

A Cognitive Model for Searching for Ill-defined Targets on the Web

— The Relationship between Search Strategies and User Satisfaction —

Mari Saito

Human Interface Laboratory

Sony Corporation

mari@ptl.sony.co.jp

Kazunori Ohmura

Human Interface Laboratory

Sony Corporation

ohmura@ptl.sony.co.jp

ABSTRACT We performed an experiment in which subjects were asked to find a gift for a friend using the Web. The subjects were divided into two groups, only one of which was instructed to form a mental image prior to the search. We found that subjects who formed a prior mental image took longer to complete their search and also reported higher degrees of satisfaction with their search result. We present a cognitive model in which the search takes place as an incremental refinement of search target candidates and their attributes.

1 INTRODUCTION

The World Wide Web (Web) makes more information available than ever before. This does not necessarily mean, however, that users are always able to obtain the information they want. In fact, because so much information is available users sometimes have difficulty obtaining the information they require. These problems are of two main types:

1. Users do not know *where* to find the desired information (Location unknown / target defined).
2. Users do not know *what* specific information is desired (Target ill-defined).

Users usually do not know their targets when starting search. As they search, their targets gradually become clear. Therefore, they should carry out two tasks: to specify the target and to select the information that satisfies the target.

The main goal of this paper is to show the cognitive process by which users move from ill-defined targets to defined targets.

2 RELATED WORK

In the early stage of information retrieval (IR) research the goal of IR systems was to match the user's request, which

investigated problem 1. The topic of searching for desired information has conventionally been investigated using library databases or research paper databases. This work focuses on how to efficiently locate and select target information from within a body of stored information.

In recent years, problem 2— that of an ill-defined target — has been addressed by various IR researchers. Early research in this area includes the THOMAS system proposed by Oddy (1977 [1]) and the IR system proposed by Belkin (1982 [2]).

How does the cognitive process work, if the user has only an ill-defined target? Belkin (1982) mentioned this point, and proposed the idea of the 'ASK' (Anomalous State of Knowledge)[3]. The ASK hypothesis is that there exists an information need from a perceived anomaly in the user's state of knowledge concerning some topic situation. Users can make their target clear as a result of interacting with IR systems. Therefore the ASKs of users come to have explicit structural representations through the evaluation of retrieved documents.

This idea that users are unable to specify their needs in general had a great impact on IR research.

Later, Ingwersen (1988) revised Belkin and Vickery's model to include the classification of a users' IR activities [4][5]. In this model, cognitive processes and their data were classified into three steps: pre-retrieval activities, retrieval activities, and post-retrieval activities. It is proposed that IR systems should be designed to adapt to the user's cognitive activities.

As a result of these and other studies [6], the cognitive process of searching for ill-defined targets, expressed variously as 'ill-defined', 'uncertain', 'vague', or 'unclear' searches, has become a very important theme in IR and information search sciences.

3 SEARCHING ACTIVITIES FOR ILL-DEFINED TARGETS IN THIS STUDY

Normally users search for the information they want in a database, they describe their search strategies and attribute values as search conditions using attributes given by the database system. For example, a library or research paper database might provide an input area for titles or authors. Users then input appropriate attribute value such as title keywords or authors that match the desired search targets.

Permission to make digital/hard copy of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage, the copyright notice, the title of the publication and its date appear, and notice is given that copying is by permission of ACM, Inc. To copy otherwise, to republish, to post on servers or to redistribute to lists, requires prior specific permission and/or fee. SIGIR 98, Melbourne, Australia © 1998 ACM 1-58113-015-5 8/98 \$5.00.

However users search for ill-defined targets, they have to determine not only attributes but also attribute values. In this study we discuss *the specification of both attributes and attribute values* as search conditions. It is more difficult for users to describe their targets clear than in the case in which they specify attribute values only — such as a search in a library database. A typical example of an ill-defined target search is a Web search. Information on the Web is structured in various non-uniform ways due to the fact that many members of the general public create it. In such a situation,

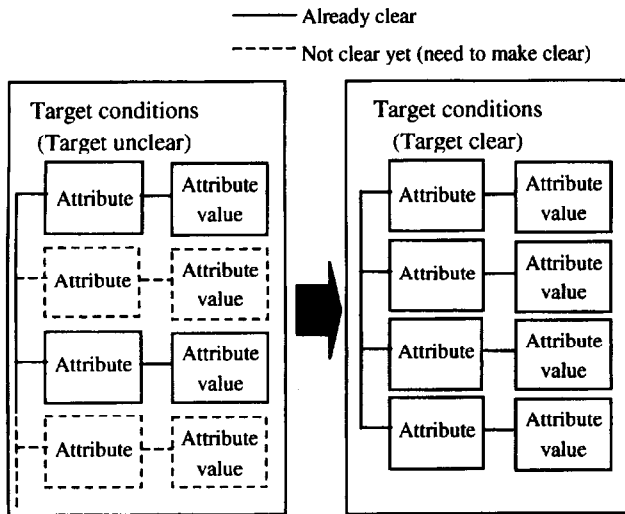


Figure 2. Set of search target conditions

users consider what search target attributes and corresponding attribute values they believe necessary to find their target information.

