XBSG, i.e., those characteristics of the XBSG which are not shared by the standard story grammar approach.)

Black and Bower — a problem-solving transition network

Black 1978 and Black and Bower 1980 proposed a theory called the Hierarchical State Transition theory (HST). According to these authors, who work within a transition network framework (see also Brewer and Lichtenstein 1980, 1981), knowledge acquired through reading is represented in terms of Problem-solving structure (for example, Black and Bower, 1980; Brewer and Lichtenstein, 1980, 1981; see also Rumelhart, 1977). Furthermore, this approach is based on 'goal-subgoal' hierarchies which are revealed in other domains of behavioral action and hence are not unique to stories.

At the local level of immediate connectivity between events these authors argue that many stories have an overall structure consisting of STATE-transition-STATE sequences. For example, in one of the stories used by Black, the character is looking in the library and bookstore for a book (i.e., NEED BOOK - look in library - FAILURE; STILL NEED BOOK - look in bookstore - SUCCESS). Nested within each of these superordinate actions is a hierarchy of subordinate actions, each of which also consists of STATE-transition-STATE sequences that describe the particulars of looking in the library and bookstore.

From this analysis, Black makes two hypotheses:

1. Content high in the analysis' hierarchy is remembered better than content which is lower.
2. Content of the 'critical path' that provides the successful transition from the initial state to the ending state of the story is remembered best.

Black 1978, and Black and Bower 1980, report a number of experiments supporting these hypotheses.

Comparison to the present theory

Black and Bower's theory (as well as that of Brewer and Lichtenstein) share with the present one the basic observations that stories are about human actions and that problem-solving notions are involved in processing stories. This may explain why the evidence given in Black and Bower, 1980 is in full agreement with the XBSG's predictions — as a (re)analysis of the evidence supporting Black and Bower's theory within the XBSG framework would demonstrate. (Due to space limitations I will not elaborate on this reanalysis.)

The theories differ, however, in the representional system they use; Black and Bower's approach relies on a transisition network system, ours is based on an X-Bar type of grammar. Black and Bower raise several arguments against the use of 'Grammar' in the domain of stories. These arguments have already been discussed and rejected (cf. for example, Frisch and Perlis, 1981; Rumelhart, 1980; Mandler and Johnson, 1981, and therefore will not be discussed here. Rather, I will point out three advantages of the XBSG as a type of story grammar vis-a-vis the HST).

1. The XBSG is a more constrained representational system, in that it constrains the possible 'Problem Solving' structures which can be generated. Thus, coupling the problem solving structure with the X-Bar scheme (or X-Bar rule format) yields a restricted form of formalism, which both uses the action (or problem-solving) categories and is at the same time capable (as argued in section 1.1) of excluding certain 'Problem solving' protocols as ill-formed texts, i.e., as non-stories.

2. Using the XBSG notations, furthermore, enables a more parsimonious representation of story structure and the knowledge involved in story understanding in comparison to Black and Bower's proposal. Thus, within this framework, the basic distinction between an essential and a non-essential proposition(s) stems from a single principle, operating on all levels of the tree.

3.The XBSG system is capable of representing more refined distinctions among 'important' events. Thus, Black and Bower's proposal offers a distinction between certain levels in the hierarchy but only on (what story grammarians would call) the Episode level, while differences of 'importance' among propositions belonging to an Episode sub-component (for example, the propositions which comprise the Episode's Goal) are not accounted for by this model. In contrast, the XBSG's distinction between HEAD and MODIFIERs, which operates on all levels of the tree, does provide such refined distinctions.

As for the other dimension of 'importance' proposed by Black and Bower's theory, namely, the inclusion (or exclusion) of a given event in the 'critical path' of a given story, it should be noted, again, that not all events belonging to the critical path are of equal importance, a fact which goes unexplained in this theory, but is accounted for by the XBSG.

