Readers' Memory Representations of the Goals of Multiple Narrative Characters

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Abstract

The ability to understand written text is critical in many daily activities. Much research has focused on the importance of goal structures and goal inferences in text comprehension, but there has been little work in understanding how this information is stored in a reader's memory representation of a text. The present study examines a reader's memory representation of the goals of multiple narrative characters during routine text comprehension. Specifically, I have undertaken an examination of how two characters who have a goal in common, but are unrelated, are represented by readers (Experiment 1) and how subtle changes in goal relations between characters affect a reader's memory representation (Experiment 2). Participants were presented with sets of sentences designed to convey different goal relations, and the participant's memory representation for character goals were tested with a modified fan-effect procedure. It was found that readers associate goals with the individual character attempting to achieve them, even when both characters superficially have a goal in common. In addition, it was found that readers were sensitive to differences in character goal relations and represented these differences accordingly in memory. A discussion of the results is presented with reference to the ACT-R (Anderson & Lebiere, 1998) cognitive architecture. This study is reflective of theories that conceive of the situation model as a quantifiable representation of information extracted by readers during text comprehension.

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Introduction

The ability to understand text is essential in people's performance of many daily tasks. Whether for recreation, study, or personal correspondence, text comprehension is required for most modern activities. Understandably, text comprehension has received great attention within the field of psychology and a number of things are known about how text comprehension is achieved by normal readers. It has been shown that there are two critical sources of information in narrative comprehension. The first, and most apparent, source of information is that which is directly stated in the text. The second source of information, the reader's general knowledge, is also of great importance.

Consider the following excerpt adapted from Sharkey and Bower (1987):

(1) a. Harry spent yesterday evening rummaging through garbage cans.

b. He has always worked hard and earned good money.

The reader of this text encounters an apparent contradiction. Someone who always works hard and earns good money should have no need for going through other people's garbage cans. To make sense of a passage, readers access their world knowledge. For example, a reader might postulate that Harry has been fired from work.

Suppose the previous example had been followed by the sentence:

(1) c. Harry is a private eye.

With the new information of sentence (1c), the passage now makes sense. By accessing our knowledge of the nature of a private detective's job, such as snooping through garbage, Harry's initially bizarre behaviour suddenly seems quite rational. By combining world knowledge with information directly stated in the text, the reader creates a coherent representation of the ideas that the author of the text intends to convey.

The reader's knowledge about underlying causal structure of a message particularly aids in constructing a coherent representation of the text, and plays a crucial role in overall text comprehension (Schank & Abelson, 1977; van Dijk & Kintsch, 1983). The goals, plans, and intentions of human actors within narratives play a predominant role in this regard, and as such have received much attention in the literature (van Dijk & Kintsch, 1983).

Consider this brief passage adapted from Suh and Trabasso (1993):

(2) a. One day, Jimmy saw his friend, Tom, riding a new bike.
   b. Jimmy wanted to have a new toy.
   c. He went to a department store.
   d. He found a nice bike.
   e. He bought the bike.

Example (2) demonstrates a simple goal structure involving Jimmy's goal of having a new toy. Sentence (2b) contains Jimmy's original goal. This goal motivates Jimmy's later actions expressed in sentences (2c) and (2d), as he attempts to satisfy his goal. In the final sentence (2e), Jimmy's goal of wanting a new toy is satisfied. The extracted causal structure provides a frame of reference for interpreting subsequent text information. Any new information that is presented is understood and related to the overall causal structure of the text (Lutz & Radvansky, 1997; Suh & Trabasso, 1993).

This thesis focuses on readers' sensitivity to goal-related text information, and how this information is represented when readers are constructing coherent representations of texts. Specifically, the way in which the goals of protagonists are represented by readers is studied, using a procedure of Sharkey and Bower (1987).

In the first part of this thesis, cause and goal representation will be examined, highlighting causal inferences. A discussion of causality is of concern because cause is often broadly defined to include relations of motivational as well as physical causes (Trabasso, van den Broek, & Suh, 1989). According to these analyses, a character's intentional actions are considered to be caused by the goals and motives that instigated them. A specific class of causal inferences, termed goal inferences, will be examined in that section, and relevant empirical evidence will be offered. Next, an examination of previous research examining how goals may be represented by readers during routine comprehension will be offered. A reader's memory organization of the situation model, and goal organization specifically, will be the focus of this section. Finally, two experiments that were conducted will be presented. Hypotheses about how goal information is extracted and stored by readers will be provided, with specific reference to the ACT-R (Anderson & Lebiere, 1998) cognitive model.

Cause and Goal Representation in Text

Understanding a text depends on the reader's ability to draw causal inferences. Comprehension is often viewed as a problem-solving process, an aspect of which is readers' inferences regarding the described ideas, states, and events (O'Brien & Myers, 1987; Schank & Abelson, 1977). Furthermore, it has been shown that the coherence of a text is associated with a representation of the causal structure of that text (Trabasso & van den Broek, 1985). The representation of causal information can include what is termed causal substructures. Within these substructures, clauses that make up a causally related passage can be represented as settings, events, goals, actions, outcomes, and reactions. All of the clauses are related to one another by enabling, psychological, motivational, and physical cause relations (Kintsch, 1974; Trabasso et al., 1989). This section will begin with a discussion of causal inferences in general, including an examination of some of the relevant empirical evidence. Most importantly, this section will end with a discussion of how causal representation can include goals.

An individual's ability to represent text meaning is a critical aspect of text comprehension. Theorists have distinguished among three different levels of representation that readers construct during normal comprehension (Kintsch, 1988; van Dijk & Kintsch, 1983). First, the surface level represents the exact wording and grammatical construction of the text. Second, the textbase representation contains the semantic content in the form of a network of propositions (Kintsch, 1974). In some circumstances, the textbase may also contain a limited number of inferences that are necessary to maintain the coherence of the passage (Haviland & Clark, 1974). The third level is a representation of the situation to which the text refers. Van Dijk and Kintsch (1983) described the "situation model" as consisting of representations of the people, actions, settings, and events that are both explicitly stated and implied in the text. It can also be thought of as a dynamic system, integrating each new sentence into the representation as it is encountered.

Causal Inferences

In certain circumstances, for a reader to comprehend fully a written passage, an inference may be needed to connect the current text event with information previously presented in the text. Due to working memory capacity constraints, it would be impossible for a reader to maintain all relevant text information simultaneously. This section focuses on how the generation of causal inferences may, at times, be necessary to maintain text comprehension.

A coherent text can be described as one that is clear and can easily be comprehended by readers. A text is considered coherent when the information presented is well connected and related (Kintsch & van Dijk, 1978). One way that readers maintain coherence is by drawing text inferences. A text inference is information generated by the reader that is not explicitly stated in the text. Text inferences are often based on world knowledge. Consider the sentence, The wine bottle tipped. Readers might infer that the wine spilled (Singer, 1990, p. 168). Suppose that the sentence, The carpet was ruined, followed in a passage. When readers are presented with information that the carpet was ruined, inferring that the wine spilled adds to the coherence of the text. Inferences can provide connections between explicit text ideas, and so clarify meaning. A specific class of inferences, termed goal-related inferences, can provide connections between the actions or events and the known goals of the protagonists. In the Jimmy story, a likely goal-related inference may be connecting Jimmy's purchasing a new bike (2e) with his original goal of having a new toy (2b).

There is evidence that a reader first attempts to find a cause for actions and events in text by searching the information that is contained in working memory (Bloom, Fletcher, van den Broek, Reitz and Shapiro, 1990). Consider the sequence, Jason dropped the banana peel. Mark fell on his back. (van den Broek, 1990). Because no direct relationship between these two sentences is specified in the text, the reader must draw a connecting inference. This is an example of a local coherence break. The causal inference that Mark must have stepped on the banana peel is a likely candidate to restore coherence. The causal inference re-establishes local coherence and the reader can continue processing subsequent sentences in the text.

Sometimes, a cause for a text event does not reside in working memory. Readers may then engage in a search of long-term memory to understand the event. This process can be described as an attempt to maintain global coherence. Global coherence is thought to be achieved through a connection of information at a high level of representation (such as the situation model).

Consider the following example (Singer & Halldorson, 1996):

(3) a. Laurie left early for the birthday party.

b. She headed north on the freeway.

c. She exited at Antelope Drive.

d. She spent an hour shopping at the mall.

With sentences (3b) and (3c) intervening between sentences (3a) and (3d), it can be assumed that any causal information provided in sentence (3a) is not held over in working memory by the time sentence (3d) is read (Jarvella, 1971). It can also be assumed that, in order for a reader to fully understand the passage, a reason for the protagonist's actions in sentence (3d) must be identified. The reader of the passage must generate a motive inference (such as Laurie wants to buy a birthday present) to maintain the causal coherence of the passage by linking the cause in sentence (3a) to the action in sentence (3d).

Empirical evidence. There is much evidence that people construct causal inferences when they comprehend narratives. This evidence derives from three experimental measures: reading time, probe judgments, and question answering. This thesis is primarily concerned with reading time and probe judgements. Converging evidence obtained from these two procedures supporting the routine generation of causal inferences during comprehension is described next.

When the causal relatedness of sentences has been experimentally manipulated, reading time of certain critical sentences in narratives has been shown to be affected (Bloom et al., 1990; Fletcher et al., 1990; Myers, Shinjo, & Duffy, 1987). This procedure illustrates that high causal relatedness between sentence pairs seems to facilitate causal inferences, whereas low causal relatedness makes drawing such inferences much more difficult. For example, consider the following sentences:

(4) a. Lucas punched his boss in the stomach. The next day he found a pink slip in his locker.

b. Lucas was late for work for the third time. The next day he found a pink slip in his locker.

c. Lucas had not yet finished his big assignment. The next day he found a pink slip in his locker.

In the preceding example, sequence (4a) portrays high causality, sequence (4b) portrays medium causality and sequence (4c) portrays low causality. Myers et al. (1987) observed that as causality between sentences decreased, reading time for the critical sentence (e.g., <u>The next day he found a pink slip in his locker</u>) increased. The results indicate that processes that generate causal inferences are affected by differing levels of causal relatedness. For example, a bridging inference in a highly causally related sentence pair (4a) (e.g., Lucas was fired from his job because he assaulted his boss) is easily generated. As the causal relatedness between sentence pairings declines, comprehension difficulties arise, causing readers to require more time to fully comprehend the second sentence.

In probe-judgement inference experiments, readers are interrupted during normal reading by a stimulus (probe) and are required to respond. For example, a reader might encounter sequence (5) (Klin & Myers, 1993):

(5) a. The boys had played catch in the living room with a baseball.

b. Dick found a broken lamp lying on the living room floor.

A number of intervening sentences would separate (5a) and (5b), and at the end of the passage participants would be presented with a probe word to name aloud (such as baseball). The probe word was representative of the intended causal relationship between (5a) and (5b), such as the baseball hit the lamp and broke it. Klin and Myers (1993), found that the probe word was named faster in an inference passage than in a control passage (one where no causal relationship is intended). This procedure is thought to assess directly the contents of a reader's memory representation for the text. Many studies have shown that when probe words refer to causal information implied by the text, judgements to the probe words are comparatively fast (Klin, 1995; Klin & Myers, 1993; Rizzella & O'Brien, 1996).

Taken together, these findings support the assertion that readers are utilizing the underlying causal relationships among ideas present in narrative text to construct a coherent representation of that text. In the next section, a discussion of inferential processes related specifically to goal information will be presented.

Goal Inferences

The type of causal inference that is the focus of this thesis is goal inference. Goal inferences are often formed between propositions that represent focal actions or events and the previously presented information about a protagonist's goals. Consider the following example:

(6) a. Sam wanted to play for the NHL.

b. He tried out for the team, but did not make the cut.

c. He wanted to get better at the sport.

d. He practiced every day, and played whenever he could.

e. His hard work paid off, he became a great player.

f. He tried out again and easily made the NHL team.

In this example, readers are able to infer that Sam's goal to get better at the sport (6c) is caused or motivated by his failure to make the team (6b). Further connections will be made between the result of Sam's practicing (6e) and his wanting to get better (6c). A final inference connection will be established between the outcome (6f), and Sam's initial goal (6a). A graphical representation can be seen in Figure 1.

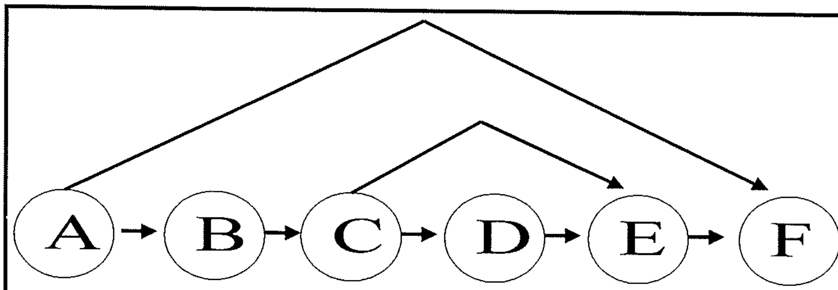

Figure 1. Network representation of goal relations in 'Sam's NHL Dreams'.

In passage (6), the goals and actions of the protagonist are consistent with the overall goal plan. Therefore, each subsequent goal, action, and result can be connected to the preceding goal by means of inferences. It is easy to see that the cause for the character's actions are motivated by trying to achieve the main goal. In sentence (6b), Sam's main or <u>superordinate</u> goal of making the NHL fails, and the establishment of a subgoal takes place. In this case, Sam now has the goal of becoming a better hockey player. When more than one unsatisfied goal is present in a passage, the reader evaluates the protagonist's actions and attempts as being related to the *most recent unsatisfied goal.* This process leads to a hierarchy of unsatisfied goals (Suh & Trabasso, 1993). Each time a subgoal is satisfied, subsequent actions are evaluated with respect to the prior goal in the hierarchy. This process of evaluation continues until all the goals of a character are satisfied. A passage in which a subgoal fails, and the resulting goal representation constructed by a reader, will be discussed shortly.

There is evidence that the monitoring of goal structures is very critical in comprehending narratives. Even preschoolers have the ability to monitor goal structures, and the efficiency of this monitoring is directly related to later comprehension tests (Wenner, 2004). Two studies of readers' use of goal information during comprehension will be presented next.

Empirical evidence. Suh and Trabasso (1993) examined specific conditions under which goal information is inferred. They created texts that were thought to allow or prevent goal inferences, based on the expectations generated from an analysis of causal networks. For example, inference generation was thought to be dependent on whether a subgoal or action directly fit the plan of a superordinate goal, and which goal was the most recent unsatisfied one. Two sets of passages (goal failure and goal success) were created describing a character's goals and the actions taken to achieve them (e.g., Jimmy wanted to have a new bike). In one type of passage, the first goal of the character fails (e.g., His mother refused to buy him a bike). In the second type of passage, the first goal of the character succeeds (e.g., His mother bought him a bike). In both passage types, the first goal is followed by a second goal (e.g., Jimmy wanted to earn some money). In the goal failure passages, this new subgoal can easily be related to Jimmy's original goal of wanting a new bike through the formation of the goal inference Jimmy wants to earn money to buy a new bike. In the goal success passage, when readers encounter Jimmy wanted to earn some money, a different representation is expected. Specifically, an inference relating the first goal to subsequent goals should not be drawn, but rather a new superordinate goal should be created.

Suh and Trabasso's (1993) participants made a recognition judgement about a probe phase that was relevant to the first goal (e.g., Jimmy wanted a new bike). They found that participants responded more quickly to the probe in the goal failure passages than in the goal success passages after reading sentences that were thought to promote a goal inference back to the first goal (e.g., Jimmy wanted to have a new bike so Jimmy wanted to earn some money).

Suh and Trabasso's (1993) results indicated that readers are accessing superordinate goal information to comprehend the actions of a protagonist. Goal inferences are generated between current text events and the most recently unsatisfied goal, and readers are striving to understand the actions and events of the narrative with respect to the overall goal plan of the characters.

