EMPIRICAL EVALUATION OF THE USEFULNESS OF MODEL-BASED RELATIONSHIP LINKS IN SEEKING COMMITTEE INFORMATION

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By

Srinivas Raghavan, MSc, M.S.

The Ohio State University

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Dissertation Committee:

Gary Perlman, Adviser

Bruce Weide, Adviser

Mary Jean Harrold

Neelam Soundararajan

Approved by

_____

Adviser

_____

Adviser

Department of Computer & Information Science

ABSTRACT

Forming a committee is an accepted process to effectively involve a group in decision making and problem solving. However, it is commonly observed that committees are ineffective mainly due to lack of member preparation, poor process knowledge, and ineffective meetings. Prior research has focused primarily on improving meeting effectiveness by providing support for the decision making process during meetings. Little attention has been given to supporting member preparation. An important task in preparing for a meeting is seeking information about the relationships between information artifacts (agendas, minutes, documents, action items, etc.) generated in the committee process. For example, a member may seek answers to questions such as

- *How do the new requirements differ from the version approved by the committee?* (relationship between Documents and Meetings)
- *Which members were responsible for the action items generated by the enrollment subcommittee?* (relationship between People and Sub-committee action items)

Typically, these questions are answered by searching through the documented committee information. Would it be faster/more accurate if the relationships were directly represented as links between related information?

I have developed an Entity-Relationship (E-R) model to represent the entities and relationships in committees. The model presents eight entities ([Committee], [Sub-Committee], [People], [Role], [Topic], [Meeting], and [File]) and the relationships between entity pairs. A web-based tool (LinkER) implements the model and presents the entities in a tabular format. The relationships in the model are presented as hyperlinks, tagged with the first letter of the related entity. For example, a relationship between [People] and [Meeting] is represented by a link **M** in the [People] entity page and by **P** in the [Meeting] entity page.

In this thesis, I present the results of an experiment conducted to evaluate the usefulness of the relationship links. Subjects sought answers to eight questions in each of four comparison conditions, which represented the committee information as follows:

Online

1. With Links (LinkER)
2. Without Links (web-based keyword search)

Paper

3. With Links (cross-referenced documents)
4. Without Links (indexed documents)

The questions were generated based on three factors: Number of entities (2 or 4), Timeframe (current or past), and Nature of the relationship (lexical or semantic). Thus, the eight questions were unique combinations of the three question factors. The performance of subjects answering the questions was measured by three dependent variables:

1. Question answer time (seconds)
2. Answer Accuracy
3. Concurrent Ratings of Confidence in Answer (10-point scale)

A post-testing questionnaire gathered subject background information and retrospective ratings of Subjective Usability, Subjective Speed, and Subjective Accuracy across the four conditions. The web-server and LinkER recorded usage statistics that included the number of entities, links, and documents accessed in Linked Online.

There were significant differences in performance across the conditions and question factors. The major results showed that subjects were:

- Over 21% faster using Links Online over any of the other three conditions.
- Equally accurate across conditions.
- Faster and more confident answering questions with 4 over 2 entities
- Faster, more accurate, and confident answering current over past questions.
- More accurate answering lexical over semantic questions.

Thus, the relationship links are useful and facilitate faster task completion times online as compared to just keyword search. The committee information model serves as the basis for the relationships links in LinkER which was significantly faster than keyword search. Thus, model-based linking shows promise as it helped subjects find information more quickly.

Comparison of the predictions (hypothesis) and subjective ratings of users showed that the predictions (designer's intuition) were well supported by subjects' retrospective impressions. However, neither of them matched actual subject performance. Subjects'

retrospective ratings of accuracy did not match their concurrent ratings of confidence or accuracy, and their rated speed did not correlate with their actual performance. This shows that human intuition is a poor predictor of performance in systems for supporting cooperative activities. Thus, the thesis underscores the importance of collecting objective performance data to evaluate systems such as LinkER.

Dedicated at the Lotus Feet

Of

Bhagavan Sri Sathya Sai Baba

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VITA

January 19, 1966 …….	Born – Bombay, India
1987 ……	MSc Computer Science, Birla Institute of Technology and Science, India.
1990 ……	M.S. Computer and Information Science, The Ohio State University.
1991-1994 ……..	Consultant at AT&T Bell Laboratories through Keane Inc., Columbus, Ohio.
1995-Present ……..	Dept. of Computer and Information Science, The Ohio State University.

PUBLICATIONS

Raghavan, S., "Group Support in Software Maintenance Teams" *Proceedings of the 1st International Workshop on Social Science Technical Systems and Collaborative Work,* Paris, France 1993.

Raghavan, S. et al., "Image compression applied to MRI Images" *IEEE Conference on Engineering in Biology and Medicine Society,* Seattle, WA. November 1989.

Fields of Study

Major Field: Computer and Information Science

Studies In: Human Computer Interaction: Dr. Gary Perlman
Software Engineering: Dr. Bruce Weide
Information Retrieval: Dr. Dik Lun Lee

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CHAPTER 1

INTRODUCTION

Life is a challenge, meet it
Life is Love, share it
Life is a Dream, realize it
Life is a Game, play it
Sathya Sai Baba

Committees are an integral part of our society. Forming a committee is an accepted process for involving a group in decision making and problem solving. The power of a committee lies in its effectiveness as a decision making body. However, it is commonly observed that committees are ineffective and work becomes drudgery. Lack of member preparation, poor process knowledge, and ineffective meetings are among the main reasons for ineffectiveness in committees. Prior research has focused primarily on improving meeting effectiveness by providing support for the decision making process during meetings. Little attention has been given to study the effects of preparation on meeting effectiveness.

Member preparation has a direct impact on the quality of the meetings. Preparation can improve the participation as well as the outcome of the meetings.

Members prepare by studying the material for the upcoming meeting and relating it to the information artifacts (e.g., prior meeting agendas and minutes, documents, action items, etc.) generated in the committee process. These relationships are derived based on the members' experience, which is seldom retained after the member leaves the committee. Thus, the relationship information should constitute an important part of the committee memory. These relationships are of potential interest to the committee participants to find related information. In this research, I examine the usefulness of information relationships in supporting member preparation for committee meetings.

1.1 Committee Process

Committees are commonly formed to serve as a forum for addressing issues and making decisions. Members meet regularly, serving in various roles for a period of time after which the makeup of the committee changes. Thus, the work of the committee transcends the membership. The committee process is a repetitive set of ordered tasks [Brown, B.M., et al 1985]:

1. Formulating an Agenda

   The agenda serves as the guide for the meetings and a carefully crafted agenda is crucial to the effectiveness of a meeting [Tropman et al., 1992].

2. Organizing and Distributing Meeting Information

   The agenda, meeting logistics, and a collection of relevant documents is distributed to the committee members and others who will attend the meeting. This information is important to allow the members of the committee to prepare for the meeting.

3. Meeting

   Meetings are a predominant factor in committee work. Meetings may be face to face or distributed across different sites, connected through an electronic meeting system [Nunamaker et al., 1995].

4. Post Meeting Analysis

   Post meeting tasks include writing the minutes, recording decisions, and follow-up of action items. Sub-committees may be created to work on some of the items.

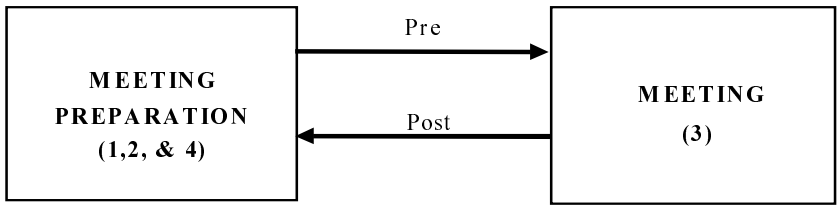


Figure 1.1 Committee Process

Work done outside of the actual meeting time comprises the preparation phase for meetings (Figure 1.1). The combination of the first two tasks (1,2) forms the pre-meeting phase. Since committees have a continuous series of meetings, post meeting analysis (4) serves as preparation for subsequent meetings. Thus, meeting preparation can be broken

down into the effort to organize meetings (1,4) and member preparation (2). Organization of meetings (1,4) involves:

- Meeting Scheduling

  The schedules of the committee members have to be coordinated to find a common meeting time. Committee meetings tend to be scheduled at a regular place and time, thereby simplifying the scheduling problem.

- Organizing Committee Information

  Since committee work is an ongoing process, information is continuously generated (agenda, minutes, documents). Additionally there are informal discussions of issues (e.g., via newsgroups, mailing lists, and private conversations). This information needs to be organized in order for it to be effectively used by the committee members in preparing for meetings.

- Communication

  The meeting information needs to be distributed to the members. Additionally, members may continue discussion on some topics outside of the meetings in sub-committees or through informal conversations (face to face and online).

Committee members prepare for meetings (2) in several ways:

- Agenda Item Preparation

  Members read the meeting documents and prepare for agenda items by producing reports, studying previous committee work, and examining the work of other committees.

- Action Items

  Action items assigned from previous meetings may be in various stages of completion. Members may prepare the status of the items they have been working on.

- Sub-Committees

  Sub-Committees meet to work on a specific sub-topic of the committee. Members on the sub-committee have to prepare for the meetings and report on their progress.

1.2 Meeting Preparation for Effective Meetings

Since committee work revolves around meetings, its effectiveness depends on both preparation and conduct of effective meetings. However, research on supporting the committee process has focused exclusively on conducting effective meetings [Bennett 1994, Bennett & Karat 1996, Gordon 1981, Johansen et al. 1980, Renton 1980, Welty 1982]. Considerable attention has been given to supporting face to face as well as distributed meetings through electronic meeting systems (EMS) and decision rooms [Bostrom 1992, Gray, 1983, Nunamaker et al. 1996, Romano et. al. 1998], distributed meeting (conferencing) management [Nunamaker 1991], electronic meeting facilitation [Bennett 1994, Bostrom et.al. 1993, Dubs and Hayne 1992], GCSS - Group Communication Support Systems and GDSS - Group Decision Support Systems [Pinsonneault & Kraemer 1989]. The GDSS tools support various meeting tasks (e.g., brainstorming, organizing decision alternatives, voting, etc.) by utilizing formal models of the decision process [Adams 1993, Carter et al. 1992, Dennis & Gallupe 1993, Kraemer & King 1988, Migliarese & Paolucci 1993].

Empirical studies of the use of group support systems (GSS) in face to face as well as distributed groups have considered the impact of GSS technology on the group process and effectiveness of meetings through laboratory experiments as well as field studies [Dennis & Galluppe 1992]. However, the research does not consider meeting preparation as a factor affecting the effectiveness of meetings [Pinsonneault & Kraemer 1989]. This can be seen in the research model of the University of Arizona researchers, one of the leading groups working on meeting support systems [Nunamaker et. al 1996]. Their model (Figure 1.2) indicates that the meeting outcome depends on several factors (group, task, context of work, electronic meeting systems (EMS) technology used, and the process). The model can be extended to include preparation as shown in Figure 1.2. Organization of a meeting affects the process since poor organization can lead to an ineffective meeting. Additionally, the group members must prepare for meetings. Thus, preparation affects both the group and process of meetings. The outcome of a meeting results in preparation work for subsequent meetings. Thus, meeting preparation is affected by the meeting process, the outcome, and the factors affecting it.

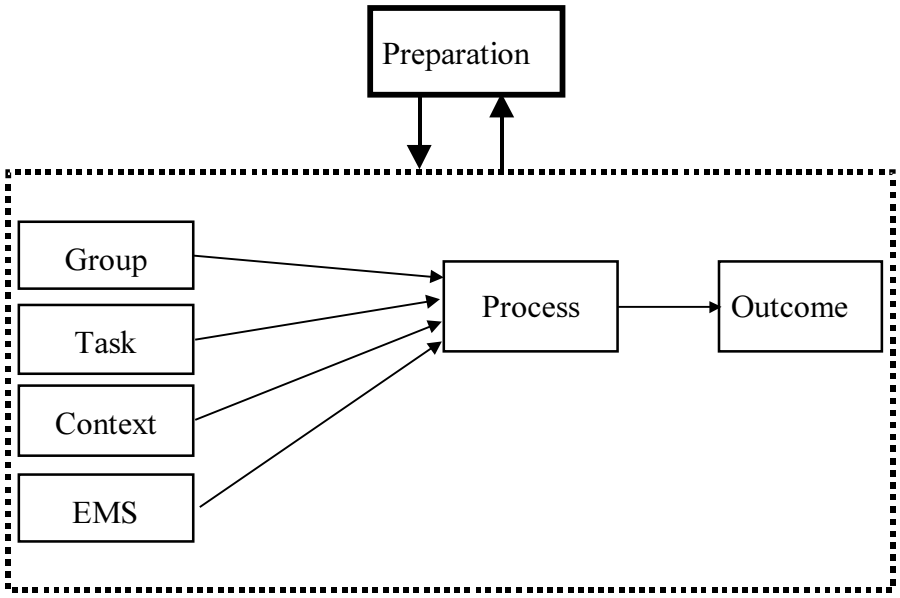


Figure 1.2 Extending the University of Arizona Model

Intuitively we would expect that a well-organized meeting attended by members who are well-prepared should be effective. However, in order to study the effect of preparation on meeting effectiveness we need to be able to measure the terms "well organized", "well prepared", and "effective" meetings. Subjective measures have been used to study meeting effectiveness (e.g., decision quality, decision time, process satisfaction ratings, level and quality of participation [Dennis & Galluppe 1992, Nunamaker et al. 1992]). A number of studies have investigated the effects of EMS technology and its individual features on the process and outcome of meetings

[Pinsonneault & Kraemer 1989, Dennis & Galluppe 1992]. However, despite its importance, little empirical research has been conducted to study the effects of member preparation on the effectiveness of meetings. In this thesis, I examine ways to support the information seeking aspect of member preparation. I evaluate the usefulness of tools to organize and preserve the committee information relationships.

1.3 Supporting Meeting Preparation

Ineffective meetings waste time and money, lead to bad decisions, and cause work frustration. Committee meetings have been found to be ineffective due to lack of member preparation, poor process knowledge, and no organized "memory" of the information generated by the committee [Petrovic 1992, Tropman et al. 1992]. Empirical studies of managers [Petrovic, 1992] has shown that 22.4% of their working time is spent in meetings. However, of this time 34% was rated as inefficient. These managers indicated that lack of preparation for meetings was one of the main reasons for the inefficiency. They emphasized the need for tools to support meeting preparation tasks. A survey of managers and professionals [Stazinger and Olfman 1992] in a variety of organizations also indicated that support for group work between meetings was perceived to be more useful than support for either face to face or electronic meetings.

The support for meeting preparation must facilitate the organization of meetings as well as assist committee member preparation. Support tools can be classified as follows:

1. Task Support

   Tools provide support for repetitive organizational tasks such as meeting scheduling,

action item or to-do list tracking [Kreifelts et al. 1993], formulation of the agenda and minutes, etc., [Brown et al. 1985].

2. Communication and Coordination

   Tools such as email and newsgroups are used to disseminate information and continue discussions on topics outside the meeting. Organizing committee work also requires coordinating people who may be distributed at several locations. Thus, support tools are required to enhance the communication and coordination in committees.

3. Organizing Information

   The committee information needs to be organized and accessible to allow members to prepare for meetings. Research has focused on capturing meeting information and integrating it with the organizational information so that it can be accessed during and outside of meetings [Sandoes et al. 1991, Schwabe 1994].

1.4 Committee Information Relationships

The committee process produces a number of information artifacts (topics, agendas, minutes, etc.). The information is gathered over time as the committee discusses various topics and issues. Since the discussions are distributed over several meetings, information tends to be interrelated in several ways. These relationships are connections between artifacts (e.g., topics are on the agenda and discussed in several meetings). In addition, several committees may be addressing the same topic in different ways giving rise to relationships across committees. Members accumulate information during their tenure on different committees. Thus, they are able to relate information both within a

committee and across multiple committees. Unless these relationships are preserved, the relationship knowledge (committee memory) is lost after the members leave the committee.

In preparing for meetings, members often ask questions that seek information about these relationships. The relationships record committee knowledge (e.g., decisions and their rationale). In addition, the relationships (e.g., between topics and meetings) can be used to answer questions such as, When was the topic first discussed? Or Which meetings discussed a topic, or When did we last talk about ...? These questions have several attributes:

1. Number of Related Artifacts

   Some questions are about a single artifact (e.g., Was this topic discussed in the meeting on April 24th?) whereas others require the examination of the relationship between two or more artifacts (e.g., Which members were responsible for each of the action items generated by the billing subcommittee?).

2. Timeframe

   A question may refer to the past (e.g., How do the new requirements differ from the original version approved by the committee?) or current work of the committee (e.g., Which members are currently working on an action item?). Availability of historical information depends on how long the committee has been tracking it.

3. Type of Relationship

   A relationship may be discovered by matching keywords or phrases (lexical), e.g., a search for a keyword “Abracadabra” will bring up all the related documents that

> mention it. Thus, these documents are related lexically. In some cases the relationship may arise only in the context of a discussion without any common lexical terms, e.g., meeting A may discuss the annual sales and meeting B may discuss the new computers. They may be related because the new computers are discussed in the context of good sales figures. However, there may be no common lexical terms between the two meeting records. These semantic relationships represent a meaning which is not apparent by scanning the text [Tuomi, 1995].

Typically, members recall the relationships based on their experience in the committee. Otherwise, they search the artifacts in order to find the related information. Depending on the information sought (attributes of the questions), the complexity of the task and the time taken to find the information will vary. Over time, committee members are likely to answer similar questions leading them to seek the same information repeatedly. Preserving the information relationships allows a member to get to the related information without having to remember it. Incrementally adding to this information base allows it to represent an organized memory for the committee.

Lack of an organized memory creates several problems:

Re-work: New members are unable to salvage the work of the old committee members and are forced to start over.

Meeting Preparation: Many items on the agenda are tabled for subsequent meetings because members are not prepared. Some of the tabled items get completely lost, as they may not appear in future agendas.

Rationale and Progress: The rationales for decisions are seldom recorded and subsequently get lost after the responsible members leave. This makes it difficult to assess the committee progress on a given topic or goal.

Reporting authority: Every committee has to report to some authority (e.g., manager, chairperson, board, etc.). Reports vary in degree of formality from oral presentations to written reports. Without an organized memory, these reports may present information about decisions taken without much background or justification.

Research has been done on the capture of design rationale and organizational memory, e.g., Issue Based Information System (IBIS, gIBIS) [Conklin, et al. 1988], Answer Garden [Ackerman, 1993], SIBYL [Lee, 1990], etc. Such research addresses the capture of rationale through the use of a methodology, e.g., IBIS, where conversational structure of issues, positions, and arguments are used to capture design rationale. However, these systems are aimed at capturing expertise (design, frequently asked questions, etc.) not information relationships in general.

1.5 Usefulness of Relationships

Relationships among interconnected artifacts transcend committees and can be seen in several other scenarios, e.g.,

- Threaded newsreaders [Johnsson 1995] maintain discussion threads by relating an article with all its responses. This allows readers to follow the relationship between news articles from the original postings to the related replies.

- Movie critics seek information about relationships between movies, actors, directors, music, themes, scripts, etc. Besides commenting on a particular movie, they use the relationships to present comparisons [Bernhardt 1990].
- Sportscasters, besides giving commentary on a particular game, also talk about the relationships between games, players (achievements, salary, etc.), teams, and conferences.

In all these scenarios the question remains whether these relationships will be useful, i.e., will people be able to reduce the time to accurately seek information about relationships if they are explicitly represented (e.g., as cross-references or hypertext links; [Conklin, 1987]? We can look for differences in the speed and accuracy in answering questions about the relationships i.e., Is it just as fast to search through the information space as opposed to using explicitly represented relationships to answer questions about related information [Egan et al. 1991]? The absence of differences would also provide useful data about seeking such information. Thus, the results of the research would have general implications on the computer support of human processing of information about related objects.

1.6 The Thesis

The work done in this dissertation is based on the following assumptions:

1. It is assumed that the process of meeting preparation can improve the effectiveness of face to face meetings. This seems plausible since preparation is likely to improve the effectiveness of any activity. In addition, studies of managers have shown that it is

more important to support the activity between meetings than the actual face to face meeting [Petrovic 1992, Tropman et al. 1992].

2. I assume that seeking answers to questions about information relationships can assist members in preparing for meetings. The committee process produces a number of interrelated artifacts which members (especially new members) are likely to access. Thus, seeking information relationships is an important aspect of member preparation. Work done in the capture of design rationale and organizational memory suggests that capture and representation of information relationships can be useful in maintaining continuity in the process ([Conklin, et al. 1988], [Ackerman, 1993], [Lee, 1990]).

Based on these assumptions this dissertation addresses the following research issues:

1. How can support be provided for committee meeting (member) preparation?
2. What are some of the relationships between committee information artifacts? How can they be represented?
3. Are model-based relationship links useful in seeking committee relationship information over a keyword search of the documentation?

In answering these questions, this dissertation defends the following thesis:

> Model-based relationship links will be useful in seeking committee relationship information (i.e., they will facilitate faster task completion times with more accuracy) if the relationships are represented as links between related artifacts as compared to a keyword search of the documentation.

CHAPTER 2

EFFECTS OF RELATIONSHIPS

"Science must make man humble by revealing that he knows so little of what is worth knowing"

Sathya Sai Baba

In a meeting the members either continue discussions of old topics or take up new topics. Due to the ongoing nature of the committee process, threads of related discussions are formed as the topics are discussed in meetings. An important task in preparing for a meeting is to be cognizant of these threads and other relationships among the information artifacts, which would allow a member to place current discussions in context. A member with the knowledge of these relationships can aid the decision making process through the recall of rationale for past decisions and by making comparisons with similar or related contexts from prior discussions.

Some members may recall related information based on their experience in the committee (e.g., having attended several meetings they are able to connect discussions). Others may be able to locate related information by searching the meeting records. Given sufficient time it should be possible to find the related information. In the worst case, the

entire information space may need to be scanned. Thus, seeking information about relationships is an important aspect of member preparedness. Performance in the information-seeking task is determined by time as well as the accuracy of the search. Inaccurate information can cause an agenda item to be postponed to a later meeting with an action item to find out the correct information. In addition, if it takes a long time to locate information, members may be less likely to repeat the process.

Preparation for a meeting involves several other factors besides locating related information (e.g., reading material for review, writing proposals, completing action items, etc.,). However, in order to be able to assess the usefulness of relationships, I measure the performance in the information seeking aspect of member preparedness. Performance is measured by the task completion time and accuracy in answering questions about related information.

