Ali Shiri
School of Library and Information Studies
University of Alberta, Edmonton, Alberta, Canada

Thesaurus-enhanced Search Moves: An Evaluation of Search Term and Search Result Satisfaction

Abstract: This paper reports on a user-centred evaluation of search process characteristics within a thesaurus-enhanced search environment and the ways in which these characteristics affect users' judgment of search terms and results. The study has addressed the questions relating to the types of search moves and the relationship between search moves and search terms and results.

Résumé : Cet article présente une évaluation orientée-utilisateur des caractéristiques du processus de recherche à l'intérieur d'un environnement de recherche enrichi d'un thésaurus et les manières dont ces caractéristiques ont un impact sur le jugement des utilisateurs sur les termes de recherche et les résultats. Cette étude examine les problèmes reliés aux types de procédures de recherche et la relation entre ces procédures, les termes de recherche et les résultats.

1. Introduction

The study and evaluation of end-user search moves and any effects of their moves while interacting with online bibliographic databases is important to achieve a better understanding of the interactive Information Retrieval (IR) process. This paper identifies and classifies cognitive and physical moves made by end-users within a thesaurus-enhanced search environment and evaluates the effects of the moves on search term and search result satisfaction.

2. Prior research

IR researchers have investigated the searching behaviour of various types of users and have looked in particular at their search term selection behaviour. Studies have suggested that the selection of terms can be improved if thesauri are incorporated into the search interface (Hsieh-Yee, 1993; Efthimiadis, 2000;; Sutcliffe, 2000; Vakkari, 2000). A number of researchers have identified thesauri as one of the main sources of search terms in both the query formulation and expansion processes (Spink, 1994; Spink and Saracevic, 1997). Intelligent interfaces, through which the vocabulary of a searcher can be automatically matched to the vocabulary of a thesaurus, have also been suggested as being of value (Fidel, 1991).

In a series of experiments on designing various interfaces to the Okapi search engine (experimental IR system), it was found that both implicit and explicit use of a thesaurus during automatic and interactive query expansion was beneficial. It was also suggested that while the system can find useful thesaurus terms through the query expansion process, those terms that were explicitly selected by users are of particular value (Jones et al.; Beaulieu, 1997). Other IR interface evaluation studies have found that users view search term selection as a process which requires terminological assistance within the interface (McMath et al., 1989; Brajnik et al., 1996).

Marchionini et al. (1991), in studying user interaction with IR interfaces, have defined a move as a conceptual act manifested as one or more keystrokes, for instance entering an entire query or pressing the page down key. This definition has been adopted in this

study. Various approaches have been taken in defining search moves in studying online search behaviour. For instance, Bates (1979) has introduced a number of search moves or tactics some of which specifically relate to search formulation and search terms. Fidel (1985) has identified two types of online search moves namely operational moves and conceptual moves. These moves are more specific than Bates' search tactics in the sense that they are mainly concerned with the use of free-text and controlled vocabulary terms for broadening or narrowing down the search. However these two sets of moves were primarily suggested for professional online searchers rather than end-users. Solomon (1993) has studied children's information retrieval behaviour and has proposed a number of moves. These are: opening moves, simple (single concept) and complex moves (multiple concepts), exploratory moves to investigate the system's features, and confused moves where the user was not able to perform basic tasks using the system. In a study of end-user searching behaviour Manglano et al. (1998) classified search moves based on the following stages: choose search system, formulate query, query reformulation, examine results, extract information, and stop.

In addition to the above empirical studies, a number of interfaces enhanced with thesauri have been developed over the last two decades (McMath et al., 1989; Agosti et al., 1992; Belkin et al., 1993; Pollard, 1993; Pollitt et al., 1994; Jones et al., 1995; Johnson and Cochrane, 1995; Beaulieu, 1997;; Hearst and Karadi, 1997; Lin, 1999). However very few of these interfaces have been evaluated in terms of users search term and search results satisfaction. The present study investigated the effects of end-users search moves in a thesaurus-enhanced search setting and the ways in which the moves affected their satisfaction with the terms they selected and the results they retrieved.