To model of this situation, in which the user has only ill-defined attributes or attribute values as search conditions, we create a hypothetical model based on Ingwersen's model. This model dictates that query formation is equivalent to the process of specifying users' targets. (Figure 1)

When searching on the Web we believe that, users use similar process as that of a database search. Suppose that we model the process of searching for information on the Web as a database search. At first, users desire certain target information, but do not realize that their target is ill-defined. They then decide to search for the information on the Web.

After deciding on search strategies, users consider the external information, browsing on the Web. Then they evaluate that information, and revise their targets or strategies. In a Web search, users browse the information space sequentially to find their target information, and do not take in all the information simultaneously. Each time they read a web page, they need to evaluate it. Pages that seem to meet the user's target are stored, and at last the user decides from among these the most adequate alternatives.

Users must continually both revise their search strategy and attribute values, and specify their targets by making their attributes and attribute values clear. Therefore, users search and select external information by comparing it with their targets. After these processes, users evaluate their search activities and justify the result. A part of this process can be understood using a decision-making model [7].

In this study we define the target not as the Web page that the user finally selects after a successful search, but as *the final set of search conditions*. The set of conditions includes attributes and attribute values, and the targets consist of some combination of the sets of attributes and attribute values.

Users who have ill-defined targets have only a partial set of conditions, and need to make clear additional conditions at the end of their search. For instance, users who search for information on the Web to purchase items need to identify attributes such as size, design, or price, and also to determine the attribute values (e.g. "about \$50, just 20inches and so on). (Figure 2)

As users determine how to specify their targets, two separate activities are involved in the specification of a search target. One is the ability to express a vague desire that they cannot put into words at the beginning of the search. The other is the discovery of new conditions that are discovered during the search and the addition of them to their target conditions.

In this study we discuss the cognitive process in which users have only ill-defined targets, centering on the process of specifying search targets. After showing that the cognitive model mentioned above can be applied to actual search activities, we verify the following hypotheses.

- 1) There are typical patterns in adding new conditions.
- 2) Different strategies for specifying a search target influence certain aspects of the search activity.

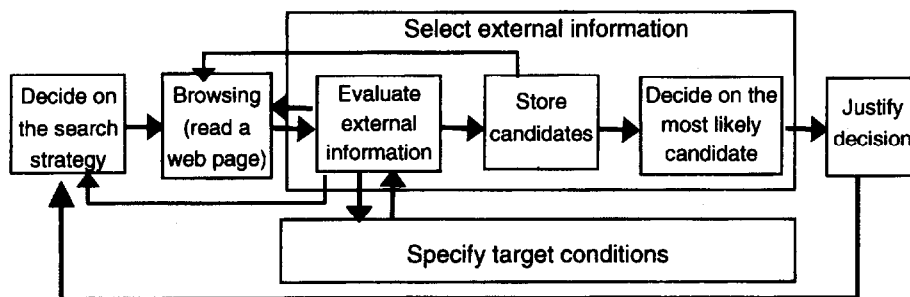


Figure 1. Model of search for an ill-defined target

- 3) Different strategies for specifying a search target influence the quality of the search target.
- 4) The choice of a search strategy has an effect on user satisfaction with the search result.

We propose a cognitive model for searching for ill-defined targets after demonstrating that the above four points hold true.

4 PSYCHOLOGICAL EXPERIMENT

In this experiment, we chose the task of searching for information in online shopping sites on the Web as follows:

4.1 Subjects

The subjects were 20 adults (10 pairs; age 23-51; average age 31.8)

- The two subjects in each pair were friends of each other.
- The 10 pairs were divided into two groups (Group A and Group B)

Each group included three patterns; 2 male-male pairs, 2 female-female pairs, and 1 male-female pair.

4.2 Environment

The experimental environment is shown in Figure 3.

Paired subjects were seated side by side in front of the desk. There was a personal computer (Dell Optiplex GXMT5166; OS: Microsoft Windows95) with two computer display monitors (25 inch) and a mouse on the desk. One display was for use by the subjects, the other for recording their activities. The second display showed the same picture as the first, but was set behind a partition. Each subject wore a small microphone for recording his verbalizations. Two video cameras (SONY CCD-TR705) were used in the experimental room. One recorded the faces of subjects in order to know which subject was speaking, and the other recorded pictures of the Web browser during the search activities. Subjects accessed web sites with a commercial web browser (Microsoft Internet Explorer 3.02). The homepage of the browser was set to a page specifically made for this experiment contained links

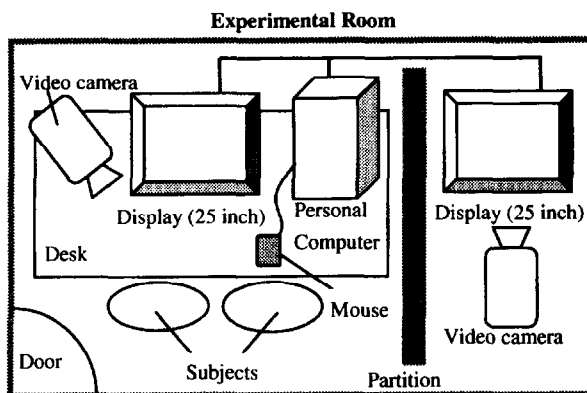


Figure 3. Experimental environment

to shopping sites on the Web. All sites on the Web were classified by country and category, and included over 20,000 online shopping sites — far too many for a subject to visit one by one.