2.1 Representing and Accessing Relationships

Committees record information (agenda, minutes, action items, documents, etc.) which is typically maintained either on a computer (online) or on paper. On either medium, relationships can be explicitly represented and accessed to seek information. If the relationships are not represented, information seeking is possible by searching or browsing the information space. Thus, we have four comparison conditions as shown in Figure 2.1:

- With Links Online (Linked Online) is presented by the information model and LinkER tool
- Without Links Online (Unlinked Online) is presented by an online keyword search

- Without Links on Paper (Linked on Paper) is presented by cross-referenced documentation
- Without Links on Paper (Unlinked on Paper) is presented by a keyword index.

The details of the four conditions are presented in the following sections.

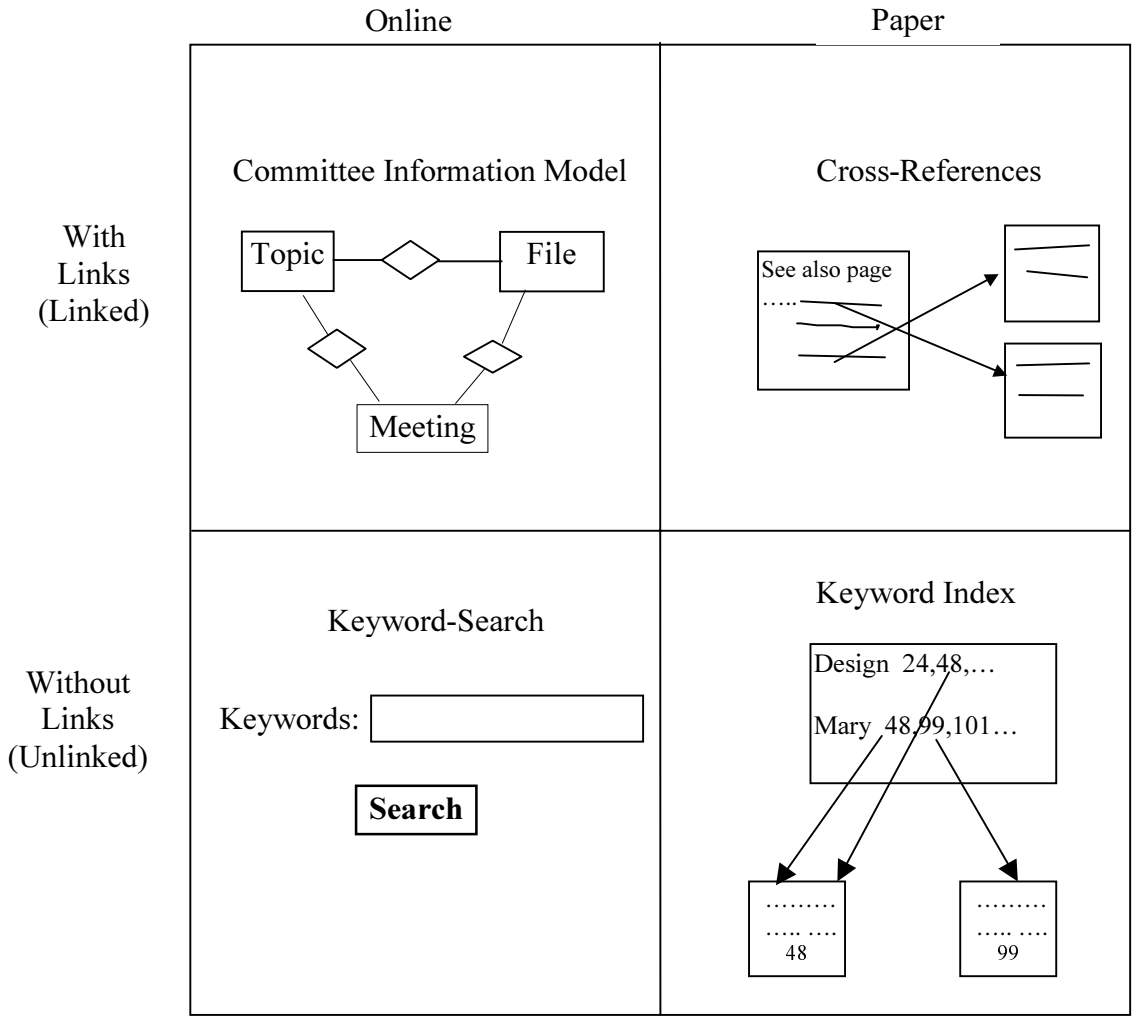


Figure 2.1 Summary of Relationships Representation (Linked vs. Unlinked) in Presentation Medium (Online vs. Paper)

2.2 Relationships Represented Online (Linked Online)

In order to study the information needs of committees, I have developed an information model that represents various committee information artifacts (entities) and their relationships (Appendix A) as in an Entity-Relationship (ER) model [Elmasri & Navathe 1989]. The model represents typical relationships that are present in the committee information space. A web-based tool (LinkER) implements the model and represents the relationships as hyperlinks.

2.2.1 Committee Information Model

The model presents eight entities ([Committee], [Sub-Committee], [People], [Role], [Topic], [Action], [Meeting], and [File]) which are related to each other in several ways ([square brackets] are used to indicate the entities, and <angled brackets> are used for relationships):

1. [Committee] summarizes the information about different committees and is related to all the other entities. A committee <has> several Sub-Committees and is <made of> people and <has> roles played by different people (e.g., chair, vice chair, member, visitor, etc.). It <conducts> meetings in which the members <discuss> topics and <produce> action items that need to be worked on. A committee may <refer> to several documents (files).
2. [Sub-Committee] represents the information about the subcommittees of a committee. A subcommittee is <made of> members of the committee (people) who <conduct> meetings to <discuss> one or more topics and <produce> action items to work on.

The subcommittee <has> roles played by different members who may <refer> to several documents.

3. [People] represents the committee participants. They may be <members> of one or more committees and can be <assigned> to several subcommittees. People <play> different roles, <work on> action items, <attend> meetings, and <discuss> topics. They also <own> documents (files) which they may be working on.
4. [Role] represents the different roles <played by> the committee participants (e.g., member, visitor, chair, vice chair, etc.). While some roles are common to all committees (e.g., chair), others may be specific to a committee or subcommittee (<has>), e.g., vice chair for publicity. The roles vary across committees, e.g., in smaller committees the chair may also play the role of the secretary and staff person; larger committees may be assigned a staff person to handle administrative work.
5. [Topic] gives a high level view of the committee work. A committee or subcommittee may <discuss> a topic at a meeting (via an agenda). A topic can have an <owner> and it may <refer> to several documents (files). The discussion on a topic may <result in> action items which are worked on by members of the committee.
6. [Action] summarizes the action items <for> a committee or subcommittee. An action item is <taken in> a meeting <for> one or more topics. Typically an action item is <owned> by a committee member and it may <refer> to several documents (files).
7. [Meeting] provides information about the committee meetings. A meeting is <for> a committee or subcommittee and is <attended> by people. Several topics may be

discussed at a meeting through an <agenda>. Additionally, a meeting may <refer> to one or more documents given to the members prior to the meeting.

8. [File] covers all the documents and other information recorded by the committee. A file is <owned> by a member. It can be <referred in> a meeting, action item, or a topic (via an <agenda>). The file is typically created <for> a particular committee or subcommittee. However, other committees may reference it as well.

The entities and relationships presented in the model provide an instance in a large class of such models. Therefore, this model serves as a starting point for research into the usefulness of relationships. It is not presented as the definitive model of committee information. Usefulness of the relationships would warrant further investigation and comparisons between models.

2.2.2 Information Seeking Using the Model

Consider a university committee in charge of designing the undergraduate curriculum of study. With the advancement of knowledge and new techniques, the courses and curricula also change to adapt to the changing requirements of the university. A member of this committee, while preparing for work, may ask questions such as "Has this committee discussed the university requirements earlier? If so when?" Or "How do the new university requirements differ from the old ones and how do they affect us?" In order to address these questions, the member would have to explore the relationships between [Topic], [Meeting], [File], and [Action].

In another situation, a committee member may be seeking information about relationships between the entities [Topic] and [Meeting] (e.g., Find all the meeting

agendas in which a particular topic appeared for discussion). In order to answer such questions, the member would have to look through the information about meetings and search for all discussions about the particular topic. Using the model, the member could find the particular [Topic] and follow the relationship to locate all the related [Meeting] instances.

2.2.3 LinkER: A Tool that Implements the Model

Relationships can be represented and accessed in the online medium in several ways:

a) Relational database systems represent the relationships in tables and support a query mechanism allowing access to related information [Elmasri & Navathe 1989]. However, database systems are highly structured and would require considerable effort to maintain and access committee information.

b) Hypertext provides a means of embedding relationships through links [Berners-Lee et al. 1992, Conklin 1987]. These links are jump points in a document to related information. Following a link between the documents involved in the relationship can access related information. Hypertext links have to be setup as part of document preparation in order for the relationships to be accessible. Text processing techniques have been used to automate the creation of links [Allan 1996, Cleary & Bareiss 1996]. Links connecting information that are lexically related can be processed automatically while others, such as the semantic links which are related depending on the context, may require human intervention.

I developed a tool (LinkER) which implements the information model as a hypertext-based system. The tool has been written as a Perl5 module (Wall 1996) and uses the Common Gateway Interface (CGI) [Gundavaram 1996] on the World Wide Web (WWW) platform [Berners-Lee et al., 1992]. LinkER tracks the entities and relationships as specified in the information model by recording the data in text files. The users may view and edit entities and relationships. The user interface and online help is generated using a customizable set of template HTML files. Thus, the system is lightweight and portable allowing it to be used both independently as well as a component within other applications.

2.3 Absence of Relationship Representation Online (Unlinked Online)

Questions about relationships in Unlinked information can be answered by searching the information space. Online search engines provide access to unstructured information via a keyword search. While these searches may be fast, they may not bring up the desired information since it depends on the search strings provided by the user. The speed and accuracy of locating information about relationships is dependent on the context of the search.

2.4 Relationships Represented on Paper (Linked on Paper)

Cross-references represent relationships between documents or sections of a document. In the committee information space, cross-references create threads of related discussions among the meetings, e.g., a topic may be discussed in several meetings and the related minutes are cross-referenced. Relationships can be accessed by following

cross-references to look up the pages containing the related information. Thus, cross-references represent the condition Linked on Paper as seen in Figure 2.1.

2.5 Absence of Relationship Representation on Paper (Unlinked on Paper)

On paper, related information can be located by individually browsing the material or using an index. Although it is possible to accurately locate the related information using the index, it is likely to take time due to the nature of the paper medium. Additionally, repeated attempts to locate the same information will have to go through the same process.

2.6 Hypotheses

2.6.1 Time

While the Linked information can directly represent semantic relationships, Unlinked information has to be searched in order to locate these relationships. Questions about relationships involving more than two entities would require a complex search of the Unlinked information. Hence, it will take longer to locate related information by searching as opposed to directly accessing the represented relationships. Therefore, we have the hypothesis:

H1: Information seeking will take less time in Linked over Unlinked committee information.

The information model provides direct access to the relationships involving two or more entities as well as the semantic and lexical relationships. Thus, seeking

information using the model should be faster than both the keyword-search as well as the paper index. On the paper medium, the cross-references provide direct access to information about current as well as past work and semantic relationships. Also questions about relationships involving more than two entities would require a more complex search using the paper index. This gives us the following hypotheses:

H2: The medium of presentation will moderate the effect of relationship representation on the time to seek information.

H2a: Information seeking in Linked Online will take less time than in Unlinked Online (i.e., information seeking using the committee information model is faster than using a keyword-search).

H2b: Information seeking in Linked on Paper will take less time than in Unlinked on Paper (i.e., information seeking using the cross-references is faster than using a paper index).

Searching for information online should be faster than a manual search of the information using a paper index due to the nature of the paper medium. This gives us the following hypotheses:

H3: The medium of presentation will have an impact on the time taken for meeting preparation.

H3a: Information seeking in Linked Online takes less time than in Linked on Paper (i.e., information seeking using the committee information model is faster than using cross-references).

H3b: Information seeking in Unlinked Online takes less time than in Unlinked on Paper (i.e., information seeking using the keyword-search is faster than using a paper index).

The above hypotheses are summarized in the Figure 2.2.

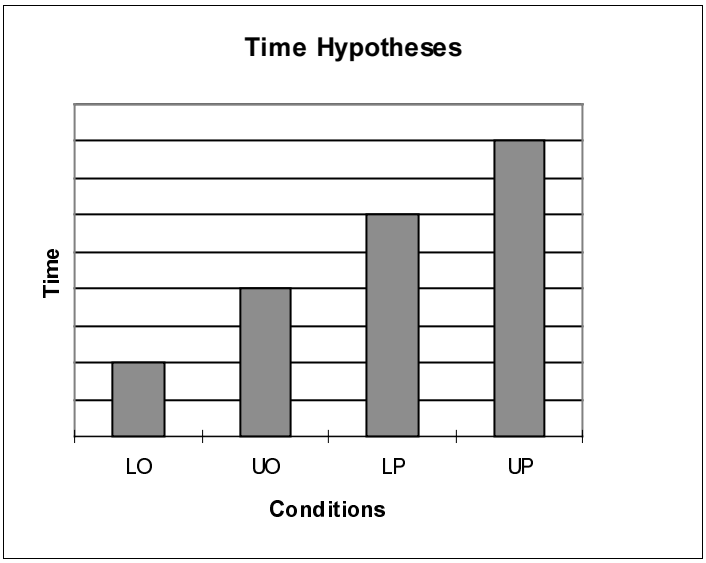


Figure 2.2 Summary of Hypotheses on Time to Seek Information across the major conditions (LO – Linked Online, UO – Unlinked Online, LP – Linked on Paper, UP – Unlinked on Paper)

2.6.2 Accuracy

The Unlinked information requires either a search or a browsing mechanism to be able to locate related information. Keyword, full-text search (online), or an index (paper) can be used to locate information that are related lexically (keyword or phrase). However, the search will not be able to find relationships that do not have any connection at the lexical level. For example, consider Meeting A (6/12/96) which involved sales figures for the year. It may be related to Meeting B (5/6/97) which involved the hiring of new designers. At the lexical level, there are no common terms or phrases between the two documents. However, they are related because the new positions are open as a result of the high sales figures. Such semantic relationships can be located manually and represented explicitly. Therefore, answers to questions about lexical relationships can be found by searching for the keywords or phrases. However, semantic relationships are harder to find. Online search as well as a paper index may not directly reveal the semantic relationships, which leads to the following hypotheses:

H1: Seeking information will be more accurate in Linked over Unlinked information.

H2: The medium of presentation of the relationships will moderate the effect of relationship representation on the accuracy.

H2a: Seeking information in Linked Online will be more accurate (fewer errors) than in Unlinked Online (i.e., information seeking using committee information model is more accurate than using a keyword-search).

H2b: Seeking information in Linked on Paper will be more accurate (fewer errors) than in Unlinked on Paper (i.e., information seeking using cross-references is more accurate than using a paper index).

Due to the linear nature of the paper medium, cross-references as well as indexes on paper are likely to be more difficult to use as compared to the tools in the online medium. However, on either medium it should be possible to locate information with the same accuracy given sufficient time. In the worst case, the entire information space can be browsed to locate the information. Therefore,

H3: The medium of presentation will have no impact on the accuracy of information seeking.

The above hypotheses are summarized in the Figure 2.3.

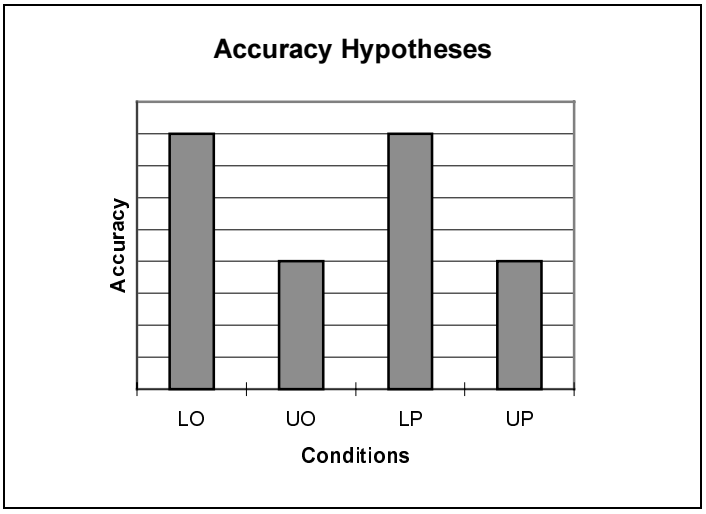


Figure 2.3 Summary of Hypotheses on Accuracy of Information Seeking across the major conditions (LO – Linked Online, UO – Unlinked Online, LP – Linked on Paper, UP – Unlinked on Paper)

These hypotheses for Time and Accuracy are intuition-based predictions of performance. In the next chapter, I discuss the details of an experiment designed to collect data and examine the actual performance of subjects in the major conditions.

CHAPTER 3

EVALUATING THE USEFULNESS OF RELATIONSHIPS

Knowledge is for Life not for Living
Sathya Sai Baba

The laboratory setting has been chosen to examine the usefulness of the relationships in order to provide strong internal validity through experimental controls. If the relationships are found useful, it will warrant further research using other methods such as a field study. The generality (external validity) results from the effects observed assessing the theory and the theory in turn explaining events beyond the research setting [Calder, 1981]. Internal and external validity are complementary in nature as pointed out by [Hogarth, 1986], who asserts the need for "going from highly controlled laboratory conditions to quite 'loose' field studies" as a part of a scientific program of research.

3.1 Experimental Design

The two major factors, relationship representation (Linked vs. Unlinked) and medium (Online vs. Paper) were combined in a four-level within subjects design. The four experimental conditions were Linked Online – LO, Unlinked Online – UO, Linked

on Paper – LP, and Unlinked on Paper – UP. In each condition, subjects sought answers to eight questions each having four equivalent sub-questions (Appendix D). The dependent variables Time, Accuracy, and Confidence were measured for each subject, question, and condition as follows:

- *Time* was measured as the number of seconds elapsed between presenting the question and collecting the response.
- *Accuracy:* The number of correct responses measured accuracy of information seeking.
- *Confidence* in the accuracy of the response for each question was measured on a ten-point scale. Immediately after the subject answered a question they were asked for the confidence rating as follows:

  How confident are you about the accuracy of your answer? (1-10)

  Extremely Unsure 1 2 3 4 5 6 7 8 9 10 **Extremely Sure**

In order to provide the experimental context, a product review committee for a fictitious toy company was created (Appendix C). The committee documented meeting information between 1995-1997. The meeting agendas specify which topics are discussed in each meeting. The meeting record (minutes) summarizes the discussions on each of the agenda items. Additional documents (files) recorded information that was created or referenced by the committee. The committee information was generated to create related threads of discussions on different topics. This served as a basis for examining the usefulness of relationship representation in information seeking.

3.1.1 Experimental Conditions

3.1.1.1 Linked Online (LO)

Linked Online used LinkER, accessed via a web browser (Netscape 3.1). LinkER displays the entities in a tabular format (Figure 3.1). By default, meeting dates are sorted in reverse chronological order; names/titles are sorted lexicographically in ascending order. The order can be changed using the buttons at the bottom of the page.

Based on the model, an entity row may be related to one or more rows in other entities. For each such relationship, a hypertext link tagged by the first letter of the related entity is available. This letter link is displayed in the Links column of the entity table (e.g., in the [Topics] entity, **M** relates individual topics to rows in the [MEETING] entity). The letter link only appears on rows that actually have values for the relationship. Hence, the presence of a letter link indicates the existence of related information. Selecting the hyperlink brings up the relevant instances of the related entity in a tabular format. Therefore, a user can locate related information by following the letter links from a starting entity.

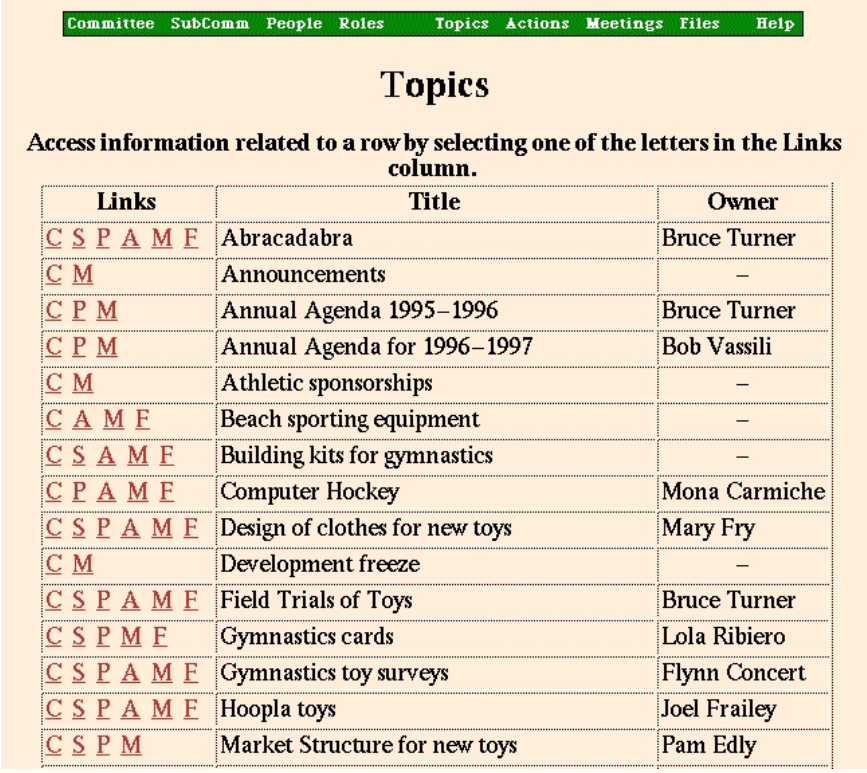
Consider the following interaction with LinkER to seek the answer to a question (Appendix D)

Qn. *Did Flynn Concert attend all the meetings discussing the gymnastics toy surveys? (Y/N)*

The tool shows the [Committee] entity by default (Figure 3.1). The toolbar at the top of the display allows the user to select each entity page. Some of the members of the product review committee also serve on the other two committees as shown by the **P** links on the first two rows. However, all the information provided in the tool was for the product review committee.

Figure 3.1 [Committee] entity page in LinkER

Selecting "Topics" from the toolbar (top of page) brings up the [Topic] entity listing the topics discussed by the committee (Figure 3.2 shows a partial listing)



Committee SubComm People Roles Topics Actions Meetings Files Help

Topics

Access information related to a row by selecting one of the letters in the Links column.