3. METHODOLOGY

Experimental Environment

3.1 System

The Ovid version of the CAB Abstracts database on the Web, the largest agricultural thesaurus, was selected for this study. The Ovid search interface accommodates a range of thesaurus-enhanced facilities in its advanced search mode which allow users to map, search and browse terms. Terms entered by the user are mapped to CAB Thesaurus terms through an interface facility. The CAB Thesaurus contains about 59,000 terms, of which 48,500 are *preferred terms* (descriptors) and 10,500 are *non-preferred terms*. The thesaurus provides all the standard thesaurus relationships and features.

3.2 Participants

Thirty academic staff and postgraduates were recruited from Glasgow University's Faculty of Veterinary Medicine, a subject area well covered within CAB Abstracts (break down of participants is shown in Table 1). Participants were asked to come to the experimental session with three of their own topics in order to create a search environment that was as natural as possible. This decision was made on the assumption that an evaluation of user interaction with the thesaurus and interface can be effectively undertaken only if users having genuine information requests participate in the study.

Status	*Gender*		*Total*
	Male	*Female*	

Faculty member	7	8	15
Postgraduate/PhD students	6	9	15
Total	13	17	30

Table 1. Participants grouped by gender and status

3.3 Data Gathering Tools

A combination of data collection tools was used to capture data at all levels of user interaction. Pre-search questionnaires were used to collect personal information as well as users' search topics and their level of familiarity. The ScreenCam software package was employed to capture user interaction throughout the search process. Post-search questionnaires elicited data on users' perception of terms provided by the thesaurus and users' satisfaction with search results. A post-session interview was carried out to gather information on users' general impressions about the thesaurus, search interface and their interaction experience.

3.4 Search Process Characteristics

Search process characteristics, which were taken into consideration in this study, include cognitive moves, physical moves, time spent per search, Boolean operators used, and screenshots viewed during the search process.

Cognitive and Physical Moves

Since the theoretical framework underlying the present study focused on cognitive aspects of user interaction with IR systems, two general categories of moves were defined for the purpose of analysis, namely:

- *Cognitive moves*: those in which users perform some kind of conceptual analysis of terms and/or documents;
- *Physical moves*: those associated with the use of system features.

Table 2 and 3 show these categories and provide a description of each move type.

Cognitive move type	*Description*
Term input	input initial concept
Browse: mapping	browsing system suggested terms in the mapping state
Browse: thesaurus hierarchy	browsing system suggested terms in the hierarchical thesaurus state
Term selection	selection of terms in either mapping or hierarchical state
Combine search terms	choosing to combine search terms using Boolean operators
Browse titles	browsing the titles of retrieval records
Query reformulation	any move to modify, enhance or expand the query

Table 2. Description of cognitive moves

Physical move type	*Description*
Perform search	executes the query
Scroll up & down	all pages
Back & forward	browser option for backtracking or moving forward
Continue	move forward in every stage of the search
Combine	activate combination
Citation display and e-mail	choose to view and e-mail the retrieved set
Main search page	return to main search page
Previous & next page	buttons for flicking through result pages
Search history	view the search history
Expand & contract	buttons for collapsing or contracting search history

Table 3. Description of physical moves

3.5 Hypotheses

In order to investigate the impact of cognitive and physical moves on search term and search result satisfaction the following hypotheses were developed.

H1: There is a relationship between result relevance and cognitive and physical moves.

H2: Cognitive and physical moves affect users' satisfaction with the number of records retrieved.

H3: There is a relationship between the number of selected terms and users' judgement of the relevance of result sets.

H4: There is a relationship between cognitive and physical moves and users' evaluation of term usefulness.

H5: There is a relationship between the number of selected terms and users' evaluation of term usefulness.

H6: Users who spend more time looking at search terms make more cognitive moves.

4. Results

Search Process Characteristics

4.1 Cognitive Moves

The number of cognitive moves taken to complete each search was examined. Seven cognitive move types were identified as part of the search process. These move types together with the total number of moves of each type and the mean number per search are

shown in Table 4. The mean number of cognitive moves taken per search over all searches was 13.

Cognitive move types	*Total number of moves*	*Mean number of moves per search*
Term input	252	2.8
Browsing terms in mapping state	210	2.4
Browsing terms in thesaurus hierarchy state	55	0.6
Selection of terms	265	2.9
Combine search terms	192	2.1
Browsing retrieved titles	111	1.2
Query reformulation	104	1.1

Table 4. Total and mean number of cognitive moves per search

4.2 Physical moves

In total ten physical move types were identified. The total and mean number of moves made per search are shown in Table 5. The mean number of physical moves made per search was 21.

