

TASK COMPLEXITY AFFECTS INFORMATION SEEKING AND USE

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TASK COMPLEXITY AFFECTS INFORMATION SEEKING AND USE

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Abstract

It is nowadays generally agreed that a person's information seeking depends on her tasks and the problems encountered in performing them. The relationships of broad job types and information seeking characteristics have been analyzed both conceptually and empirically, mostly through questionnaires after task performance rather than during task performance. In this article, the relationships of task complexity, necessary information types, information channels and sources are analyzed at the task level on the basis of a qualitative investigation. Tasks were categorized in five complexity classes and information into problem information, domain information and problem solving information. Moreover, several classifications of information channels and sources were utilized. The data were collected in a public administration setting through diaries, which were written during task performance, and questionnaires. The findings were structured into work charts for each task and summarized in qualitative process description tables for each task complexity category. Quantitative indices further summarizing the results were also computed. The findings indicate systematic and logical relationships between task complexity, types of information, information channels and sources.

1. Introduction

The tradition of research into information seeking considers information seeking from a systems perspective and information users as passive, situation independent receivers of objective information (Dervin & Nilan, 1986). Yet it has been often accepted that information needs and information seeking processes depend on worker's tasks (Belkin *et al.*, 1982 ; Ingwersen, 1992; Mick *et al.*, 1980). For example, Belkin *et al.* (1982) state that information seeking is based on a worker's task (or problem). Ingwersen (1992) points out that effective information retrieval must be based on an understanding of a worker's tasks and problems.

Thus many studies have investigated the relationships of various types of tasks (e.g. in sciences, technology, social studies, administration) and information seeking behaviour (e.g. various types of channels and sources preferred or consulted ; Brittain, 1974 ; Dervin & Nilan, 1986) or communication (e.g. Tushman, 1978). However, there is insufficient empirical analysis of the relationships of task types and the types of information needed in those tasks. These are the focus in the present study.

Information has been categorized in many ways in information science. Wersig and Neveling (1976) consider information as structures, processes, messages, knowledge, meaning and effects. Buckland (1991) discusses information as thing (i.e. recorded knowledge), knowledge (personally believed by somebody) and process (becoming informed, a change in knowledge). In information seeking, information-as-thing is collected and assimilated in the hope of a positive change in information-as-knowledge. This is compatible with the cognitive view on information interaction where potential information gained from information systems may transform the information user's knowledge structures (Ingwersen, 1992). In this paper we consider information from a problem solving viewpoint based on expert systems development (e.g. Barr & Feigenbaum, 1981). In this view, information can be categorized into domain information (e.g. known scientific facts), problem information (i.e. the problem characteristics), and problem solving information (i.e. expertise in problem treatment). This viewpoint is particularly relevant to our view on tasks and information needs. It can be applied on information as thing, as knowledge (structure) and as process.

Many factors formulating worker's information needs and the seeking process have been identified and analyzed since Paisley's (1968) review. These include cultural and political settings, professions, reference groups, invisible colleges, organizations, work groups, personalities, etc. Dervin and Nilan (1986) call for a new paradigm for the research into information seeking processes which would view information as being constructed and information seeking as a situation-sensitive sense-making process. It should focus on the information seekers and assess information systems from their viewpoint. Kuhlthau (1991) argues convincingly that a holistic model for information seeking processes must consider three realms of activity : physical (the actions taken), affective (feelings experienced), and cognitive (thoughts about the process and content). In this paper tasks and information seeking are considered from the worker's viewpoint and in the cognitive domain.

Information needs and information seeking processes depend on worker's tasks. The tasks impose information requirements which must be met if the task is to be completed (Wersig, 1973). Confronted with a task, the worker perceives information needs which reflect her interpretation of information requirements, her prior knowledge and her ability to memorize it. There may be a gap between the worker's knowledge about the task and the perceived requirements of the task (Belkin *et al.*, 1982). This gap is the information need.

The tasks performed by a worker can be analyzed and classified in many different ways. Typical job related analysis criteria like job variety or autonomy (Hackman & Oldham, 1975 ; Tushman, 1978 ; Daft & Macintosh, 1981) are here unsuitable because they do not describe individual tasks. Task complexity or difficulty is one of the most essential factors affecting task performance as observed in psychological experiments (e.g. Locke *et al.*, 1981 ; Wood *et al.*, 1987), in organizational studies (e.g. March & Simon, 1967 ; Van de Ven & Ferry, 1980) as well as in information seeking studies (e.g. Culnan, 1983 ; Hart & Rice, 1991 ; Tiamiyu, 1992). However, task complexity is multidimensional (Campbell, 1988) and has been understood in many different ways. This will be discussed in Section 2.