Links	Title	Owner
C S P A M F	Abracadabra	Bruce Turner
C M	Announcements	–
C P M	Annual Agenda 1995–1996	Bruce Turner
C P M	Annual Agenda for 1996–1997	Bob Vassili
C M	Athletic sponsorships	–
C A M F	Beach sporting equipment	–
C S A M F	Building kits for gymnastics	–
C P A M F	Computer Hockey	Mona Carmiche
C S P A M F	Design of clothes for new toys	Mary Fry
C M	Development freeze	–
C S P A M F	Field Trials of Toys	Bruce Turner
C S P M F	Gymnastics cards	Lola Ribiero
C S P A M F	Gymnastics toy surveys	Flynn Concert
C S P A M F	Hoopla toys	Joel Frailey
C S P M	Market Structure for new toys	Pam Edly

Figure 3.2 Topics discussed by the Product Review committee. Links column shows links to related entities (C – Committee, S – SubCommittee, P – People, A – Action, M – Meeting, F – File)

Following the **M** link for the topic "*Gymnastics toy surveys*" gives a list of all the meetings in which the topic was discussed (Figure 3.2)

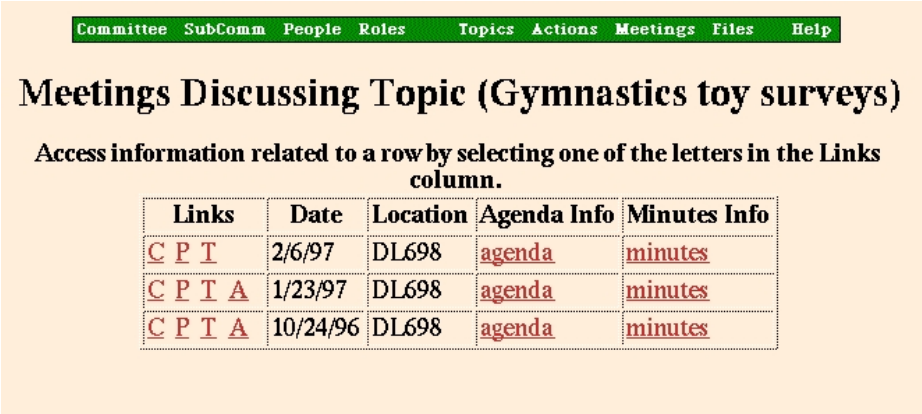


Figure 3.3 Meetings discussing the "Gymnastics toy surveys" topic

The user can now examine the people who attended the meeting on 2/6/97 by following the **P** link in the first row (Figure 3.3). As can be seen in Figure 3.4, Flynn Concert attended the meeting on 2/6/97.

Committees SubComms People Roles Topics Actions Meetings Files Help

Meeting Attended By People (2/6/97)

Access information related to a row by selecting one of the letters in the Links column.

Links	Name	Address	Phone	Fax	Email
C S R T A M E	Bob Vassili	29EL	278-9088	-	vassili@toysworth.com
C S R T A M E	Bruce Turner	672BH	273-0022	-	turner@toysworth.com
C S R T A M	Flynn Concert	240NJ	278-8322	-	flynn@toysworth.com
C S R A M	Hari Govind	68BH	273-0034	-	govind@toysworth.com
C S R T A M E	Joel Frailey	33BH	273-0832	-	jfrailey@toysworth.com
C S R T A M E	Jose Gonzales	23EL	280-8382	-	jgonzales@toysworth.com
C S R A M E	Kurt Price	74EL	280-6639	-	kprice@toysworth.com
C S R T A M E	Mary Fry	219NJ	278-9843	-	mfry@toysworth.com
C S R T A M	Mona Carmiche	230EL	280-9382	-	carmiche@toysworth.com
C S R T M E	Pam Edly	280NJ	278-1843	-	edly@toysworth.com

Figure 3.4 List of people who attended the meeting on 2/6/97

Following the **P** link for the meetings on 1/23/97, 10/24/96 in Figure 3.3 shows that Flynn had attended all the meetings discussing *Gymnastics toy surveys.*

3.1.1.2 Unlinked Online (UO)

This condition used the freeWAIS-sf (Ulrich 1995) software to provide indexing and keyword-searching capability online. A WWW interface to the freeWAIS-sf search engine provided a simple dialog with an input box to enter the search string and a button to initiate the search. The results, sorted by a computed document relevance score, are returned in a tabular format with hypertext links to the documents. The higher the score the more relevant is the resulting document.

Consider the interaction needed to seek the answer to a question (Appendix D)

Qn. *Did Flynn Concert attend all the meetings discussing the gymnastics toy surveys? (Y/N)*

To begin the search enter the search string "*Gymnastics and toy and surveys"* in the text box and select the Search button (Figure 3.5).

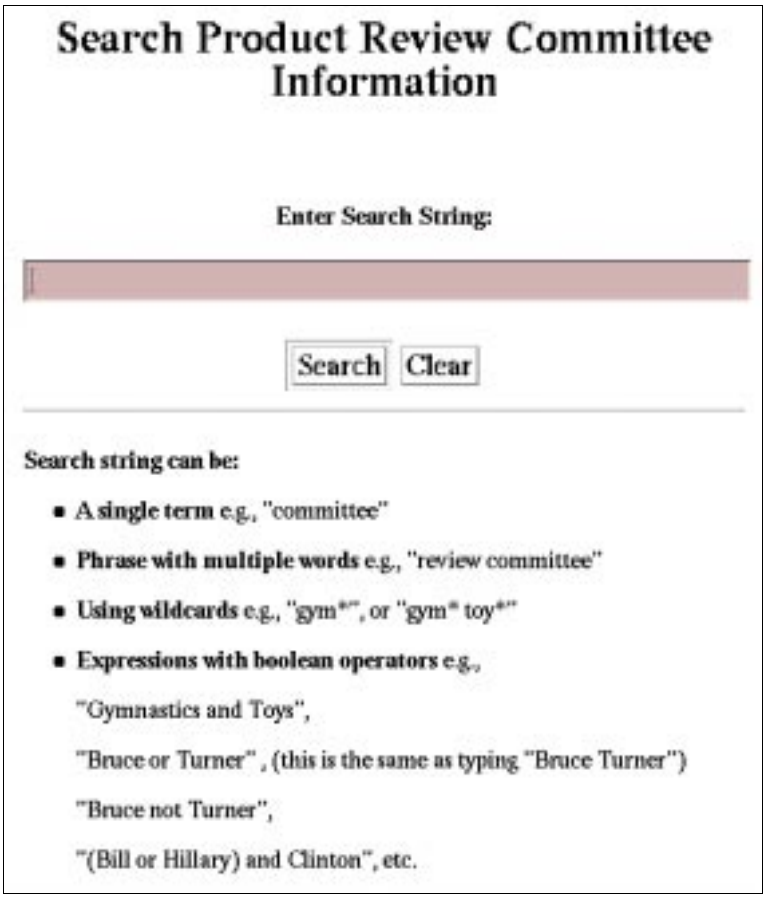
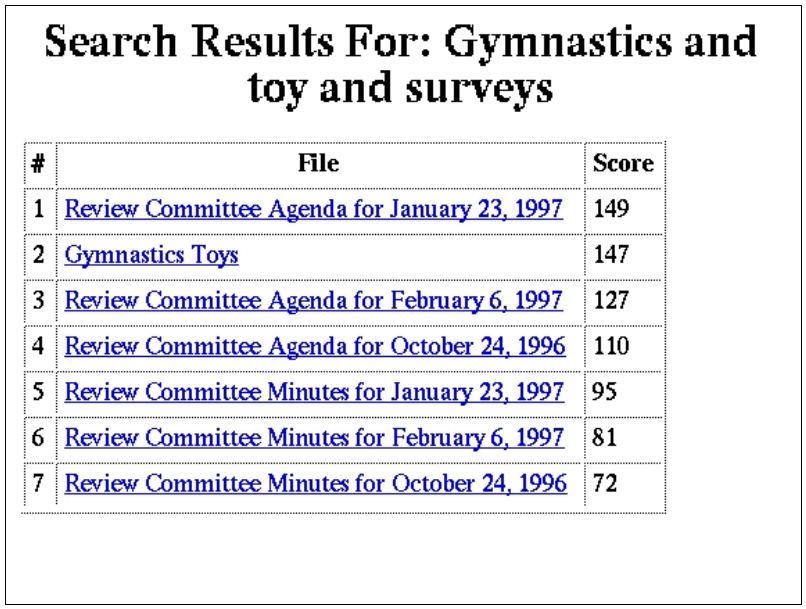


Figure 3.5 Web search screen

The search results are displayed in a tabular format sorted by the relevancy score. The files can be accessed by selecting the hyperlinks (Figure 3.6).



Search Results For: Gymnastics and toy and surveys

#	File	Score
1	Review Committee Agenda for January 23, 1997	149
2	Gymnastics Toys	147
3	Review Committee Agenda for February 6, 1997	127
4	Review Committee Agenda for October 24, 1996	110
5	Review Committee Minutes for January 23, 1997	95
6	Review Committee Minutes for February 6, 1997	81
7	Review Committee Minutes for October 24, 1996	72

Figure 3.6 Results of search

The search revealed that the topic was mentioned in the meetings on 1/23/97, 2/6/97, 10/24/96 and the document *Gymnastics Toys*. The meeting minutes can be examined to see that Flynn Concert attended all the meetings discussing the topic.

3.1.1.3 Linked on Paper (LP)

In this condition, the links were represented as cross-references. Cross-references referred to agenda, minutes, and document titles as follows:

- **See also the minutes** of the meeting on 12/5/95 (pp. 88-90) or
- **See also the agendas** for the meetings on 5/3/97 (pp. 12-13), and 11/10/96 (pp. 50) or
- **See also the document** Gymnastics Toys Proposal (pp. 100-102).

The committee information was organized in a three-ring binder with the contents in the following order:

1. *Cross-Reference Index*

   This index listed the cross-referenced topics with a reference to the latest meeting discussing it. Thus, the index served as a starting point for this condition.

2. *Table of Contents*

   List of meetings and documents with the corresponding page number.

3. *Meeting Information (Agenda, Minutes)*

   The information was sorted in reverse chronological order by meeting date.

4. *Additional Documents*

   Files that were either generated or used by the committee were organized in alphabetical order by title

Cross-references in meeting documentation referred to information in previous meetings thereby producing historical threads of discussions on related topics. In seeking

related information, the cross-references can be followed as textual pointers to examine the relevant pages of the binder.

Consider the interaction needed to seek the answer to a question (Appendix D)

Qn. *Did Flynn Concert attend all the meetings discussing the gymnastics toy surveys? (Y/N)*

1. Examining the cross-reference index we find a line for the topic which indicates that the latest meeting in which it was discussed was 2/6/97 on page 26-29.

Gymnastics toy surveys	February 6,1997(2/6/97)	26-29

2. The minutes for the meeting on 2/6/97 indicates that Flynn Concert was present. Furthermore, discussion for the topic contains cross-references to earlier meetings (1/23/97, and 10/24/96) discussing the topic.

   See also the minutes of the meetings on 1/23/97(pp. 31) and 10/24/96(pp.44-45).

3. The minutes of the cross-referenced meetings show that Flynn Concert was present in all meetings discussing the topic.

3.1.1.4 Unlinked Paper (UP)

Unlinked on Paper was presented as keyword index on paper. The index was generated such that it matched the keywords used in the Unlinked Online condition. The committee information was organized in a three-ring binder in the following order:

1. *Keyword Index*

   An alphabetically sorted list of keywords with the page numbers on which they occur. The keywords were either single words or phrases that commonly occur together, e.g., "Bill Ogden" would be presented as

   Bill 2, 4, 15, 27, 45

   Ogden 15

   Thus, the word "Bill" occurred on pages 2, 4, 15, 27, and 45 and the words "Bill" and "Ogden" appeared on page 15 only. The words in a phrase need not appear contiguously on the page.

2. *Table of Contents*

   List of meetings and documents with the corresponding page number.

3. *Meeting Information (Agenda, Minutes)*

   The information was sorted in reverse chronological order by meeting date.

4. *Additional Documents*

   Files generated or used by the committee were organized in alphabetical order by title.

Consider the interaction needed to seek the answer to a question (Appendix D)

Qn. *Did Flynn Concert attend all the meetings discussing the gymnastics toy surveys? (Y/N)*

The keyword index had the following entry corresponding to gymnastics toy surveys:

gymnastics

toy surveys 19, 20-21, 22, 23, 34, 35, 86

The table of contents can be examined to find the corresponding meetings 2/6/97 (pp. 19-21), 1/23/97 (pp. 22-23), 10/24/96 (pp. 34-35) and the Gymnastics Toys Proposal document (pp. 86). The minutes of the meetings shows that Flynn Concert attended all the meetings discussing the topic.

3.1.2 Task

Subjects were asked to seek answers to a set of eight questions (Appendix D). Each question was constructed to have four equivalent parts e.g., the name of the subcommittee may be varied to give four equivalent versions of the question

a. *Who is the chair of the Web Advertising subcommittee?*

b. *Who is the chair of the Costume Design subcommittee?*

c. *Who is the chair of the Toy Design subcommittee?*

d. *Who is the chair of the Pricing Structure subcommittee?*

Questions were phrased with commonly used terms in committees and were based on three dimensions:

1. Number of Entities

   The questions asked to seek information about the relationships between two or four entities from the committee information model. All the relationships in the model involved two entities. Hence two entity questions would require the examination of at least one entity and one relationship and four entity questions would involve the examination of at least one entity and three relationships. Thus, it was expected that four entity questions would take longer than questions involving two entities. For example consider the question

   Is Bruce Turner a member of the review committee in this year (1997)? (Y/N)

   In order for Bruce Turner to be a member, he should have attended at least one committee meeting in 1997. Therefore, by examining the relationship between [People] and [Meeting] we can find the meetings attended by Bruce Turner to check

for attendance in 1997.

*A*lternatively, consider the following four entity question

e.g., *Who is the chair of the Web Advertising subcommittee?*

To find the chair you would have to look for the sub-committee ([Sub-Committee]) discussing the web advertising topic ([Topic]) and seek the members ([People]) who are on the sub-committee. Examining their roles ([Role]) should reveal the chair of the sub-committee.

2. Timeframe

   The questions asked either about the current committee information or past committee work. The committee documentation was organized in reverse chronological order by meeting date. Hence, it was expected that questions about the past would take longer to answer. For example, consider a current question

   Is the action item to evaluate the pommel horse design still open?

   The answer to the question is found in recent committee information, which was available in the beginning. Additional scanning may be required to answer past questions e.g.,

   What is the date of the earliest meeting announcing the changeover of the committee from old members to new members?

   Therefore, the difference in performance is expected because of the organization of information not anything intrinsic in time itself.

3. Type of Relationship

   These questions asked about information related through keywords (lexical) or content (semantic). For example, consider a lexical question

   Did Bob Vassili attend all the meetings discussing the web based advertising of the gymnastics toys?

   The meeting minutes recorded the names of the attendees and examination of the minutes shows that Bob Vassili attended all the meetings discussing the web-based advertising of gymnastics toys. Thus, the keywords "Bob Vassili" should be common to the meetings discussing the topic.

   Alternatively, consider a semantic question

   Did the review committee discuss the gymnastics toys proposal document in any meetings?

   Parts of the document were discussed in different meetings. Examination of the minutes of these meetings shows that the name of the document is not mentioned explicitly. The relationship between these discussions and the document is implied by the content of the discussions rather than keywords. In the unlinked conditions, semantic questions would require the examination of the content of such discussions to relate it to the document. Thus, it is expected that semantic questions will take longer and will be less accurate than lexical questions in the unlinked conditions.

Each question was generated as a combination of the three dimensions as shown in Table 3.1

Qn	Entities	Timeframe	Relationship
1	2	Current	Lexical
2	2	Past	Lexical
3	2	Current	Semantic
4	2	Past	Semantic
5	4	Current	Lexical
6	4	Current	Semantic
7	4	Past	Lexical
8	4	Past	Semantic

Table 3.1 Summary of Question Types

3.1.2.1 Task Window

A web-based display automated the order of presentation of the conditions, questions, and gathered the responses. Subjects answered eight questions in the same order (1-8) in each condition. To control for order effects a 4x4 Latin Square counterbalanced the order of presentation of the four conditions. To control for learning effects, the four equivalent sub-questions of each question were assigned to the conditions using a nested 4x4 Latin square within the order of presentation of the conditions. The task window presented the following screens:

- New Condition Screen

  This screen indicates the method of access to be used for the upcoming condition. When ready the subject selects the "Start" button, which records the time and brings up the first question.

- Question Screen

  A question is displayed with a text box provided for the response (Figure 3.7). The subject enters the response and selects the "Next" button, which records the time and brings up the confidence screen.

Figure 3.7 Task Window: Question screen

- Confidence Screen

  Immediately after the subject enters the response, they are asked to enter a confidence value (1-10) indicating how sure they are about their answer to the question (Figure 3.8).

Figure 3.8 Task Window: Confidence screen

- The questions are presented for each condition and the responses recorded. After all the conditions have been completed, the subject is thanked for participating.

3.1.3 Subjects

Eighteen subjects were students at the Ohio State University. All the subjects had a background in using computers to find information. They were either respondents to an advertisement or students from a senior/graduate level Software Engineering Project course. Thirteen students from the course were given extra credit whereas the seven students who responded to the advertisement were paid $20 for their participation. An alternative assignment had been provided to the course students to earn the extra credit in

lieu of participation in the study. Two of the course subjects had to be dropped due to procedural problems; one subject referred to the online tools while working on the paper conditions and the other used the documentation for the training curriculum committee instead of the product review committee. Thus, data collected from sixteen subjects was used.

Fourteen subjects were male and two were female. The distribution of the ages is shown in Figure 3.9. The distribution of the Hrs/Wk of computer usage shows that subjects used a computer regularly (Figure 3.10). Figure 3.11 shows that subjects were familiar with web access.

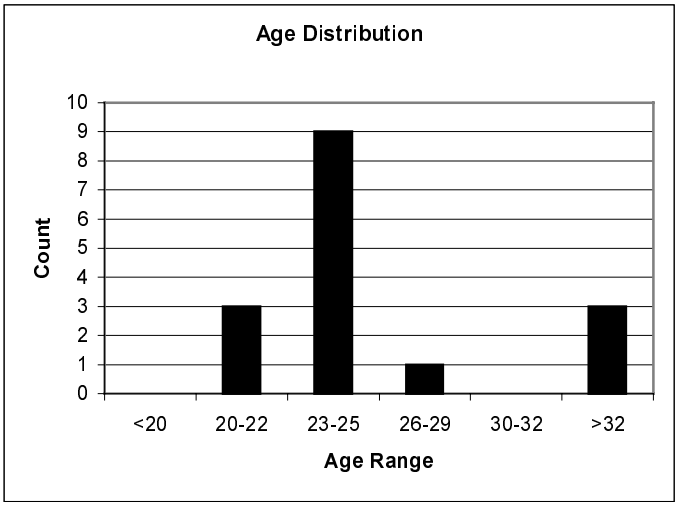


Figure 3.9 Distribution of Subject Age

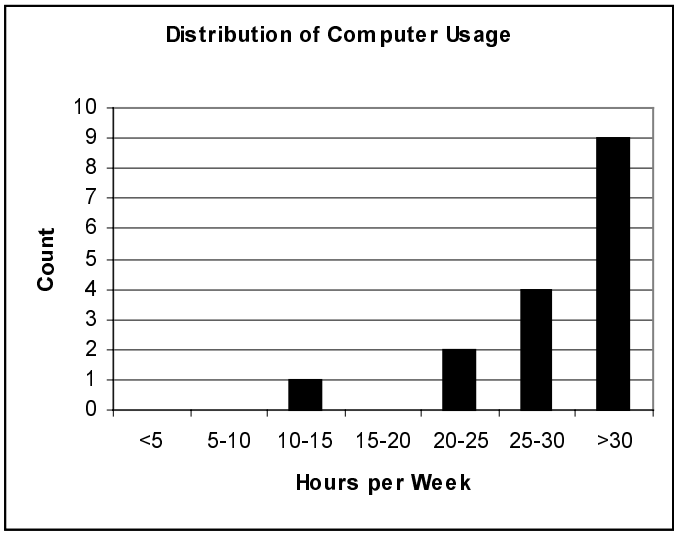


Figure 3.10 Distribution of the Hrs/Wk of computer use by subjects

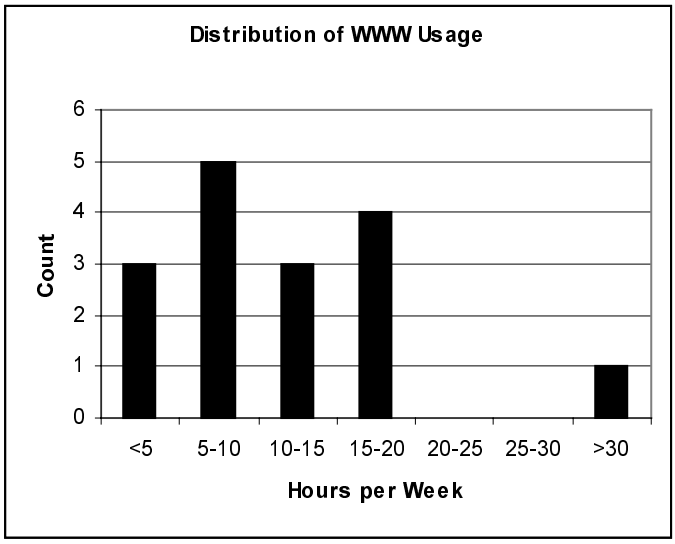


Figure 3.11 Distribution of the Hrs/Wk of web access by subjects

3.1.4 Materials

3.1.4.1 Consent Form

The research study was registered with the Office of Research Risks at the Ohio State University and the appropriate consent form was used under the protocol number 97E0023 (Appendix H).

3.1.4.2 Hardware/Software

The subjects were seated in a cubicle with an L-shaped desk. They used an HP 9000 UNIX workstation with a 17" color monitor, running X-Windows (X11) under the TVTWM window manager (LaStrange 1988).

3.1.4.3 Committee Information Online

In the Online conditions, the web-browser Netscape Navigator 3.1 was used to access the committee information. The Linked Online condition accessed LinkER through the browser. The web-based keyword search software was accessed through the browser for the Unlinked Online condition.

3.1.4.4 Committee Information on Paper

Subjects were provided with two binders organizing the paper versions of the committee information. Linked on Paper used the "Cross-Reference Binder" and Unlinked on Paper used the "Index Binder" (keyword index).

3.2 Procedure

In order to control for differences in handling subjects, a written script was used to conduct the experiment (Appendix G). Pilot testing was conducted in order to eliminate problems in the experimental procedure and provide an estimate of the time needed to complete the task. The procedure had the following steps in order:

1. Introduction

   The subjects were asked to read the general information about the study (Appendix F).