Physical move types	*Total number of moves*	*Mean number of moves per search*
Perform search	254	2.8
Scroll up & down	671	7.5
Back & forward	39	0.5
Continue	192	2.1
Combine	331	3.7
Citation display & e-mail	284	3.2
Main search page	10	0.1
Previous & next page	71	0.8
Search history	15	0.2
Expand & contract	38	0.4

Table 5 Total and mean number of physical moves per search

4.3 Time

The amount of time spent by users to complete searches was assessed. In order to provide a more finely grained time analysis, two search stages were taken into consideration in terms of the time spent namely the *concept search* stage and the *search combination and result viewing* stage. The concept search stage refers to all user actions related to the input of a concept, browsing the terms suggested by the system, selecting term(s) and submitting the search terms to the database. The second stage consists of two main tasks namely combining different search terms using Boolean operators and viewing the retrieved results.

Search stage time	*Mean time per search (minute/second)*
Time per concept search Time per combination and result viewing Total time per search	3" 15 sec 3" 40 sec 6" 57 sec

Table 6. Mean time spent per search

The rationale for separating search stages into two main categories as above is because the time spent on browsing and selecting search terms can be easily compared with the time spent on the rest of the search process. Table 6 shows the mean time (in minutes and seconds) for each search and each user in terms of the defined stages.

4.4 Boolean Operators

The number of Boolean operators used during the search process was assessed. As there were only two operators i.e. AND and OR available, the use of these two operators is reported. There were three situations where users could choose these operators: the mapping state, the thesaurus hierarchy state, and the combine state.

All users made use of the AND operator while only 21 (70%) users introduced the OR operator while performing their searches. The use of operators was influenced by the mapping situation where one or more terms were suggested to the user. The AND operator was used in the *combine state* by the majority (70%) of users. The OR operator was utilised in either the mapping or hierarchical states as the terms appear in these two states. One of the main reasons for extensive use of operators, in particular the OR operator, lies in the fact that the Ovid search interface makes operators explicitly available at search term selection and search combination situations. Table 7 shows the total number of operators used in each of the search states.

Operator	*Mapping State*	*Hierarchical thesaurus State*	*Combine State*	*Total*
AND OR	28 52	4 11	97 0	129 63
Total	80	15	97	192

Table 7. Number of times operators were used in each state

As can be seen from Table 7 users made use of the OR operator mostly in the mapping state where the user is provided with a list of terms for browsing and selection.

Table 8 shows the mean number of operators used per search and per user. On average a total of two operators were used in each search.

Operator	*Mean per search*
And	1.4
Or	0.7

Table 8. Mean number of operators per search

4.5 Screenshots Viewed

The number of screenshots users viewed while interacting with the search interface was assessed. Screenshots relating to search concepts, search term combination and result viewing were counted. The mean number of screenshots per search for these stages is shown in table 9.

Screenshots	*Mean per search*
Input, browsing and selecting terms	9.2
Combining terms and viewing results	7.7
Total search screenshots	16.8

Table 9. Mean number of screen shots viewed per search

On average users viewed 9 screenshots while browsing and selecting search terms and 8 screenshots viewing search results and combining terms. The table indicates that on average just over half of the screen shots viewed were associated with the input, browsing and selection of search terms.

4.6 Hypotheses tested

Results of statistical tests associated with search process variables namely cognitive and physical moves and their effect on result relevance, term usefulness and search result satisfaction are reported in this section.

H1: There is a relationship between result relevance and cognitive and physical moves.

A two-sample *t*-test was conducted to establish whether there was any relationship between cognitive moves and the relevance rating of result sets by users. The p-value

(p=0.22) indicated there was not sufficient evidence to support this hypothesis. Indeed as Table 10 shows searches in the category of *very relevant* are associated with slightly

Relevance	*Cognitive*		*Physical*	
	N	Mean	N	Mean
Partially relevant	27	13.3	29	23.4
Very relevant	59	12	59	19

Table 10. Cognitive moves and result relevance

fewer cognitive moves than those in the *partially relevant* category. Thus, simply making more cognitive moves dose not guarantee the retrieval of very relevant document sets.