Richards and Singer (2001) investigated readers' sensitivity to more complex goal structures. Narratives described two characters' attempts to accomplish independent subgoals in order to achieve a single superordinate goal. By manipulating the success of the one character's subgoal, an opportunity to assess whether readers were sensitive to this complex goal structure was afforded. Passages first described the characters' joint superordinate goal, such as meeting for lunch. Next, four sentences described one character attempting to achieve one subgoal, such as catching a bus to get to the lunch. The success of this subgoal was manipulated in the last sentence of this section. The next four sentences described a second character attempting to achieve another subgoal (e.g., finishing a report), which always succeeded. Critical to the experiment was the next region, the target. The target did not mention any of the concepts of the first subgoal, and was causally coherent with the second subgoal (e.g., At 12:30 Pam entered McDonald's. McDonald's was very busy, and she had to wait for a table.). Richards and Singer (2001) found that reading times of the second sentence in the target region were greater in the succeed condition than the fail condition of the passages. In addition, the time needed to recognize a probe word representing the manipulated subgoal (e.g., BUS) was shorter in the succeed condition than in the fail condition. These results were interpreted to indicate that readers consolidate goal information at the target region in the succeed condition, which involves the reinstatement of the first subgoal into working memory. The results thus suggest that readers are sensitive to goal relations, even in the absence of superficial overlap between critical regions of the narrative.

Prior research has demonstrated the importance of both goal inferences and the monitoring of goal structure when readers are comprehending text. However, the way in which the reader represents goal information is still relatively uncertain. The next section will examine some previous work concerned with how goals may be organized in a reader's memory.

Memory Organization for Goals

The importance of goal structures and related goal inferences is well-documented but there is much we do not know about memory representation of this information. A fruitful paradigm for testing memory organization has been the fan effect. A fan effect refers to the finding that, as the number of facts about a particular concept increases, the time to retrieve a specific fact about that concept also increases (Anderson, 1974). The present section will first address previous work concerning a reader's organization of information retrieved from situation models, but not specific to goals. Next, I will examine research suggesting that goal organization is similar to the organization of other aspects of the situation model, such as object-location facts. This section will end with a proposal of experiments designed to assess how goal information may be organized by readers during routine comprehension.

Memory Organization and the Situation Model

The idea that elements of the situation model are organized and stored in a consistent and predictable manner by readers was presented by Radvansky (1998). He used the fan effect paradigm to assess the organization of memory representations in recognition tasks using either object-location facts or person/small-location facts. Object-location facts were sentences such as: The payphone is in the city hall, The payphone is in the airport, The car dealership has the payphone. Person/small-location sentences had the form: The banker is on the witness stand, The banker is at the desk, The mechanic is at the desk).

A fundamental difference is conceivable between the possible ways in which readers can organize the information presented in the study lists. Readers might organize information in a manner that is most compatible with the learned facts. With object-location facts Radvansky (1998) speculated that there is only one plausible organizational structure, namely an organization by location rather than object, this is because it is unlikely a reader would represent an object moving from one location to another. With person/small-location facts, Radvansky (1998) proposed there are two possible organizational structures, by location or by person. For person/small-location facts, it is possible to conceive of a person moving from location to location, resulting in a situation model based around each person. Alternatively, one can imagine a location with multiple people cycling through it, resulting in a situation model based around each location. Thus, there are two possible memory representations for the study list.

In Radvansky's (1998) study, with both object location and person/small-location facts, the participants memorized a list of 18 facts, using a study-test procedure. The facts were of the form "The *object* is in the *location*" or "The *location* has the *object*" and "The *person* is in/at the *location*" or "In/at the *location* is the *person*" . Concepts were combined to form study sentences in a way that there could be one to three associations for both concepts. For example, an object-location fact may have the forms: The *welcome mat* is in the *cocktail lounge*, The *welcome mat* is in the *office building*, The *high school* has the *welcome mat.* Participants judged whether test probes were studied or nonstudied facts. A suitable test item for the object-location facts above could be: The welcome mat is in the cocktail lounge, . A location-based organization of facts was observed for object-location facts, demonstrable by a strong fan effect present for the multiple-location condition. Response times to a probe item that was associated with multiple locations (e.g., the *welcome mat* being in the *cocktail lounge*, *office building* and *high school*) were greater than response times to test items that were associated with a only single-location. With person/small-location facts, a person-based organization was observed in recognition. A fan effect was present for the single-location, but not the multiple-location condition. Response times to a probe associated with numerous people in a single location were larger than when a probe was associated with a single person in multiple locations (e.g., the banker is in the *office*, the *lounge* and the *witness stand*).

The work of Radvansky illustrates two important things about how elements are stored and retrieved from the situation model, and how one might go about testing this organization. First, Radvansky (1998) has shown that the fanning paradigm is sensitive enough to test various hypotheses about how information of the situation model may be organized, and to distinguish between competing ideas. Second, that retrieval of information from the stored situation model can be consistent with, and indicative of, the manner in which the information is stored (for example, location versus object organization).

When taken as a whole, the work of Radvansky (1998) demonstrates the plausibility of using the fan effect paradigm to test the organization of character goals extracted by a reader during comprehension. However, Radvansky required participants to memorize entire lists of facts to perfection, requiring a lengthy study phase. Furthermore, Radvansky was not specifically dealing with a reader's monitoring and retrieval of goal structures. The next section will discuss a study that examined goal structure specifically, and utilized a different experimental method.

Goal Organization

In a series of four experiments, Sharkey and Bower (1987) tested a number of notions about how goals and plans may be stored in memory. The first step taken was to demonstrate that goals are stored as an associative structure, and that as such, goal representation will display the fan effect when probed. To test this, participants were presented with stimulus materials such as those found in Table 1:

Table 1

Experimental Items from Sharkey and Bower (1987)

One goal condition		
1.	GOAL1:	Heather wanted to: overcome her shyness.
2.	ACTION:	And so Heather took classes in social skills.
Three goal condition		
3.	GOAL1:	Heather wanted to: overcome her shyness.
4.	GOAL2:	Heather wanted to: live very extravagantly.
5.	GOAL3:	Heather wanted to: have some time on her own.
6.	ACTION:	And so Heather took classes in social skills.

Participants were required to respond to a probe (e.g., And so Heather took classes in social skills.) as either being consistent or inconsistent with one of the character's goals. The mean response times can be seen in Figure 2.

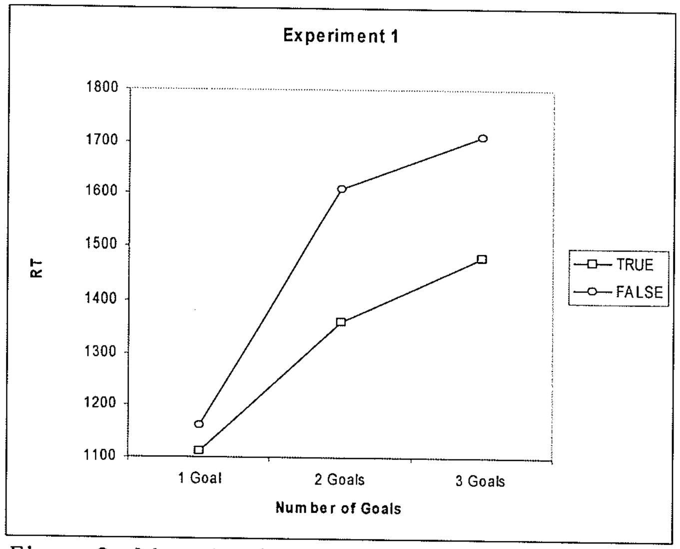

Figure 2. Mean RT in milliseconds for Sharkey and Bower (1987), Experiment 1.

Figure 2 displays a fan effect for the number of goals related to a character: The response time to a probe systematically increased with the number of goals of that character. This result is consistent with the idea that goals are represented in memory as a specific structure, and is similar to the findings of Radvansky (1998) involving object-location and person-small location facts.

However, it is rare for a narrative to have only a single character. The way in which goals of multiple characters are monitored and stored by readers was explored in another experiment (Sharkey & Bower, 1987, Experiment 4). To accomplish this Sharkey and Bower presented participants with materials describing two characters. The first character had one goal, and the second character had two goals. By varying the number of goals associated to a single character, there was the opportunity to examine whether goals are stored and retrieved based on character.

A pattern of results consistent with readers organizing the information presented by character was observed in the mean decision times. There was a strong fan effect. The mean response time for a two goal character probe (1800 ms) was larger than for a one goal character probe (1400 ms).

The findings of Sharkey and Bower (1987) offer some insight into the way goals are organized when extracted by a reader; however, there are many unanswered questions. The focus of the current experiments is to examine some of the more complicated goal structures that readers of texts may face, and how the reader may represent this information in memory. Narratives often contain multiple characters, leading to an increase in the complexity of the goal representation the reader must extract. Narratives may also consist of multiple relations between the goals and characters. For example, it is possible that two characters may superficially have the same goal in common, but are seeking to satisfy it independently. During routine comprehension, there may be a number of different goal relations, all of which must be represented distinctly by the reader.

Present Experiments

The first experiment was intended to serve two purposes. The first purpose was to replicate the findings of Sharkey and Bower (1987), demonstrating that response times to a probe related to a character with one goal will be lower than the response time to a probe related to a character with two goals. Consider example (7):

(7) a. Dianne wanted to go to the movies.

b. Beth wanted to throw a dinner party.

c. Beth wanted to go for a bike ride.

d. Probe: And so Dianne bought tickets.

e. Probe: And so Beth set the table.

In this instance, two characters are attempting to achieve three goals. All of the goals are distinct, with no goals being common between the two characters. Response time to a probe associated with the two goal character (7e) should be greater than response time to a probe associated with the one goal character (7d). The presence of the fan effect with this goal set would be comparable to the results of Sharkey and Bower (1987, Experiment 4), and fulfill the first purpose of the proposed experiment.

The second purpose of the experiment is to examine how goal information is stored by readers when two characters happen to have a goal in common, but are completely unrelated. Consider example (8):

(8) a. Dianne wanted to go to the movies.

b. Beth wanted to go to the movies.

c. Beth wanted to go for a bike ride.

d. Probe: And so Diane bought tickets.

e. Probe: And so Beth bought tickets.

If a reader's memory representation associates each goal of the characters separately, one would expect the response times to probes about the two goal character to be the same regardless of whether the goal is distinct (7b) or in common with another character(8b). That is, if readers are maintaining the common goal as separate for both characters, the common goal is present in both character representations (see Figure 3).

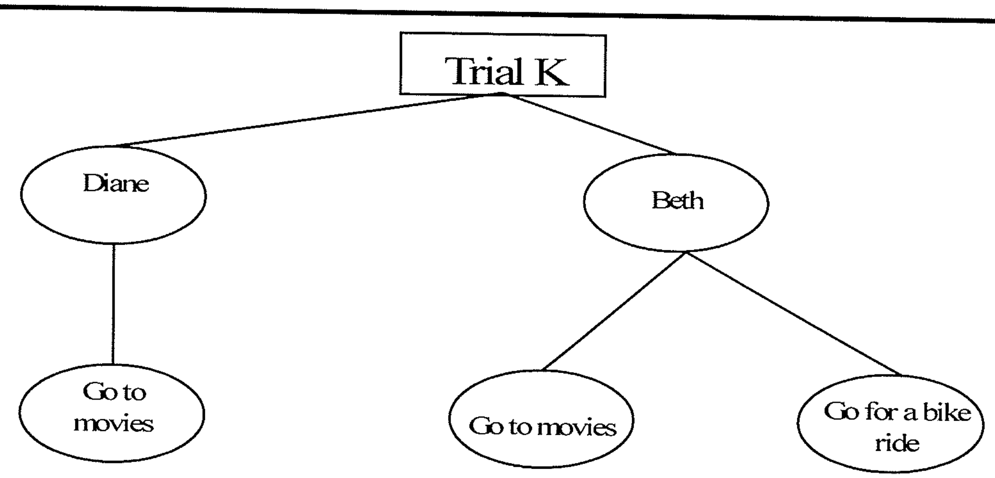

Figure 3. Theoretical associative structure for a shared goal set in Experiment 1.

A reader still associates two goals with the second character, and one goal with the first character. A fan effect comparable to that anticipated in the distinct goal example (7) should be observed.

In Experiment 1, the distinct one-goal character condition consisted of two characters attempting to achieve three independent goals. An example of a complete experimental item in all conditions is provided in Appendix A.1. One character is attempting to achieve one goal (e.g., Mary wanted to buy home insurance); the second character is attempting to achieve two goals (e.g., Bonnie wanted to organize a baseball game. Bonnie wanted to get a flu shot). The probe item was associated with the goal of the one-goal character (e.g., And so Mary chose the coverage). The distinct two-goal character condition is similar to the distinct one-goal-character condition, with the exception that agent names are rearranged so that the probe will now be referring to the two-goal character. In the same-goal condition, it was again the case that one character had one goal and the other character had two. However, one of the goals of the two-goal character was the same as the single goal of the one-goal character. The shared goal is called the "common unshared goal".

In the same one-goal character condition, the probe targeted the common (and only) goal of the one-goal character. In the same two-goal character condition, a similar adjustment was made to the agent names as was done with the distinct goal conditions. The probe now represented the common goal of the two-goal character. This resulted in goal sets that could vary in both the goal structure (shared versus distinct) and number of goals (one goal character versus two goal character).

Response time patterns should be indicative of an organization of goals in which common unshared goals are represented separately in a reader's memory representations. Measuring a fan effect in both the distinct and same goal set types would be consistent with the previous work of Sharkey and Bower (1987), and with more general studies examining the situation model of text representation.

Experiment 1

Method

Participants. Seventy-five University of Manitoba introductory psychology students participated in this experiment. All of the participants were native speakers of English, and received course credit for their participation. Each participant was tested in a single session lasting approximately 40 minutes.

Materials. The materials were derived from a pool of 132 potential goals created for this experiment. Each of the goals was associated with five actions consistent with trying to achieve the goal. Three goals were randomly selected to be grouped together, resulting in 44 sets of sentences. Probe items were randomly selected from the five potential actions for each goal. Table 2 illustrates the materials in the distinct goal condition:

Table 2
Sample Distinct Goal Condition used in Experiment 1.

Distinct One-Goal

1. Mary wanted to buy home insurance.
2. Bonnie wanted to organize a baseball game.
3. Bonnie wanted to get a flu shot.
4. Probe: And so Mary chose the coverage.

Distinct Two-Goal

5. Bonnie wanted to get a flu shot.
6. Mary wanted to buy home insurance.
7. Mary wanted to organize a baseball game.
8. Probe: And so Mary chose the coverage.

Each set consisted of four sentences, including three distinct goals in the distinct condition and two goals (with one common between characters) in the same goal condition, and a target probe. An example of the same goal condition can be seen in Table 3:

Table 3
Sample Same Goal Condition used in Experiment 1.

Same One-Goal	
1.	Mary wanted to buy home insurance.
2.	Bonnie wanted to buy home insurance.
3.	Bonnie wanted to organize a baseball game.
4.	Probe: And so Mary chose the coverage.
Same Two-Goal	
5.	Bonnie wanted to buy home insurance.
6.	Mary wanted to buy home insurance.
7.	Mary wanted to organize a baseball game.
8.	Probe: And so Mary chose the coverage.

Item protagonist names were randomly selected from a list of common names used in previous experiments (Richards & Singer, 2001). The names were randomly assigned to the goal sets, with the restriction that they were assigned in same-sex pairs.

From these materials, four experimental lists were constructed. First, 24 goal sets randomly chosen from the pool of 44 were designated as the experimental items. In List 1, one quarter of the 24 experimental items were randomly assigned to each of the distinct one-goal, distinct two-goal, same one-goal, and same two-goal character conditions. The goal sets were then randomly assigned to list position, subject to the restriction that half of the experimental items in each condition appear in each half of the list. In lists 2-4, the assignment of goal sets to condition was manipulated using a Latin-square procedure resulting in a counterbalanced design across lists, with each goal set appearing once in each experimental condition.