Paired subjects used a computer, a display and a mouse, and were free to operate the browser or to exchange positions. To deduce their cognitive states, thinking-aloud verbalizations were recorded.

Subjects were asked to speak aloud whatever they were thinking during the task. Paired subjects were used in this experiment to allow users to feel more at ease when verbalizing their thought processes. We plan on investigating the effects of conversation during searching in a separate study. The time required to search for their targets, and the number of categories, sites, and web pages were recorded.

4.3 Experimental conditions

Conditions of each group were as follows (shown in Figure 4):

These two groups used different strategies for specifying their targets.

Group A: Subjects were asked to form an image of their gift (search targets) before starting their search.

Group B: Subjects were asked to start searching for information immediately without forming a concrete image of their gift (search targets).

4.4 Experimental procedure

Two subjects were asked to collaborate with each other in completing a task that required them to search for a designated target.

1) First, paired subjects were asked to decide on a mutual friend to whom they would like to give a gift without being told about the information space, materials or software applications. After deciding on a friend, they were asked to write the name of their friend on a memo sheet. Both groups

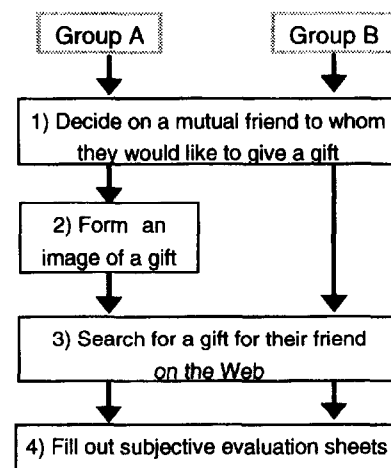


Figure 4. Experimental procedure

were told to find a gift costing approximately 30,000 yen (about 250 dollars) or less for the friend.

2) Subjects in Group A only were asked to decide on what kind of gift they wanted to give their friend before beginning their search.

3) Subjects began their Web search for a gift.

In both groups, subjects were told to voice all of their thought processes so that their partners could better understand what they were thinking. The task finished when subjects reported their final selection to the experimenter.

The experimenter explained how to use the web browser in this experiment, although all subjects had previous experience with the Internet and a web browser. Both groups started searching from the same homepage which subjects could return to by clicking on the "home" icon.

4) After they completed the task of searching for their gift, evaluation sheets were handed out to each subject pair. Each subject was asked to fill out a separate subjective evaluation sheet.

Questions given to each subject were as follows:

- Question #1: Have you changed your target since the beginning of the task? (Yes/No)
- Question #2: Were you able to make a thorough search? (Evaluations were made on a five-grade scale. 1: Insufficiently Thorough / 2: Not Very Thorough / 3: Not Sure / 4: Somewhat thorough / 5: Very Thorough)
- Question #3: Are you satisfied with the results of the task? (Evaluations were made on a five-grade scale. 1: Very

Unsatisfied / 2: Not Very Satisfied / 3: Not Sure / 4: Somewhat Satisfied / 5: Very Satisfied)

Subjects were asked not to consult each other when making their evaluations.

4.5 Experimental data

Using the videotapes recorded during the experiment, we obtained the following data: the number of accessed categories, sites, and pages, and the time required for searching and selecting targets.

Subjective evaluations were obtained from the "subjective evaluation sheets" that each subject filled out after they finished the tasks.

Verbalization data related to the tasks was used for analysis and excluded any data unrelated to the experimental tasks.

The verbalization data was classified as shown in Table 1 in accordance with the sub-processes of the cognitive model shown in Figure 1. Except for verbalizations that were unrelated to the search task, all verbalizations were able to be classified into these categories (Table 2) and 98% of

Table 1. Classification of verbalization

Verbalizations that relate to the "Select external information" process		used for analysis
Decide on the search strategy	A	
Browsing (Read a web page) and evaluate external information	B	
Store candidate	C	
Decide on the most likely candidate	D	
Justify decision	E	
Verbalizations that relate to "Specify target conditions" process		
Add new conditions	F	
Review existing conditions	G	
Verbalizations which are unrelated to the search task	H	not used for analysis