2. Consent

   Following ethical procedures in the use of human subjects, they were asked to read and sign the consent form (Appendix H).

3. Demonstration

   The experimenter demonstrated the four methods to be used to access the information. Subjects observed the demonstration that followed a written script (Appendix J).

4. Training

   Documentation of the curriculum committee for the department of Computer and Information Science at the Ohio State University was used to provide the context for

the training exercise (Appendix C). After examining the information about the curriculum committee, subjects used the Task Window to answer three practice questions using each of the four methods. The practice questions were on the training committee information (Appendix E). The experimenter answered questions about the interface for each of the four access methods.

5. Testing

   Subjects were given the information about the product review committee for Toysworth Inc (Appendix B). Subsequently they used the Task Window to answer the set of eight equivalent questions in each of the four conditions (Appendix D). A 4x4 Latin Square counterbalanced the order of presentation of the four conditions and a nested 4x4 Latin square within the order of presentation controlled the assignment of the equivalent sub-questions of each question to the conditions.

   Subjects were encouraged to work as quickly and accurately as possible while working on the questions in each condition. Subjects were not permitted to ask the experimenter any questions during testing.

6. Post Testing

   A post test questionnaire was used to collect subject background information (age, gender, computer usage, WWW usage) and subjective preference about the tools used in the four conditions (perceived ease of use, speed and accuracy) (Appendix I).

CHAPTER 4

RESULTS

Genius is 1% inspiration and 99% perspiration.

Thomas Alva Edison

Summary statistics for the three measures (time, accuracy, and confidence) are provided in section 4.1. The major results for Medium & Links (Conditions) factors is shown in Figure 4.4. The results for the question factors are shown in Figure 4.5 (Number of Entities), Figure 4.6 (Timeframe), and Figure 4.7 (Type of Relationships). Higher order interaction effects are presented in section 4.3. The analysis of the LinkER access logs are presented in section 4.4. The effect of the order of presentation of the four major conditions is shown in Figure 4.8. Finally, a summary of the subjective ratings (questionnaire data) is provided in Figure 4.10 and the ratings are related to the three dependent measures (Table 4.11-4.15).

4.1 Data Summary

4.1.1 Descriptive Statistics

Descriptive statistics are presented in Table 4.1 for the three dependent variables. All the data for the Time, Accuracy (correct or incorrect), and Confidence measures were included in the analyses. For presentation purposes, the confidence ratings were transformed to a percentage by multiplying the ratings by 10. In addition, accuracy is presented as a percentage of the correct responses.

	Task Completion Time (seconds)	Accuracy (%)	Confidence (%)
Mean	104.0	77.0	87.8
Standard Deviation	90.1	42.2	21.4
Standard Error	4.0	1.9	1.0

Table 4.1 Descriptive Statistics Summary

4.1.2 Time

The Figure 4.1 shows a histogram of the task completion time (Time).

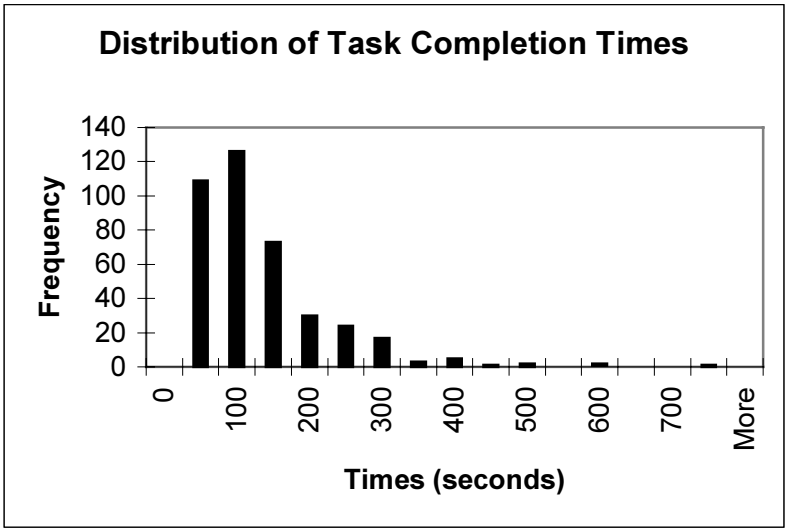


Figure 4.1 Distribution of Task Completion Times

4.1.3 Accuracy

The accuracy by the question type is shown in Table 4.2**.** Accuracy was low for three Y/N questions and for Q2 (Date). The lowest accuracy (56.2%) was in the Y/N question (Q8).

Question Type	Response Type	Correct (%)
2, Lexical, Current	Y/N	96.9
2, Lexical, Past	Date	65.6
2, Semantic, Current	Y/N	68.7
2, Semantic, Past	Y/N	67.2
4, Lexical, Current	Name	79.7
4, Lexical, Past	Y/N	92.2
4, Semantic, Current	Y/N	89.1
4, Semantic, Past	Y/N	56.2

Table 4.2 Accuracy by question type

The percentage of correct and incorrect responses as well as the mean task completion time and confidence ratings are shown in Table 4.3. A oneway analysis of variance of the confidence ratings and task completion times for correct vs. incorrect indicated that subjects were significantly faster when correct ($F(1,510)=17.6$, $p<0.001$). Although subjects were encouraged to work fast in each condition, they did not make errors by trying to work quickly. Therefore, we can see that there was no tradeoff between task completion time and accuracy.

	N	Response (%)	Time (seconds) Mean	SD	Confidence (%) Mean	SD
Correct	394	77	95.0	82.4	92.3	15.8
Incorrect	118	23	134.0	106.9	72.9	29.5

Table 4.3 Summary of Accuracy

4.1.4 Probability of Guessing

The subjects answered eight questions in each condition (Appendix D). Based on the type of response, these eight questions were divided into three groups as shown in Table 4.4. The table shows the number of possible responses for each type of question

and the probability (P) of guessing the correct answer for the question type. Thus, the subjects had the best chance of guessing the correct answer in the Y/N type of questions.

Response Type	# of Questions	# Possible Responses	P
Y/N	6	2	0.5
Meeting Date	1	37	0.027
Person's Name	1	19	0.055

Table 4.4 Probability (P) of guessing the right answer

4.1.5 Correctness of Response

To determine correctness, each response was compared against the correct answer for the question as follows (Appendix D):

- Y/N type responses of "Yes", "yes", "Y", "y", "No", "no", "N", "n" were accepted as correct.
- Meeting dates in the format mm/dd/yy (e.g., 12/16/96), or Month Date, Year (e.g., November 12, 1996) was accepted.

- Name responses were accepted if they were either the first name and last name, first name only, or last name only, e.g., Mary Fry, Mary, or Fry were all acceptable. All the names of the people in the committee were unique.

Table 4.5 shows the average answer size for each response type.

Response Type	Avg. answer size (# characters)
Y/N	1.5
Date	7.0
Name	12.0

Table 4.5 Average answer size in characters for date and name responses

Estimating an average typing speed of 20 words/min at 0.6secs/character, the Date question would require 4.2 seconds and the Name 7.2 seconds as compared to 0.9 second for the Y/N questions. The results showed that the Date question was slower than other questions by over 60secs and the Name question by over 37 seconds (see section 4.3). Thus, the results were not affected by the time required to type out additional characters in these two questions.

4.1.6 Confidence vs. Accuracy

Subjects were also significantly more confident when correct ($F(1,510)=87.4$, $p<0.001$) as can be seen in the distribution of the confidence ratings (Figure 4.2).

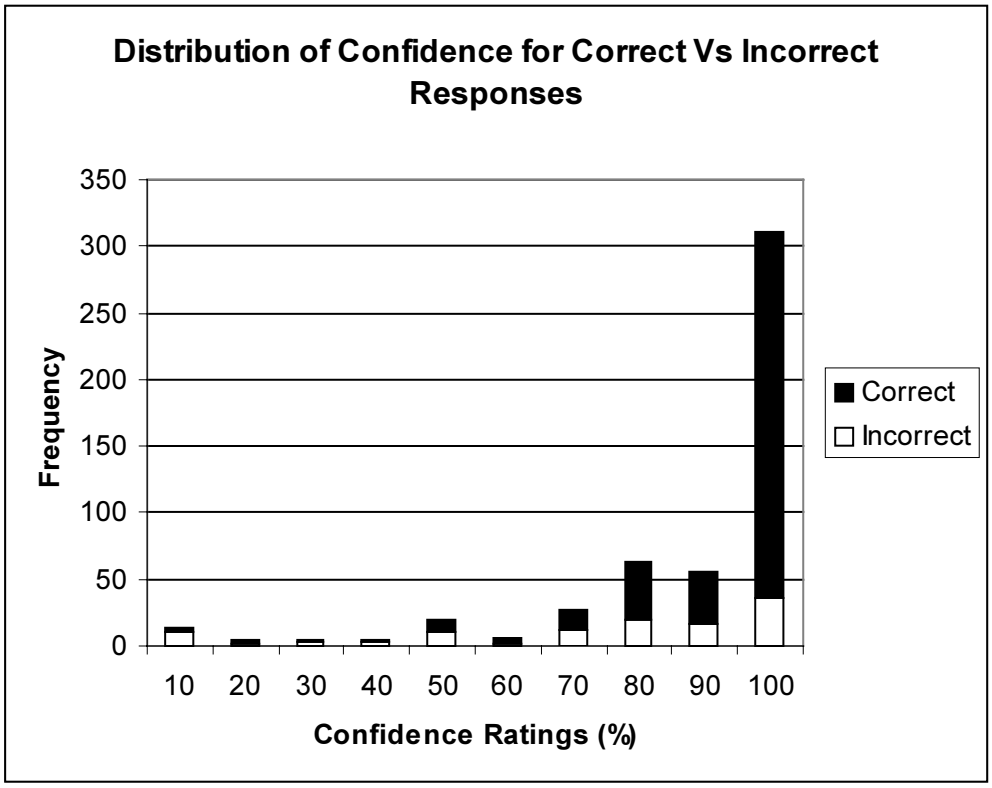


Figure 4.2 Distribution of Confidence Ratings

4.1.7 Time vs. Confidence

The paired comparison of the task completion time (Time) and confidence ratings (Figure 4.3) showed a significant correlation of -0.49 ($t(509)= -12.6$, $p<0.001$).

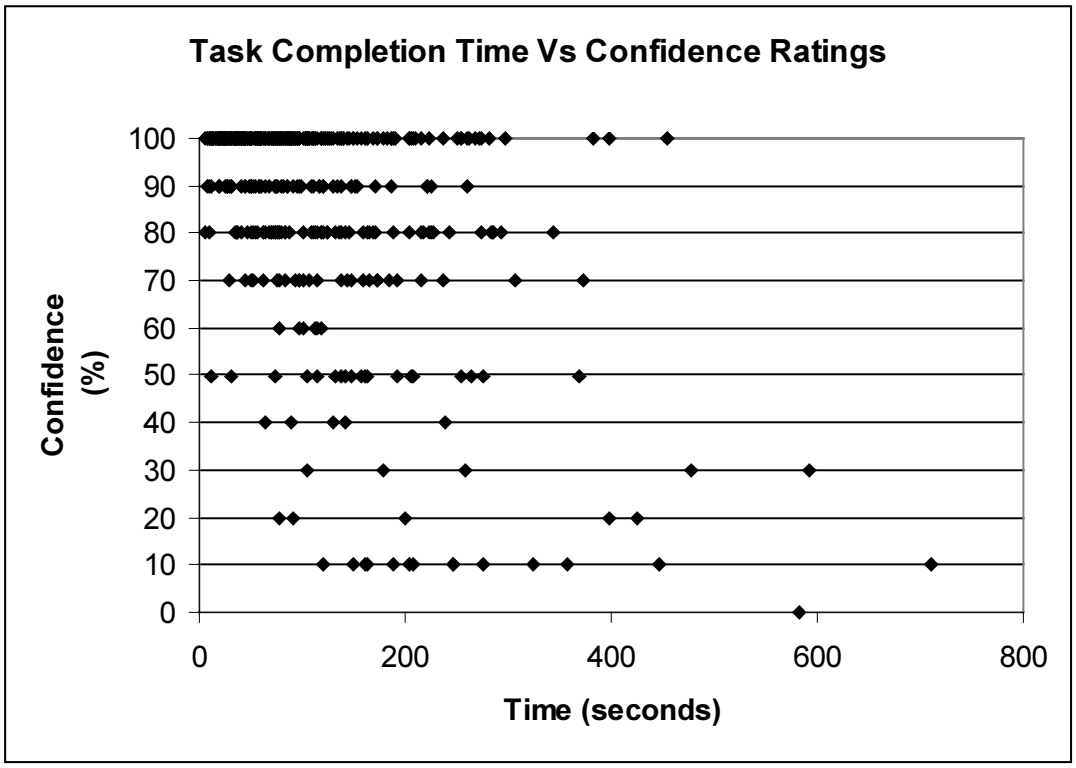


Figure 4.3 Paired comparison of task completion time (Time) and confidence ratings

4.2 Data Analysis

The data was analyzed by a 4-factor analysis of variance using the factors shown in Table 4.6.

	Conditions (Links & Medium)	**Entities (E)**	**Timeframe (T)**	**Relationships (R)**
Levels	4	2	2	2
Values	Linked Online (LO) Unlinked Online (UO) Linked on Paper (LP) Unlinked on Paper (UP)	2 4	Past (P) Current (C)	Lexical (Lx) Semantic (S)

Table 4.6 Analysis Factors & Levels

The graphs present a combined view of the three measures accuracy, confidence ratings, and the task completion time. Accuracy and confidence are presented as percentages (bars) on the primary Y-axis. To allow for comparisons, the bars for each

measure are clustered together. Time is presented as points connected by lines on the secondary Y-axis. Error bars indicate one standard error of the means.

Comparisons of the performance among the four main conditions overall as well as for each of the three question factors are considered as a-priori or planned comparisons [Lane 1996].

4.2.1 Effects of Medium & Links (Conditions)

Time The task completion times for conditions in Figure 4.4 differed significantly ($F(3,45)=5.1$, $p<0.01$). Planned comparisons of the means showed subjects were significantly faster in Linked Online over Unlinked Online (diff=23.3s, $t(45)=2.4$, $p<0.05$), Linked on Paper (diff=38s, $t(45)=3.9$, $p<0.001$), and Unlinked on Paper (diff=21.3s $t(45)=2.2$, $p<0.05$) conditions.

Accuracy No differences were found ($F(3,45)=0.1$).

Confidence Ratings differed significantly across conditions ($F(3,45)=2.9$, $p<0.05$). Planned comparisons of the means showed that subjects were significantly less confident in Linked on Paper (LP) over Linked Online (diff=7.5, $t(45)=2.7$, $p<0.01$), Unlinked Online (diff=6.2, $t(45)=2.2$, $p<0.05$), and Unlinked on Paper (diff=5.6, $t(45)=2.0$, $p<0.05$).

The means and standard errors are summarized in Table 4.7.

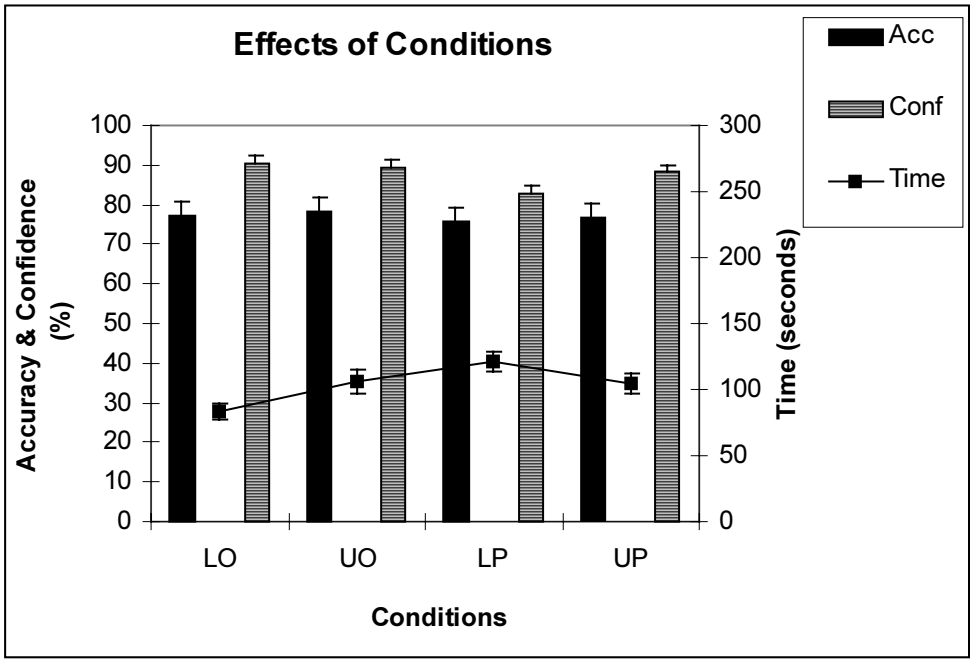


Figure 4.4 Mean time, accuracy, and confidence for major conditions (LO=Linked Online, UO=Unlinked Online, LP=Linked on Paper, UP=Unlinked on Paper)

	Time	Accuracy	Confidence
LO	83.3 (6.2)	77.3 (3.7)	90.6 (1.7)
UO	106.6 (9.3)	78.1 (3.8)	89.2 (2.4)
LP	121.3 (8.2)	75.8 (3.7)	83.1 (1.7)
UP	104.6 (7.7)	76.6 (3.8)	88.6 (1.5)

Table 4.7 Summary of means and standard errors for the four major conditions

4.2.2 Effects of Number of Entities

Time Subjects were significantly faster in questions with four entities over two entities ($F(1,15)=24.5$, $p<0.001$). In particular, planned comparison tests showed that subjects were significantly faster in four entity over two entity questions in Linked Online (diff=46.8s, $t(45)=2.9$, $p<0.01$). The difference in time between four and two entities did not differ significantly across the four conditions ($F(3,45)=0.9$).

Accuracy There were no significant effects ($F(1,15)=1.6$). The difference in accuracy between four and two entities did not differ significantly across the four conditions ($F(3,45)=0.6$).

Confidence Subjects were significantly more confident in questions with four entities over two entities ($F(1,15)=12.6$, $p<0.01$). In particular, planned comparison tests showed that subjects were significantly more confident in four entity over two entity questions in Linked Online (diff=8.3, $t(45)=2.5$, $p<0.05$). The difference in confidence between four and two entities did not differ significantly across the four conditions ($F(3,45)=0.2$).

The means and standard errors for the three measures are shown in Table 4.8.

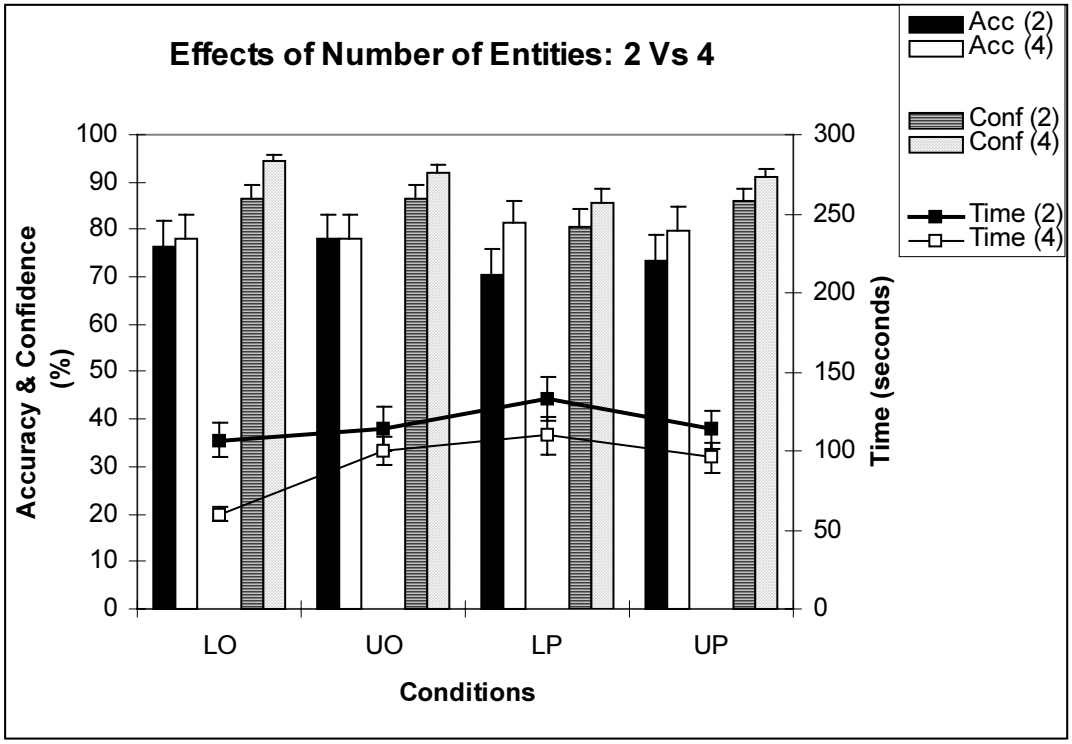


Figure 4.5 Mean time, accuracy, and confidence broken down by number of entities (2 vs. 4) across the major conditions (LO=Linked Online, UO=Unlinked Online, LP=Linked on Paper, UP=Unlinked on Paper)

	Time (2)	Time (4)	Accuracy (2)	Accuracy (4)	Confidence (2)	Confidence (4)
LO	106.7 (10.7)	60.0 (4.7)	76.6 (5.3)	78.1 (5.2)	86.4 (3.2)	94.7 (1.3)
UO	113.7 (13.6)	99.5 (9.0)	78.1 (5.2)	78.1 (5.2)	86.5 (2.9)	91.9 (1.9)
LP	133.1 (14.1)	109.6 (11.9)	70.3 (5.8)	81.3 (4.9)	80.6 (3.6)	85.5 (3.2)
UP	113.4 (11.8)	95.8 (9.8)	73.4 (5.6)	79.7 (5.1)	86.1 (2.4)	91.1 (1.9)

Table 4.8 Summary of the means and standard errors for the major conditions broken down by the number of entities (2 vs. 4)

4.2.3 Effects of Timeframe

Time

Subjects were significantly faster with current questions over past ($F(1,15)=20.2$, $p<0.001$). The difference between current and past times differed significantly across the four conditions ($F(3,45)=2.8$, $p<0.05$) (Figure 4.6). In Linked Online, current was significantly faster than past as shown by a planned comparison test (diff=63.7s, $t(45)=3.7$, $p<0.001$). In Unlinked Online and Linked on Paper, current took less time than past and in Unlinked on Paper, current took more time than past but the difference was not significant.