It should be added that the HST's hypotheses as to the representation of stories in memory are generally consistent with the hypotheses of the present analysis. Recall that the distinction between subordinate and superordinate actions (a mainstay of the HST approach) is also represented within the XBSG, through the use of the MODIFIER and HEAD nodes, respectively. Similarly, this principle holds for the distinction between events that contribute to the transition from initial to end state and those that do not. The latter (for example, Dead end events) will usually belong to the third level of importance; the former, to either the first or second levels.

Summary of Schank and Abelson's theory

Schank and Abelson's 1977 influential book is concerned (among other topics) with the representation of the knowledge involved in the processing of narratives. Three levels of representation are described: 1. the Knowledge Structure level, for themes, goals, plans and scripts; 2. the Macroscopic Conceptual level; 3. The Microscopic Conceptual Dependency level.

1. The first level, namely, the Knowledge Structure level is the most global level in which global structures are represented, such as themes, goals, plans and scripts.

2. The Macroscopic Conceptual level is the level in which goal-oriented global actions that are summaries of action sequences are represented. For each script there is a fixed Conceptual Dependency event that 'best describes or summarizes the actions in the script' (Schank and Abelson, 1977: 161), and which is called the MAINCON (Main Conceptualization). This MAINCON belongs to a higher level of representation, and functions as a 'pointer' to the script; it is 'an abstraction that names the entire sequence. It allows for the hearer to concentrate on the main flow and retrace the details later' (163). Thus, at this level a given story can be represented by all the MAINCONS of the scripts comprising that story and connected to each other causally. These MAINCONS provide a summary of the goal-oriented actions in a story.

3. The most detailed level is the Microscopic Conceptual Dependency level for interconnected causal claims of physical events. It consists of conceptually 'primitive' actions and states called conceptualizations which are thought to comprise the meaning of each sentence in a text. These primitive actions and states, as identified by Conceptual Dependency theory, are connected in memory by four types of causal relations (enable, result, initiation, reason).

When Schank and Abelson address the question of how well specific actions and states are remembered, two principles are introduced. The first is that of connection: dead end sequences, and events with few connections, are hypothesized to be poorly recalled (Schank, 1975b). The second is that of the level of the action described: actions and states in the macroscopic level are hypothesized to be remembered better than those in the microscopic level.

Comparison to the present theory

Both theories share the assumption that processing is (at least partially) schema driven, and that this schema is a type of problem-solving structure. The two theories differ, of course, with regard to the basic components of representations: whereas the XBSG uses propositions as its basic components, Schank and Abelson's theory uses conceptualizations.

As to the question of how well specific actions and states are remembered, the first principle proposed by Schank and Abelson, namely, 'connection', is shared by the present theory as well. Thus, within the present framework a 'Dead end' event is hypothesized to be poorly recalled, since it is represented under the 'Complement' node of a given constituent in the tree (see section 4).

The main difference lies in the second principle. Whereas Schank and Abelson's theory assumes a definite inventory of scripts, with a fixed and predetermined semantic unit (the MAINCON) for each script referred to in the story, the present theory assumes no such apriori semantic content; rather, our use of the notion of HEAD (namely, that component which is of the highest importance) is a relational notion, in that the semantic content represented by a given Head proposition can represent a Specifier in another story or at another level of the same story (see also Shen, 1985).

The advantage of using such a relational term is twofold:

1. The claim that a fixed and predetermined event always summarizes the script in question fails to account for the fact that the importance of a given conceptualization may vary in different contexts (as discussed in Shen 1985).

2. Instead of specifying the MAINCON for each script (or even for sets of scripts), a **general** principle, applicable to a wide variety of narratives regardless of the scripts that they represent, is obviously preferable for reasons of parsimony. On these grounds, too, the XBSG outperforms Schank and Abelson's theory, in that it proposes a single principle of 'importance', while the latter appeals to two unrelated principles, each belonging to a different level of representation.

Summary of Trabasso's proposal

Recently, Trabasso and his colleagues have been developing a new model of story structure and comprehension, the Causal Network model. According to this model comprehension is based on a problem-solving process (see Black and Bower 1980) in which the reader's goal is to discover a sequence of causal links that connect the story's opening to its final outcome. The story is represented as a causal network whose nodes represent story statements; the arrows between the nodes in the network indicate the causal (or temporal) relations between the nodes in question.