The relationships of task complexity and information seeking have been investigated in several empirical studies (e.g. O'Reilly, 1982 ; Tiamiyu, 1992 ; Tushman, 1978). O'Reilly (1982) studied through questionnaires the relationships of perceived task complexity, the quality of information and its accessibility as well as information seeking. Hypotheses relating perceived task complexity and uncertainty to the frequency of use of various types of information sources were not confirmed. This is explained by the fact that all subjects in the study were employed in the same job and the analysis was at the level of jobs — there was no variation in complexity. Tushman (1978) classified R&D-projects into four complexity classes (from basic research as the most complex to technical service as the least complex) and found out that oral communication was considerably more frequent within research projects than technical service projects and that the communication networks of high-performing projects were different between these project types. No findings on individual tasks or relating information types and project types were reported. Tiamiyu (1992) reports that the number of sources used by civil servants was directly related to their task complexity, degree of discretion and task duration. Task complexity was defined as the average complexity of the most common tasks of each servant. The types of information searched was not investigated. Moreover, the study was based on questionnaires and thus the respondents were judging their tasks and information behaviour at hindsight.

In conclusion, it seems that empirical studies relating task complexity and information seeking are rather based on whole jobs (or projects) than individual tasks, collect their data on information seeking (or communication) through questionnaires after task performance rather than during task performance and do not consider the types of information sought or used. Also organizational studies typically consider whole jobs (e.g. the widely used job diagnostic survey by Hackman & Oldham, 1975). On the contrary, psychological studies often consider individual tasks of varying difficulty and associated goal setting as well as performance (e.g. Huber, 1985 ; Locke & *al.*, 1981 ; Campbell & Gingrich, 1986) but do not relate these to information seeking. Thus there is insufficient evidence on the effects of task complexity at the

task level on information types, seeking and use. The present study is a step toward filling this gap.

Information is accessed through various channels (e.g. colleagues, phone catalogues and retrieval systems) from various sources (e.g. colleagues, reference books and internal memoranda). From the worker's point of view, a source contains (or is expected to contain) relevant information while a channel guides (or is expected to guide) the worker to pertinent sources. Therefore there is no absolute difference between channels and sources. A channel may turn into a source and vice versa. In this paper we consider the type (e.g. personal collections, experts) and location (internal, external) of information channels and sources.

The problem studied in this paper is how task complexity affects information seeking both in terms of the types of information sought and the channels and sources of this information. Our aim is to provide qualitative evidence on how the task complexity dimension systematically affects information needs and seeking. Due to the strong dependence of information needs and seeking on tasks, a holistic general model of information seeking and use must take the task complexity dimension into account. The problem is stated in more specific terms at the end of Section 2. The problem was studied in a public administration context.

Section 2 presents the conceptual framework of this study. It is based on an earlier broader framework (Järvelin, 1986). Task complexity and categories as well as types of information needed in performing tasks are presented followed by the information seeking model employed. Section 3 considers the methods of data collection and analysis. Section 4 reports major findings of the study. Discussion and conclusions are in Sections 5 and 6.

2. Framework and Research Problem

2.1. Task Complexity

A worker's job consists of tasks which, again, consist of levels of progressively smaller sub-tasks. Tasks are either given to, or identified by, the worker. Each task has a recognizable beginning and end, the former containing recognizable stimuli and guidelines concerning goals and/or measures to be taken (Hackman, 1969). Seen in this way, both a large task as such or any of its (obviously simpler) subtasks may be considered as a task. This relativity in definition is necessary in order to analyze tasks of different levels of complexity.

In the context of information seeking we are interested in information-related tasks. These can be seen as perceived (or subjective) tasks or objective tasks. The relationships of objective and perceived tasks have been considered in organizational psychology (Campbell, 1988 ; Hackman, 1969 ; Wood, 1986) where task descriptions based on perceived tasks are generally held invalid for many purposes (e.g. Roberts & Glick, 1981). However, in this study per-

ceived tasks must be considered because each worker may interpret the same objective task differently (e.g. as regards its complexity) and the perceived task always forms the basis for interpreting information needs and the choice of promising actions for satisfying them.