The lists also included 16 false-response goal sets, created and assigned in virtually the same manner as the experimental items from 20 goal sets remaining in the pool. Probe items in this condition were randomly selected from other false goal sets. This resulted in a pairing of goal sentences with a probe item to which the correct response would be "no". The various false-response conditions were created in the same manner as the experimental items. An example of a false-response goal set in all conditions is provided in Appendix A.2. False-response goal sets were randomly assigned to list position, subject to the restriction that half of the false-response goal sets appear in each half of the list. The counterbalancing methods for the false-response goal sets across the four lists was achieved using the same procedure as the experimental items.

The four lists were preceded by four practice items created from the last four goal sets remaining in the pool, in the same manner as both the experimental and false-response goal sets. Two of the practice items had "yes" probe responses, and two had "no" responses. The practice items were identical in all four lists. One of each of the goal type and character type conditions appeared in the practice items.

Procedure. The data were collected with participant groups of one to four students. Each participant was tested in a separate, dimly lit, closed room, at a station consisting of a personal computer, keyboard, and a monitor. The monitor was positioned with its screen 22 cm from the near edge of the participant's table. The experimental events were programmed, and data were recorded, using the Micro Experimental

Laboratory software (MEL; Schneider, 1988). Participants were given both written and verbal instructions prior to beginning, and correct finger placement was demonstrated by the experimenter. See Appendix B.1. for the instructions used.

Each experimental trial was initiated with a message indicating that the participant press the space bar of the keyboard, which functioned as a "ready" key. When the participant pressed the "ready" key, the first sentence of the goal set was presented, beginning at row 13 column 1 of the monitor. The participant was instructed to read the sentence to understand it, and then to press the "ready" key to view the next sentence. The second sentence replaced the first on the screen. The participant read the entire goal set in this self-paced way. If the participant did not respond in 10 s, the next sentence was automatically presented.

After the three goal sentences were presented, there was an interval of 1 s. Next, the message "Test Items" appeared on the screen for 3 s at row 13 column 1. Then a fixation point appeared on the screen at row 13, column 1, for 500 ms. Then the test probe appeared. The participants answered "yes" or "no" as to whether the action was consistent with a goal of one of the protagonists, using the "." and "x" keys, respectively. Participants were not be given feedback about their accuracy. If no response was made within 10 s, an incorrect response was credited. After a 3-s intertrial interval, the message to press "ready" for more text initiated the next trial. There was a rest period of 40 s halfway through the list, disregarding practice items. At the end of the experiment participants were told of the purpose of the study using the debriefing sheet shown in Appendix B.2.

Results

Incorrect responses were disregarded. Only response times within 2.5 standard deviations of the mean for each participant were subjected to the analysis. This resulted in the elimination of 2.1% of the observations. Participants with an overall accuracy rate of below 67% were also removed from the overall analysis, resulting in the elimination of eleven participants. Therefore, the data were those of the remaining 64 participants.

Response Times - Experimental Items. One experimental item was removed from the analysis due to an accuracy rate of below 50%. The experimental items had a mean accuracy rate of 0.88 (S.D. = .14) and a mean response time of 3,156 ms (S.D. = 840.17). The response time data were submitted to an ANOVA alternatively treating participants (F_1) and items (F_2) as the random effect, in which goal structure (distinct versus same) and number of goals (one goal character versus two goal character) were within-participant factors. In the participants-random ANOVA, list (1 - 4), was a between-participants variable. Effects involving the list variable will not be reported, because it was not of theoretical interest. In the items-random ANOVA the verbal set variable was entered into the analysis; but because it was also not of theoretical interest, its effects will not be reported. A graphical representation of the data can be seen in Figure 4:

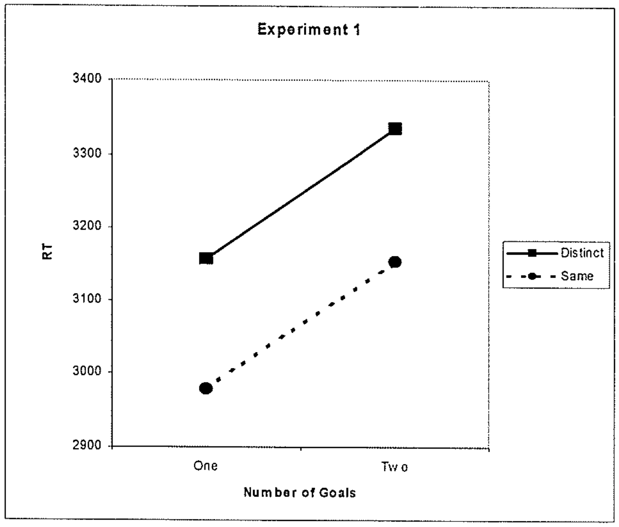

Figure 4. Mean response times (in ms) for experimental items in Experiment 1.

The main effect of number of goals was significant, F_1 (1, 60) = 6.23, *MSE* = 344,677, F_2 (1,19) = 13.824, *MSE* = 89,496: Response times to one-goal character probes were significantly lower than response times to two-goal character probes. The main effect of goal structure was significant, F_1 (1,60) = 4.52, *MSE* = 445,764, F_2 (1,19) = 9.42, *MSE* = 87,660, reflecting a 181 ms advantage in the same condition. Critically, no interaction was found between number of goals and goal structure, F_1 (1,60) < 1, *MSE* = 343,179, F_2 (1,19) < 1, *MSE* = 58,127.

Planned comparisons were also conducted for the number of goals variable at each level of goal structure. In the distinct-goal structure, the number-of-goals effect was significant in the items-random analysis only, F_1 (1,60) = 2.36, *MSE* = 462,284, $p > .10$, F_2 (1,19) = 9.37, *MSE* = 91,210. In the same-goal structure, a significant effect of number of goals was detected, F_1 (1,60) = 4.68, MSE = 225,573, F_2 (1,19) = 7.46, MSE = 56,413. For the complete analysis of variance, see Appendix E.1.

Errors - Experimental Items. ANOVAs were applied to the error data, using the same designs as for the response time data. There was a main effect of goal structure, F_1 (1,60) = 27.58, *MSE* = 162, F_2 (1,19) = 66.193, *MSE* = 24: The distinct condition had significantly poorer performance (84%) than the same condition (92%). Because the Same condition was both more accurate and faster, a speed-accuracy trade-off is ruled out. No other effects were significant in the error data. The accuracy data can be seen in Table 4. For the complete ANOVA table, see Appendix E.2.

Table 4
Accuracy Rates for the Experimental Items of Experiment 1

	Experimental Items
Distinct One Goal	0.85
Distinct Two Goal	0.82
Same One Goal	0.92
Same Two Goal	0.92

Reaction Times - False-Response Items. The overall mean response time to a false probe was 3,818 (S.D. = 1,076), and a mean accuracy rate of 0.84 (S.D. = 0.19) (a correct rejection of the probe item being consistent with any of the protagonist's goals). The data were submitted to the same ANOVAs as the experimental items. The data can be seen in Figure 5:

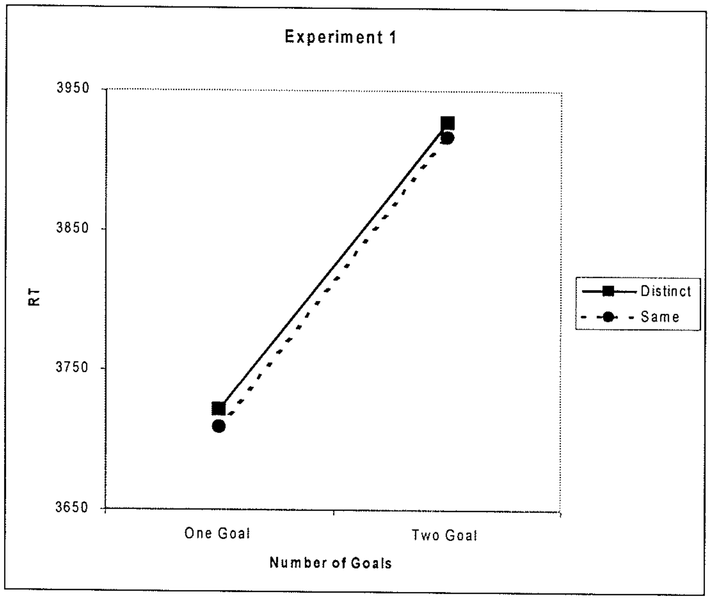

Figure 5. Mean response times (in ms) for false-response items in Experiment 1.

The main effect of number of goals was significant, F_1 (1, 60) = 4.30, *MSE* = 728,001, F_2 (1, 12) = 6.60, *MSE* = 178,608: Response time to the one-goal character probes was slower (207 ms) than response time to the two-goal character probes. No other effects reached significance. For a complete ANOVA table see Appendix F.1.

Planned comparisons for the number of goals variable at each level of goal structure revealed a significant difference in the distinct-goal structure condition in the items random analysis only, F_1 (1,60) = 1.71, *MSE* = 837,037, $p > .10$, F_2 (1,12) = 5.87, *MSE* = 141,741. In the same-goal structure condition, a marginally significant effect was found in the participants-random, and in the items-random analyses a significant effect was found, F_1 (1,60) = 3.46, *MSE* = 492,451, $p = .07$, F_2 (1,12) = 4.90, *MSE* = 79,551.

Error Rates - False-Response Probes. There was a main effect of goal structure, F_1 (1,60) = 6.45, *MSE* = 298, F_2 (1, 12) = 4.13, *MSE* = 117: Accuracy rates in the distinct condition was less than those in the same condition (81% vs. 88%, respectively). There were no other significant effects observed in the error data. The accuracy data can be seen in Table 5. For the complete ANOVA table see Appendix F.2.

Table 5
Accuracy Rates for the False-Response Items of Experiment 1

	False-Response Items
Distinct One Goal	0.83
Distinct Two Goal	0.79
Same One Goal	0.88
Same Two Goal	0.87

Discussion

Experiment 1 was intended to serve two purposes: To replicate previous findings that goal structures extracted by readers can be tested using the fan effect, and to examine how goal information is stored by the reader when two characters have a goal superficially in common. The result that response time to a probe relating to a character with one goal is faster than response time to a character with two goals, in the distinct condition, demonstrates that goal structures can indeed be tested using the fan effect. The second important result, an absence of a Number of Goals x Goal Structure interaction is indicative of a reader's memory representation organizing each goal separately. If a reader represented goal information of the common goal together, one would expect an interaction in which the fan effect related to the two goal character would not be present in the same goal condition. One would expect this interaction because response time to a single node in a reader's memory representation of the text should not differ. The marginally significant finding that response times are faster in the same conditions than in the distinct conditions is not surprising. Even though I argue that readers represent the shared goal separately in both the same and distinct goal passages, a benefit of having the shared goal repeated during experimental trials is conceivable. This added benefit of repetition for the shared goal results in better performance both in accuracy and in response times. An overall improvement in accuracy in the same condition may be further enhanced because there are fewer goals to compare a probe item to, regardless of how readers attribute goals to protagonists.

Similar to Sharkey and Bower (1987), data patterns for false response probes are quite comparable to the data patterns from probes that were consistent with a protagonist's goals. The main effect of number of goals is indicative of the same fan effect that was observed in the experimental items, with a participant's response to one-goal character probes being considerably faster than response time to two-goal character probes. There is one considerable variation in the data obtained from the false response probes and the experimental probes; there is no main effect of goal structure in the response time data of the false-response probes. I speculate that, with the false-response probes, there would be no benefit to having a goal repeated in the same goal structure conditions, because the probe is not relevant to any of the presented goals. Additionally, the effect of passage structure on accuracy is still accounted for because there continues to be fewer goals presented in the same goal structure condition than in the distinct goal structure condition. The important finding is that for neither the experimental nor false-response items was the Passage Structure x Number of Goals interaction significant. Therefore, the analysis of the false-response probe data suggests that when two characters have a goal superficially in common, they are still represented as separate in a reader's memory.

Most importantly, the combination of a main effect of number of goals, and an absence of any Number of Goals x Goal Structure interaction, in both the experimental and false-response data, allows for a further examination of how readers store goal information in more complicated goal situations. These more complex goal structures are the focus of Experiment 2.

Experiment 2

With the results of Experiment 1 turning out as expected, it is possible to examine how subtle differences in goal organization affect a reader's memory representation. In many narratives, readers must also keep track of complex relations between the goals of multiple protagonists. Consider the following familiar example:

(9) Jack and Jill went up the hill, to fetch a pail of water.

The readers of (9) fully understand that Jack and Jill are working together to achieve the goal of fetching the pail of water. The memory representation that a reader extracts during comprehension of sentence (9) must, in some substantive way, be different from when people read a slightly modified sentence pair:

(10) a. Jack went up the hill to fetch a pail of water.

b. Jill went up the hill to fetch a pail of water.

The second experiment is intended to compare the memory representations of goal sets in which characters have a goal in common, but are completely unrelated (Experiment 1) and when two characters are working to achieve the same goal together. When two characters are truly sharing a goal, one would expect a reader's memory representation of such a goal set to have a link between the common goal of both characters (See Fig. 6).

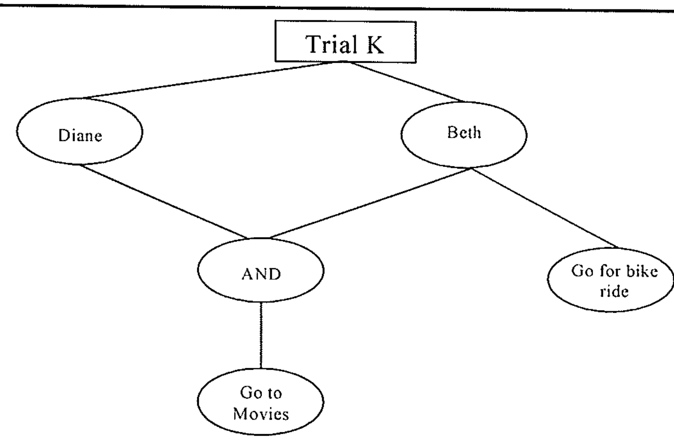

Figure 6. Theoretical associative structure for a shared goal set in Experiment 2.

Method

Participants. The participants were 77 naive individuals from the same pool that was sampled for Experiment 1.

Materials. The materials were identical to those that were used in Experiment 1, with the exception that the shared goal in the same-goal structure passages was described in a single sentence (see Appendices C.1 and C.2). An example of a complete same-goal condition experimental item can be seen in Table 6:

Table 6
Sample Same Goal Condition used in Experiment 2.

Same One-Goal

1. Mary and Bonnie wanted to buy home insurance.
2. Bonnie wanted to organize a baseball game.
3. Probe: And so Mary chose the coverage.

Same Two-Goal

4. Bonnie and Mary wanted to buy home insurance.
5. Mary wanted to organize a baseball game.
6. Probe: And so Mary chose the coverage.

This change in the materials was made to ensure that the collaborative nature of the goal is noticed by the reader.

Procedure. The procedure was identical to that of Experiment 1, with the exception that participants were not given any instructions as to how to view goal relations between characters (see Appendices D.1. and D.2. for instruction and debriefing sheets used in Experiment 2).

Results

Incorrect responses were disregarded. Only response times within 2.5 standard deviations of the mean for each participant were subjected to the analysis. This resulted in the elimination of 2.1% of the observations. Participants with an overall accuracy of below 67% were removed from the analysis, resulting in the elimination of six participants. Therefore, the data are based on the remaining 71 participants.

Response Time - Experimental Items. One experimental item was removed from the analysis due to an overall participant accuracy rate of below 50% (the same item that was removed from Experiment 1 analyses[1]). The remaining experimental items had a mean accuracy rate of 0.89 (S.D. = 0.13). The overall mean response time was 3,038 ms (S.D. = 918).

The response time data were submitted to ANOVA as was described in Experiment 1. A graphical illustration of the data can be seen in Figure 7.