The main thrust of this model is the idea that causal relations play a central role in the comprehension of stories. In particular, two properties of the causal network were found to predict judgments of importance (cf. for example, Trabasso and Sperry, 1985):

1. The number of direct causal connections; thus, it was argued that the higher the number of causal connections leading from a given statement to other story statements, the higher its probability of being recalled, retained in memory, and/or being assigned a high rate of importance.

2. Whether or not an event was in a causal chain from the opening to

the closing of the story. Thus, it was found that 'events that were in causal chains were recalled and retained over one week better than events that lacked causes or consequences'. Furthermore, the authors found that '... the coherence of a story and its memorability were related directly even when we defined coherence in terms of the percentage of events on the causal chain' (108).

Among those two factors, however, occurrence on the causal chain was found to be of higher value in determining recall than the number of causal connections. Trabasso et al. continue: When we examined conditional recall, the results showed that being on the causal chain overrode any single causal-link effects.... We noted, however, that those events that define the causal chain, open the field (i.e., the causal field — Trabasso et al. are referring to the Setting), and end the chain are best recalled. Goals, which have the most causal chain consequences, however, were most important in judgments' (ibid.).

Two points should be emphasized with respect to this model.

1. In order to identify the causal chain of a given story, a more global analysis must be conducted to identify the opening and closing of the story; once the opening and closing statements are identified, the comprehender traces the story events via causal conncections from the opening to the closing events. Those events having causes and consequences leading from the opening to the closing are in the causal chain, while those which lack causes or which do not eventually lead to the closing events are 'dead-ends' events. Thus, the 'local' analysis in terms of causal relations between pairs of statements is supplemented with a 'global' analysis in terms of opening and closing a certain causal chain. This 'global' analysis represents the main 'story grammar' categories, such as setting, initiating event, goal, outcome etc.

2. A main advantage of representing stories in a causal network (rather than, for example, a tree diagram) is that a network allows for representing 'non-linear' causal relations. Thus, Trabasso et al. assume that direct causal relations between pairs of statements may operate over a distance in the text. This important observation which can be represented by networks but not by trees, allows for a given statement to have more than two causal connections (namely, to its antecedent and to following statements).

Comparison to the present theory

Both theories share the assumption that processing a narrative is based on identifying both the global organization of the story — which is basically a 'problem solving' structure — and the 'local' causal relations between propositions in the story.

Moreover, on the issue of importance, both models share the view that the events comprising the causal chain are more important than 'dead-ends'. Recall that within the XBSG framwork 'dead-ends' are represented on the 'importance scale' as 'Complements' and these are of the lowest degree of importance. As for the other importance determinant, namely, the number of connections, the apparent difference between the models can be reduced to a minor one on the basis of the following two considerations.

1. As mentioned above, this factor is the less effective of the two.

2. Note that the main evidence for the role played by this factor relates to: A) The fact that recall for dead-ends is poorer than for causal chain events, which can be explained by the fact that the dead-ends have fewer causal connections than do causal chain events. As already argued, this finding is in full accordance with the XBSG which assigns the lowest degree of importance to dead-ends. B) The second consideration relates to the high probability of recall of the Setting of a given story, which can be accounted for by the high connectivity of this category. Since the XBSG has nothing to say regarding the memorability (and hence the importance) of the Setting category, there is at present no contradiction between the two models on this issue. Further development of XBSG, however, should take into consideration this finding. C) The third point is that the importance of goals depends not on their position in the hierarchy, but rather on their degree of connectivity. The XBSG model, too, shares with Trabasso et al.'s model the claim that the hierarchical position of a given goal proposition is not the sole, or even the main determinant of its importance. An analysis of the degree of importance of goals within the XBSG, does indeed suggest a correspondence between importance and connectivity.