The literature suggests many task characteristics related to complexity : repetitiveness, analyzability, apriori determinability, the number of alternative paths of task performance, outcome novelty, number of goals and conflicting dependencies among them, uncertainties between performance and goals, number of inputs, cognitive and skill requirements, as well as the time-varying conditions of task performance (Campbell, 1988 ; Daft *et al.*, 1988 ; Fisher, 1979 ; Fiske & Maddi, 1961 ; Hart & Rice, 1991 ; Järvelin, 1986 ; March & Simon, 1967 ; MacMullin & Taylor, 1984 ; Tiarniyu, 1992 ; Tushman, 1978 ; Van de Ven & Ferry, 1980 ; Wood, 1986 ; Zeffane & Gul, 1993). Also these characteristics have been understood in many different ways. They belong into two main groups : characteristics related to the apriori determinability of tasks and characteristics related to the extent of tasks.

In this paper we utilize a simple, uni-dimensional complexity categorisation of tasks based on, from the worker's point of view, apriori determinability of, or uncertainty about, task outcomes, process and information requirements. This dimension is related to the above task characteristics : repetitiveness, analyzability, apriori determinability, the number of alternative paths of task performance and outcome novelty. Similar uni-dimensional complexity categorisations are used by Tiarniyu (1992) and Van de Ven and Ferry (1980). Simple tasks are routine information processing tasks, where the inputs, process and outcomes can be apriori determined, while difficult or complex tasks are new and genuine decision tasks, where they cannot be apriori determined. Such a categorisation is generic and thus widely applicable on many types of tasks and domains.

Problem formulation and problem solving have been identified in information seeking studies (e.g. Caplan, 1984 ; Kuhlthau, 1991) as distinct steps in task performance. Problem formulation creates the solution space and determines the information requirements of the task. After the formulation step, the worker has a problem that may be solved and knows what kind of information is relevant — there is less uncertainty and confusion left (Kuhlthau, 1991). In terms of Kuhlthau's six-phase model, the phases initiation, selection, exploration and formulation belong to the problem formulation step, while the phases collection and presentation belong to the problem solving step. In routine problems there is no problem formulation phase : the inputs, process and outcomes are apriori known. In difficult problems these cannot be apriori determined and thus there are two kinds of information needs : (1) information needed in problem formulation, and (2) information needed in problem solving. These needs relate to different types of information as discussed below.

2.2. Task Categorisation

In this paper, tasks are classified into five categories ranging from an automatic information processing task to a genuine decision task. This categorisation is based on the apriori determinability (or structuredness) of tasks and is closely related to task difficulty or complexity. Task complexity is often seen to depend on the degree of apriori uncertainty about the task inputs, process and outcome (e.g. Van de Ven & Ferry, 1980). In automatic information processing tasks, the type of the task result, the work process through the task, and the types of information used can all be described in detail in advance. In genuine decision tasks, on the contrary, none of them can be determined apriori. Our task categorisation is presented in Fig. 2.1 where information (both input and result) is represented by arrows and the task process by boxes. The apriori determinable parts of tasks are represented by solid arrows and solid boxes, and the apriori indeterminable parts of tasks are represented by dashed arrows and shaded boxes. Dashed arrows and shaded boxes thus represent case-based arbitration. Three arrows are used in the input side to visualize that many inputs are often needed and that there are degrees of apriori determinability among them.

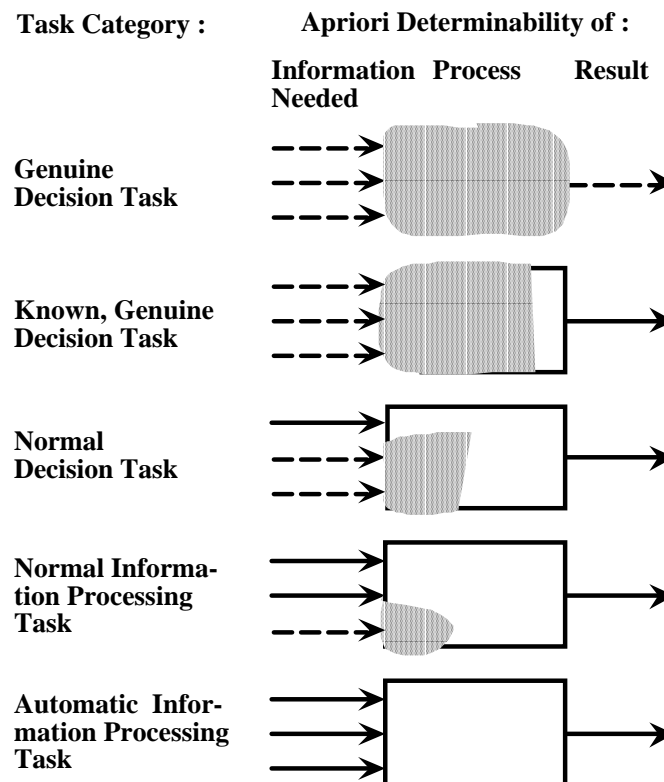


Fig. 2.1. Task categories (Anon., 1974)

Tasks in different categories can be characterized briefly as follows :

- *Automatic information processing tasks* are apriori completely determinable so that, in principle, they could be automated — whether actually automated or not. Example :

computation of a person's net salary yields a real number in some known range and requires this person's gross salary and tax code, and the taxation table.