Transition of classified verbalization

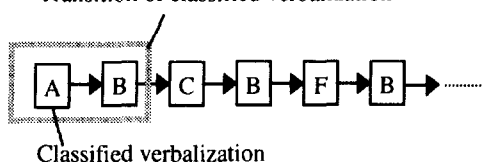


Figure 5. Sequence of classified verbalizations

Table 2. Typical examples of verbalization and classifications

X: Let's go to each category .		
Y: Wait, I don't like to go all categories but would like to select some suitable categories .		A
X: Hmm, something to add a nice mood		
Y: Yeah, something like that would be good.... Anything that would liven up the room will do.... Some sort of interior decoration or ...		F
X: Ah, ' welcome to the gardening page '... It gets a little different from here.		
Y: Yes, here's the gardening section . This page gives some ideas how to take care plants, and does not have interior items for our gift.		B
Y: That reminds me, I went to shopping at reopened department store a week ago. Do you know the store?		H
X: How about this house plant?		
Y: Yes, it is pretty cactus. Let's mark up .		C
Y: How about these flowers?		
X: Yes, those are pretty.... Hey this is really expensive!		
Y: That's right. But, this plant is nice and pretty cheap , too.		F
X: Hmm, but the planter looks kind of weird		
X: I wonder interior decorations are not suitable .		
Y: Why?		G
X: There's no space to put a big decoration . Yes, that's right. Let's pick up some small decorations .		F
X: I think this is the most suitable for him.		
Y: Yes, I think so, too...		D
Y: It is the best choice isn't it, regarding all our conditions?		
X: Yes! Price, size and design... This is the best .		E

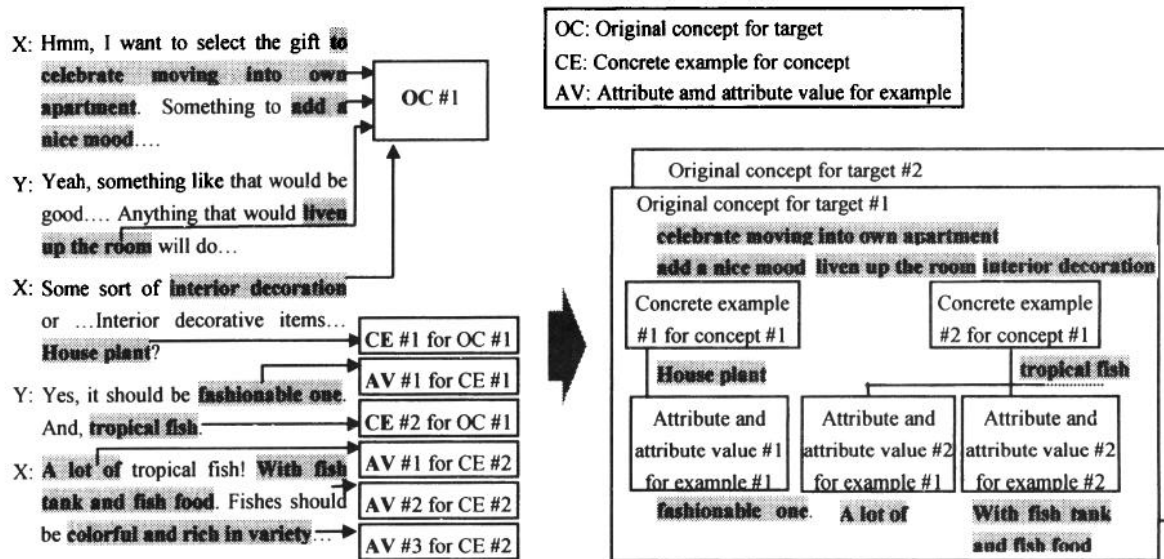


Figure 6. Example of verbalization (Left) and Pattern of target (Right)

5 RESULT

The results of this experiment were as follows, in the same order as the hypotheses mentioned above.

- 1) The addition of search conditions followed regular patterns.
- 2) The entire search process was influenced by the target specification strategy.
- 3) The target specification strategy influenced the quality of the search target.
- 4) The specification strategy influenced user satisfaction with the search results.

- 1) The addition of search conditions followed regular patterns.

- The sequences of classified verbalizations were consistent with the hypothesis that typical patterns occur when adding new conditions.

- There were no significant differences in the sequences of verbalizations between Group A and Group B.

- A consistent pattern of three kinds of target conditions emerged in the process of specifying a target. (Figure 6: Right)

1. The original concept of the desired information
2. Concrete examples that are consistent with the original concept
3. Attributes and attribute values for these examples

The users' original concepts were expressed in the abstract gift images. In the next step, they produced concrete examples that were consistent with the target image. In some cases, only a single example was considered, while in other cases several examples were produced. Users then discussed various

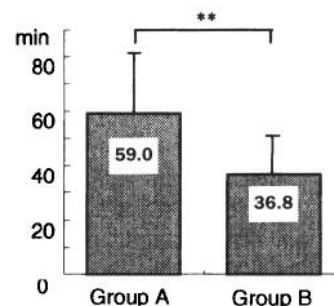


Figure 7. Average time required to complete the search for each group

T-test was conducted between two groups: **, $p < .01$
Vertical bars indicate the standard deviations.