All these considerations argue that Trabasso's contribution regarding connectivity can be viewed as a way of supplementing the XBSG (or, for that matter, similar representational systems) with a procedure for identifying the importance of the story categories (such as Setting and goals) rather than an alternative way of representing story structure.

Trabasso's proposal has several other major contributions to make as regards the various proposals that have been discussed so far, as well as with respect to the XBSG. In particular, it is worth mentioning in passing that the definition of causal relations, by appealing to the logical criteria of 'necessity in the circumstances' and counterfactual reasoning provides, no doubt, the most fully developed framework ever proposed in the field of story comprehension.

However, in addition to the aforementioned advantages of Trabasso et al.'s proposal, there are several major shortcomings in comparison to the XBSG model. I will mention three.

1. Perhaps the major shortcoming of Trabasso et al.'s proposal is the lack of parsing procedures, such as those proposed by the XBSG. As already noted, Trabasso et al.'s analysis relies heavily on both 'local' and 'global' organization of stories. Thus, in order to identify whether or not the event depicted by a statement is in the cause chain, 'one needs further criteria for opening, continuing and closing the chain of events' (Trabasso and Sperry, 1985: 605). The problem is that, as in the case of the S-G standard model, no procedures are specified which map the local units (causally related statements) onto the global ones.

2. Another problem has to do with the limited capacity of STM (Short Term Memory). The idea of connectivity implies that every statement in the story has to be held in Short Term Memory before its importance degree can be assessed. This follows directly from both the assumption that the causal relations are not necessarily linear, and that one factor determining the importance of a given statement is the number of connections it has. Such a view implies that the comprehender of a story must hold a story statement in his STM all the way to the end of the story (unlike the XBSG, which requires the comprehender to hold it only until the next causal statement). Such a model is obviously incapable of meeting the constraint imposed on any theory of text comprehension by the limited capacity of STM (cf. Fletcher and Bloom, 1988, who address the issue, although without a complete solution as regards the factor of connectivity).

3. Compared to the XBSG, Trabasso et al.'s causal network is a less constrained representational system, in that it does not constrain the possible 'Problem Solving' structures which can be generated. Recall that the XBSG model yields a restricted form of formalism, which both uses the action (or problem solving) categories and is at the same time capable of excluding certain 'Problem solving' protocols as non- (or ill-formed) stories (as argued in section 1.1).

In sum, then, despite the substantial contributions of Trabasso et al. as a theory of story comprehension, in particular with regard to the use of logical criteria of 'necessity in the circumstances' and counterfactual reasoning in defining the causal relations in stories, their model still suffers from some of the main shortcomings of more traditional approaches to story comprehension.

Notes

* This paper is a revised version of a chapter of a PhD thesis written at Tel Aviv University under the supervision of Prof. Tanya Reinhart. I am indebted to Tanya Reinhart for her fruitful suggestions and help during the writing of this paper, as well as for the time she devoted to discussions of the various issues presented in the paper. Thanks are also due to Ruth Berman, David Gil, Benny Shanon, Yosef Grodzinsky, Rachel Giora and Ruth Ronen for their helpful comments on an earlier draft of the paper.

1. In Rumelhart's analysis these propositions occur only in the tree diagram in which they are represented by their predicate and argument(s). This slight modification is necessary for ease of presentation and has no influence on the original analysis.
2. An alternative to this analysis would suggest that propositions 2–5 constitute the Setting category and that the actual chain of events begins with the girls being kidnapped by the dragon. The reason for analyzing propositions 2–5 as events is that the information they convey involves a change in the state of the (fictional) world described. However, even if the alternative analysis would have been accepted, it does not affect the basic analysis we are proposing here, as the XBSG does not make any claims regarding the procedures for identifying the Setting or its internal structure.
3. 60 subjects (undergraduate students of literature) participated in a summary experiment: 22 read the first story, 19 read the second, and 19 the third. Each subject was then asked to write down a summary consisting of no more than 80 words, and without any time limitations.