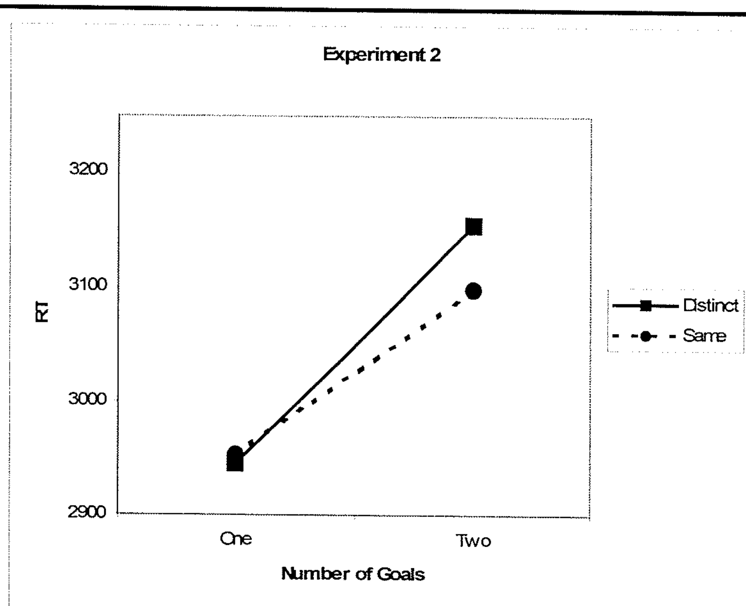

Figure 7. Mean response times (in ms) for experimental items in Experiment 2.

A main effect of number of goals was found, F_1 (1, 67) = 9.38, *MSE* = 239,656, F_2 (1, 19) = 12.74, *MSE* = 60,149: Response times to one-goal character probes were significantly faster than response times to two-goal character probes. No main effect of goal structure was found, F_1 (1,67) < 1, *MSE* = 301 761, F_2 (1,19) < 1, *MSE* = 73 360.

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[1] The omitted item concerns playing tennis, apparently a sport university undergraduates are unfamiliar with.

No interaction was found between number of goals and goal structure, F_1 (1,67) < 1, MSE = 274 666, F_2 (1,19) < 1, MSE = 109 987 . For the complete ANOVA, see Appendix G.1.

Planned comparisons revealed significant effects of number of goals in the distinct-goal structure condition in both the participants and items random analyses, F_1 (1,67) = 5.57, MSE = 284,545, F_2 (1,19) = 4.88, MSE = 83,875. Marginally significant effects of number of goals were found in the same-goal structure condition, F_1 (1,67) = 3.19, MSE = 229,777, p = .08, F_2 (1,19) = 4.15, MSE = 86,260, p = .06.

Errors - Experimental Items. There was a main effect of goal structure, F_1 (1,67) = 15.72, MSE = 3,216, F_2 (1,19) = 15.02, MSE = 69: The distinct condition had significantly poorer performance (86%) than the same condition (93%). No other effects were significant in the error data. The accuracy data can be seen in Table 7. For the complete ANOVA table, see Appendix G.2.

Table 7
Accuracy Rates for the Experimental Items of Experiment 2

	Experimental Items
Distinct One Goal	0.86
Distinct Two Goal	0.86
Same One Goal	0.94
Same Two Goal	0.91

Response Times - False-Response Items. The mean response time for the false response probes was 3,539 ms (S.D. = 1115), with an accuracy rate of 0.85 (S.D. = 0.19).

The response time data can be seen in Figure 8:

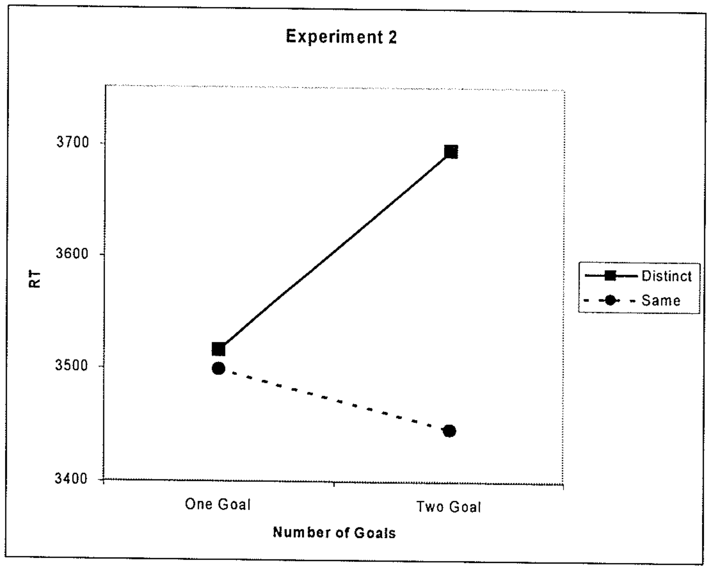


Figure 8. Mean response times (in ms) for Experiment 2 false-response probes.

There was a marginally significant Number of Goals x Goal Structure interaction, F_1 (1, 66) = 3.07, *MSE* = 1 065 922, $p = .09$, F_2 (1,12) = 3.13, *MSE* = 117 879, $p = .10$. Response times to the two-goal character probes were lower in the same-goal condition than in the distinct-goal structure. There was a significant effect of goal structure in the items random analysis only, F_1 (1,66) = 2.16, *MSE* = 581,316, $p > .10$, F_2 (1,12) = 6.04, *MSE* = 95 481, in which response time to the distinct condition was slower than response time to the same-goal structure condition. There were no other significant effects. For a complete ANOVA table see Appendix H.1.

Planned comparisons revealed marginally a significant effect by items, of number of goals in the distinct-goal structure condition, $F_1(1,66) = 2.46$, *MSE* = 485, 812, $p > .10$, $F_2(1,12) = 3.36$, *MSE* = 194 349, $p = .09$. No other significant effects were found, *F*s < 1.

Error Data - False-Response Items. The error data were consistent with the response time data. There was a main effect of goal structure, F_1 (1, 67) = 7.00, *MSE* = 1 940, F_2 (1,12) = 8.08, MSE = 54, with the same-goal structure associated with a higher accuracy rate (87% vs. 82%). There were no other significant effects found in the error data. The accuracy data can be seen in Table 8. For a complete ANOVA table, see Appendix H.2.

Table 8
Accuracy Rates for the False-Response Items of Experiment 2

	False-Response Items
Distinct One Goal	0.82
Distinct Two Goal	0.81
Same One Goal	0.86
Same Two Goal	0.89

Discussion

Experiment 2 was designed to assess a reader's memory representation for goal sets in which two characters share a goal, but attempt to satisfy it independently, and sets in which two characters are working together to achieve the same goal. Response times for the experimental items showed little evidence of the interaction that would have been consistent with the shared goal of two characters being represented as a single unit. However, the false-response probe response times showed the predicted pattern of results. Since previous research (Sharkey and Bower, 1987) has not demonstrated these same differences between false-response and goal-consistent probes, the stimuli must be examined. It was not hypothesized a priori, but the probe item itself may be having an impact on response times to the experimental items. More specifically, the mentioning of an action consistent with only one of the character's goals in Experiment 2, even when this goal is shared, may be conflicting with the participant's memory representation at time of retrieval. When participants encounter a shared goal (e.g., Mary and Bonnie wanted to buy home insurance), the goal may very well be represented as a single unit in the participant's memory. However, when participants are later presented with a test probe that features a single character (e.g., And so Mary chose the coverage), a direct match between the target goal and probe is not possible, resulting in some sort of interference.

Experiments 1 and 2 were not designed to directly assess any effect the probe may have on assessing a reader's memory representation. However, both experiments included a condition in which any interfering effect of the probe should be removed. The false-response passages of both Experiment 1 and Experiment 2 use a probe that is not related to the described character's goals, but they still reference a particular character. Using the false-response probes, in the distinct condition, there is a fan effect of goals as expected. When the characters are not collaborating on a goal, response times to the two goal character probes are slower than response times to the one goal character probes. In the same-goal condition this fan effect is completely eliminated: response times to the one goal character and two goal character are approximately equal.

The presence of a main effect of goal structure in the error data is consistent with the previous conclusion that accuracy in the same condition is improved because there are fewer goals overall. Accuracy is significantly improved (88% vs. 82%) when there are only two goals to monitor.

The overall pattern of data is consistent with the theory that participants are representing the truly shared goal as a single unit in memory. It is speculated that some sort of interference between the probe and the goal sentences used in Experiment 2 resulted in an unexpected pattern of data. In the false-response data, the interference effect due to the mismatch between the probe sentence and target goal is eliminated, resulting in response times that are reflective of the conjunctive nature of the shared goal.

The results of Experiment 1 demonstrate that a reader's representation of the goals of two characters can be tested using the fan-effect. This conclusion also has implications for how the situation model should be conceived. Some researchers view the situation model as more abstract, and less predictable than other levels of text representation. This view is somewhat understandable, as it is known that a large part of what a reader incorporates into the situation model is world knowledge. The current research, in contrast, demonstrates that at least certain aspects of the situation model, such as goal organization, are both quantifiable and predictable.

Experiment 1 data also displays a pattern that is conducive to the notion that readers represent two goals that are common (not shared) between two characters separately. The overall pattern of results found in Experiment 2 support a theory in which truly shared goals of narrative characters are represented as conjunctive by a reader. The next section will examine the ACT-R cognitive architecture, and whether the present effects can be modelled using this theory.

ACT-R Cognitive Architecture

The Adaptive Control of Thought - Rational (ACT-R; Anderson & Lebiere, 1998) is a cognitive architecture that is aimed at understanding how people organize, and act upon, knowledge in a variety of different domains. Research involving ACT-R has been published most notably within the fields of perception and attention, learning and memory, problem solving, and language processing (Budiu, 2005). Most relevant to the present study is work conducted by Anderson and Reder (1999), who used the ACT-R theory to provide quantitative predictions for the fan effect using data from a wide range of experimental paradigms. In this section I will first present a brief description of how ACT-R accounts for the basic fan effect. Following the general description of ACT-R, I will assess whether the present effects can be modelled with ACT-R.

The Basic Fan Effect

The analysis of the fan effect using ACT-R is reliant on the assumption that basic networks of associations between concepts are formed, and that activation introduced into the network spreads from presented terms to connected nodes representing learned facts. For example, using four sentences from the original fan effect (Anderson, 1974) experiment, an extracted network representation may be similar to the one presented in Figure 9:

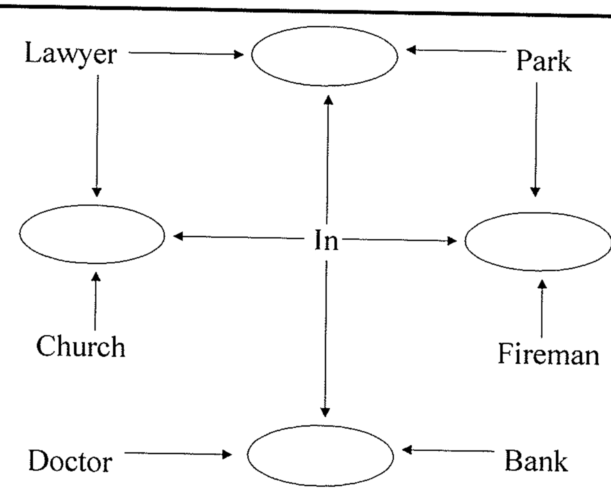


Figure 9: Network representations for the sentences: "The doctor is in the bank," "The fireman is in the park," "The lawyer is in the church," and "The lawyer is in the park". Ovals represent encoded facts, while the words represent concepts.

Based on ACT-R theory, the response time latencies associated with any specific fact is a direct result of its level of activation. The basic formula used to determine this activation is given below:

$$A_i = B_i + \Sigma_j W_j S_{ji} \qquad (1)$$

Using this formula, the level of activation for a particular fact (A_i), such as The doctor is in the bank is equal to the base level of activation associated with that fact (B_i) plus the summation over the concepts of the probe that provide the sources of activation ($\Sigma_j W_j S_{ji}$), such as doctor, in, bank, where W_j represents the amount of attention given to a source in the probe, and S_{ji} is equal to the strength of association between source (j) and fact (i). In order to account for processing limits in retrieval, (W_j) is given the restriction that it must sum to one (Anderson, Reder, & Lebiere, 1996). Further decomposing the formula, the strength of associations between sources (S_{ji}) can be represented by the following formula:

$$S_{ji} = S - \ln (f_j) \qquad (2)$$

In formula (2), the strength of association (S_{ji}) is determined by a constant (S) minus the base e logarithm of the fan (f) associated with concept (j). Using the information provided in Figure 9, for example, the fan associated with the concept doctor would be equal to one. In comparison, the fan associated with the concept park would be two, because both concepts, fireman and lawyer, are associated with it. This formula demonstrates how the level of activation of a concept decreases as a logarithmic function of the fan associated with that concept. One additional formula is necessary to translate levels of activation into specific response times:

$$T = I + Fe^{-A_i} \qquad (3)$$

Response time (T) is equal to an intercept, (I), representing actions not related to retrieval of the critical fact, plus the retrieval time (Fe^{-A_i}). From this equation, it can be seen how as activation of a particular fact increases (A_i), the time to retrieve that fact decreases (T). The (F) parameter is used to account for differences in measuring response times. A more in-depth discussion of the formulas described can be found in Anderson and Reder (1999) and Anderson, Bothell, Byrner, Douglass, Lebiere, and Qin 2004 (2004).

Using these formulas, ACT-R has had considerable success in accurately predicting response times in a wide assortment of fan effect experiments (such as, Anderson, 1974; Anderson, & Spellman, 1995; and Radvansky, Spieler, & Zacks, 1993). Next, I will present an examination of some basic ACT-R predictions related to Experiments 1 and 2, and the ability of ACT-R to model the present data will be discussed.

The Present Data

Due to the nature of the stimuli used in this study, further simplifications of the ACT-R formulas are possible. First, the amount of attention given to a source in the probe (W_j) is thought to be equal for all sources; and because it must sum to 1 with three sources of activation in all conditions, it can be set to .333. Second, the constant (S) of formula (2) is set to equal 1, for simplicity of calculations. An additional formula is required to predict activation patterns in the same one-goal and same two-goal experimental conditions of Experiment 1. Because the target goal is repeated in these conditions, it can be expected that the base level of activation is increased. The formula for determining (B_i) in a simple fan effect experiment can be seen in formula 4 (Anderson, et al., 2004):

$$B_i = d^*\ln(n) \qquad (4)$$

The constant (*d*) is most often assigned a value of .50 (Anderson et al., 2004). The parameter (*n*) is simply the number of times the concept has been presented. In Experiment 1, a goal is never seen more than twice. The base level of activation for a repeated goal can therefore be set to .347. One last assumption is necessary to model the data from Experiments 1 and 2. In the more traditional fan-effect experiments, the probes are comprised of either studied or non-studied facts. In the present study, the probe comprises a studied character and an action related to a studied or non-studied goal. One must assume that there are no systematic differences between the stimuli of the relation between the action and the goal; that is, that every action is related to the goal to a similar degree. For example, it must be assumed that the action <u>choosing the coverage</u> is as related to <u>buying home insurance</u> as the action <u>renting a stage</u> is to <u>producing a play</u>. This assumption is supported by both the randomization procedures used in creating the materials and the results of the items random analysis of both Experiments 1 and 2. Using these formulas, the resulting ACT-R predictions for the level of activation in all conditions of Experiment 1 are given in Table 9:

Table 9
ACT-R Activation Prediction For Experiment 1

	Experimental Items	**False-Response Items**
Distinct One Goal	.67	.33
Distinct Two Goal	.44	.10
Same One Goal	.78	.33
Same Two Goal	.55	.10

The hypothesized activation networks for each condition can be found in Appendix I.1, and a graph showing the response times of both the false-response and experimental items with their predicted latencies (1 - activation) can be seen in Figure 10:

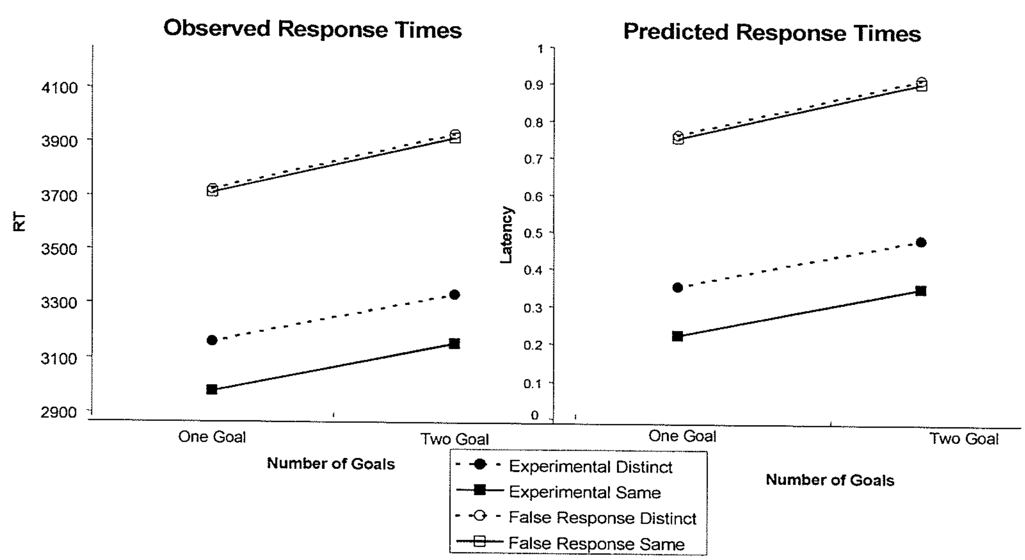


Figure 10: Experiment 1 response times (in ms) and associated ACT-R latency predictions (equal to 1 - activation level).