Table 3. Average number of web accesses

	Accessed categories	Accessed Sites	Accessed Pages
Group A	9.6	13.8	46.4
Group B	7.6	11	39.6

ANOVA was conducted : 2×3 design.

attributes and attribute values in order to determine which characteristics of the examples were desirable. Most of the subjects followed these patterns when specifying their target.

- 2) The entire search process was influenced by the target specification strategy.

- The average time required for Group A to search for a gift was significantly longer than that of Group B, indicated by T-test ($p < .01$) . (Figure 7)

- There was no significant difference in the average number of accessed categories, accessed sites, and accessed pages between Group A and Group B. (Table 3)

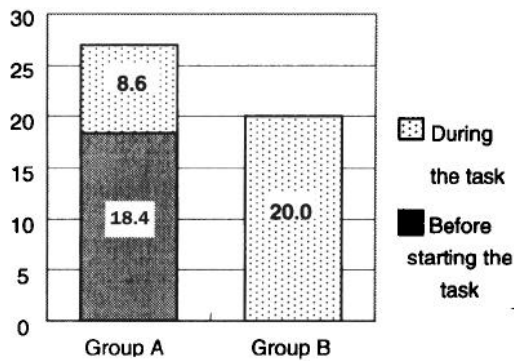


Figure 8. Average number of search conditions produced for each group

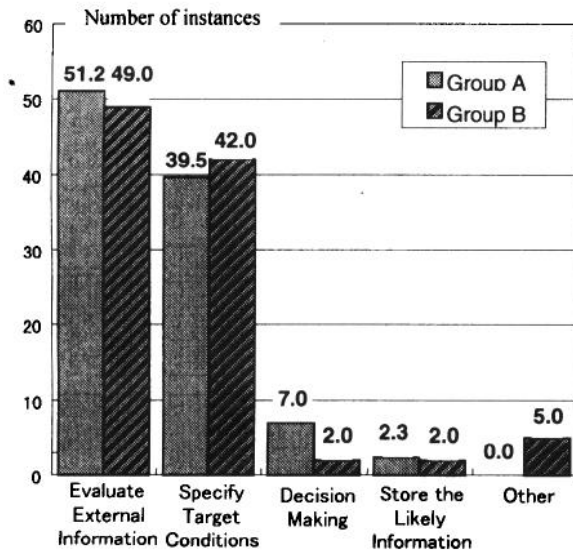


Figure 9. Average number of situations that resulted in the addition of new conditions

3) Target specification strategy influenced the quality of the search target.

- The number of conditions produced during the search was not significantly different between Group A and Group B (indicated by T-test). (Figure 8)
- There was not different between Group A and Group B in the situation in which they added new conditions shown in Figure 9. It was frequent for subjects in both groups to add new conditions in two situations. According to the sequences of verbalizations, one was the situation in which conditions were added after reviewing external information, and the other was the situation in which conditions were added after specifying target conditions.

Verbalizations of specifying target conditions were divided into two types (shown in Table 2.): those in which new conditions were repeatedly added to the target (Figure 10: transition type F-F), and those in which new conditions were

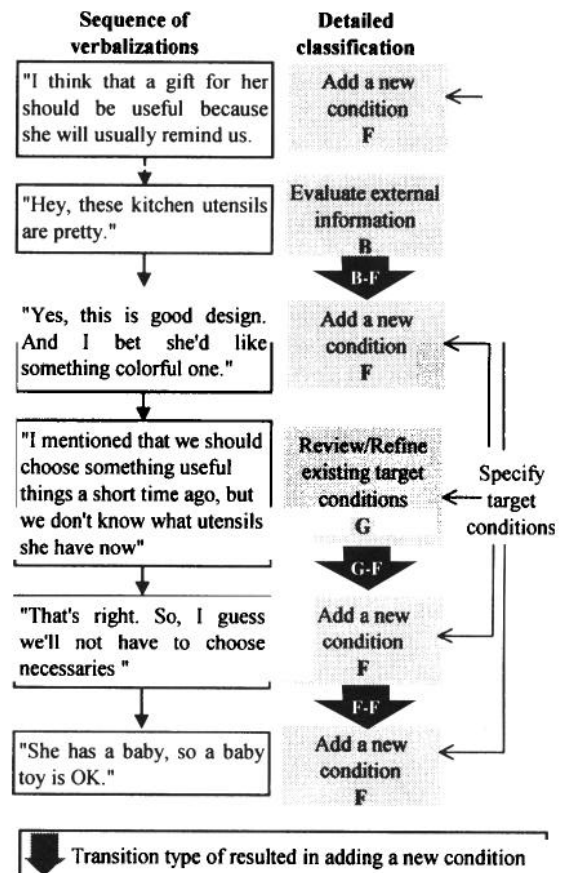


Figure 10. Classified verbalizations and transition type

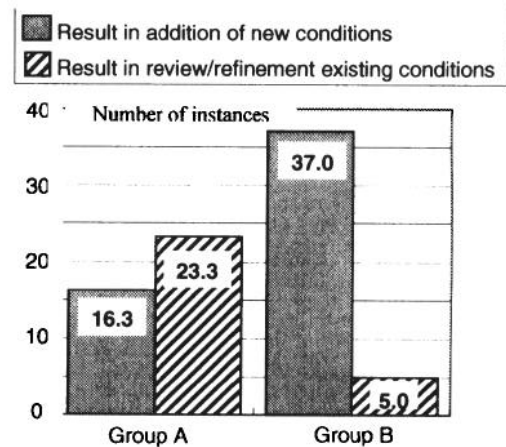


Figure 11. Average number of situations that resulted in the addition of new conditions (A breakdown of "specify of target conditions" in Figure 9.)