Accuracy

Subjects were significantly more accurate with current questions over past ($F(1,15)=21.2$,$p<0.001$). In particular, subjects were significantly more accurate in current over past questions in Linked Online as shown by a planned comparison test (diff=20.3, $t(45)=2.6$, $p<0.05$). The difference in accuracy between current and past did not differ significantly across the four conditions ($F(3,45)=1.0$).

Confidence

Subjects were significantly more confident in current questions over past ($F(1,15)=5.1$, $p<0.05$). The difference in confidence between current and past differed significantly across the four conditions ($F(3,45)=4.3$, $p<0.01$) (Figure 4.6). In particular, subjects were significantly more confident in current over past questions in Linked Online as shown by a planned comparison test (diff=15.2, $t(45)=4.0$, $p<0.001$). In Unlinked Online,

confidence was higher in current than past but the difference was not significant. In Linked on Paper, confidence was lower in current than past but the difference was not significant. In Unlinked on Paper, the confidence was the same in current and past.

The means and standard errors for the three measures are shown in Table 4.9.

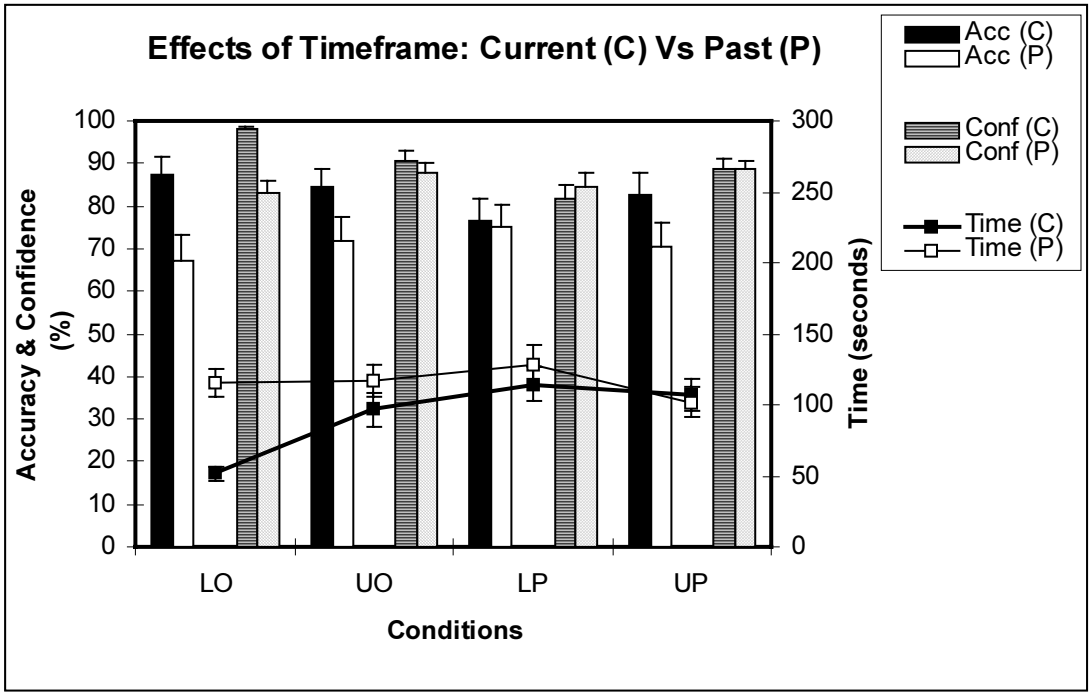


Figure 4.6 Mean time, accuracy, and confidence broken down by timeframe of questions (Current vs. Past) across the major conditions (LO=Linked Online, UO=Unlinked Online, LP=Linked on Paper, UP=Unlinked on Paper)

	Time (C)	Time (P)	Accuracy (C)	Accuracy (P)	Confidence (C)	Confidence (P)
LO	51.5 (4.5)	115.2 (10.0)	87.5 (4.2)	67.2 (5.9)	98.1 (0.6)	83.0 (3.2)
UO	96.8 (11.7)	116.4 (11.3)	84.4 (4.6)	71.9 (5.7)	90.8 (2.3)	87.6 (2.6)
LP	114.4 (11.9)	128.3 (14.3)	76.6 (5.3)	75.0 (5.5)	81.6 (3.6)	84.5 (3.2)
UP	107.4 (11.3)	101.8 (10.5)	82.8 (4.8)	70.3 (5.8)	88.6 (2.3)	88.6 (2.0)

Table 4.9 Summary of the means and standard errors for the major conditions broken down by timeframe (Current vs. Past)

4.2.4 Effects of Type of Relationship

Time The effect of relationships on the task completion time was marginally not significant ($F(1,15)=4.5, p=0.051$). Planned comparison tests showed that subjects were significantly faster in semantic over lexical questions for Linked Online (diff=23.0s, $t(45)=2.04$, $p<0.05$), and Linked on Paper (diff=24.31, $t(45)=2.14$, $p<0.05$). The difference in time between lexical and semantic did not differ significantly across the four conditions ($F(3,45)=1.3$).

Accuracy Lexical was significantly more accurate than Semantic ($F(1,15)=11.901$, $p<0.01$). In particular, planned comparison tests showed subjects were significantly more accurate in lexical over semantic questions for Unlinked Online (diff=18.8, $t(45)=3.5$, $p<0.05$), Linked on Paper (diff=14.1, $t(45)=2.6$, $p<0.05$), and Unlinked on Paper (diff=18.8, $t(45)=3.5$, $p<0.01$). The difference in accuracy between lexical and semantic did not differ significantly across the four conditions ($F(3,45)=1.0$).

Confidence Lexical was also significantly more confident than semantic ($F(1,15)=6.6$, $p<0.05$). The difference in confidence between lexical and semantic differed significantly across the four conditions ($F(3,45)=5.4$, $p<0.01$) (Figure 4.7). In Linked Online, confidence was lower in lexical over semantic but the difference was not significant. Planned comparison tests showed that subjects were significantly more confident in lexical over

semantic questions in Unlinked Online (diff=7.8, $t(45)=3.2$, $p<0.01$), Linked on Paper (diff=7.3, $t(45)=3.0$, $p<0.01$), and Unlinked on Paper (diff=10.3, $t(45)=4.2$, $p<0.001$).

The means and standard errors for the three measures are shown in Table 4.10.

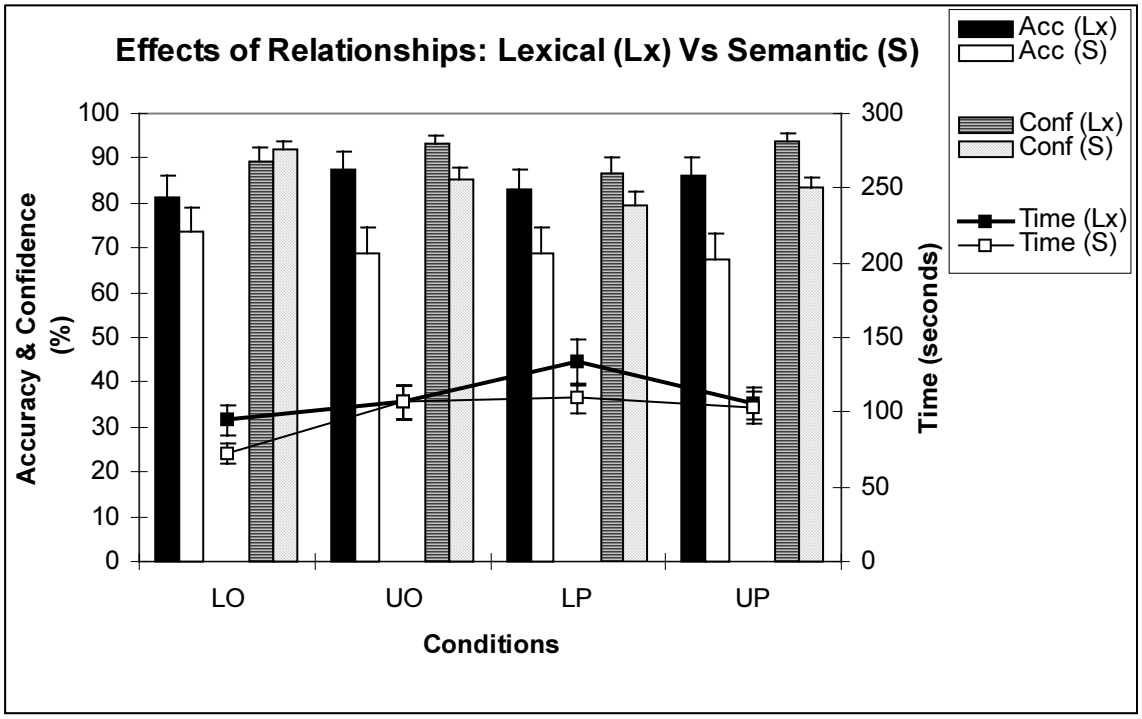


Figure 4.7 Mean times, accuracy, and confidence broken down by relationships (Lexical vs. Semantic) across the major conditions (LO=Linked Online, UO=Unlinked Online, LP=Linked on Paper, UP=Unlinked on Paper)

	Time (Lx)	Time (S)	Accuracy (Lx)	Accuracy (S)	Confidence (Lx)	Confidence (S)
LO	94.8 (10.1)	71.8 (6.8)	81.3 (4.9)	73.4 (5.6)	89.2 (3.0)	91.9 (1.8)
UO	106.5 (11.9)	106.7 (11.3)	87.5 (4.2)	68.8 (5.8)	93.1 (2.1)	85.3 (2.7)
LP	133.5 (15.4)	109.2 (10.2)	82.8 (4.8)	68.8 (5.8)	86.7 (3.6)	79.4 (3.1)
UP	106.1 (10.7)	103.1 (11.1)	85.9 (4.5)	67.2 (5.9)	93.8 (1.7)	83.4 (2.4)

Table 4.10 Summary of the means and standard errors for the major conditions broken down by the relationships (Lexical vs. Semantic)

4.3 Higher Order Effects

The performance of subjects differed significantly across the eight questions, which were combination of the three secondary factors (Number of Entities, Timeframe and Type of Relationship).

Time The times were significantly different across the question types ($F(1,15)=90.4$, $p<0.001$). A Scheffe 95% confidence interval showed that the question 2 entities, lexical relationship, past timeframe (2,Lx,P) was the slowest question. The difference in task completion time between the question types differed significantly across the four conditions (four-way interaction) ($F(3,45)=3.1$, $p<0.05$).

Accuracy Accuracy differed significantly across the eight question types ($F(1,15)=24.5$, $p<0.001$).

Confidence Confidence differed significantly across the eight question types ($F(1,15)=39.0$, $p<0.001$).

Subjects took the longest time in question 2,Lexical,Past which asked for the date of the meeting making a specific announcement e.g., *What is the date of the earliest meeting announcing the changeover of the committee from old members to new members?*

To answer this question in the Linked conditions, subjects had to examine the [Topic] entity and find the topic “Announcements” and follow the link to the [Meeting] entity. By contrast, a search for specific keywords (e.g., “changeover” or “new

members") would locate the meeting making the announcement in the Unlinked conditions. A specific announcement made at a meeting is seldom a topic of discussion. Hence, they were not listed individually in the [Topic] entity. Subjects had difficulty locating this relationship link between the common "Announcements" topic ([Topic]) and meetings dates ([Meeting]). In the Linked Online condition, subjects had to spend time examining individual documents (meeting agenda, minutes) to find the meeting in which the specific announcement was made. LinkER access logs showed that subjects accessed the most number of entities in 2,Lexical,Past (see section 4.4). The logs also showed that subjects accessed the most number of documents in two over four entity questions and past over current questions. This indicates that subjects answering the question 2,Lexical,Past may have been browsing around different entities and documents in an effort to find the appropriate relationship link.

Analysis of the data without the 2,Lexical,Past question showed lower task completion times for both Linked conditions. The difference between Linked Online and the other three conditions increased from 23secs to 33secs and the difference between the Unlinked conditions and Linked on Paper decreased from 14secs to 6secs. Analysis of the four-way interaction for task completion time showed that subjects did not perform significantly worse in Linked Online for any of the questions. Therefore, the interaction of the secondary factors did not contradict any of the results of the main factors.

4.4 LinkER Access Logs

The web-based LinkER tool saved a temporal log of the subject interactions (e.g., selection of entities, links, and documents) for the questions answered by each subject. From this data I derived the following counts, which presented a total number for different types of accesses:

- Number of Entities Accessed

  Clicking on one of the eight entities in the menubar at the top of each LinkER page counted as one entity access (Figure 3.1).

- Number of Links Accessed

  Selecting a relationship link between two entities (e.g., **M** or **T**) counted as one link accessed (see example in Figure 3.2 and Figure 3.3).

- Number of Documents Accessed

  In addition to relationship links, LinkER supports links to the actual committee information. Selecting such a link to view a meeting agenda, minutes or a file, counted as one document access.

The log data was analyzed across the three question factors: Number of Entities (2 vs. 4), Timeframe (current vs. past), and Relationships (lexical vs. semantic).

Number of Entities Accessed

Subjects accessed significantly more entities in the following:

- Two entity (mean=1.6, se=0.1) over four entity (mean=1.2, se=0.1) questions ($F(1,15)=10.0$, $p<0.01$),
- Past (mean=1.7, se=0.1) over current (mean=1.1, se=0.0) questions ($F(1,15)=21.8$, $p<0.001$),
- Lexical (mean=1.7, se=0.1) over semantic (mean=1.1, se=0.0) questions ($F(1,15)=13.1$, $p<0.01$).

This count, of the number of entities accessed, differed significantly across the question types. A 99% Scheffe confidence interval showed that subjects accessed the most number of entities in the question 2,Lexical,Past.

Number of Links Accessed

Subjects accessed significantly more links in answering past (mean=2.3, se=0.3) over current (mean=1.2, se=0.1) questions ($F(1,15)=10.3$, $p<0.01$). The number of links accessed did not differ significantly across the question types ($F(1,15)=1.549$).

The access counts showed that the relationship link from [Topic] entity to [Meeting] entity was accessed the most (24.3%) while some links (e.g., [SubCommittee] to [Role]) were not accessed at all.

Number of Documents Accessed

The number of entities accessed and the number of documents accessed showed a significant correlation of 0.42 ($t(126)=5.2$, $p<0.001$) indicating that subjects accessed more documents in conjunction with accessing more entities. Subjects accessed significantly more documents in answering past

(mean=2.0, se=0.1) over current (mean=0.3, se=0.1) questions ($F(1,15)=20.2$, $p<0.001$). The number of documents accessed did not differ significantly across the question types ($F(1,15)=0.362$).

4.5 Order Effects in Presenting Conditions

In each of the major conditions, subjects answered a set of eight questions in order (Q1-Q8) shown in Appendix D. The order of presentation of the four conditions was counterbalanced using a 4x4 Latin Square. In addition, a nested 4x4 Latin Square controlled the assignment of the four equivalent sub-questions of each question to the conditions. Analysis of the data showed no effects of the order for all three measures Time ($F(3,45)=2.1$), Accuracy ($F(3,45)=0.9$), and Confidence ($F(3,45)=1.5$) (Figure 4.8). This lack of effect overall, validates the use of a within subjects design. Specifically, it suggests that subjects were not learning answers to the questions from previous conditions.

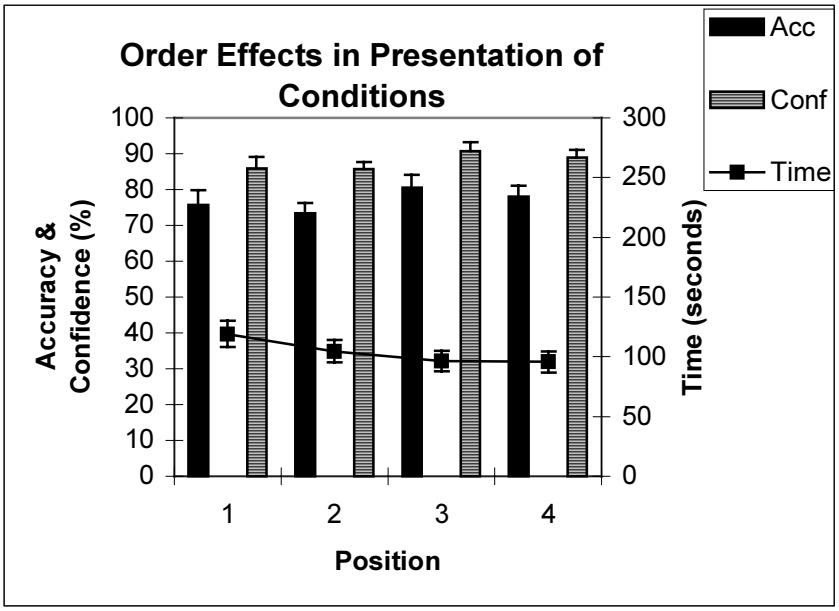


Figure 4.8 Mean task completion time, accuracy, and confidence for the order of presentation of the major conditions

The differences between two and four entities differed significantly across the four positions for accuracy ($F(3,45)=4.3$, $p<0.01$) and confidence ($F(3,45)=3.1$, $p<0.05$) as shown in Figure 4.9. A Scheffe 95% confidence interval showed that in positions 1 and 2, subjects were significantly more confident in questions with four over two entities.

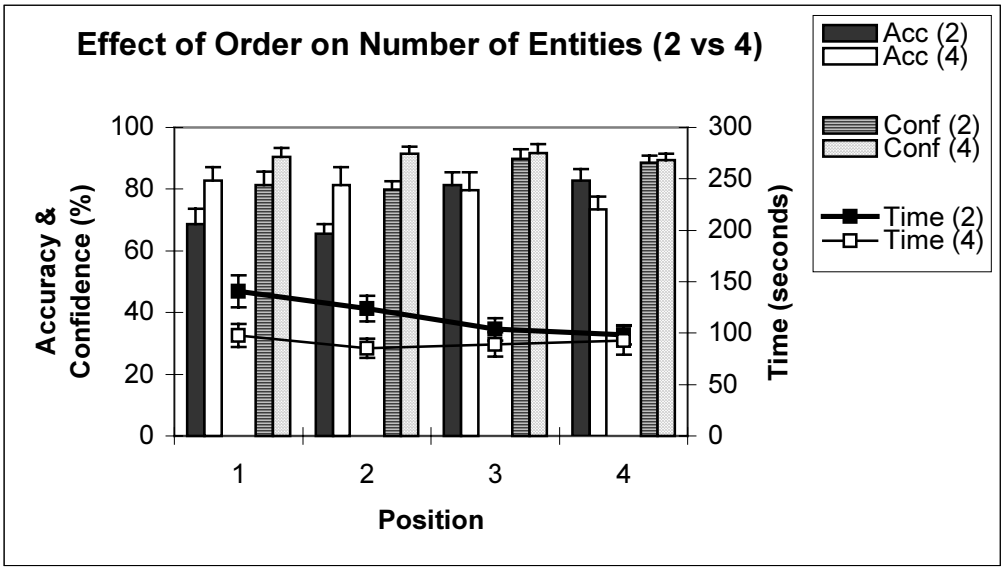


Figure 4.9 Mean task completion time, accuracy, and confidence for the order of presentation of the conditions broken down by number of entities (2 vs. 4)

The difference in timeframe (current vs past) and type of relationship (lexical vs semantic) did not differ significantly across the four positions (Table 4.11).

Order * Qn. Factor	Time	Accuracy	Confidence
Number of Entities	F(3,45)=1.4	**F(3,45)=4.3, p<0.01**	**F(3,45)=3.1, p<0.05**
Timeframe	F(3,45)=0.5	F(3,45)=1.8	F(3,45)=0.8
Type of Relationship	F(3,45)=0.8	F(3,45)=2.0	F(3,45)=0.7

Table 4.11 Results of the analysis of interaction between order and question factors

4.6 Subjective Ratings

Subjective ratings were gathered through the post-test questionnaire (Appendix I) for Subjective Usability (ease of use), Subjective Speed, and Subjective Accuracy for the four major conditions. The results are summarized in Figure 4.10. The graph shows a combined view of all three ratings. The ratings for Subjective Speed and Accuracy are presented (bars) on the primary Y-axis. Subjective Usability is presented as points connected by a line on the secondary Y-axis.

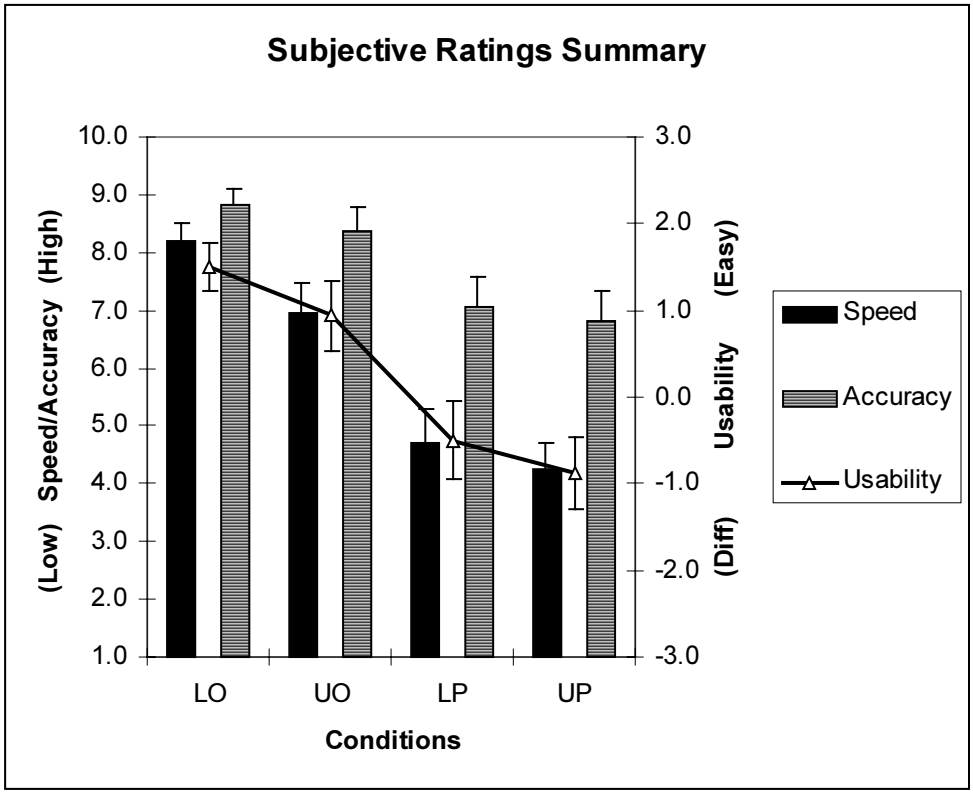


Figure 4.10 Ratings for Subjective Speed, Subjective Accuracy, and Subjective Usability of the four major conditions (LO - Linked Online, UO - Unlinked Online, LP - Linked on Paper, UP - Unlinked on Paper)

The subjective ratings were significantly correlated across the major conditions and overall as shown in Table 4.12. For each subjective rating, a mean rating value was calculated across the four conditions. Mean ratings were compared to obtain the "Overall" correlation.