The predicted latencies that are derived form the activation levels are graphed so that a direct comparison between response times and ACT-R predictions can be made. It can be seen in Table 5 and Figure 10 that the ACT-R predictions are consistent with the data of Experiment 1. Specifically, main effects of number of goals in both the distinct and same goal conditions with both the experimental and false response items are predicted on the basis of the computed activation levels. Furthermore, the model also predicts the observed main effect of goal type in the experimental item response times of Experiment 1. Due to the repetition of the shared goal in the experimental same-goal condition, activation of that goal is increased. Finally, the ACT-R model predicts a lower activation level, and so an overall larger response time to the false-response items, a pattern also seen in the data. This differing level of activation is a result of the false-response items receiving only one source of activation, the character.

Experiment 1 displays what can be conceived of as the typical fan effect, something ACT-R is very good at predicting. Experiment 2 has a more complicated pattern of results. The distinct conditions of Experiment 2 do not vary from those used in Experiment 1, and so the ACT-R predictions are identical to those made previously. The predicted activation levels for all conditions in Experiment 2 can be seen in Table 10:

Table 10
ACT-R Activation Predictions for Experiment 2

	Experimental Items	**False-Response Items**
Distinct One Goal	.67	.33
Distinct Two Goal	.44	.10
Same One Goal	.67	.33
Same Two Goal	.44	.33

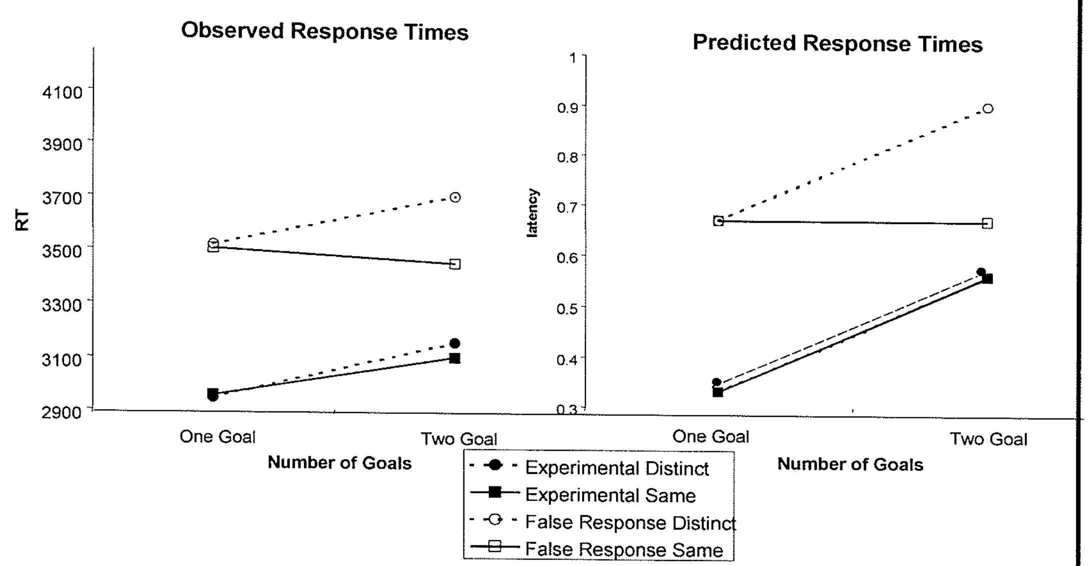


Figure 11: Experiment 2 response times (in ms) and associated ACT-R latency predictions (equal to 1 - activation level).

In Experiment 2, two different patterns of data were observed in the experimental items and the false-response items. The only difference between Experiments 1 and 2 is the goal collaboration conveyed in the same-goal condition. In Experiment 1, even when two characters had a goal in common, there was no collaboration between them. In Experiment 2, when two characters had a goal in common, it was conveyed that they had the same conjunctive goal. In the experimental items of Experiment 2, response times were larger in the same two-goal condition than in the same one-goal condition. This pattern is replicated by ACT-R, if it is assumed that only partial activation reaches the target goal in the experimental same two-goal condition, as in Figure 12:

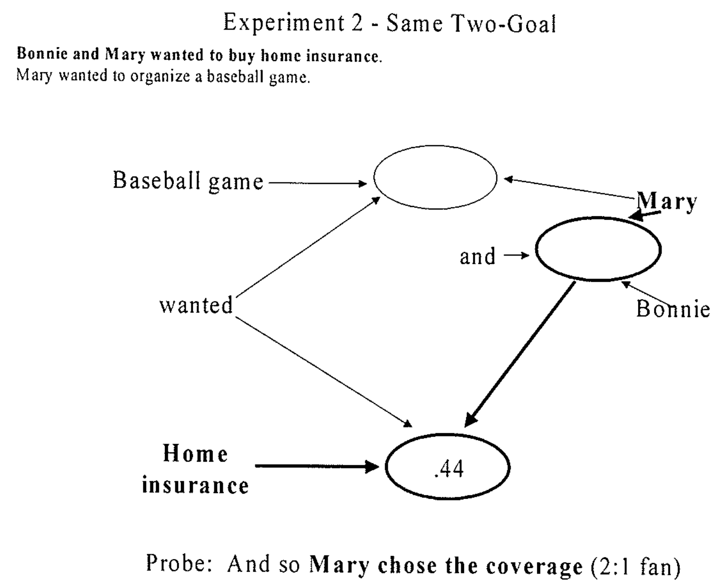
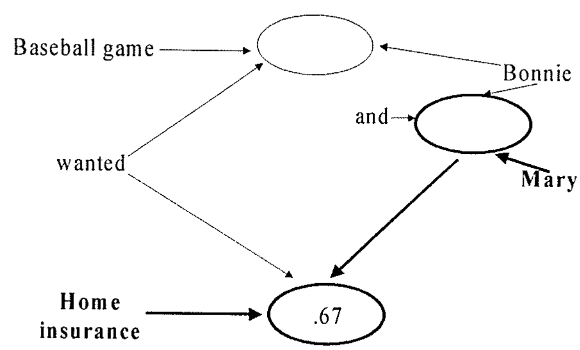


Figure 12. Network representation of an experimental same two-goal condition.

One reason for this lower activation may be that the probe character (e.g., Mary) is not completely consistent with the target goal (e.g., Mary and Bonnie buying home insurance), giving an opportunity for activation to spread to nearby nodes, such as the second goal of that character. In the same one-goal condition, no other nodes are connected to the probed character (e.g., Mary) and even with this mismatch between the probe character and target goal, activation spreads to the appropriate fact (Figure 13).

Experiment 2 - Same One-Goal

Mary and Bonnie wanted to buy home insurance.
Bonnie wanted to organize a baseball game.



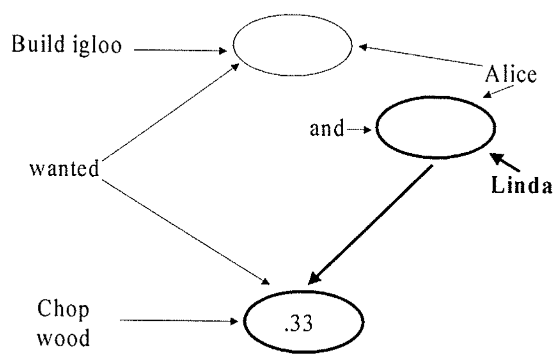
Probe: And so **Mary chose the coverage** (1:1 fan)

Figure 13. Network representation of an experimental same one-goal condition.

For the false-response items, response times were approximately equal in the same one goal and same two goal conditions. It is speculated that the false-response same one-goal condition behaves exactly like the experimental counterpart. In the same one-goal condition, no other nodes are connected to the probed character, and activation is correctly spread (Figure 14).

Experiment 2 - Same One-Goal False Response

Linda and Alice wanted to chop some wood.
Alice wanted to build an igloo.



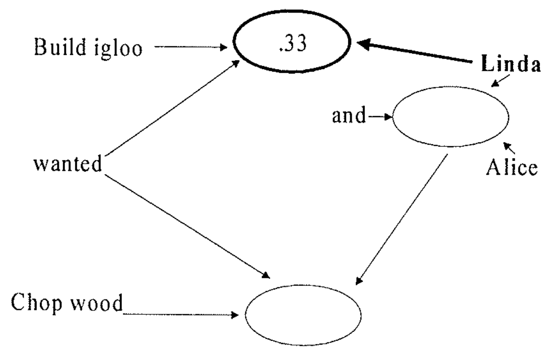
Probe: And so **Linda** shuffled the deck (1:0 fan)

Figure 14. Network representation of a false-response same one-goal condition.

In the false-response same two-goal character condition, it is suggested that without a mismatch between the probed character and one of the goals (the solitary goal of the two goal character), all activation is found only in the solitary goal of the two goal character (Figure 15).

Experiment 2 - Same Two-Goal False Response

Alice and Linda wanted to chop some wood.
Linda wanted to build an igloo.



Probe: And so **Linda** shuffled the deck (1:0 fan)

Figure 15. Network representation of a false-response same two-goal condition.

All of the postulated networks and their associated activation patterns for Experiment 2 are shown in Appendix I.2.

Even though there is much work left to be done regarding an ACT-R model of goal scenarios like those presented above, I believe that this thesis provides a start. The ACT-R activation patterns fit quite well with the data of the both Experiments 1 and 2. In view of the similarity between Experiment 1 and other fan effect paradigms, it should be possible to extract response time predictions for later experiments. Unfortunately, Experiments 1 and 2 were not initially intended for this purpose, and as such, much of the data required for accurate modeling of response time patterns was not collected. The ACT-R predictions involving Experiment 2 are a close fit to the response times, but no work has been done validating the posited network representations, so they must be evaluated cautiously.

General Discussion

In this study, I inspected a reader's memory representations of more complex goal situations. Specifically, I examined how participants represented a scenario in which two characters have a goal superficially in common (Experiment 1) and when two characters are truly working to achieve a joint goal (Experiment 2). From the results of this study, a number of conclusions can be made about how goal information is stored by readers during comprehension.

First, participants are organizing the presented goals in a systematic and predictable manner, and this goal structure can be tested using the fan effect. This conclusion has implications for how the situation model should be conceived. At present, some researchers view the situation model as more abstract, and less predictable than other levels of text representation, such as the textbase. This view is somewhat understandable, as a large part of what constitutes the situation model is a reader's own knowledge. The current research, in contrast, demonstrates that at least aspects of the situation model, such as goal organization, are both quantifiable and predictable. The findings in the present study are comparable to those found in studies using other features typically ascribed to the situation model such as distance (Glenberg, Meyer, & Lindem, 1987), or causal relations (Lutz & Radvansky, 1997; Suh & Trabasso, 1993). Both distance and causal relations are dimensions of the situation model that have been consistently predicted. One major difference between this study and those preceding it is the complexity of the goal relations examined. Previous work involving a reader's ability to monitor goal structures have focused on simplistic relations. The most common form of these goal structures are short stories in which a protagonist is faced with a main goal. In order to achieve this main goal, a number of subgoals must be achieved, and if a subgoal fails, it is replaced by another. For example, a girl may want to buy her mother a birthday present, but when her attempt fails she decides to make a gift instead (Suh & Trabasso, 1993). The results of these basic goal structure experiments are a good start at quantifying elements of the situation model, but in order to be convincing one must be able to account for a wide range of scenarios readers may encounter. Many ordinary narratives require the coordination of complex goal relations, such as when two characters are working to achieve the same goal together.

Second, intuitions about how a common, but unshared, goal of two characters would be represented by readers were confirmed. The evidence suggested that participants maintained each of the protagonist's goals as separate, despite the superficial conjunction between two of the goals (Experiment 1). Experiment 2 is interpreted as evidence that readers represent truly shared goals differently in memory than common but unshared goals. The results of the experimental items in Experiment 2 did not display the predicted pattern of data. It was found that response times to a shared one-goal character probe was less than response time to a shared two-goal character probe, but it is speculated that the probe used was inappropriate. More specifically, the mentioning of an action consistent with only one of the character's goals in Experiment 2 may have interfered with the participant's memory representation at the time of retrieval. Using a different probe item (false-response probes), the results were as initially predicted: Response times to the two-goal character probes were considerably reduced in the same-goal structure passage. The differing pattern found in the response time is hypothesized to result from the conjunctive nature of the shared goal being represented in the reader's memory representation. In essence, the shared goal is represented as a single node in the reader's memory, and therefore the extracted goal network is substantially different from that seen in Experiment 1.

Applying the ACT-R account to the data of Experiment 1 revealed a consistent match between the predicted levels of activation of the various goals and the response times observed. The ability for ACT-R to correctly predict the data pattern observed in Experiment 1 is not surprising because it has been used in numerous previous studies for similar purposes. The present study begins laying the foundation for more accurate and descriptive modeling work. Further work should allow precise response time predictions to be made using a similar paradigm and stimuli. The predicted activation patterns for Experiment 2 were also consistent with the response time data. However, more work will be needed to begin to truly explain the pattern of results seen in Experiment 2 using a mathematical model.

A critical next step would be to test a participant's representation for a superficially shared goal, and a truly shared goal in a single experiment. Due to the methods employed in the current study, such as using the same probe across conditions, and using a fully counterbalanced design, a method to do this is not readily apparent. One alternative may be to use more false response passages, and remove the goal structure variable. With the results of both Experiments 1 and 2 confirming the presence of a number of goals fan effect in response times in the distinct goal condition, it may not be necessary to include it in future experiments. Instead, goal statements would be manipulated to vary by shared nature (superficial versus true), and number of goals (one versus two).

When taken as a whole, this research provides a backing for further experiments assessing a reader's representation of goal structures. One line of such experiments could target some of the many other goal relations a reader may encounter (such as competitive goals), or examine goal relations using more naturalistic passages derived from real world texts. Work by researchers such as Radvansky (1998) provides a compelling argument for using simplistic text structures like those used in the present study as a starting point. In order to fully demonstrate the representations readers extract from texts, passages that are more naturalistic must be used. Alternatively, the relation between the ability to accurately represent varying goal structures and general comprehension of narratives may be an interesting line of research. Because goal comprehension plays such an important role in understanding narratives (Wenner, 2004), it may be that individuals who are unable to accurately represent complex goal structures found in texts have difficulty in fully understanding various relations among protagonists an author is trying to convey.

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Appendix A.1
Sample experimental item in all conditions for Experiment 1.

Distinct 1 Goal Character

Mary wanted to buy home insurance.
Bonnie wanted to organize a baseball game.
Bonnie wanted to get a flu shot.