The same test was carried out for the relationship between physical moves and the relevance ratings of result sets (Table10). The p-value was found to be significant (p=0.015) indicating that searches whose result sets were evaluated as *very relevant* were associated with fewer physical moves than those which were evaluated as *partially relevant*. This finding may have two implications. First, it may indicate that poor results led the users to more wandering around and making more physical moves. Second, it may reflect the significance of the quality of physical moves rather than their quantity.

H2: Cognitive and physical moves affect users' satisfaction with the number of records retrieved.

One-way ANOVA tests were carried out for both cognitive and physical moves with respect to users' satisfaction with the number of records retrieved. Neither of the tests showed any significance indicating that user satisfaction with the number of retrieved records is not dependent on the number of search moves. Therefore, this hypothesis is rejected.

H3: There is a relationship between cognitive and physical moves and users' evaluation of term usefulness.

A two-sample *t*-test of cognitive moves and term usefulness was conducted and the results are shown in Table 11 There was a significant difference (p=0.043) between cognitive moves made by those who had evaluated the selected terms as useful and those who did not. On average just over two more cognitive moves were associated with those searches whose selected terms were evaluated as being useful.

Term usefulness	*Cognitive*		*Physical*	
	N	Mean	N	Mean

Useful Not useful	62 24	13.1 10.8	63 25	21.0 19.0

Table 11. Cognitive and physical moves and term usefulness

The same test was conducted for physical moves and term usefulness. However, the p-value (p=0.28) indicated that physical moves did not have any relationships with users' evaluation of term usefulness. These findings point to the fact that while cognitive moves are important in satisfying users with their search term selection experience using a thesaurus, physical moves are not.

H4: There is a relationship between the number of selected terms and users' evaluation of term usefulness.

A two-sample *t*-test showed a significant relationship (p=0.006) between the number of selected terms and term usefulness. As Table 12 shows those who evaluated their search terms as being useful selected on average around two more search terms than did those who did not evaluate the terms as being useful.

Status	*N*	*Mean*
Useful Not useful	65 25	5.8 4

Table 12. Number of selected terms and term usefulness

H5: There is a relationship between the number of selected terms and users' judgement of the relevance of result sets.

The relationship between the number of selected terms and the relevance evaluation of retrieved sets was assessed using a *t*-test and the results are shown in Table 13.

Status	*N*	*Mean*
Very relevant Partially relevant	60 30	4.8 6.4

Table 13. Number of selected terms and result relevance

The p-value was found to be marginally significant (p=0.06) indicating that there may exist a relationship between the number of search terms users select and the way they evaluate the relevance of the retrieved set. As can be seen from Table 13 searches whose results were judged as being very relevant were associated with fewer selected terms whereas those searches whose results were evaluated as being partially relevant were associated with more selected terms. Searches in the *partially relevant* category had an average of two more search terms selected than those in the *very relevant* category. This

finding indicates that the quantity of search terms is not the prime determinant of the relevance evaluation of retrieved records.

H6: Users who spend more time looking at search terms make more cognitive moves.

It should be noted that unlike previous hypotheses this particular hypothesis was tested at the user level rather than search level. The reason for this lies in the fact that time has been considered as a search process variable in this study, hence this hypothesis has been coupled with other search process related hypotheses.

The time spent for entering a search term, browsing the mapped terms and selection of terms, and the users' cognitive moves. A *t*-test was run to compare the mean number of cognitive moves of users who spent less than or more than 10 minutes in these search activities. In order to undertake this analysis, two categories of users were identified; those who spent 10 or less than 10 minutes on search terms and those who spent more than 10 minutes. Table 14 shows cognitive moves and time spent on search terms. The test shows a significant difference (p=0.029) indicating that users who spent more time on browsing and selecting search terms tend to make more cognitive moves.

Time	*N users*	*Mean cognitive*	*StDev*	*CI*
Spending less than 10 minutes	19	27.4	4.67	(-8.78, -0.67)
Spending more than 10 minutes	9	33.1	5.99	

Table 14. *t*-test for Cognitive moves and searches time spent for search term

Physical moves were not evaluated against time, as it is self evident that more physical moves make users spend more time searching.

5. Conclusion

The aim of this study was to investigate different types of search moves in a thesaurus-enhanced search environment and their impact on search term and search result satisfaction. Cognitive and physical moves were defined to provide a framework for the evaluation of user interaction with the thesaurus-enhanced search system.