   The Results. An analysis of the protocols had been performed as follows. The sentences comprising each protocol were divided into three levels of Importance according to the XBSG analysis. The decision as to whether a given sentence matches in fact the corresponding proposition has been determined according to the presence or absence of the Predicate: a sentence which contained the corresponding predicate was considered as representing the corresponding proposition. (As for the reliability of this analysis, see the description of the procedure that have been used in analyzing Rumelhart's protocols.) The results are presented in Table 9A,B.

Table 9: *Results of the summary experiments*

Table 9A: *Mean Square (percentage) and Standard deviations (Standard deviations are in parentheses)*

	Story 1	Story 2	Story 3
Level 1	100% (.00000)	100% (.00000)	99% (.10928)
Level 2	73% (.14156)	65% (.13498)	82% (.15532)
Level 3	32% (.18582)	10% (.17105)	19% (.12692)

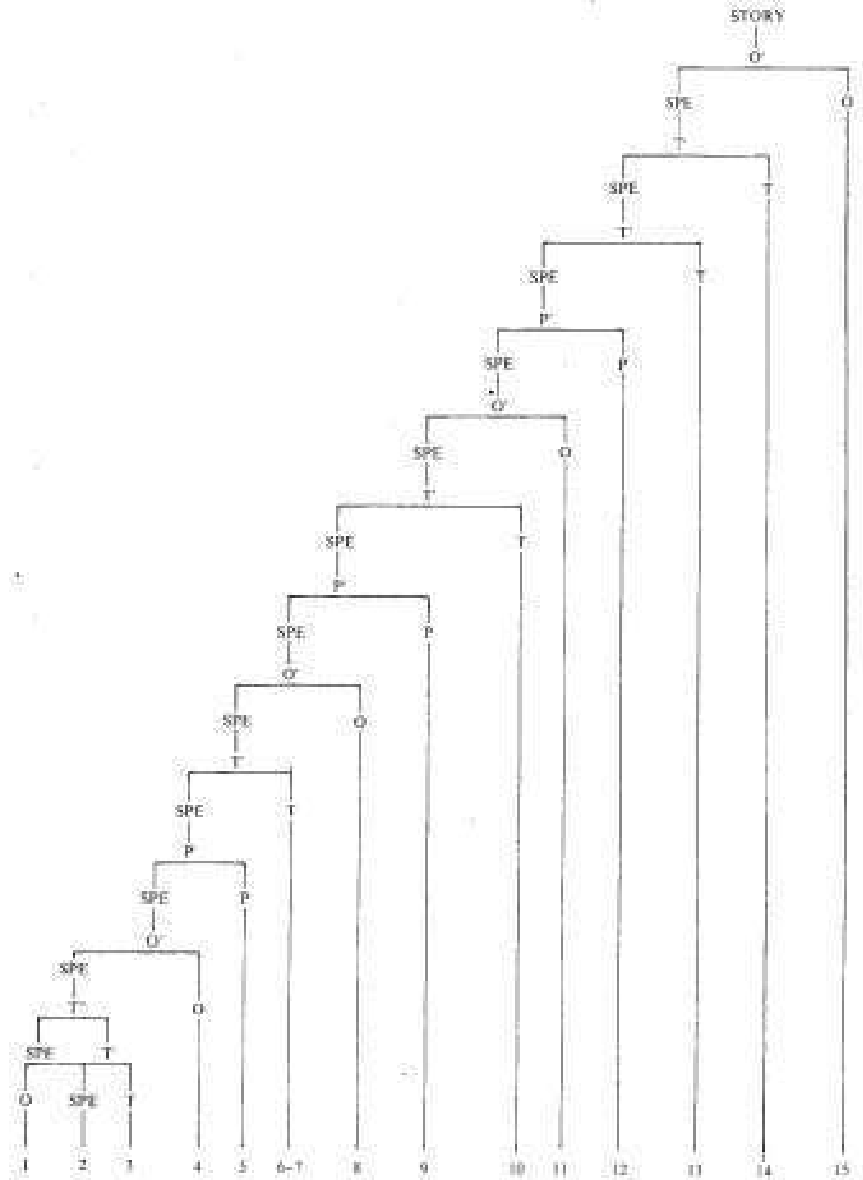
Table 9B: *Results after transformation*