Probe: And so Mary chose the coverage.

Distinct 2 Goal Character

Bonnie wanted to get a flu shot.
Mary wanted to buy home insurance.
Mary wanted to organize a baseball game.

Probe: And so Mary chose the coverage.

Same 1 Goal Character

Mary wanted to buy home insurance.
Bonnie wanted to buy home insurance.
Bonnie wanted to organize a baseball game.

Probe: And so Mary chose the coverage.

Same 2 Goal Character

Bonnie wanted to buy home insurance.
Mary wanted to buy home insurance.
Mary wanted to organize a baseball game.

Probe: And so Mary chose the coverage.

Appendix A.2
Sample false item in all conditions for Experiment 1.

Distinct 1 Goal Character

Linda wanted to chop some wood.
Alice wanted to build an igloo.
Alice wanted to go horseback riding.

Probe: And so Linda shuffled the deck.

Distinct 2 Goal Character

Alice wanted to chop some wood.
Linda wanted to build an igloo.
Linda wanted to go horseback riding

Probe: And so Linda shuffled the deck.

Same 1 Goal Character

Linda wanted to chop some wood.
Alice wanted to chop some wood.
Alice wanted to build an igloo.

Probe: And so Linda shuffled the deck.

Same 2 Goal Character

Linda wanted to chop some wood.
Alice wanted to chop some wood.
Alice wanted to build an igloo.

Probe: And so Linda shuffled the deck.

Appendix B.1.
Instructions for Experiment 1.

DURING THIS EXPERIMENT, PLEASE DO NOT MOVE THE MONITOR OR ADJUST ANY OF ITS SETTINGS. THANK YOU FOR YOUR HELP.

Instructions - SARNIA -

You have as much time as you need to read these instructions. Feel free to read them more than once.

In this experiment, your task will be to read sets of three sentences on the computer monitor. After each sequence, you will have to answer a question.

The keyboard will sit on the table in front of you. Throughout the experiment, keep your index fingers on the buttons labelled YES and NO, and one thumb on the space bar, labelled "READY". The experimenter will illustrate this. Please note carefully which button is YES and which is NO.

Here is the exact procedure. When the word READY appears in the centre of the screen, press the space bar with your thumb. The first of three sentences will appear on the screen. All of the sentences will describe the goal of a character, such as "The announcer wanted to go to graduate school." Some characters will be described as having two goals. Read the sentence so that you understand what it says, and then press the space bar to proceed to the next sentence.

After the third sentence of a set, the message TEST ITEM will appear on the screen for three seconds. An X will then appear. Look directly at the X. A test item will appear that will refer to an action that one of the characters performs. Answer Yes if the action is consistent with any goal of that character. Answer No if the action is inconsistent with the goals of the character. Register your answer by pressing the Yes and No buttons with your index fingers.

For illustration, here is a sample set, followed by some test items, their answers, and explanations for the answers.

In this set, the two characters have one goal in common. However, always interpret the two characters to be working independently -- there is no connection between them.

The Jackie wanted to take a photograph.
The Alyssa wanted to change the flat tire.
The Alyssa wanted to take a photograph.

Test Item: And so the Alyssa filled the box. Answer - NO. Filling the box is unrelated to both of the Alyssa's goals of changing the flat tire and taking a photograph.

Test Item: And so the Alyssa took off the lens cap. Answer - YES. Taking off the lens cap is consistent with the Alyssa's goal of taking a photograph.

Test Item: And so the Jackie loaded film in the camera. Answer - YES. Loading film in the camera is consistent with the Jackie's goal of taking a photograph.

It is very important to (1) read each of the three goal sentences of each set so that you understand what it says, and (2) then answer each test item as quickly as you can without getting the wrong answer. The test item will remain on the screen for 10 seconds, and you will be counted wrong if you do not respond by then. However, you should respond as quickly as possible. You won't be told if you are right or wrong.

After the three sentences and its question, there will be a brief pause, and the READY signal will appear again. In summary, your task is to press the space bar to read and understand each sentence. After each set of three sentences, respond YES or NO to the test item according to whether it describes an action consistent with one of that character's goals. Respond as quickly as you can without getting the wrong answer.

During the experiment, there will be a rest period, followed by a 10 second warning to get ready again.

You may reread these instructions if you wish. There will be an opportunity to ask the experimenter any questions you may have before the experiment begins.

Appendix B.2.
Debriefing form from Experiment 1

Debriefing Sheet

Thank you very much for participating in the experiment. **Since many of your classmates will also take part, please be sure not to discuss it with them until completion of the study in June.**

Consider the brief sentence, <u>the haystack was important because the cloth ripped</u>. While this sentence is completely grammatical, it strikes us as virtually nonsensical. Suppose you are next asked to think about a parachutist floating over a field. The original sentence suddenly takes on a new dimension of meaning.

One thing that has been learned by psychologists studying language is that language only has meaning in the frame of reference of our knowledge about the world. From this perspective, we can view the reader or listener as striving to continually compare each new sentence with familiar concepts and knowledge.

The experiment you just participated in is one of a series which aims to study the way we understand ordinary language. In particular, these experiments have addressed the problem of whether we know more, after reading a sentence, than was directly stated. Take, for example, the sentences <u>the tooth was drilled</u> and <u>the floor was swept</u>. After reading the former, most of us would agree that t was (probably_ a dentist who performed the action. For the latter, we would similarly argue that the sweeping was accomplished with a broom. It was hypothesized that when a sentence strongly implies a related concept in this way, that the reader of a sentence "infers" the concept during reading. To test this hypothesis, people were asked to read brief sentences like (1) and (2):

1. The dentist drilled the tooth painlessly.
2. The tooth was drilled painlessly.

Immediately after seeing (1) or (2), the reader had to say whether a test sentence like 3. <u>a dentist drilled the tooth</u> was true or false in context of the previous sentence. If the reader infers the participation of a dentist while reading (2), it should take no longer to judge the test sentence as "true" after (2) than (1). If, however, this inference is not drawn, the truth judgment would take longer after (2) than (1).

Surprisingly, it was found that people do need more time to judge (3) true when it follows (2) than (1). This outcome supported the position that people do not necessarily draw inferences about even strongly implied concepts. It was speculated that one reason for this is that, since even the simplest sentence has many implications, it is not possible for the reader to draw every corresponding reference.

The next step, therefore, was to try to identify factors that guide the inferences that people draw during reading. An important factor can best be explained in terms of an example. Consider the sequence, The patient was examined at the clinic. The doctor was worried. If the reader of this sequence did not infer that the doctor examined the patient, the sequence would appear as disjointed as The car turned the corner. The ice cream was melted. The inference that the doctor examined the patient is **necessary** for the sequence to appear coherent. In previous experiments, we contrasted directly stated ideas, necessary inferences, and likely but unnecessary inferences. It was found that judgments about necessary inferences were generally the same as directly stated ideas (e.g., The patient was examined **by the doctor** at the clinic.) This supported the notion that necessary inferences are drawn during reading.

Finally, the experiment you participated in described two characters who were trying to achieve certain goals. You were shown sentences such as:

4. Jackie wanted to make a milk shake.
5. Alyssa wanted to sing karaoke.
6. Alyssa wanted new eyeglasses.

Later, you read an action (target item) these characters performed such as:

7. And so Jackie got out the ice cream.
8. And so Alyssa went on stage.

Previous experiments have demonstrated that response time to target items associated with characters who have multiple goals (the preacher) are generally slower than when the test item is associated with a character who has only one goal. (the photographer).

This experiment was aimed at determining what happens when multiple characters have the same goal. It is hypothesized that even when characters **superficially share** the same goal, response time to target items will be slower with the two goal character when compared to the one goal character.

Consider the example:

9. Jackie wanted to cut the grass.
10. Jackie wanted to learn to play the drums.
11. Alyssa wanted to learn to play the drums.

Later, target items were presented such as:

12. And so Jackie took out the lawnmower.

13. And so Jackie bought some cymbals.
14. And so the Alyssa practiced everyday.

In this example, it can be assumed that the two characters are not collaborating on their goal of learning to play the drums. For this reason, it is hypothesized that readers will treat the two goals as separate, even though the characters share the same goal. This hypothesis is based on previous evidence that complex goal structures are monitored by readers during normal comprehension.

In summary, the main aim of the experiment was to determine the extent to which people represent and monitor the goals of story characters.

Other students from your class may take part in this experiment, so please do not discuss it with others.

Thank you very much for your participation and cooperation.

Appendix C.1.
Sample experimental item in all conditions in Experiment 2.

Distinct 1 Goal Character

Mary wanted to buy home insurance.
Bonnie wanted to organize a baseball game.
Bonnie wanted to get a flu shot.

Probe: And so Mary chose the coverage.

Distinct 2 Goal Character

Bonnie wanted to get a flu shot.
Mary wanted to buy home insurance.
Mary wanted to organize a baseball game.

Probe: And so Mary chose the coverage.

Same 1 Goal Character

Mary and Bonnie wanted to buy home insurance.
Bonnie wanted to organize a baseball game.

Probe: And so Mary chose the coverage.

Same 2 Goal Character

Bonnie and Mary wanted to buy home insurance.
Mary wanted to organize a baseball game.

Probe: And so Mary chose the coverage.

Appendix C.2
Sample false item in all conditions for Experiment 2.

Distinct 1 Goal Character

Linda wanted to chop some wood.
Alice wanted to build an igloo.
Alice wanted to go horseback riding.

Probe: And so Linda shuffled the deck.

Distinct 2 Goal Character

Alice wanted to chop some wood.
Linda wanted to build an igloo.
Linda wanted to go horseback riding

Probe: And so Linda shuffled the deck.

Same 1 Goal Character

Linda and Alice wanted to chop some wood.
Alice wanted to build an igloo.

Probe: And so Linda shuffled the deck.

Same 2 Goal Character

Alice and Linda wanted to chop some wood.
Linda wanted to build an igloo.

Probe: And so Linda shuffled the deck.

Appendix D.1.
Instructions from Experiment 2

DURING THIS EXPERIMENT, PLEASE DO NOT MOVE THE MONITOR OR ADJUST ANY OF ITS SETTINGS. THANK YOU FOR YOUR HELP.

Instructions - SARNIA -

You have as much time as you need to read these instructions. Feel free to read them more than once.

In this experiment, your task will be to read sets of two to three sentences on the computer monitor. After each sequence, you will have to answer a question.

The keyboard will sit on the table in front of you. Throughout the experiment, keep your index fingers on the buttons labelled YES and NO, and one thumb on the space bar, labelled READY. The experimenter will illustrate this. Please note carefully which button is YES and which is NO.

Here is the exact procedure. When the word READY appears in the centre of the screen, press the bar with your thumb. The first sentence will appear on the screen. All of the sentences will describe the goal of a character, such as "Tamara wanted to go to graduate school." Some characters will be described as having two goals. Read the sentence carefully, and press the space bar when you are ready to proceed to the next sentence.

After the second or third sentence of a set, the message TEST ITEM will appear on the screen for three seconds. An X will then appear on the screen. Look directly at the X. A test item will appear that will refer to an action one of the characters performs. Answer YES if the action is consistent with any of the goals of that character. Answer NO if the action is inconsistent with the goals of the character. Register your answer by pressing the YES and NO buttons with your index fingers.

For illustration, here is a sample set, followed by some test items, their answers, and explanations for the answers.

Jackie and Alyssa wanted to take a photograph.
Alyssa wanted to change the flat tire.

Test Item: And so Alyssa filled the box. Answer - NO. Filling the box is unrelated to both of Alyssa's goals of changing the flat tire and taking a photograph.

Test Item: And so Alyssa took off the lens cap. Answer - YES. Taking off the lens cap is consistent with Alyssa's goal of taking a photograph.

Test Item: And so Jackie loaded film in the camera. Answer - YES. Loading film in the camera is consistent with Jackie's goal of taking a photograph.

It is very important to (1) read the sentences until you feel that you have learned them, and (2) then answer the test item as quickly as you can without getting the wrong answer. The test items will remain on the screen for 10 seconds, and you will be counted wrong if you do not respond by then. However, you should respond as quickly as possible. You will not be told if you are right or wrong.

After the two to three sentences plus their question, there will be a brief pause, and the READY signal will appear again. In summary, your task is to press the space bar to read each sentence. After every two to three sentences, answer the test item by pressing the YES or NO button. Respond as quickly as you can without getting the wrong answer.

During the experiment, there will be a rest period, followed by a 10 second warning to get ready again.

You may reread these instructions if you wish. There will be an opportunity to ask the experimenter any questions you may have before the experiment begins.

Appendix D.2.
Debriefing form for Experiment 2.

Debriefing Sheet

Thank you very much for participating in the experiment. **Since many of your classmates will also take part, please be sure not to discuss it with them until completion of the study in June.**

Consider the brief sentence, the haystack was important because the cloth ripped. While this sentence is completely grammatical, it strikes us as virtually nonsensical. Suppose you are next asked to think about a parachutist floating over a field. The original sentence suddenly takes on a new dimension of meaning.

One thing that has been learned by psychologists studying language is that language only has meaning in the frame of reference of our knowledge about the world. From this perspective, we can view the reader or listener as striving to continually compare each new sentence with familiar concepts and knowledge.

The experiment you just participated in is one of a series which aims to study the way we understand ordinary language. In particular, these experiments have addressed the problem of whether we know more, after reading a sentence, than was directly stated. Take, for example, the sentences the tooth was drilled and the floor was swept. After reading the former, most of us would agree that t was (probably_ a dentist who performed the action. For the latter, we would similarly argue that the sweeping was accomplished with a broom. It was hypothesized that when a sentence strongly implies a related concept in this way, that the reader of a sentence "infers" the concept during reading. To test this hypothesis, people were asked to read brief sentences like (1) and (2):

1. The dentist drilled the tooth painlessly.
2. The tooth was drilled painlessly.

Immediately after seeing (1) or (2), the reader had to say whether a test sentence like 3. a dentist drilled the tooth was true or false in context of the previous sentence. If the reader infers the participation of a dentist while reading (2), it should take no longer to judge the test sentence as "true" after (2) than (1). If, however, this inference is not drawn, the truth judgment would take longer after (2) than (1).

Surprisingly, it was found that people do need more time to judge (3) true when it follows (2) than (1). This outcome supported the position that people do not necessarily draw inferences about even strongly implied concepts. It was speculated that one reason for this is that, since even the simplest sentence has many implications, it is not possible for the reader to draw every corresponding reference.

The next step, therefore, was to try to identify factors that guide the inferences that people draw during reading. An important factor can best be explained in terms of an example. Consider the sequence, The patient was examined at the clinic. The doctor was worried. If the reader of this sequence did not infer that the doctor examined the patient, the sequence would

appear as disjointed as The car turned the corner. The ice cream was melted. The inference that the doctor examined the patient is **necessary** for the sequence to appear coherent. In previous experiments, we contrasted directly stated ideas, necessary inferences, and likely but unnecessary
inferences. It was found that judgments about necessary inferences were generally the same as directly stated ideas (e.g., The patient was examined **by the doctor** at the clinic.) This supported the notion that necessary inferences are drawn during reading.

Finally, the experiment you participated in described two characters who were trying to achieve certain goals. You were shown sentences such as:

4. Jackie and Alyssa wanted to make a milk shake.
5. Alyssa wanted new eyeglasses.

Later, you read an action (target item) a character performed such as:

6. And so Jackie got out the ice cream.
7. And so Alyssa went on stage.

Previous experiments have demonstrated that response time to target items associated with characters who have multiple goals (Alyssa) are generally slower than when the test item is associated with a character who has only one goal. (Jackie).

This experiment was aimed at determining what happens when multiple characters have the same goal and are working collaboratively to achieve it. It is hypothesized that when characters **truly share** the same goal, response times to target items will be equal with the one goal character.