	Subj. Usability vs. Subj. Speed	Subj. Usability vs. Subj. Accuracy	Subj. Speed vs. Subj. Accuracy
LO	0.61*	0.43	0.57*
UO	0.86**	0.72**	0.79**
LP	0.59*	0.30	0.56*
UP	0.58*	0.46	0.62**
Overall	0.65**	0.32	0.55*

Table 4.12 Spearman Rank Correlation (rho) of Subjective ratings across major conditions and overall (significance (N=16): * p < 0.05, ** p<0.01)

The correlation between the three retrospective measures (subjective ratings) and the concurrent experimental measures are shown in Table 4.13 (Retrospective measures vs. Time), Table 4.14 (Retrospective measures vs. Accuracy), and Table 4.15 (Retrospective measures vs. Confidence). There appears to be little relationship between the retrospective and concurrent measures. The subjective ratings and Time are not significantly correlated in any of the conditions and overall. Accuracy is significantly correlated with Subjective Usability in Linked Online ($rho = -0.55$, $p<0.05$) and Confidence is significantly correlated overall with Subjective Accuracy ($rho = 0.62$, $p<0.01$).

	Subj. Usability	Subj. Speed	Subj. Accuracy
LO	0.36	-0.17	0.06
UO	-0.13	-0.07	-0.10
LP	0.17	0.07	-0.08
UP	-0.47	-0.17	-0.14
Overall	-0.44	-0.44	-0.26

Table 4.13 Spearman Rank Correlation (rho) between Subjective ratings and Time across major conditions and overall (significance (N=16): * p < 0.05, ** p<0.01)

	Subj. Usability	Subj. Speed	Subj. Accuracy
LO	0.22	-0.13	-0.10
UO	-0.40	-0.20	-0.31
LP	-0.55*	-0.22	-0.2
UP	-0.14	-0.53	-0.19
Overall	-0.21	-0.21	-0.36

Table 4.14 Spearman Rank Correlation (rho) between Subjective ratings and Accuracy across major conditions and overall (significance (N=16): * $p < 0.05$, ** $p<0.01$)

	Subj. Usability	Subj. Speed	Subj. Accuracy
LO	0.18	0.15	0.47
UO	-0.03	0.02	0.42
LP	-0.11	-0.06	0.24
UP	0.19	-0.08	0.22
Overall	0.24	-0.24	0.62**

Table 4.15 Spearman Rank Correlation (rho) between Subjective ratings and Confidence across major conditions and overall (significance (N=16): * p < 0.05, ** p<0.01)

CHAPTER 5

DISCUSSION

Not everything that can be counted counts, and not everything that counts can be counted.

Albert Einstein

First, I discuss the results relating to the usefulness of the relationship links. Subsequently, I discuss the differences between the set of questions, which shows that the results are both robust and general. Finally, I examine the similarities and differences between the predictions (hypotheses), results of the experiment, and the subjective ratings.

5.1 Relationship Links Useful?

The results showed that Linked Online (LinkER) was faster but not more accurate or confident over the other three conditions (Figure 4.4). Subjects were faster using LinkER than keyword search by over 22secs (21%) (Table 4.7). In a typical workweek of five 8hr days, this works out to a difference of 12.6min/hr, or 1.7hrs/workday or 1 day/workweek. The size of this difference motivates the investigation of the types of

links that are likely to give the biggest advantage in terms of task completion time. The relationship links in LinkER were based on the committee information model (Appendix A). The model has over thirty different relationship links between pairs of entities. LinkER shows links for all the relationships which suggests some of the relationships are more useful than others. For example, links from the [Topic] to [Meeting] entities were accessed the most (24%) while other links such as [SubCommittee] to [Role] entity were not accessed at all (see section 4.4). The use of links is likely to depend on the questions asked e.g., five of the eight questions expected to use the [Topic], [Meeting] entities versus only one for [SubCommittee] and [Role] entities. Since the questions asked about the relationships in the information model, they are dependent on the structure of the domain.

The performance of subjects in Unlinked Online was almost equal to Unlinked on Paper condition (Figure 4.4). This is not surprising considering that the paper index used in the Unlinked on Paper condition was a printed copy of the index used by the online keyword search. In the Unlinked on Paper condition, subjects could browse the meeting minutes and agendas in addition to using the index. The two paper conditions Unlinked on Paper and Linked on Paper, served as control conditions. They were much more enhanced over the typical paper based committee documentation, which are seldom indexed or cross-referenced.

5.2 Generality of the Advantages of Relationship Links

The advantage of the relationship links is that they facilitate faster task completion times online. In this section I examine the generality of this advantage across the question types and discuss the issue of external validity.

5.2.1 Generality Across Question Types

The task that subjects performed was to seek answers to a set of eight questions (Appendix D). The results showed that the performance of subjects differed significantly across the eight questions indicating that the questions were not similar (see section 4.3). There were differences across each of the three question factors:

Number of Entities

Subjects were faster in four over two entity questions and the examination of the web access logs showed that subjects accessed fewer entities to answer four over two entity questions (see section 4.2.2). In Linked Online, subjects had more choice with four over two entity questions. For example in the question "*Who is the chair of the Web Advertising sub-committee?*" subjects could start by examining any of four entities ([Sub-Committee], [People], [Topic], [Role]) although it was faster to use the [Sub-Committee] entity. In the two entity questions, subjects had to find the relationship links between the two entities. As seen in the case of the question 2,Lexical,Past, subjects took longer if they had difficulty finding the relationship link between the two entities (see section 4.3).

Timeframe

Since the committee information was organized in reverse chronological order, it was expected that in Linked on Paper subjects would require more time in past over current. Although the subjects were significantly faster, more accurate and confident in current over past questions (Figure 4.6), there were no significant differences in the Linked on Paper condition.

Type of Relationship

Subjects were significantly more accurate in Lexical over Semantic questions (Figure 4.7) which just goes to show that some questions were more difficult than others.

Thus, the results apply not only to questions that were similar but also to questions that were significantly different. In addition, subjects weren't significantly slower in Linked Online for any of the questions (see section 4.3). Therefore, the results are both robust and general.

5.2.2 Issues of Validity

Laboratory experimentation was used to investigate the usefulness of model-based relationship links in order to carefully control for assumptions in studying the cause-effect relationship between the independent variables (Links, Medium) and the dependent variables (task completion time, accuracy). However, there is a tradeoff between the internal validity (experimental control) and external validity (generality). External validity is multi-dimensional so it is important to find ways in which the results

can or cannot generalize [Sackett & Larson, 1990]. Three main issues commonly raised in discussions of external validity are ([Lynch, 1982], [Cook & Campbell, 1979]):

- Statistical Generalizability - generalizability to larger populations
- Robustness – replication of results across subjects, time and settings
- Realism – realistic stimuli, tasks, and settings

Statistical Generalizability

The subjects playing the role of committee members were not related in any way to the committee. They represented the case of a "new member or employee" which is only one of the many types of members based on domain knowledge, age, experience, etc. In this study, experience and domain knowledge were not variables being measured and they were controlled to ensure the homogeneity of subjects, a desirable attribute [Calder, 1981]. The factors of domain knowledge or experience in committee work would be difficult to control since such knowledge is highly variable. Thus, subjects in the study had no prior experience on the committee and their domain knowledge was limited to the information provided about product review committee for Toysworth Inc. (Appendix B).

Robustness

The subjects were non-novice computer and web users (Figure 3.9, 3.10). The experimental setting was carefully controlled to be constant across all four conditions (see sections 3.1.3 & 3.1.4). Although the subjects participated in the study at different

times of the day, the experimental settings were kept constant across subjects since the task window presented the conditions/questions and collected the response across all four conditions (see section 3.1.2.1). The task window and other web-based tools connected to a dedicated web server for the duration of the study.

Realism

The stimulus used in the study was the product review committee for the fictitious company Toysworth Inc. (Appendix B). The use of an artificial committee and company may imply artificial information. Although the company and committee are non-existent, the case is certainly plausible since it is not uncommon for a committee in a company to review new products [Smead, 1981]. In addition, all efforts were made to incorporate "real world" issues in the committee discussions. The advantage of creating such a committee was that it provided a more comprehensive and precise information base. In a real committee, there may not be an accurate answer to some questions. Thus, in order to measure the accuracy of the response, the real committee information would have to be modified which may be more difficult than creating a new committee. Besides, with such a complex domain, any individual committee's information artifacts are likely to have limited generality even if they are from a real committee.

The task performed by the subjects was to answer a set of questions that were created based on three question factors (Appendix D). These questions may not be representative of what a "real" committee member may ask. However, the questions that members may ask would depend on the domain and context of the committee work. This

would make it difficult to find "typical" questions of committee members. The factors used to generate the questions provided diversity in the task. Thus, these factors can be verified by trying to decompose sample member questions across the three factors.

The committee information is typically maintained on paper or online. The two paper conditions served as controls and provided information which was much enhanced over normal committee documentation on paper. The conditions of keyword search and model-based linking (LinkER) provided a realistic setting for access to the committee information online.

5.3 Predictions, Results, and Ratings

The predictions of performance that were made in Ch. 2 were largely based on "designer's intuition" of expected subject performance as is often the case in the design of information systems in the "real world" (see section 2.6). The goal of the experiment was to collect data to examine how subjects actually perform with or without the use of relationship links. As part of the experiment, subjects provided a confidence rating for each question. These *concurrent* ratings were gathered immediately after the subjects entered the answer to a question (Figure 3.8). A post-hoc questionnaire collected *retrospective* ratings of the four different methods used to seek relationship information (Appendix I). Given that the subjects provided both ratings, it would be reasonable to expect that these ratings would at least support each other besides supporting the actual results.

The predictions of task completion time (Figure 2.2) were well supported by subjects' retrospective ratings (Figure 4.10). The retrospective ratings for speed showed

the same trend as the prediction for task completion time (order of conditions from fast to slow: Linked Online, Unlinked Online, Linked on Paper, and Unlinked on Paper). This indicates that the "designer's intuition" for task completion time matched the subjects' retrospective impressions for speed. However, both of these turned out to be poor predictors of the actual time or accuracy. The results showed Linked Online was the fastest condition but the order of conditions for time was (fast to slow): Linked Online, Unlinked on Paper, Unlinked Online, and Linked on Paper (Figure 4.4). The difference in accuracy was not significant but subjects were least confident in Linked on Paper.

Surprisingly, the same subjects who provided the concurrent confidence ratings contradicted themselves in the retrospective ratings. The results showed that subjects were more confident when they answered questions correctly, indicating that their concurrent ratings were more accurate (Figure 4.2). The subjects gave the lowest concurrent ratings (were least confident) when answering questions in the Linked on Paper condition (Figure 4.4). However, they gave higher retrospective ratings for Linked on Paper over Unlinked on Paper, which was rated the lowest. Although, subjects seemed to have the most difficulty in Linked on Paper, their retrospective ratings as well the predictions indicated otherwise. Therefore, the results underline the importance of "objective" empirical evaluation of systems.

CHAPTER 6

CONCLUSIONS & FUTURE WORK

The End of Wisdom is Freedom
The End of Culture is Perfection
The End of Knowledge is Love
The End of Education is Character
Sathya Sai Baba

First, I present an overview of the thesis, highlighting the main aspects in its development and the central question examined. Subsequently, I present the conclusions and implications of the work for theory and practice in the design of tools to support cooperative work. Finally, I suggest areas of future work that can be conducted to further explore and expand this line of research.

6.1 Overview

In Chapter 1, I examined the committee process to show the effect of member preparation on the effectiveness of committee work. The committee process is a cooperative activity involving a group of members who meet regularly over a period of time. Committee meeting effectiveness is influenced by the quality of member

preparation. Hence, in order to support the committee process it is important to support member preparation. Since the information generated by the committee process tends to be highly interrelated, an important task of member preparation involves seeking information about these relationships.

In Chapter 2, I explored how committee members can seek relationship information with or without the representation of information relationships in the online and paper medium. I developed a committee information model (E-R model) as one possible representation of the entities and relationships in the committee information space. LinkER was built to implement the committee information model and represent the relationships as hyperlinks in the online medium. Cross-references in documentation represent the relationship links on paper. If the relationships are not directly represented, members have to search for information. A keyword-search engine allows access to the information online and a keyword index can be used on paper. This gives us four comparison conditions: Linked Online (with links online), Unlinked Online (without links online), Linked on Paper (with links on paper), and Unlinked on Paper (without links on paper).

The central question examined in this thesis involves the usefulness of these relationship links: “Are these links useful in seeking answers to questions about information relationships?” Chapter 2 concluded with a set of intuition-based predictions of performance in terms of the task completion time and accuracy of seeking such information across the four comparison conditions.

An experiment was designed to collect actual data to evaluate the usefulness of the links. Chapter 3 described the experimental design and methodology used to conduct the study. Chapter 4 presented the results of the study, which was discussed in Chapter 5.

6.2 Conclusions

The main conclusion is that model-based relationship links are useful and facilitate faster task completion times online as compared to just keyword search. The results showed over a 22sec (21%) advantage of using links over keyword search.

Since relationship information seeking is an important task in meeting preparation, the use of tools such as LinkER can assist members to better prepare for committee meetings. As suggested by Univ. of Arizona researchers, in their experience, users of the web based group support system GS_{Web} report [Romano, 1998]:

> "*They accomplish significantly more during the time they spend together and they accomplish significantly more during the times they spend apart".*

Technological advancements in electronic meeting support systems are unlikely to eliminate face-to-face meetings. However, the online meeting support tools can serve to better prepare the members thereby improving the effectiveness of face-to-face meetings.

The results obtained are general and robust since they apply across a significantly different set of questions. Relationship links can be useful in a number of other domains besides committee work:

- The process of software evolution produces a large number of interrelated artifacts (e.g., code, technical and user documentation, issue logs, bug reports, etc.). Software

maintenance tools examine the relationships between these artifacts e.g., CSCOPE (http://www.unipress.com/att/new/cscope.html) answers questions about relationships between functions, symbols, header and code files in C programs.

- Design of web-based courseware material require a variety of links to seek information about the relationships between concepts, examples, discussions, diagrams, assignments, exams, and answers [Benyon, 1997], [Perlman, 1996b].
- Capturing design rationale involves the representation of relationships e.g., gIBIS captures the relationships between issues, positions, and arguments [Conklin, 1988a]. Links represent the relationships between these entities and can answer specific questions e.g., *"Which positions are supported/opposed by this argument?"*

An important aspect of this research is that it can serve as a case study for the importance of empirical evaluation of systems developed to support cooperative activities. Here is a case where a designer's intuition was well supported by subjects' retrospective impressions. However, neither of them matched actual performance of subjects. Subjects also contradicted themselves since their retrospective ratings (intuition-based) did not match their own concurrent ratings of confidence. This shows that human intuition is a poor predictor of performance in systems for supporting cooperative activities. Other studies have also shown this mismatch between performance and preference of users, indicating the fallacy in relying primarily on the subjective evaluations of users [Bailey, 1993]. Thus, intuition should not be relied upon in the design of such systems and data must be collected to study the actual performance of

users. Lack of evaluation is an important reason for the failure and a challenge for future group support systems [Grudin, 1992]. Despite the difficulties involved in collecting meaningful data, important design decisions must be backed up with empirical evaluation.

6.3 Future Work

The results of the research conducted in this dissertation suggest several areas for further exploration:

Comparison of Models

The committee information model (Appendix A) serves as the basis for the relationships links in LinkER. Thus, model-based linking shows promise as it can speed-up the seeking of relationship information. The model developed in this thesis serves only as a first step in this direction. Further work is required to compare and validate the model in terms of its ability to accurately represent the committee information.

Usefulness of Types of Links

Additional work needs to be done to explore the 21% advantage of links vs search by examining the types of relationship links that are likely to be most useful. LinkER shows a link for all the relationships in the model. Showing links between unrelated entities would not be useful e.g., [File], and [Role]; Only people play different committee roles (chair, member, etc.,) not documents and likewise no committee role is played by a document. In gIBIS, a link from position to position leads to incorrect semantics [Conklin, 1988a]. The question remains as to which of the model-based links are useful. As discussed earlier (see section 5.1), the usefulness of specific links would depend on

the questions which in turn depends on the structure of the domain. The results and access log data suggest the following:

- A useful link may be from an entity that serves as an index or a table of contents for the destination entity e.g., the link from [Topic] to [Meeting] was accessed the most (see section 4.4). The [Topic] entity serves as an index for the contents of the meeting information.
- Links to a chronologically ordered destination entity may be useful to answer questions about the current timeframe *"Which was the most recent ..."* or "w*hat was the latest ..."* e.g., links to [Meeting].
- Link representing a lexical relationship may be useful if it were easy to find a lexical match e.g., [Topic] to [Meeting] except for the question 2,Lexical,Past (see section 4.3)

Combining Linking & Search

Typically, a "real" system would combine both linking and keyword search. Although relationship links are useful, there are some cases (e.g., the question 2,Lexical,Past) where users may have difficulty in locating an appropriate link and additional time is spent browsing through the documentation (see section 4.3). In addition, LinkER access logs showed that subjects accessed more entities and links in the past over current questions (see section 4.4). Subjects were correspondingly slower in past over current questions (see section 4.2.3). Considering that past information is less likely to be linked to current information as compared to other recent information, this

suggests that a search facility should be added to linking. LinkER can easily be extended to provide a keyword search capability in addition to the links.

Field Study

The issues of raised regarding the external validity of the results provide strong motivations for field studies (see section 5.2.2). Experimental and field research complement (not supplement) each other in a research program whose aim is to obtain the triangulation of results using different methodologies [Sackett & Larson, 1990]. Having established the usefulness of the model-based relationship links in a controlled environment, the next step would be a field study of the use of LinkER. The tool is easily portable since it is developed using Perl and uses ASCII files instead of a database system to record the entities and relationships. Since it is a web-based application, it is also easily accessible. This makes it amenable to field research where considerable flexibility is required. The study could explore a number of issues:

1. The tradeoff between costs and benefit in using the system.
2. Examine the types of questions that come up in the "real world" of committee work. In the experimental situation, the questions were generated based on three question factors. How do the experimental questions compare with those asked by actual committee members?
3. Find out which links are more useful than others.
4. Evaluate the features of the tool that are easy or more difficult to use.
5. Study the use of the tool not only in meeting preparation but also in actual meetings itself e.g., writing minutes, lookup information as part of meeting facilitation etc.

An ideal committee for such a study would have generated a considerable amount of interrelated information, where members have to prepare for the meetings by examining these relationships. For example, we could consider an academic committee working on an accreditation process or a committee working on establishing processes in a software company. Data can be collected through a combination of usage log information, direct observation of meetings, interviews, and questionnaires.

Deployment of LinkER (Cost/Benefit Analysis)

One of the challenges of successfully deploying a tool to support cooperative activity is to overcome the disparity in work and benefit [Grudin, 1998]:

> "*Groupware applications often require additional work from individuals who do not perceive a direct benefit from the use of the application*".

In order for LinkER to be used, appropriate relationship links must be available for use by the users. Creating and maintaining the links can be time consuming and tedious if done manually. LinkER can be extended to automatically generate some types of links. Links for lexical relationships can be located by using a keyword search in conjunction with the information model [Allan, 1996], [Cleary, 1996]. Thus, manual effort would only be required to add links for semantic relationships, which are much less common. Given the advantage in task completion time gained by using the links over keyword search, it should be beneficial to create these links. Since the committee work extends over a period of time, members are likely to repeatedly access the same information. Thus, manual linking can be incorporated into the process of browsing so that members may benefit from others' exploratory information seeking. In this way, the costs of

creating the links can be mitigated over the members who actually seek information. However, further research will be required to examine the effect of this tradeoff on the acceptance of such a system.

6.4 Summary

I have shown the usefulness of relationship links in seeking committee information as part of member preparation. I have also discussed the application of relationship links in other domains, and suggested areas for further research. However, they say *"A camel is a horse put together by a committee*"☺. So, why choose to support meetings and committee work, which have a reputation for being a smoke screen to shroud ineptitude and incompetence? The motivation is quite clear as put forth in [Tropman, 1992]:

> *"Whether one is in the human-service sector, the government sector, or the commercial sector, the central reason for coming together in a committee or meeting is to take effective and efficient action that will be of high quality. That action, of course, is decision making".*

Typically, the quality of preparation and support needed for a committee to achieve high quality decisions is vastly underestimated, which leads to failure, work frustration, and a bad reputation.

The work I have completed is only a fraction of what is needed. Although the ideas for future work are significant, they are beyond the scope of this dissertation. Nevertheless, I hope that it will serve as a starting point for further research in objectively

evaluating and improving the quality of information systems designed to support such group activities.

APPENDIX A

INFORMATION MODEL – ENTITIES & RELATIONSHIPS

The information model presents eight entities and their relationships. Each entity has a number of attributes which are presented in a table followed by a figure showing the relationships (rectangles represent the entities and the relationships are diamond shaped).

[COMMITTEE]

The entity has the following attributes and relationships:

Title	The committee name
URL	World Wide Web address for the committee home page
Chair	Name of the committee chairperson
News	Newsgroups associated with the committee
Group Email	Mailing lists used by the committee
Description	Brief summary of the purpose of the committee
Notes	Note pad for attaching informal notes to the information.