added after reviewing (and possibly revising) existing conditions (transition type G-F). The latter situation occurred more frequently in Group A than in Group B, while the former occurred more often in Group B. (Figure 11)

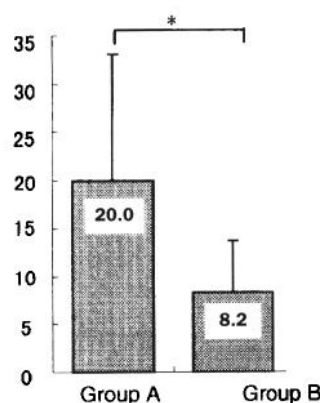


Figure 12 Average number of times existing search conditions were reviewed

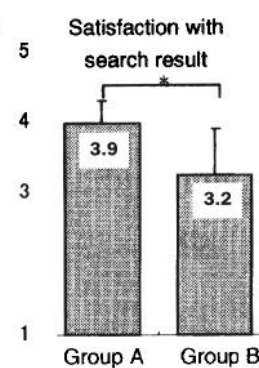
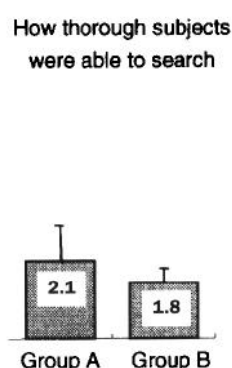
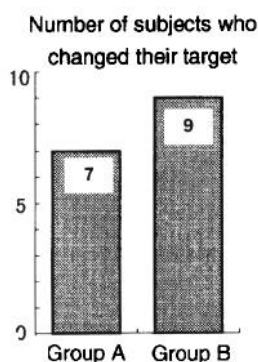


Figure 13. Subjective evaluation of each group

Figure 12 and 13: T-test was conducted between two groups: **: $p < .01$ *: $p < .05$. Vertical bars indicate the standard deviations.

- Subjects in Group A reviewed existing conditions more often than those in Group B, shown in Figure 12.

4) The specification strategy influenced user satisfaction with the search results.

- There was no significant difference between groups in the number of subjects who changed their targets. (Figure 13)
- Overall, users' evaluations of the *thoroughness* of their searches were quite low (average 1.9), with no significant difference between the two groups. (Figure 13)
- The average evaluation of the subjective satisfaction of the search results was significantly different between Group A and Group B. Evaluation of satisfaction of Group A was higher than that Group B. ($p < .05$). (Figure 13)

6 DISCUSSION

1) The process of adding search conditions

There was a typical pattern in the addition of new conditions both in Group A (those who formed a target image before the search) and in Group B (those who started the search without forming a target image). This suggests that the set of conditions is structured as in Figure 6(Right). The three types of conditions are closely interrelated, with lower level conditions being associated with specific higher level conditions. Similarly, when new concrete examples are added, they are paired with existing concepts or added at the same time as a new concept. When attributes or attribute values are added, they are associated with existing examples, or added with new concrete examples. Therefore, concrete examples reflect the users' original concepts, and attributes and attribute values refer to the concrete examples.

During the search process, condition priorities are constantly changing, and some conditions are eliminated thereby strengthening others. The change in the relationships among conditions will be discussed later.

2) The influence of target specification strategy on the overall search process

There was no significant difference in the average number of accessed categories, sites, or pages between the two groups. However it is clear that subjects in Group A, who formed their target images before starting the search, spent a significantly longer time searching than those in Group B, who started their search without forming their target images (Figure 7). Subjects in Group A took extra time to set up their search target before actually beginning the search. On the other hand, subjects in Group B needed to perform the two tasks of target specification and information selection simultaneously. Even so, it took longer for subjects in Group A to complete their search than those in Group B. There was no significant difference in the average number of accessed categories, sites, or pages between the groups. Thus, the number of accesses could not be responsible for the difference in time required to search for a target. In other words, it is possible that it took longer to evaluate external information in Group A than in Group B because of the difference in their target specification strategies.

3) Target specification strategy influenced the quality of the search target.

From the experimental results, we conclude that there was no significant difference in the number of conditions created during the tasks (from the point of deciding on the gift recipient to the end of the search) between two groups. There was no significant difference between Group A and Group B as to which situations they added the new conditions.