Consider the example:

8. Jackie and Alyssa wanted to cut the grass.
9. Alyssa wanted to learn to play the drums.

Later, target items were presented such as:

10. And so Jackie took out the lawnmower.
11. And so Alyssa practiced everyday.

In this example, it can be assumed that the two characters are collaborating on their goal of cutting the grass. For this reason, it is hypothesized that readers will treat the shared goal as one. This hypothesis is based on previous evidence that complex goal structures are monitored by readers during normal comprehension.

In summary, the main aim of the experiment was to determine the extent to which people represent and monitor the goals of story characters.

Other students from your class may take part in this experiment, so please do not discuss it with others.

Thank you very much for your participation and cooperation.

Appendix E.1
Response Time ANOVA for Experiment 1 - Experimental Items

Participants Random

Source	Sum of Squares	df	Mean Square	F	Significance
Structure	2014323.611	1	2014323.611	4.519	.038
Error (Structure)	26745826.645	60	445763.777	---	---
Number of Goals	2147500.262	1	2147500.262	6.230	.015
Error (Goals)	20680661.607	60	344677.693	---	---
Structure x Goals	147.905	1	147.905	.000	.984
Error (Structure x Goals)	20590755.256	60	343179.254	---	---

Items Random - Experimental Items

Source	Sum of Squares	df	Mean Square	F	Significance
Structure	825346.260	1	825346.260	9.415	.006
Error (Structure)	1665535.893	19	87659.784	---	---
Number of Goals	1237190.158	1	1237190.158	13.824	.001
Error (Goals)	1700423.485	19	89495.973	---	---
Structure x Goals	38076.741	1	38076.741	.655	.428
Error (Structure x Goals)	1104411.173	19	58126.904	---	---

Appendix E.2
Accuracy ANOVA for Experiment 1 - Experimental Items

Participants Random

Source	Sum of Squares	df	Mean Square	F	Significance
Structure	4464.289	1	4464.289	27.577	< .000
Error (Structure)	9712.992	60	161.883	---	---
Number of Goals	177.547	1	177.547	1.095	.300
Error (Goals)	9727.698	60	162.128	---	---
Structure x Goals	36.653	1	36.653	.249	.619
Error (Structure x Goals)	8820.135	60	147.002	---	---

Items Random

Source	Sum of Squares	df	Mean Square	F	Significance
Structure	1604.438	1	1604.438	66.193	.000
Error (Structure)	460.537	19	24.239	---	---
Number of Goals	63.809	1	63.809	1.090	.310
Error (Goals)	1112.595	19	58.558	---	---
Structure x Goals	13.173	1	13.173	.322	.577
Error (Structure x Goals)	777.985	19	40.947	---	---
Error (Structure x Goals)	513.624	19	27.033	---	---

Appendix F.1.
Response Time ANOVA for Experiment 1 - False Response Probes.

Participants Random

Source	Sum of Squares	df	Mean Square	F	Significance
Structure	15852.456	1	15852.456	.029	.866
Error (Structure)	33093077.539	60	551551.292	---	---
Number of Goals	3129080.209	1	3129080.209	4.298	.042
Error (Goals)	43680053.035	60	728000.884	---	---
Structure x Goals	6000.030	1	6000.030	.010	.921
Error (Structure x Goals)	36089224.462	60	601487.074	---	---

Items Random

Source	Sum of Squares	df	Mean Square	F	Significance
Structure	64941.514	1	64941.514	.492	.497
Error (Structure)	1585390.425	12	132115.869	---	---
Number of Goals	1179789.708	1	1179789.708	6.605	.025
Error (Goals)	2143294.256	12	178607.855	---	---
Structure x Goals	41452.451	1	41452.451	.971	.344
Error (Structure x Goals)	512212.903	12	42684.409	---	---

Appendix F.2.
Accuracy ANOVA for Experiment 1 - False Response Probes.

Participants Random

Source	Sum of Squares	df	Mean Square	F	Significance
Structure	1921.533	1	1921.533	6.453	.014
Error (Structure)	17865.103	60	297.752	---	---
Number of Goals	363.694	1	363.694	1.252	.268
Error (Goals)	17427.209	60	290.453	---	---
Structure x Goals	133.579	1	133.579	.491	.486
Error (Structure x Goals)	16319.672	60	271.995		

Items Random

Source	Sum of Squares	df	Mean Square	F	Significance
Structure	271.995	1	271.995	4.132	.065
Error (Structure)	1404.059	12	117.005	---	---
Number of Goals	91.497	1	91.497	.836	.378
Error (Goals)	1312.610	12	109.384	---	---
Structure x Goals	33.605	1	33.605	.190	.671
Error (Structure x Goals)	2121.318	12	176.776	---	---

Appendix G.1
Response Time ANOVA for Experiment 2 - Experimental Items

Participants Random

Source	Sum of Squares	df	Mean Square	F	Significance
Structure	36181.433	1	36181.433	.120	.730
Error (Structure)	20217963.626	67	301760.651	---	---
Number of Goals	2237552.884	1	2237552.884	9.337	.003
Error (Goals)	16056960.310	67	239656.124	---	---
Structure x Goals	80942.874	1	80942.874	.295	.589
Error (Structure x Goals)	18402617.942	67	274665.939	---	---

Items Random

Source	Sum of Squares	df	Mean Square	F	Significance
Structure	53681.219	1	53681.219	.732	.403
Error (Structure)	1393844.269	19	73360.225	---	---
Number of Goals	766159.113	1	766159.113	12.738	.002
Error (Goals)	1142829.668	19	60148.930	---	---
Structure x Goals	856.649	1	856.649	.008	.931
Error (Structure x Goals)	2089750.747	19	109986.881	---	---

Appendix G.2
Accuracy ANOVA for Experiment 2 - Experimental Items

Participants Random

Source	Sum of Squares	df	Mean Square	F	Significance
Structure	3215.762	1	3215.762	15.723	< .000
Error (Structure)	13702.850	67	204.520	---	---
Number of Goals	140.659	1	140.659	1.142	.289
Error (Goals)	8252.233	67	123.168	---	---
Structure x Goals	127.385	1	127.385	.923	.340
Error (Structure x Goals)	9245.334	67	137.990	---	---

Items Random

Source	Sum of Squares	df	Mean Square	F	Significance
Structure	1035.890	1	1035.890	15.017	.001
Error (Structure)	1310.646	19	68.981	---	---
Number of Goals	45.310	1	45.310	.970	.337
Error (Goals)	887.928	19	46.733	---	---
Structure x Goals	41.034	1	41.034	1.518	.233

Appendix H.1.
Response Time ANOVA for Experiment 2 - False-Response Items.

Participants Random

Source	Sum of Squares	df	Mean Square	F	Significance
Structure	1258655.093	1	1258655.093	2.165	.146
Error (Structure)	38366844.614	66	581315.827	---	---
Number of Goals	268298.669	1	268298.669	.593	.444
Error (Goals)	29878963.961	66	452711.575	---	---
Structure x Goals	1065922.041	1	1065922.041	3.066	.085
Error (Structure x Goals)	22943896.641	66	347634.798	---	---

Items Random

Source	Sum of Squares	df	Mean Square	F	Significance
Structure	577132.695	1	577132.695	6.044	.030
Error (Structure)	1145777.174	12	95481.431	---	---
Number of Goals	287979.806	1	287979.806	1.187	.297
Error (Goals)	2910709.970	12	242559.164	---	---
Structure x Goals	368618.980	1	368618.980	3.127	.098
Error (Structure x Goals)	1414545.859	12	117878.822	---	---

Appendix H.2.
Accuracy ANOVA for Experiment 2 - False-Response Items

Participants Random

Source	Sum of Squares	df	Mean Square	F	Significance
Structure	1939.945	1	1939.945	7.004	.010
Error (Structure)	18556.985	67	276.970	---	---
Number of Goals	99.578	1	99.578	.507	.479
Error (Goals)	13146.446	67	196.216	---	---
Structure x Goals	338.904	1	338.904	1.147	.288
Error (Structure x Goals)	19792.688	67	295.413	---	---

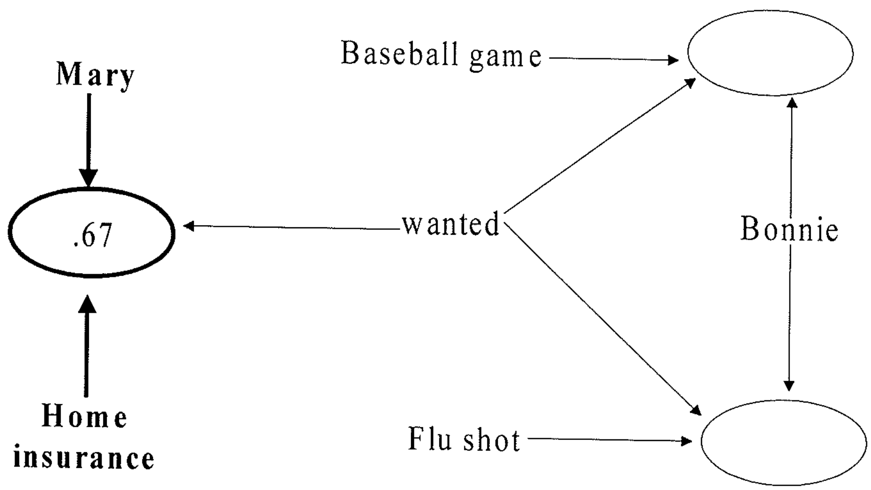
Items Random

Source	Sum of Squares	df	Mean Square	F	Significance
Structure	437.439	1	437.439	8.081	.015
Error (Structure)	649.603	12	54.134	---	---
Number of Goals	22.454	1	22.454	.339	.571
Error (Goals)	794.393	12	66.199	---	---
Structure x Goals	76.420	1	76.420	1.525	.241
Error (Structure x Goals)	601.491	12	50.124	---	---

Appendix I.1
ACT-R Network Representations and levels of activation for Experiment 1

Experiment 1 - Distinct One-Goal

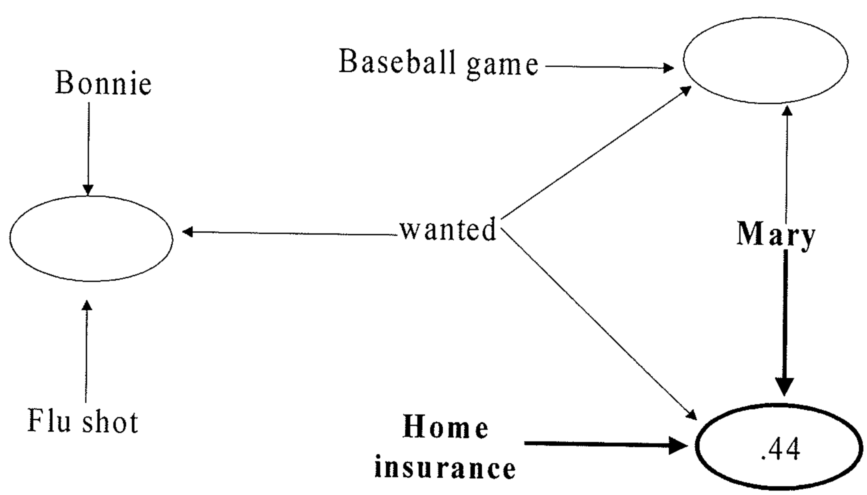
Mary wanted to buy home insurance.
Bonnie wanted to organize a baseball game.
Bonnie wanted to get a flu shot.



Probe: And so **Mary chose the coverage** (1:1 fan)

Experiment 1 - Distinct Two-Goal

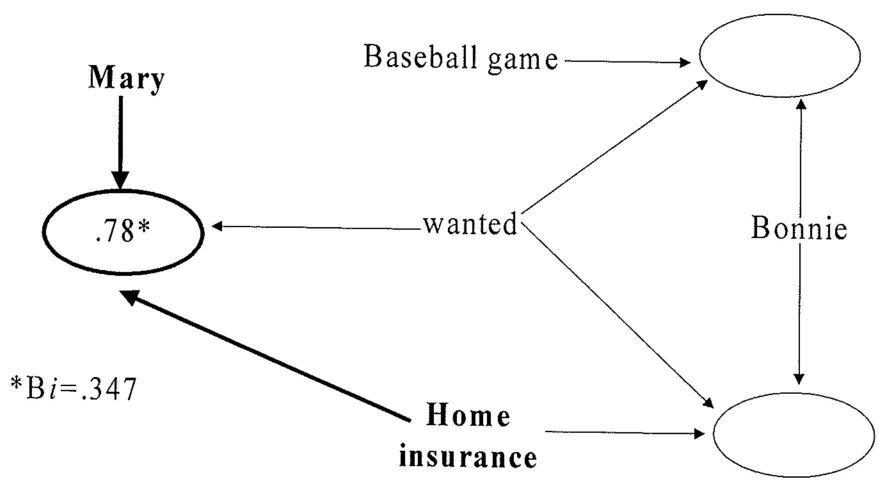
Bonnie wanted to get a flu shot.
Mary wanted to buy home insurance.
Mary wanted to organize a baseball game.



Probe: And so **Mary chose the coverage** (2:1 fan)

Experiment 1 - Same One-Goal

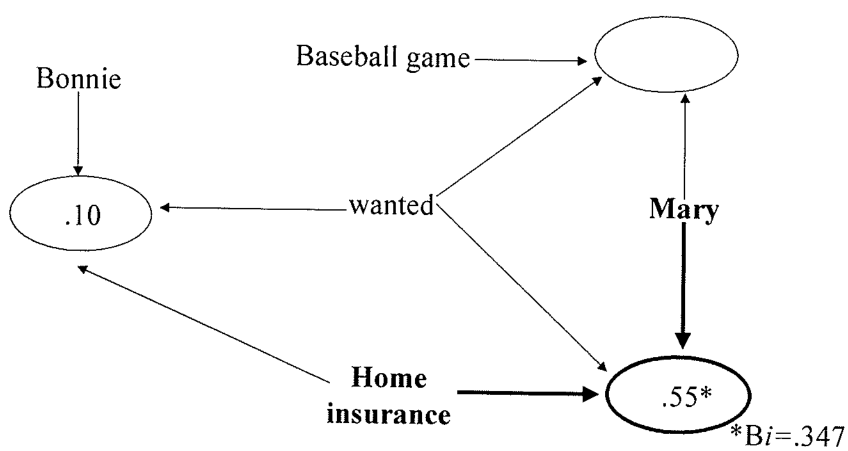
Mary wanted to buy home insurance.
Bonnie wanted to buy home insurance.
Bonnie wanted to organize a baseball game.



Probe: And so **Mary chose the coverage** (1:2 fan)

Experiment 1 - Same Two-Goal

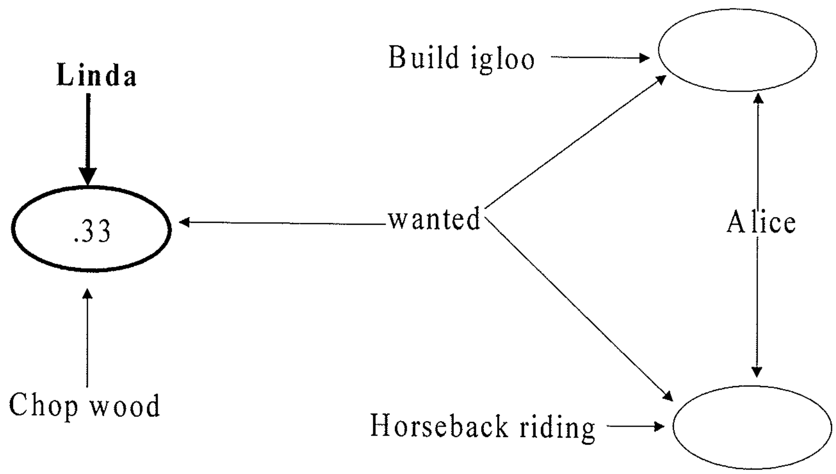
Bonnie wanted to buy home insurance.
Mary wanted to buy home insurance.
Mary wanted to organize a baseball game.