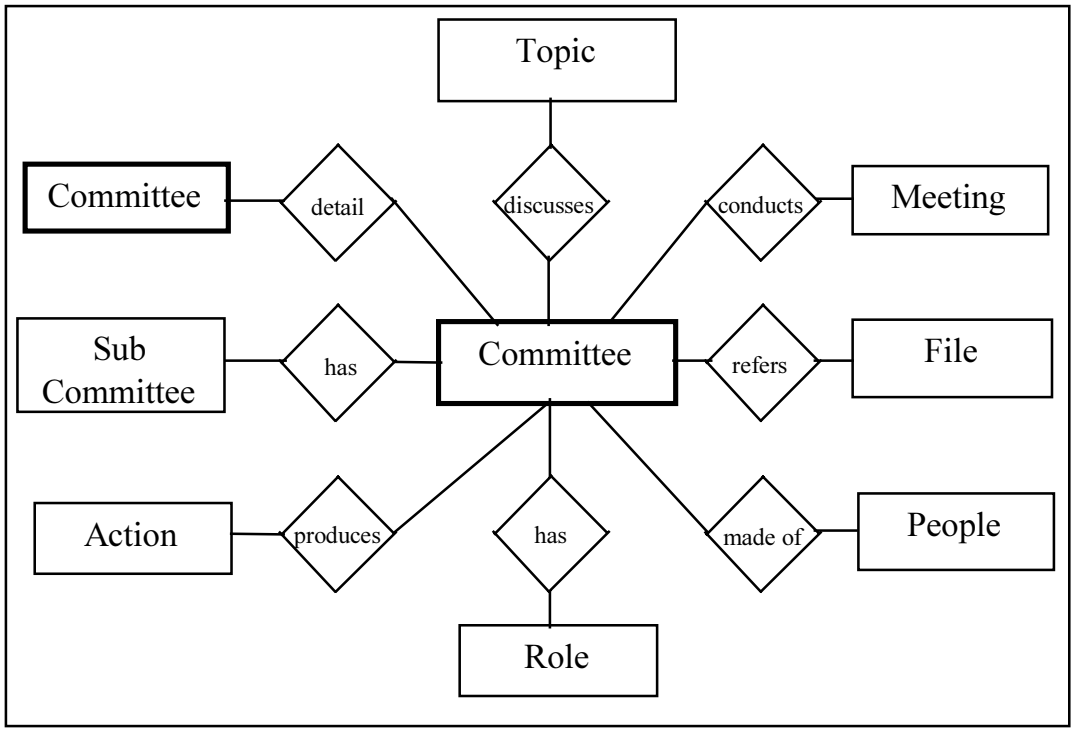


Figure A.1 Information model for [Committee] entity

[SUB-COMMITTEE]

The information about the sub-committees of a committee is summarized in this entity:

Title	The name of the sub-committee
URL	World Wide Web address for the committee home page
Chair	Name of the sub-committee chairperson.
News	Newsgroups associated with the sub-committee
Group Email	Mailing lists used by the sub-committee
Description	Brief summary of the purpose of the sub-committee
Notes	Note pad for use by the members to attach informal notes to the information.

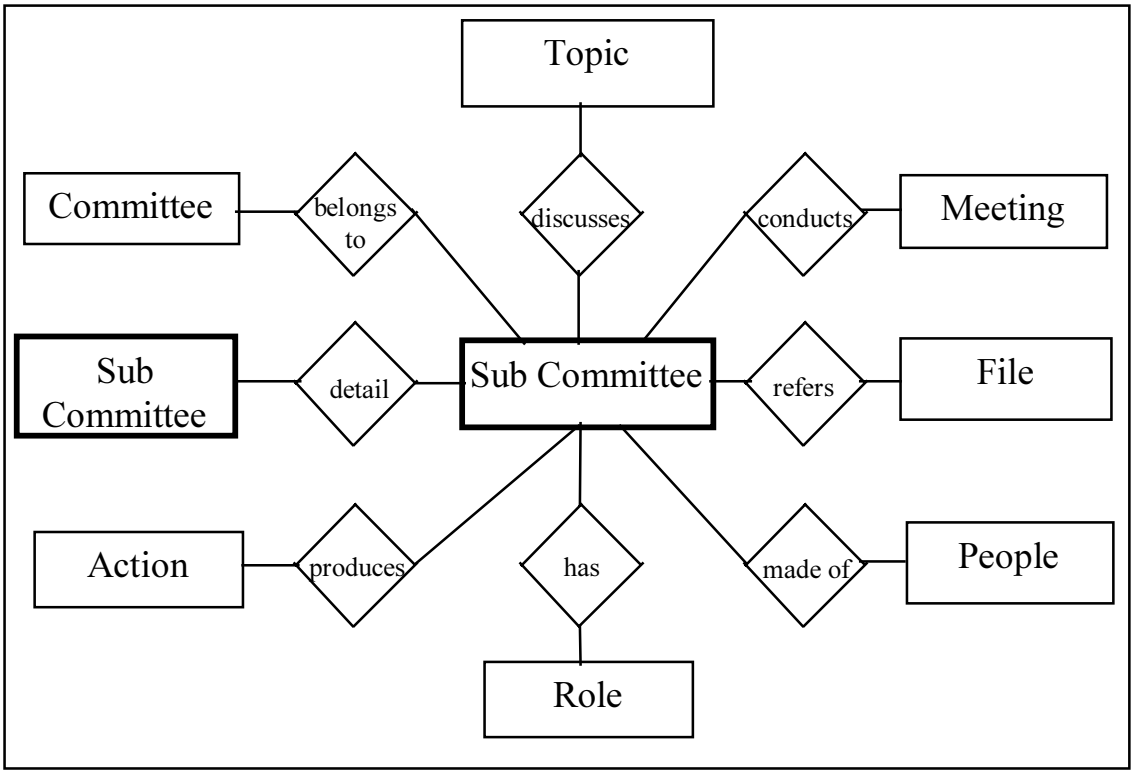


Figure A.2 Information model for Sub-Committee entity

[PEOPLE]

This entity represents the committee participants and has the following attributes and relationships:

Name	Member's full name
Address	Postal mailing address
Shortname	Commonly used short name (alias) for the member.
Email	Email address
URL	World Wide Web address
Start Date	Date on which the member joined the committee
End Date	End of the member's term on the committee
Status	Past or current member
Notes	Note pad for use by the members to attach informal notes to the information.

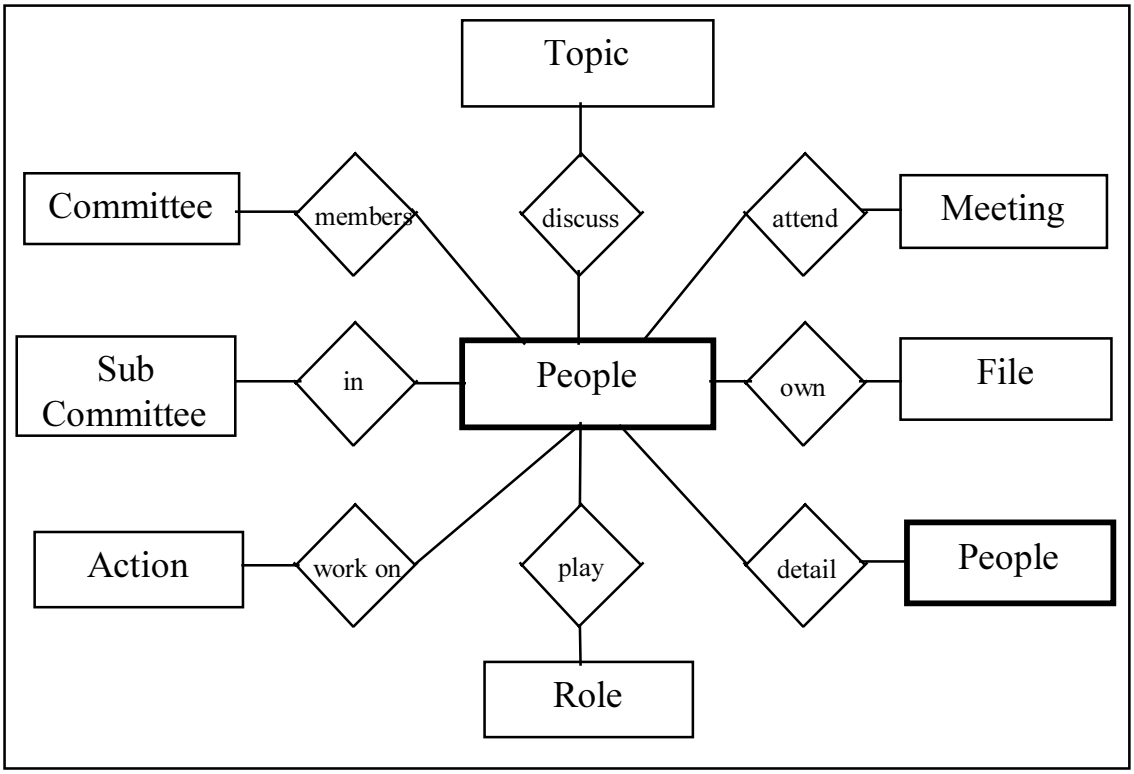


Figure A.3 Information model for [People] entity

[ROLE]

This entity summarizes the different roles played by the committee people and has the following attributes and relationships:

Title Title of the role

Duties Responsibilities of the person playing the role

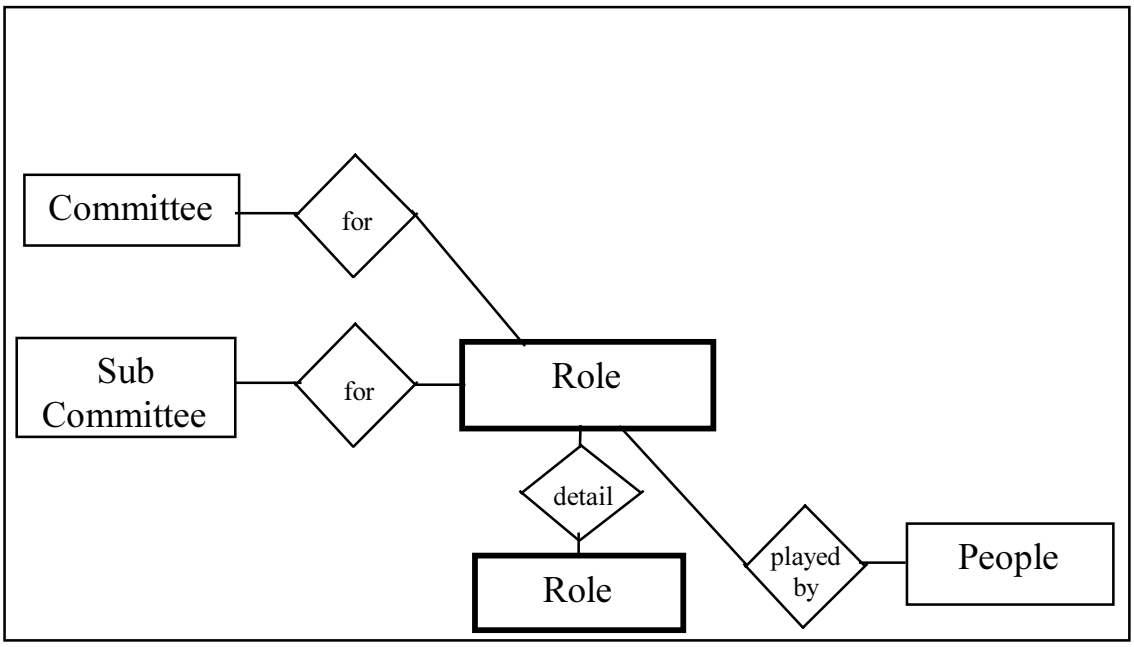


Figure A.4 Information model for [Role] entity

[TOPIC]

The topics discussed by the committee have the following attributes and relationships:

Title	Short title for the topic
Owner	Member who is responsible for the topic
Participants	Members who are actively working on the topic
Description	Detailed description of the topic
Start Date	The topic was first introduced on this date
End Date	Discussions on the topic completed.
Notes	Note pad for use by the members to attach informal notes to the information.

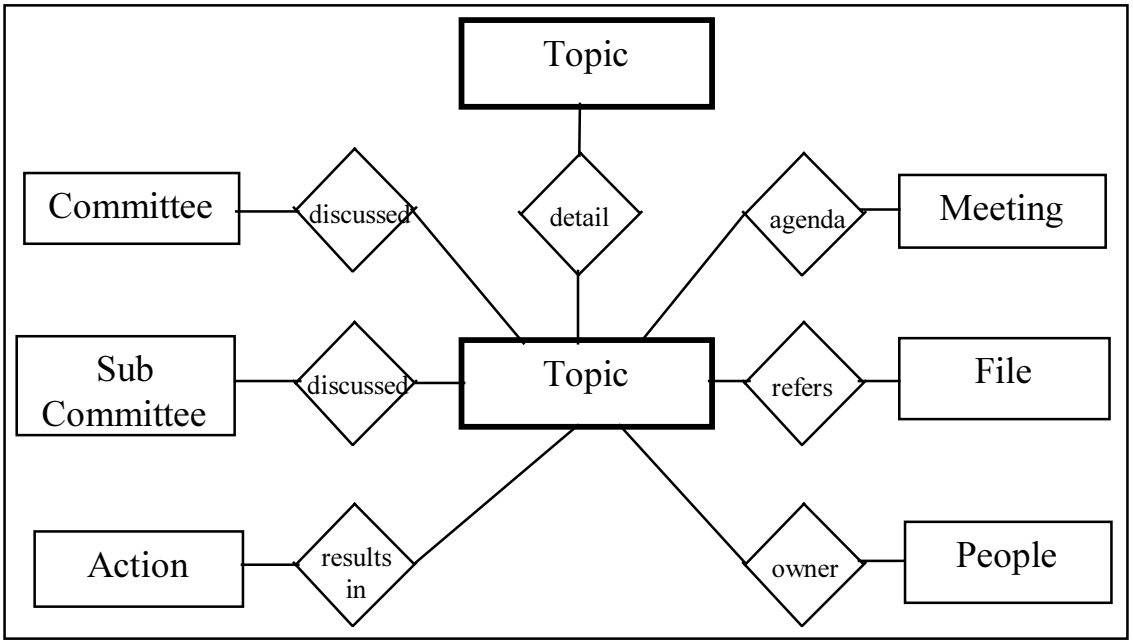


Figure A.5 Information model for [Topic] entity

[ACTION]

Action items are tracked to follow the progress of the committee work. The attributes and relationships of the entity are given below:

Title	Short title of the action item
URL	World Wide Web address for any documents describing the action item
Owner	Member to whom the item has been assigned.
Start Date	The item was created on this date.
End Date	Action item was closed on this date.
Abstract	Brief description of the action item.
Participants	Members who are working on the item.
Due	Due date
Priority	1(high) - 5(low)
Status	Indicates the status of the item (pending, complete, waiting on).
Notes	Note pad for use by the members to attach informal notes to the information.

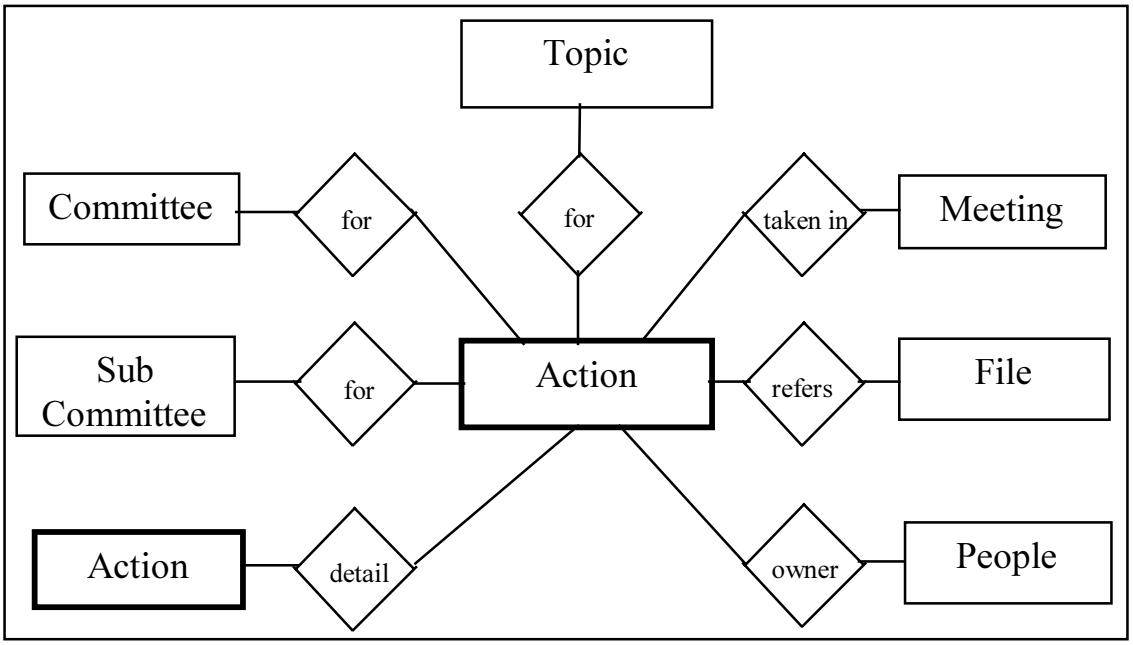


Figure A.6 Information model for [Action] entity

[MEETING]

The following attributes and relationships summarize committee meeting information:

Date	Meeting date
Location	Location of the meeting
Time	Meeting time.
URL	World Wide Web address for the meeting information packet.
Agenda Information	Short string highlighting the agenda
Agenda URL	World Wide Web address for the agenda
Minutes Information	Short string highlighting the minutes
Minutes URL	World Wide Web address for the minutes
Notes	Note pad for use by the members to attach informal notes to the information.

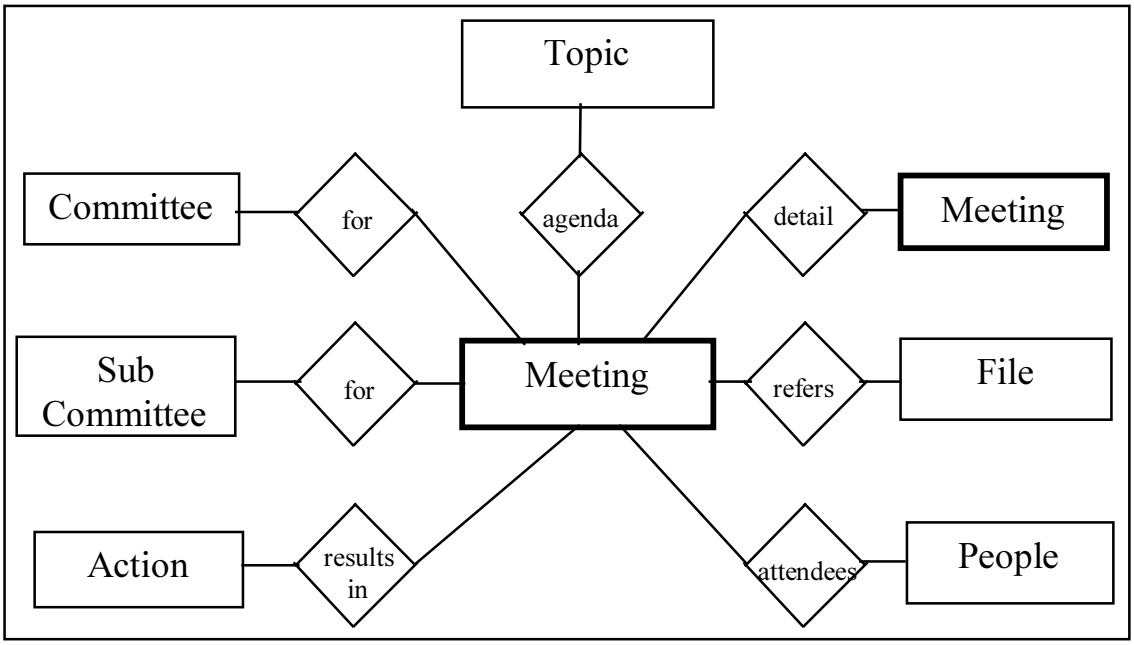


Figure A.7 Information model for [Meeting] entity

[FILE]

The File entity records the documents produced by the committee and has the following attributes and relationships:

Title	Short title for the document
URL	World Wide Web address for the document
Abstract	Brief abstract of the document contents
Owner	Member who owns the document
Participants	Members who are working on the document
Start Date	Date the document was started on
End Date	Completion date of the document.
Notes	Note pad for use by the members to attach informal notes to the information.

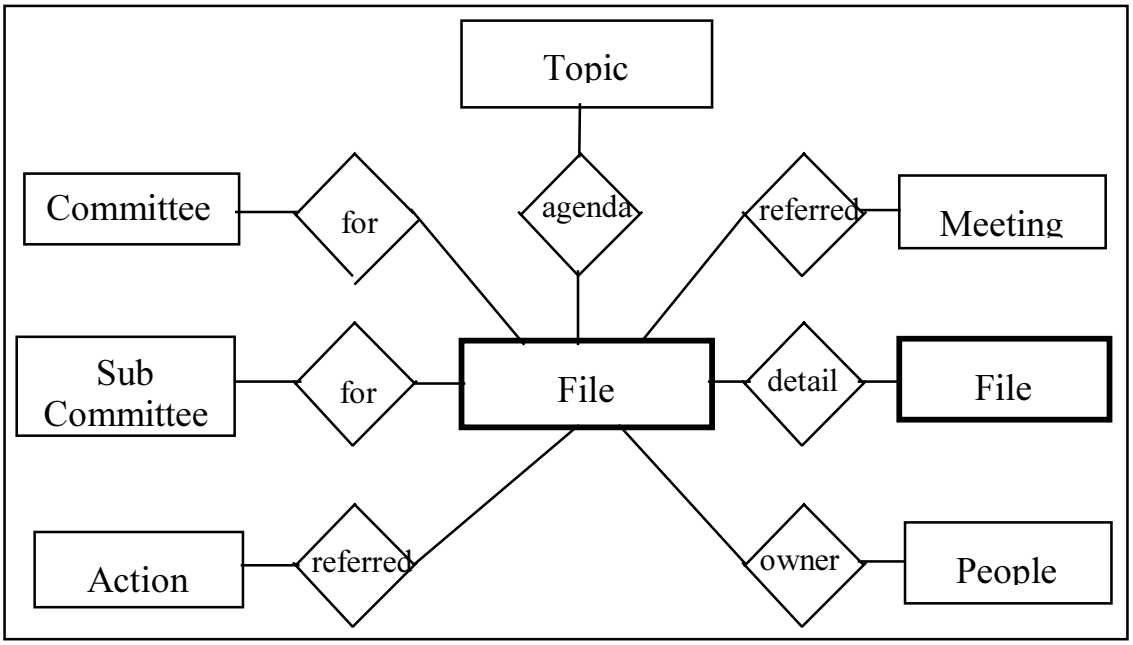


Figure A.8 Information model for [File] entity

APPENDIX B

CASE DESCRIPTION (TOYSWORTH INC.)

Toysworth is a large chain selling children's toys, video and computer games. The company has a large, distributed network of stores throughout the country. The sports toy series, featuring toys about different sports (baseball, basketball, football, soccer, and hockey) has been one of the most successful set of toys for the company. These toys have been very popular with children. Observing the increased interest in gymnastics among children, especially since the Olympic games, the new products division of the company is working on expanding the sports toy series to include toys on gymnastics. The company has been looking into the market for such products and has conducted several surveys and trials over the past year. Based on this information they feel that the market is good for such toys.