A general trend was observed with respect to the use of Boolean operators which suggested that the operators can be particularly useful within a thesaurus-enhanced search interface but that their implementation affects usage. As found in this study, all users made use of the AND operator and the majority (70%) of them introduced the OR operator in their search. However, they also noted that they required more help in order to make effective use of these operators.

An association was found between users' relevance evaluation of result sets and the number of physical moves performed. Those searches whose result sets were evaluated as being *very relevant* were associated with significantly fewer physical moves. This finding reinforces the fact that quality of moves is more important than quantity.

The finding concerning term selection and term usefulness suggests that users who evaluated the thesaurus terms as being useful selected on average around two more search terms than did those who did not find the terms useful. This indicates that term satisfaction and the number of terms selected have a significant relationship with each other. An interesting observation in relation to users' evaluation of term usefulness was the fact that those searches in the category of *useful* were associated with significantly more cognitive moves.

In this study it was found that those searches whose results were evaluated as being *very relevant* were associated with fewer search terms compared to those in the *partially relevant* category. This finding reflects the fact that quality of search terms rather than quantity plays a role in users' judgment.

Users on average spent around half of their search time entering search terms, browsing thesaurus terms, and selecting from those terms. They spent the other half combining search terms and viewing results. The screenshots viewed by users were roughly in proportion to time spent. On average users viewed nine screenshots relating to term input, browsing thesaurus terms, and term selection. They viewed around seven screenshots per search while combining search terms and viewing results. This finding indicates that in a thesaurus-aided search environment, a considerable amount of users' time is spent on browsing and/or selecting terms. This finding also suggests that some aspects of user interface interaction can be predicted based on the time users spend in their initial term selection state. This may help identify behavioural patterns subsequent to the search term selection stage.

It is suggested that the identification of major categories of move types and their relative frequencies will facilitate an evaluation of the contribution made by each type of move to the overall search process and can be of value in the design of IR interfaces. Furthermore, a framework utilising cognitive and physical moves provides a method for assessing the extent to which users take advantage of browse, search and navigation features within an IR interface and can guide the interface design process such that cognitive and physical loads are reduced during the search process.

The explicit availability of the AND and OR operators at both thesaurus mapping and thesaurus hierarchical states in the Ovid search interface promoted the use of these operators. However, users still require to be prompted to select either of them while combining thesaurus terms. It is suggested that user training in understanding Boolean logic will increase the correct and effective usage of operators and hence improve performance.

The list of thesaurus matched terms provided by the Ovid interface took up more than one screen in most cases. This demanded more physical effort from users to scroll up and down to view all terms. The list could be reduced in such a way that it takes up the standard screen and in this way users could easily view all terms without having to scroll

up and down. A list of 13 to 15 terms will be a reasonable size to allow users to have a quick glimpse at all terms with no physical effort. This change would possibly have term ranking implication as to what thesaurus terms should be displayed.

Future research should further investigate the nature and types of cognitive and physical moves in studying end-user search behaviour. It is suggested that cognitive and physical moves could be weighted based on their contribution to the whole search process and that this may provide a more sensitive method for evaluating users' search moves in relation to a particular task. When compared with search outcome measures such as relevance judgement or user satisfaction, cognitive and physical moves can be viewed as measures contributing to the evaluation of IR interaction and search efficiency. This approach to search moves also allows for an assessment of the extent to which an IR system involves users in cognitive or physical behaviour while searching for a topic.

References

Agosti, M. , Gradenigo, G., and Marchetti, P.G. (1992) A hypertext environment for interacting with large textual databases. *Information Processing and Management,* 28 (3), pp. 371-387.

Bates, M.J. (1979) Information search tactics. *Journal of the American Society for Information Science*, 30 (4), pp. 205-214.

Beaulieu, M. (1997) Experiments of interfaces to support query expansion. *Journal of Documentation*, 53 (1), pp. 8-19.

Belkin, N.J., Marchetti, P.G. and Cool, C. (1993) BRAQUE: design of an interface to support user interaction in information retrieval. *Information Processing and Management,* 29 (3), pp. 325-344.

Brajnik, G., Mizzaro, S., and Tasso, C. (1996) Evaluating user interfaces to information retrieval systems: a case study on user support. *Proceedings of the 19th Annual International ACM/SIGIR Conference on Research and Development in Information Retrieval*. August 18-22, 1996, Zurich, Switzerland, pp. 128-136.