Both groups added new conditions to the search target in two situations (Figure 14)—after considering external information (B-F) and when specifying target conditions. The latter case can be further divided into two activities: the addition of new condition (F-F) and the review/refinement of existing conditions (G-F), both which result in the addition of new search target conditions. During target specification, subjects in Group A reviewed existing conditions more often than they added new conditions (G-F). Consequently, members of

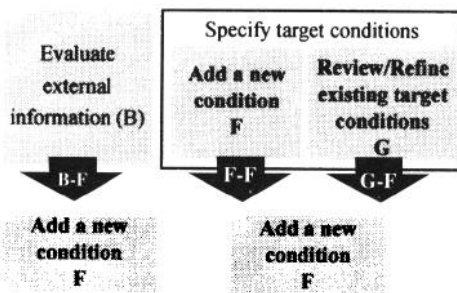


Figure 14. Sequences of resulting in new conditions

Both groups added new conditions to the search target in two situations (Figure 14)—after considering external information (B-F) and when specifying target conditions. The latter case can be further divided into two activities: the addition of new condition (F-F) and the review/refinement of existing conditions (G-F), both which result in the addition of new search target conditions. During target specification, subjects in Group A reviewed existing conditions more often than they added new conditions (G-F). Consequently, members of Group A were better able to relate their new conditions to the set of existing conditions. In Group B, although subjects were able to repeatedly add new conditions (F-F), they inquired into existing conditions (G-F) less frequently. As mentioned above, new conditions include the sets of the target concepts, concrete examples, attributes and attribute values. Both groups created multiple sets of conditions; however, it appears that the sets of conditions created by subjects in Group A were more closely related to each other.

Analysis of all verbalizations indicated that Group A reviewed existing conditions more than twice as often as Group B. (Figure 12) When searching without forming an image of the target beforehand, as in Group B, users need to create their target during the search. In such a situation, various sets of conditions exist, including target concepts, concrete examples, attributes and attribute values. But these conditions are not as closely related nor are they reviewed or refined as well as in Group A. On the other hand, when users start searching with

target conditions set to some extent before the search, it is easier for users to construct relationships between sets of conditions even when the structure of those conditions changes. Users are then able to evaluate external information being conscious of existing conditions and to add new conditions relating to such existing conditions. Consequently, deciding on at least some target conditions before beginning a search makes it possible to frequently review existing conditions during the search and makes it easy to relate new conditions to existing conditions. The process of specifying a target is simply the process of adding new conditions and of reviewing and revising existing conditions. This process progresses more smoothly when search conditions are preset before the search begins. The difference in the process of specifying target conditions is the reason why it took Group A longer to complete the search than Group B.

4) The influence of target specification strategy on user satisfaction with the search results

From the results of the subjective evaluations, subjects from both groups felt they were unable to complete a thorough search, with the same amount of dissatisfaction. In addition, both groups changed their targets during the task about the same number of times. However, subjects in Group A indicated a significantly higher level of satisfaction with their overall search results than subjects in Group B. It is suggested that without setting up search targets, users have difficulty evaluating external information. Search target conditions for those who did not set up a target beforehand tended to be unrelated to each other, resulting in an unclear evaluation and a dissatisfaction with the search result.

As mentioned above, users' setting up targets before their search lead to the creation of closer relationships between external information and subjects' search targets and conditions. This suggests that specifying targets and conditions before starting the search is related to users' satisfaction.