The Product Review Committee has been asked to examine the proposal for the new product line. The committee is made up of members of different departments who explore these proposals and make decisions on the ideas to be implemented. The

committee reports directly to the chairperson and board of directors. Committee members serve for a period of up to two years allowing for fresh ideas and outlook. The members of the committee often leave sooner. This necessitates the committee to preserve a "committee memory". The committee has been meeting regularly since January 1993. It has been keeping track of its information since June 1995 only.

Discussions on the current issue have been going on for the last six months. Several subcommittees were formed to investigate the different alternatives proposed by the new products division for the design, manufacture, distribution, and trials of the toys. They are now ready to report their findings to the entire committee in order to make a decision on developing the toys.

APPENDIX C

TRAINING COMMITTEE DESCRIPTION

The CIS Curriculum Committee is responsible for reviewing and improving the courses offered by the department. From here you can access official course syllabi, archival records of the Curriculum Committee during the 1994-96 academic years, and instructions about how to prepare for proposing a new curricular program or a new course.

Official Course Syllabi

The official syllabi for all CIS courses will soon be available here. (A subset of sample syllabi are available now). In these syllabi, the course objectives strive to capture *intended learning outcomes*. They use the following terminology to describe *familiarity level* (most to least) with respect to various kinds of material and procedures:

- *Mastery* means the student will be able to exhibit knowledge of the material and/or skill with the procedure, in a new but appropriate context, even when not instructed to do so.

- *Familiarity* means the student will be able to answer questions about the material and/or to use the procedure, in a new but appropriate context, when instructed to do so.
- *Exposure* means the student will have heard the term and/or seen the procedure, but may not be able to discuss or use it effectively without further instruction.

Computer science and engineering covers the general problem of making precise descriptions of "things": static situations, dynamic behaviors, procedures, processes, relationships, assertions, proofs--just about anything. The languages and notations used in these descriptions are themselves objects of attention. Therefore, some course objectives use the following terminology for *skill level* (least to most) to describe a student's facility in dealing with various languages and notations:

- *Reading* means the student will be able to recognize a syntactically and semantically well-formed instance of the notation, to understand its meaning.
- *Using* means the student will be able to read the notation, and will be able to apply that understanding to perform some task.
- *Writing* means the student will be able to use the notation, and will be able to create new instances of it to perform some task.

Archival Information

The Curriculum Committee keeps an archive of the minutes and agendas for meetings since the during the 1994-96 academic years, as well as the newsgroup.

New Programs or Courses

Any faculty member who is interested in proposing a new program or new course should answer the relevant questionnaire first, and contact the chair well before planning to appear before the Curriculum Committee. These questionnaires indicate what issues are likely to be raised by the Curriculum Committee in any event. It is helpful to have thought carefully about these questions in advance, as this expedites the process considerably.

APPENDIX D

MEETING PREPARATION TASK - QUESTIONS

Attributes for each question is indicated in curly brace followed by the entities. The following notation is used to represent the attributes:

{E - Entities, T - Timeframe *(Past or Current),* R - Type of Relationships (*Lexical or Semantic)*}

Note: Committee is a common entity for all the questions. Also the correct answer to each question is indicated in bold at the end of every question.

1 {E=People,Meeting; T=Current; R=Lexical}

a. Is Bruce Turner a member of the review committee in this year (1997)? (Y/N) **Y**

b. Is Mary Fry a member of the review committee in this year (1997)? (Y/N) **Y**

c. Is Jack Schultz a member of the review committee in this year (1997)? (Y/N) **Y**

d. Is Julian Williams a member of the review committee in this year (1997)? (Y/N) **N**

2 {E=Meeting,Topic; T=Past; R=Lexical}

a. What is the date of the earliest meeting announcing the changeover of the committee from old members to new members? **12/21/95**

b. What is the date of the earliest meeting in which it was announced that the board of directors commended the committee for its work? **1/9/97**

c. What is the date of the earliest meeting announcing the construction of the new office building for the development team? **1/9/97**

d. What is the date of the earliest meeting announcing the availability of discount coupons for buying Christmas toys? **10/24/96**

3 {E=Action,Topic; T=Current; R=Semantic}

a. Is the action item to evaluate the pommel horse design still open?(Y/N) **N**

b. Is the action item to create a web advertising subcommittee still open?(Y/N) **N**

c. Is the action item to enter survey results into the system still open?(Y/N) **N**

d. Is the action item to create a contest for the design of clothes for new toys still open?(Y/N) **Y**

4 {E=File,Meeting; T=Past; R=Semantic}

a. Did the review committee discuss the gymnastics toys proposal document in any meetings?(Y/N) **Y**

b. Did the review committee discuss the web advertising proposal document in any meetings?(Y/N) **Y**

c. Did the review committee discuss the Abracadabra press release document in any meetings?(Y/N) **Y**

d. Did the review committee discuss the Products and Services document in any meetings?(Y/N) **Y**

5 {E=SubCommittee,People,Role,Topic; T=Current; R=Lexical}

e. Who is the chair of the Web Advertising subcommittee? **Bob Vassili**

f. Who is the chair of the Costume Design subcommittee? **Jose Gonzales**

g. Who is the chair of the Toy Design subcommittee? **Flynn Concert**

h. Who is the chair of the Pricing Structure subcommittee? **Kurt Price**

6 {E=SubCommittee,People,Action,Topic; T=Current; R=Semantic}

a. Is Bob Vassili assigned any action items for the web advertising subcommittee? (Y/N) **Y**

b. Is Jose Gonzales assigned any action items for the costume design subcommittee? (Y/N) **Y**

c. Is Flynn Concert assigned any action items for the toy design subcommittee? (Y/N) **N**

d. Is Pam Edly assigned any action items for the pricing structure subcommittee? (Y/N) **N**

7 {E=People,Topic,Meeting,File; T=Past; R=Lexical}

a. Did Bob Vassili attend all the meetings discussing the web based advertising of the gymnastics toys?(Y/N) **Y**

b. Did Jose Gonzalez attend all the meetings discussing the design of clothes for new toys?(Y/N) **Y**

c. Did Flynn Concert attend all the meetings discussing the gymnastics toy surveys?(Y/N) **Y**

d. Did Pam Edly attend all the meetings discussing the pricing structure for the gymnastics toys?(Y/N) **Y**

8 {E=Topic,People,File,Meeting; T=Past; R=Semantic}

a. Did Bruce Turner work on the gymnastic toys proposal document?(Y/N) **Y**

b. Did Mary Fry work on the web advertising proposal document?(Y/N) **Y**

c. Did Joel Frailey work on the Abracadabra press release document?(Y/N) **Y**

d. Did Pam Edly work on the Abracadabra release notes document?(Y/N) **Y**

APPENDIX E

TRAINING QUESTIONS

1.

a. Did Bruce Weide attend the curriculum committee meetings on April 3, 1996 (10/2/96), January 10, 1996 (1/10/96), and October 31, 1995 (10/31/95)? (Y/N)

b. Did Bill Ogden attend the curriculum committee meetings on February 28, 1996 (2/28/96), October 24, 1995 (10/24/95), and April 25, 1995 (4/25/95)? (Y/N)

c. Did Neelam Soundararajan attend the curriculum committee meetings on May 22, 1996 (5/22/96), January 24, 1995 (1/24/95), and January 17, 1995 (1/17/95)? (Y/N)

d. Did Cheryl Yeack attend the curriculum committee meetings on November 13, 1996 (11/13/96), October 23, 1996 (10/23/96), and May 30, 1995 (5/30/95)? (Y/N)

2.

a. Does the curriculum committee have a subcommittee discussing Software Spine courses? (Y/N)
b. Does the curriculum committee have a subcommittee discussing the Capstone Design Course? (Y/N)
c. Does the curriculum committee have a subcommittee discussing Introductory Courses? (Y/N)
d. Does the curriculum committee have a subcommittee discussing Graphics Course Sequence? (Y/N)

3.

a. Was Cho-Yu Chiang a member of the curriculum committee in the last academic year 95-96 (9/95-5/96)? (Y/N)
b. Was Wu Chi Feng a member of the curriculum committee in the last academic year 95-96 (9/95-5/96)? (Y/N)
c. Was Feng Zhao a member of the curriculum committee in the last academic year 95-96 (9/95-5/96)? (Y/N)
d. Was Gary Perlman a member of the curriculum committee in the last academic year 95-96 (9/95-5/96)? (Y/N)

APPENDIX F

GENERAL INFORMATION

Course Participants

Our group is studying how people use computers. This will help us understand how to make computer software more useful to people. To do this, we need the help of people like you, so that we can observe people while they do particular tasks with computers. We are asking you to help us.

We will ask you to perform a task where you answer questions about a committee by seeking the answers within the committee documentation. The questions will be displayed in a window on the computer screen with instructions on the documentation to use to answer the question. After completing this task we will ask you some questions about your preferences. At the end of the exercise we will have a short debriefing session to answer any questions you may have.

We want you to understand why we need your help. We want your participation to be a cooperative venture with us in adding to our understanding of how to make computers easier to use. If you have any questions about this document, please ask us.

Task Description: Your task will be to read and answer the questions presented to you on the computer screen. As you perform this task, please keep the following in mind:

- It is not you who is being evaluated in this study; it is the method of accessing the committee information that is being evaluated.
- The time it takes you to answer each question will be recorded, so you should try to work as quickly as possible without sacrificing accuracy. There are no set standards for your performance.

No Risks: Participation is purely voluntary extra credit only, i.e., you will not lose class standing. There are no risks involved.

Questions: We will answer any questions you have about the task after the completion of the exercise. Please do not discuss this with others who might participate in this exercise.

Voluntary Participation: Participation in this exercise is voluntary. If you do not wish to participate you have the opportunity to earn the extra credit by completing the alternative exercise provided to you in class.

Confidentiality: Your participation in this exercise will be kept completely confidential.

Paid Participants

Our group is studying how people use computers. This will help us understand how to make computer software more useful to people. To do this, we need the help of people like you, so that we can observe people while they do particular tasks with computers. We are asking you to help us.

We will ask you to perform a task where you answer questions about a committee by seeking the answers within the committee documentation. The questions will be displayed in a window on the computer screen with instructions on the documentation to use to answer the question. After completing this task, we will ask you some questions about your preferences. At the end of the exercise, we will have a short debriefing session to answer any questions you may have.

We want you to understand why we need your help. We want your participation to be a cooperative venture with us in adding to our understanding of how to make computers easier to use. If you have any questions about this document, please ask us.

Task Description: Your task will be to read and answer the questions presented to you on the computer screen. As you perform this task, please keep the following in mind:

- It is not you who is being evaluated in this study; it is the method of accessing the committee information that is being evaluated.
- The time it takes you to answer each question will be recorded, so you should try to work as quickly as possible without sacrificing accuracy. There are no set standards for your performance.

No Risks: Participation is purely voluntary. You will receive a compensation of $20 for your participation. There are no risks involved.

Questions: We will answer any questions you have about the task after the completion of the exercise. Please do not discuss this with others who might participate in this exercise.

Voluntary Participation: Participation in this exercise is voluntary.

Confidentiality: Your participation in this exercise will be kept completely confidential.

APPENDIX G

EXPERIMENTAL PROCEDURE

Committees are an integral part of our society. It is an accepted process for involving a group in decision making and problem solving. The power of a committee lies in its effectiveness as a decision making body. Committees generate a considerable amount of information over a period of time. This information can be organized and accessed in many ways. In this session you will be using four different methods to access information about a committee. Using each of these methods you will be asked to find answers to a set of questions. Through this we hope to learn more about ways to better organize the committee information and prepare for meetings.

The following procedure has been designed to provide you with the information and training necessary to participate effectively. It is important for you to understand that the methods of accessing the information is what is being evaluated and not you. It is also important that you follow the instructions carefully and work as quickly and accurately as possible.

You will be doing the following steps in order. If you have any questions feel free to ask.

General Information

Read the general information about the study and express your questions/concerns.

Consent Form

Read and sign the Consent Form to participate in this study.

Demonstration of Access Methods

We will demonstrate the use of each of the methods to you. Please follow along with the demonstration as instructed.

- Keyword-Search
- LinkER
- Index Binder
- Cross-References Binder

Task Window

The task window displays the questions and also collects the responses. Locate the task window and follow the demonstration of its use.

Practice Exercise - Curriculum Committee

Take some time to read the Curriculum Committee information. In this exercise you will access the information using the four methods demonstrated and answer questions about the committee information. Please prepare to use the following:

- Locate the Keyword-Search window on the computer screen.
- Identify the Cross-References Binder placed on the table to your left.
- Identify the Index Binder binder placed on the table to your right.
- Locate the LinkER window on the computer screen.
- Locate the Task Window on the computer screen. This will be the main window displaying the questions you need to answer using the prescribed method. It is very important that you use only the prescribed method for each question.

Follow the instructions on the Task Window and proceed with the exercise to answer the set of questions using the four access methods as instructed in the task window.

Product Review Committee

Take some time to read the information about the Product Review Committee of the company Toysworth Inc. In this exercise you will access the information using the four methods in order to the answer questions. Prepare to use the following:

- Locate the Keyword-Search window on the computer screen.
- Identify the Cross-References Binder placed on the table to your left.

- Identify the Index Binder placed on the table to your right.
- Locate the LinkER window on the computer screen.
- Locate the Task Window on the computer screen. This will be the main window displaying the questions you need to answer using the prescribed method. It is very important that you use only the prescribed method for each question.

Follow the instructions on the Task Window and proceed with the exercise to answer the set of questions using the four access methods as instructed in the task window.

Questionnaire

Please fill out the Questionnaire.

APPENDIX H

CONSENT FORM

The Ohio State University Protocol Number: 97E0023

CONSENT FOR PARTICIPATION IN

SOCIAL AND BEHAVIORAL RESEARCH

I consent to participating in the research entitled:

COMMITTEE INFORMATION STUDY

Srinivas Raghavan has explained the purpose of the study,

(Principal Investigator or his/her Authorized Representative)

the procedure to be followed, and the expected duration of my participation. Possible benefits of the study have been described as have alternative procedures, if such procedures are applicable and available.

I acknowledge that I have had the opportunity to obtain additional information regarding the study and that any questions that I have raised have been answered to my full satisfaction. Further, I understand that I am free to withdraw consent at any time and to discontinue participation in the study without prejudice to me.

Finally, I acknowledge that I have read and fully understand the consent form. I sign it freely and voluntarily. A copy has been given to me.

Date: _____ Signed: _____

(Participant)

Signed: _____

(Principal Investigator or his/her

Authorized Representative)

APPENDIX I

QUESTIONNAIRE

1. **Age**:

< 20 20-22 23-25 26-29 30-32 >32

2. **Gender:**

Male Female

3. **Approximately how many hours per week do you use a computer?**

<5 5-10 10-15 15-20 20-25 25-30 >30

4. **Approximately how many hours per week do you access the World Wide Web using a browser program (e.g., Netscape, Microsoft Internet Explorer, etc.)?**

<5 5-10 10-15 15-20 20-25 25-30 >30

5. a. How easy to use was the Index Binder?

Extremely Difficult	Very Difficult	Difficult	Easy	Very Easy	Extremely Easy

b. How easy to use was the Keyword-Search tool?

Extremely Difficult	Very Difficult	Difficult	Easy	Very Easy	Extremely Easy

c. How easy to use was the LinkER tool?

Extremely Difficult	Very Difficult	Difficult	Easy	Very Easy	Extremely Easy

d. How easy to use was the Cross-References Binder?

Extremely Difficult	Very Difficult	Difficult	Easy	Very Easy	Extremely Easy

6. a. How fast were you able to find information using the Index Binder?

Extremely Slow	1	2	3	4	5	6	7	8	9	10	**Extremely Fast**

b. How fast were you able to find information using the Keyword-Search tool?

Extremely Slow	1	2	3	4	5	6	7	8	9	10	**Extremely Fast**

c. How fast were you able to find information using the LinkER tool?

Extremely Inaccurate	1	2	3	4	5	6	7	8	9	10	**Extremely Accurate**

i. **How fast were you able to find information using the Cross-References Binder?**

Extremely Inaccurate	1	2	3	4	5	6	7	8	9	10	**Extremely Accurate**

6. a. How accurately were you able to find information using the Index Binder?

Extremely Inaccurate	1	2	3	4	5	6	7	8	9	10	**Extremely Accurate**

b. How accurately were you able to find information using the Keyword-Search tool?

Extremely Inaccurate	1	2	3	4	5	6	7	8	9	10	**Extremely Accurate**

c. How accurately were you able to find information using the LinkER tool?

Extremely Inaccurate	1	2	3	4	5	6	7	8	9	10	**Extremely Accurate**

e. **How accurately were you able to find information using the Cross-References Binder?**

Extremely Inaccurate	1	2	3	4	5	6	7	8	9	10	**Extremely Accurate**

APPENDIX J

DEMONSTRATION SCRIPT

Keyword-Search

Enter A Search String:

Search **Clear**

To search through the committee information you have to enter a search string in the box and select the search button. The Search string can be:

Search string (case insensitive) can be:

A single term, e.g., "committee"

Phrase with multiple words, e.g., "curriculum committee"

Using term wildcards, e.g., "Art*", or "Artif* Intel*"

Expressions with boolean operators, e.g.,

"Artifical and Intelligence",

"Experimental or Design" (same as "Experimental Design"),

"Bill not Bruce",

"(Bill or Hillary) and Clinton", etc.

Results

The results are displayed in a table with a link to the files containing the keyword and a score for each file. The results are sorted in descending order of the score.

Example:

What is the date of the latest meeting to discuss the Boeing educator award?

LinkER

LinkER organizes the committee information into 8 entities (Committee, Sub-Committee, People, Roles, Topics, Actions, Meetings, and Files). Each entity is displayed in a tabular format on a web page, e.g., Committee entity is displayed as a table with each row showing a different committee as shown:

Committee SubComm People Roles Topics Actions Meetings Files Help

Committees

Access information related to a row by selecting one of the letters in the Links column.

Links	Title	News	Group Email
S P R T A M F	Curriculum	cis.committee.curriculum	–
–	Graduate Studies	cis.committee.grad–studies	–
–	Undergraduate Studies	cis.committee.undergrad–studies	–

Sort by Title asc Sort

Links

Entities are related to each other and the relationships are represented in the Links column by the first letter of the related entity, e.g., in the example above the links are

S	SubCommittee
P	People
R	Roles
T	Topics
A	Actions
M	Meetings
F	Files

A link is shown **ONLY IF** there is related information, e.g., Graduate Studies committee no Link. Selecting the link gives a list of related entity values, e.g., the **P** link brings up a list of People on the Curriculum committee,

e.g., Follow the **S** link of the Curriculum committee to view the Subcommittees of the Curriculum Committee. Follow the **M** link for the Capstone Design subcommittee to view the meetings involving the subcommittee. Follow the **P** link to view the members of the subcommittee

e.g.,

- Committee is related to all the other entities.
- Subcommittee - Each subcommittee has a chairperson and members (**P** link).

- People - **M** link shows the meetings attended by People.
- Role Links show the People and Committee for which the role is played.
- Topic has an owner responsible for the topic.
- Action Items have a Priority and a Status indicating the completion of the item.
- Meetings have Agenda and Minutes whose formats are fixed. The meeting agenda is in a tabular format. The first column indicates the topic to be discussed, the second column shows a brief description, the third column indicates the type of item (Action to be taken, an Approval, or a Discussion) and the last column indicates the time. Each item in the minutes matches the corresponding agenda item. The agenda description is indicated in small font in the minutes item followed by a summary of the discussion. The Attendees of the meeting are listed at the top of the meeting minutes.
- Files - Are the supporting documents used by the committees. Each document is marked with the owner who has worked on it.

Entity Menubar & Sorting

A menubar of all the 8 entities and help is provided at the top of each page. The rows of the entity page are sorted by default. A Sort button is provided at the bottom of the page to resort the information by a different criteria.

Example

What is the date of the latest meeting to discuss CIS 694K?

Index Binder

The binder has a "BLUE" cover sheet and organizes the committee information as shown below:

Keyword Index

The index contains a comprehensive list of keywords and the page numbers of the documents in which it appears. The keywords are not case sensitive.

Table of Contents

Gives the title and page number of each document in the committee information

Committee Information

Each document is marked with the page number on the upper right hand corner.

- **Meeting Information**

  The meeting information is presented in reverse chronological order by meeting date. The agenda presents a list of items, the time to be spent on it, and the type of activity - Announcement, Action or Discussion.

  The minutes are written for each item on the agenda. The agenda item description is shown in a small font in each item of the minutes.

- **Documents**

  Supporting documentation used by the committee is included at the end of the file.

Searching For Information

The keyword index provides a list of words and the page numbers in which they occur. By examining the question and following the keyword index you can search for information.

Example

What is the date of the latest meeting to discuss the Capstone Design Course for HW/SW option?

Cross-References Binder

The binder has a "YELLOW" cover sheet and organizes the committee information as shown below:

Cross-References Index

Cross-references are made to agendas or minutes of meetings held earlier. This index contains a list of the cross-referenced topics along with the page numbers to the first reference for each topic.

Table of Contents

Gives the title and page number of each document in the committee information

Committee Information

Each document is marked with the page number on the upper right hand corner.

- **Meeting Information**

  The meeting information is presented in reverse chronological order by meeting date. The agenda presents a list of items, the time to be spent on it, and the type of activity - Announcement, Action or Discussion. Cross-references to earlier meeting agendas are indicated by "**See also the agenda** of the meetings...".

  The minutes are written for each item on the agenda. The agenda item description is shown in a small font in each item of the minutes. Cross-references to earlier meeting minutes are indicated by "**See also the minutes** of the meetings...".

- **Documents**

  Supporting documentation used by the committee is included at the end of the file. Cross-references to meeting minutes are indicated by "**See also the minutes** of the meetings..." and to other documents are indicated by "**See also the document** ...".

Searching For Information

The Cross-reference Index and the Table of Contents provide the starting point for a search. The cross-references "**See also the agenda ...", "See also the minutes...",** or "**See also the document ..."**, provide a link to additional information.

Example

What is the date of the latest meeting to discuss the Networking Curriculum?

Task Window

This window displays the task you have to perform and method to use. Answers to each question should be entered in the field provided in the window itself.

The following steps should be followed:

1. The Task Window will indicate what method you should use to answer the questions that follow. Prepare to use the method and then select the **"Start"** Button..

2. Find the Answer to each question and answer it in the space provided. The answers will either be a **Y** (for Yes) or **N** (for No), a name, or a meeting date. Enter the date using the **mm/dd/yy** format (e.g., June 26, 1997 would be 6/26/97).

3. After you answer the question select the **"Next"** Button.

4. Continue to follow the instructions till you see the "Thank You" screen.

It is very important that you use only the specified method for each question. Try to work as quickly and accurately as possible.

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