	Story 1	Story 2	Story 3
Level 1	1.57	1.57	1.45
Level 2	1.05	0.81	1.06
Level 3	0.61	0.28	0.43

1. As can be seen, the probability of a given group of propositions to occur in the protocols does indeed increase as a function of its 'Importance'.
2. In general, the standard deviation increases as we move down in the importance level.
3. The assumption of equal variances on which the variance analysis is based, does not apply in this case, and therefore I have used an arcsin transformation (for justification, see Winer, 1970) in order to stabilize the variance. The results are presented in Table 9B. A two way analysis of variance with repeated measures of the level of importance variable had been performed on these grades, of the type 3*3 split plot design, and the following results were obtained: in accordance with the study's hypothesis, we found a main effect in the level of importance variable — ($f(2,114)=1302.67$; $p<0.0001$)), i.e., the propositions belonging to the first level occurred more times than in the second level: ($f(1,114)=55.79$; $p<0.001$)), and those which belong to the second level occurred more times than those belonging to the third level: ($f(4,114)=14.85$; $p<0.0001$)). These data were interpreted as strongly supporting the above analysis. (For a more detailed analysis and discussion of these data the reader is referred to Shen, 1985.)

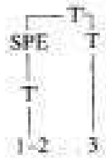
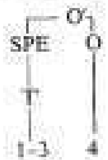
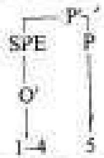
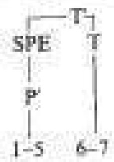
Appendix 1

1. A countryman's son, by accident, trod upon a serpent's tail.
2. The serpent turned
3. and bit him,
4. so that he died.
5. The father, in revenge,
6. got his axe,
7. pursued the serpent,
8. and cut off part of his tail.
9. So the serpent, in revenge,
10. began stinging several of the farmer's cattle.
11. This caused the farmer severe loss.
12. Well, the farmer thought it best to make it up with the serpent.
13. So he brought food and honey to the mouth of its lair
14. and asked for reconciliation.
15. But the serpent refused.

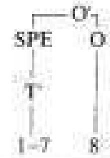
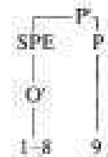
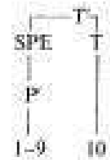
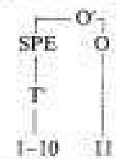
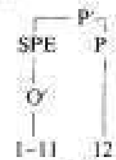


The tree diagram of the Farmer story

Appendix 2: *The Processing of the Farmer story*

Category Identification				The Construction of the Tree	
Pr. held in STM rel. = released inf. = inferred	Pr. processed & relations → = encause , = does not encause	Rules used R = rule pr. = procedure	Result	NC (Node Construction Rules	Result
–	1→2	R3	1=O		
P inf.	2→3	R2	2=T	NC1	
P inf.	3→4	R2	3=T	NC1	
P rel.	4→5	R3	4=O	NC1	
5	5→6	R1	5=P	NC1	
	6,7	pr.II	move to 8		
5	6,7→8	R2	6,7=T	NC1	

Appendix 2 (*continued*)

Category Identification				The Construction of the Tree	
5 rel.	8→9	R3	8=O	NC1	
9	9→10	R1	9=P	NC1	
9	10→11	R2	10=T	NC1	
9 rel.	11→12	R3	11=O	NC1	
12	12→13	R1	12=P	NC1	
12	13→14	R2	13=T	NC1	
12	14→15	R2	14=T	NC1	

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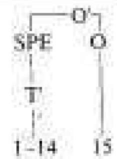
Appendix 2 (*continued*)

Category Identification				The Construction of the Tree
12 rel.	R3	15 – O		
			NC4 (Since the O dominating 15 does meet the 'Central Ep' conditions	

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