Probe: And so **Mary chose the coverage** (2:2 fan)

Experiment 1 - Distinct One-Goal False Response

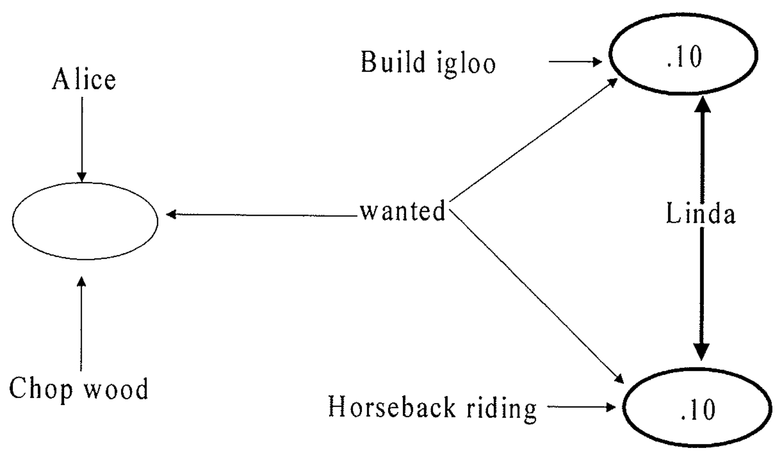
Linda wanted to chop some wood.
Alice wanted to build an igloo.
Alice wanted to go horseback riding.



Probe: And so **Linda** shuffled the deck (1:0 fan)

Experiment 1 - Distinct Two-Goal False Response

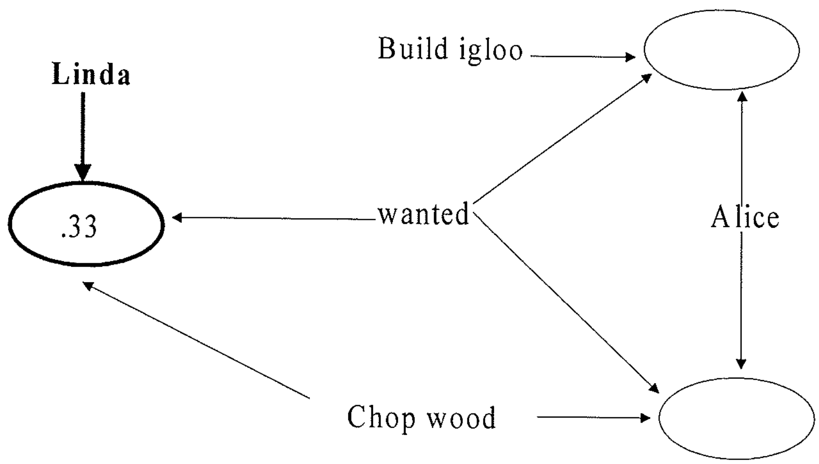
Alice wanted to chop some wood.
Linda wanted to build an igloo.
Linda wanted to go horseback riding.



Probe: And so **Linda** shuffled the deck (2:0 fan)

Experiment 1 - Same One-Goal False Response

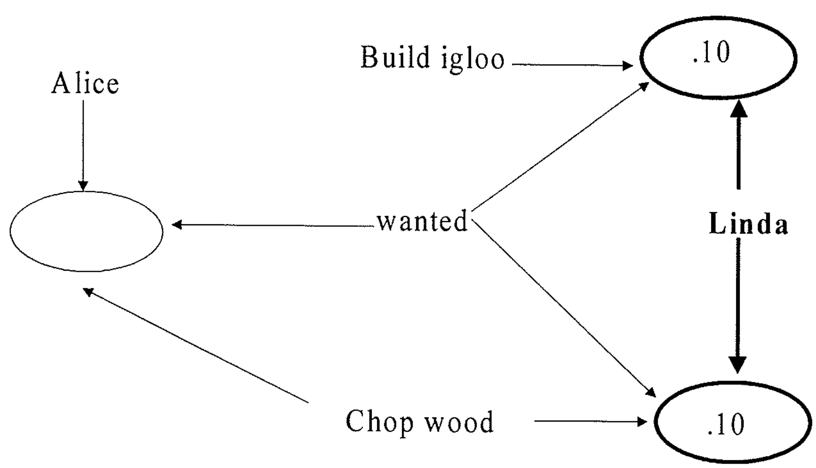
Linda wanted to chop some wood.
Alice wanted to chop some wood.
Alice wanted to build an igloo.



Probe: And so **Linda** shuffled the deck (1:0 fan)

Experiment 1 - Same Two-Goal False Response

Alice wanted to chop some wood.
Linda wanted to chop some wood.
Linda wanted to build an igloo.

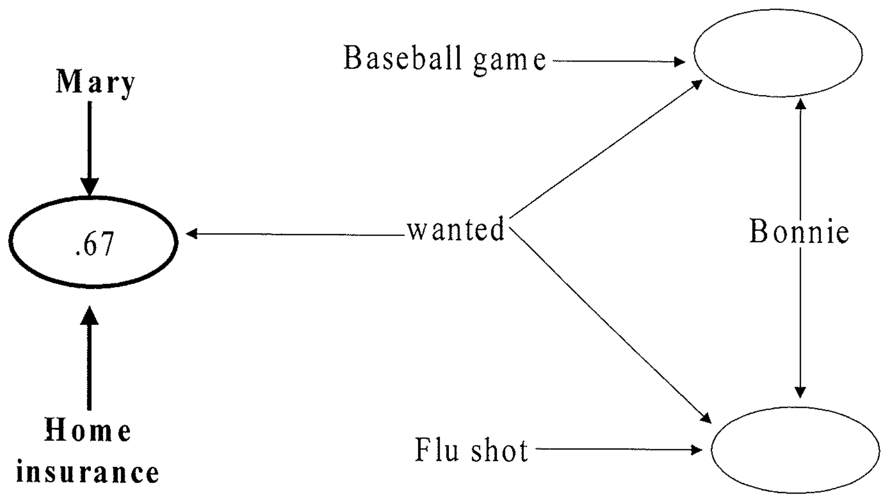


Probe: And so **Linda** shuffled the deck (2:0 fan)

Appendix I.2
ACT-R Network Representations and levels of activation for Experiment 2

Experiment 2 - Distinct One-Goal

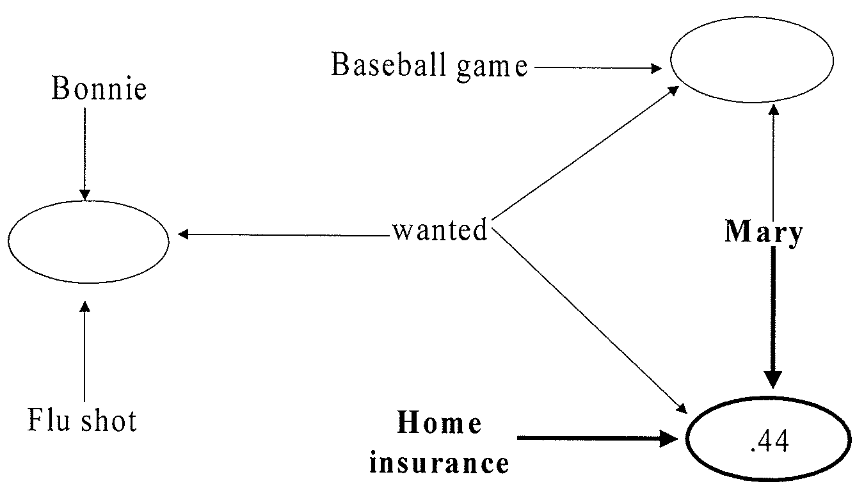
Mary wanted to buy home insurance.
Bonnie wanted to organize a baseball game.
Bonnie wanted to get a flu shot.



Probe: And so **Mary chose the coverage** (1:1 fan)

Experiment 2 - Distinct Two-Goal

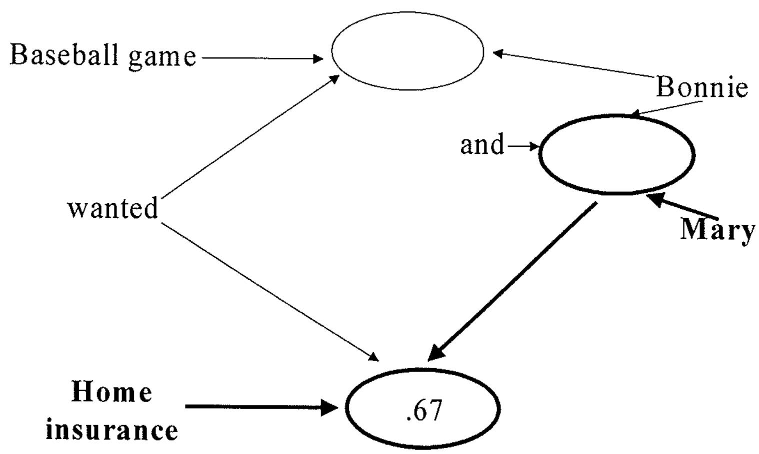
Bonnie wanted to get a flu shot.
Mary wanted to buy home insurance.
Mary wanted to organize a baseball game.



Probe: And so **Mary chose the coverage** (2:1 fan)

Experiment 2 - Same One-Goal

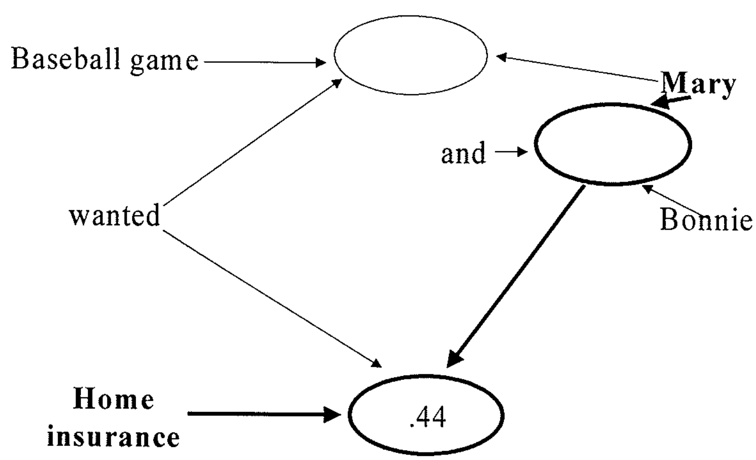
Mary and Bonnie wanted to buy home insurance.
Bonnie wanted to organize a baseball game.



Probe: And so **Mary chose the coverage** (1:1 fan)

Experiment 2 - Same Two-Goal

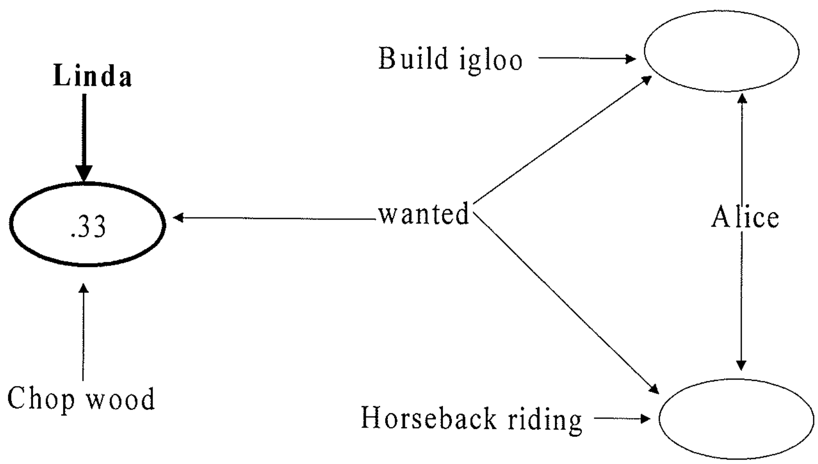
Bonnie and Mary wanted to buy home insurance.
Mary wanted to organize a baseball game.



Probe: And so **Mary chose the coverage** (2:1 fan)

Experiment 2 - Distinct One-Goal False Response

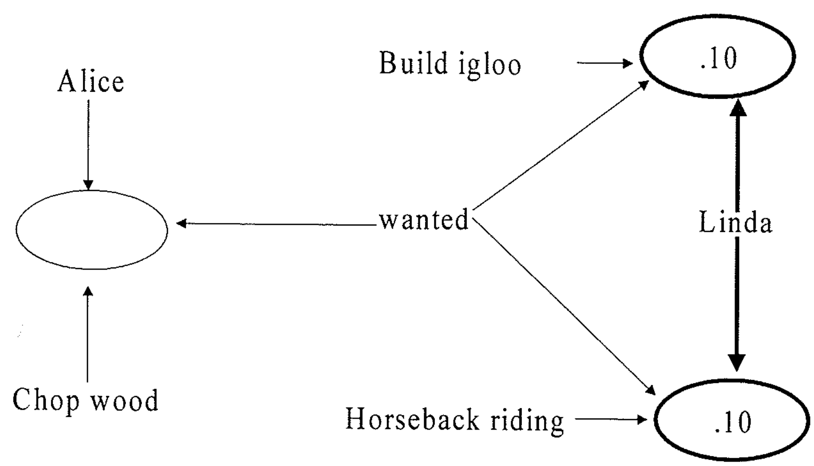
Linda wanted to chop some wood.
Alice wanted to build an igloo.
Alice wanted to go horseback riding.



Probe: And so **Linda** shuffled the deck (1:0 fan)

Experiment 2 - Distinct Two-Goal False Response

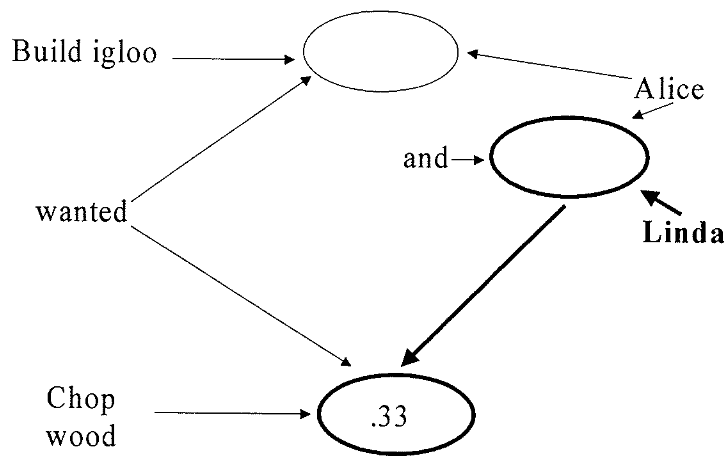
Alice wanted to chop some wood.
Linda wanted to build an igloo.
Linda wanted to go horseback riding.



Probe: And so **Linda** shuffled the deck (2:0 fan)

Experiment 2 - Same One-Goal False Response

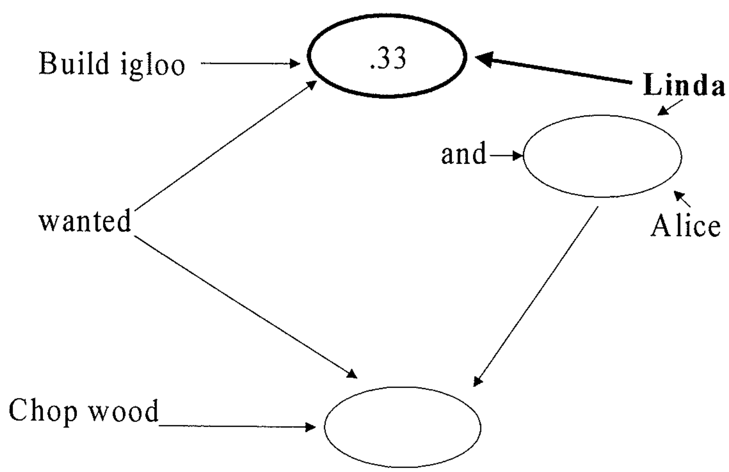
Linda and Alice wanted to chop some wood.
Alice wanted to build an igloo.



Probe: And so **Linda** shuffled the deck (1:0 fan)

Experiment 2 - Same Two-Goal False Response

Alice and Linda wanted to chop some wood.
Linda wanted to build an igloo.



Probe: And so **Linda** shuffled the deck (1:0 fan)