Efthimiadis, E.N. (2000) Interactive query expansion: A user-based evaluation in a relevance feedback environment. *Journal of the American Society for Information Science*, 51 (11), pp. 989-1003.

Fidel, R. (1985) Moves in online searching. *Online Review*, 9 (1), pp. 61-74.

Fidel, R. (1991) Searchers' selection of search keys: III. Searching styles. *Journal of the American Society for Information Science*, 42 (7), pp. 515-527.

Hearst, M.A. and Karadi, C. (1997) Cat-a-Cone: An interactive interface for specifying searches and viewing retrieval results using a large category hierarchy. In: *Proceedings of*

the 20th Annual International ACM/SIGIR Conference on Research and Development in Information Retrieval of the Association for Computing Machinery Special Interest Group on Information Retrieval. Philadelphia, PA, USA, July 27- 31, 1997. New York: ACM, pp. 246-255.

Hsieh-Yee, I. (1993) Effects of search experience and subject knowledge on the search tactics of novice and experienced searchers. *Journal of the American Society for Information Science*, 44 (3), pp. 161-174.

Johnson, E.H. and Cochrane, P.A. (1995) A hypertextual interface for a searcher's thesaurus. In: *Digital Libraries '95: Proceedings of the Second Annual Conference on the Theory and Practice of Digital Libraries*. Austin, Texas June 11-13 1995.

Jones, S., Gatford, M., Hancock-Beaulieu, M., Robertson, S.E. , Walker, W. and Secker, J. (1995) Interactive thesaurus navigation: Intelligence rules Ok? *Journal of the American Society for Information Science,* 46 (1), pp 52-59.

Lin, X. (1999) Visual MeSH. In: Hearst, M. et al.(eds.) *Proceedings of 22nd Annual International ACM/SIGIR Conference on Research and Development in Information Retrieval of the Association for Computing Machinery Special Interest Group on Information Retrieval,* Berkeley, CA, USA, August 15-19 1999, New York: ACM, pp 317-318.

Manglano, V., Beaulieu, M. and Robertson, S. (1998) Evaluation of interfaces for IRS: Modelling end-user searching behaviour. *20th British Computing Society Information Retrieval Special Group (BCS/IRSG) Colloquium on Information Retrieval*, 25-27 March 98, Grenoble (France), (Electronic Workshops in Computing), Grenoble: Springer-Verlag, 1998, pp. 137-146.

Marchionini, G., Meadow, C., Dwiggins, S., Lin, X., Wang, J. and Yuan, W. (1991) A study of user interaction with information retrieval interfaces: progress report. *The Canadian Journal of Information Science*, 16 (4), pp. 42-59.

McMath, C.F., Tamaru, R.S. and Rada, R. (1989) A graphical thesaurus-based information retrieval system. *International Journal of Man-Machine Studies,* 31 (2), pp. 121-147.

Pollard, R. (1993) A hypertext-based thesaurus as subject browsing aid for bibliographic database, *Information Processing and Management,* 29 (3), pp. 345-357.

Pollitt, A.S., Ellis, G.P. and Smith, M.P. (1994a) HIBROWSE for bibliographic databases. *Journal of Information Science* 20 (6), pp. 413-426.

Solomon, P. (1993) Children's information retrieval behaviour: A case analysis of an OPAC. *Journal of the American Society for Information Science*, 44 (5), pp. 245-264.

Spink, A. (1994) Term relevance feedback and query expansion: Relation to design. Croft, W. B. and Van Rijsbergen, C. J. (eds.) *Proceedings of the Association for Computing Machinery Special Interest Group on Information Retrieval (ACM/SIGIR) 17th Annual International Conference on Research and Development in Information Retrieval*. Berlin: Springer-Verlag, pp. 81-90.

Spink, A. and Saracevic, T. (1997) Interaction in information retrieval: Selection and effectiveness of search terms. *Journal of the American Society for Information Science*, 48 (8), pp. 741-761.

Sutcliffe, A.G., Ennis, M., and Watkinson, S.J. (2000) Empirical studies of end-user information searching. *Journal of the American Society for Information Science*, 51 (13), pp. 1211-1231.

Vakkari, P. (2000) Cognition and changes of search terms and tactics during task performance: A longitudinal case study. *Proceedings of RIAO 2000, Content-based Multimedia Information Access RIAO Conference, Paris, April 12-14 2000*. Paris: C.I.D., pp. 894-907.