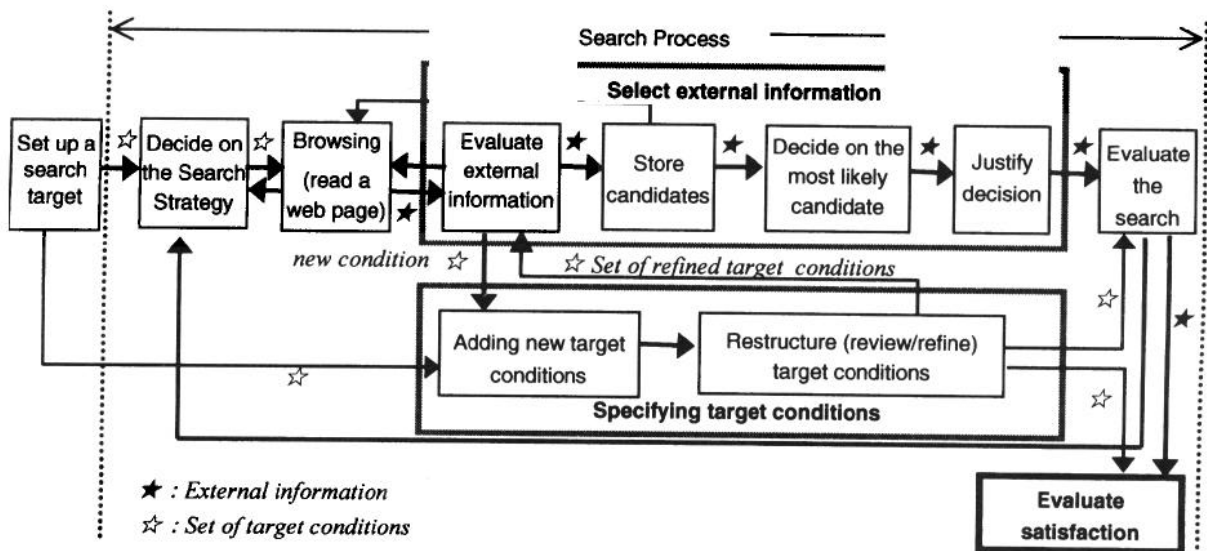


Figure 15. Cognitive model for information search for a ill-defined target

specifying the search target. These two processes function iteratively and alternatively. Therefore, users select external information by comparing it to their search targets, by adding new conditions, and by revising existing conditions and the relationships between them. Information obtained through Web browsing is communicated to the "process of information selection" and to the "process of search target specification." In the process of specifying the search target, attributes and attribute values are extracted from new information. The user chooses relevant attributes and uses their values to decide whether or not the new information should be used to create a new search condition. These new search conditions are then fed into the next process, "search target condition restructuring," during which a target structure may change when adding new conditions based on existing information. If there are any changes as a result of the process of specifying the search targets, these changes are communicated to the process of selecting external information. In this process, users compare search target conditions with external information. In the next process "search evaluation and justification," users evaluate their search targets by considering whether their search target conditions had been adequately specified, whether their search results matched their search target conditions, and whether they had searched the information spaces thoroughly. These processes are repeated until the evaluation in this box is good enough to be considered a complete search.

There seemed to be some differences in the extent to which users analyzed external information in the process of specifying the search target. This difference depends on how well the search targets and the structures of their sets of conditions were specified. The time required to search targets in Group A was longer than in Group B because, especially during the process of specifying search targets, it took longer to analyze external information in Group A than in Group B.

The results obtained in this discussion demonstrate that users are much more satisfied with their search results when they set up a target before starting the search than when they search without setting up a target in advance, even if the target is ill-defined.

7 CONCLUSIONS AND FUTURE DEVELOPMENT

When users search for ill-defined targets, their targets are structured, and include sets of related conditions. In addition, the strategy used to set targets has an effect on the process of specifying targets. It should be noted, too, that the method by which users specify target conditions has a direct impact on user satisfaction. When searching for an ill-defined target in general, user satisfaction was found to be relatively low. In order to continue this type of activity and increase user satisfaction, it is important for users to set targets before beginning a search. It will be a great help in supporting searching activities of Internet users to specify the cognitive processes that occur during this kind of information search.

Further analysis, especially that concerning the cognitive sub-processes of adding and structuring new conditions and user satisfaction, will be carried out in the next step of this study. We intend to use the result of this study to develop systems that will allow users to make more effective Internet searches in the future.

ACKNOWLEDGMENTS

Thanks are due to my colleagues for their discussion and helpful suggestions for improving this paper.

REFERENCES

1. Oddy, R.N., Information retrieval through man-machine dialogue', *Journal of documentation*, 33, 1977, 1-44
2. Belkin, N.J., Oddy, R.N. and Brooks, H.M., ASK for information retrieval II: result of a design study, *Journal of documentation*, 38, 1982, 61-71
3. Belkin, N.J., Oddy, R.N. and Brooks, H.M., Ask for information retrieval I: background and theory, *Journal of documentation*, 38, 1982, 61-71
4. Belin, N. and Vickery, A. Interaction in Information Systems. London: British Library, 1985
5. Ingwersen, P. Toward a new research paradigm in information retrieval. In: I. Wormell (ed), *Knowledge Engineering*. London: Taylor Graham, 1988, 150-168.
6. Williams, M. D., What makes RABBIT run? *Int. J. Man-Machine Studies*, Academic Press, 21, 1984, 333-352
7. Montgomery, H. Decision rules and the search for a dominance structure: Towards a process model of decision making. In P. Humphreys, O. Svenson, and A. Vari. (Eds). *Analysing and aiding decision processes* North-Holland. 1983, 343-369
8. Varlejs, J. (Eds) Information seeking: Basing Services on User's Behaviors. McFarland & Company, Inc (entire issue)
9. Mackinlay, J. D., Rao, R. and Card, S. K. An organic user interface for searching citation links. *Conference Proceedings of CHI'95* (Denver CO, May 1995), ACM Press, 67-73
10. Saito, M., and Ohmura, K. A cognitive model of information search for user-unknown targets, *IPSJ SIG HI Notes* 96-109, 1996, 9-16 (in Japanese)
11. Capineto, C. and Romano, G. Information retrieval through hybrid navigation of lattice representation *Int. J. Human-Computer Studies*, Academic Press, 45-5, 1996, 553-578
12. Dubrau, G. The attributistical understanding of information. *ACM SIG CHI bulletin*, ACM Press, (October 1996), 79-84
13. Klein, H. J., Whitener, E. M. and Ilgen, D. R. The role of goal specificity in the goal-setting process. *Motivation and Emotion*, Plenum Publishing Corp., 14, 3, 1990.