- *Normal information processing tasks* are almost completely apriori determinable but require some case-based arbitration concerning e.g. the sufficiency of the information normally collected. Thus part of the process and information needed is apriori indeterminable. Example : tax coding is mostly rule-based but some cases require additional clarification, i.e. case-dependent information collection.
- *Normal decision tasks* are still quite structured but in them case-based arbitration has a major role. Example : hiring an employee or evaluating student's term paper.
- In *known, genuine decision tasks* the type and structure of the result is apriori known but permanent procedures for performing the tasks have not emerged yet. Thus the process is largely indeterminable and so are its information requirements. Example : deciding about the location for a new factory or medium-range planning in organizations.
- *Genuine decision tasks* are unexpected, new and unstructured. Thus neither the result, the process nor the information requirements can be characterized in advance. The first concern is task structuring. Example : the collapse of Soviet Union from the viewpoint of other governments.

Information seeking research has focused mostly on tasks in the middle and upper parts of the categories (normal decision task to genuine decision task) although this dimension has only rarely been recognized (Belkin (1980) describes a similar scale of problem situation levels). The categories above are relative to the worker : what is a genuine decision task to a novice may be a normal decision to an expert.

2.3. Types of Information Needed in Tasks

In expert systems design, the types of information (as thing when recorded or as knowledge when seen as the focus of knowledge acquisition) are classified as problem information (PI), domain information (DI), and problem solving information (PSI) (e.g. Barr & Feigenbaum, 1981). These concepts have been proposed for information seeking research also by Järvelin and Repo (1983 ; 1984). These information categories can be characterized as follows :

- *Problem information* describes the structure, properties and requirements of the problem at hand. For example, in bridge construction, information on the type and purpose of the bridge and on the site where it must be built constitute problem information. It is typically available in the problem environment — but in the case of old problems it may be also available in documents.
- *Domain information* consists of known facts, concepts, laws and theories in the domain of the problem. For example, in bridge construction, information on the strength and thermal expansion of steel constructs belongs to domain information. This is typically

tested scientific and technological information published in journal articles and textbooks.

- *Problem solving information* covers the methods of problem treatment. It describes how problems should be seen and formulated, what problem and domain information should be used (and how) in order to solve the problems. For example, in bridge construction, the design engineer's heuristics concerning the pros and cons of various bridge design types constitute problem solving information. It is instrumental information and typically available only from knowledgeable persons (or experts).

These three information categories are orthogonal, i.e. represent three different dimensions and have different roles in problem treatment. All are necessary in problem treatment but, depending on the task, may be to different degrees available to a worker performing the task. Because their typical sources are different, typical channels for acquiring them may also be different.

2.4. The Information Seeking Model

When confronted with various tasks in their contexts, the worker performing the task experiences gaps in her knowledge and thus information needs which reflect her interpretation of information requirements, her prior experience and knowledge, and her ability to memorize it. Personal factors (e.g. attitude, motivation, mood) also come into play here (Kuhlthau, 1991). After a more or less conscious analysis of the needs and recognition of possible actions, she chooses some action to obtain pertinent information. The possible actions consist of a (in part consciously) ranked host of information channels and sources to be utilized. Having chosen an action, the worker implements it and evaluates the result for sufficiency and pertinency. This information seeking model, based on the model by Feinman *et al.* (1976) and Mick *et al.* (1980), is depicted in Fig. 2.2. The interpretation of information needs is affected by situational (e.g. available time) and organizational factors. The choice of action depends on the needs, the perceived accessibility (whether cognitive, economic or physical) of information channels and sources and the personal information seeking style which evolves on the basis of successfulness of attempted actions. We have focused on the factors and phases indicated by thick ellipses and boxes. This model represents the information seeking layer of performing a task — other layers of the task are performed simultaneously.

A complex task may require several processes through the information seeking flow-chart. If the needs are satisfied, the task (or one step through it) can be completed. If the needs cannot be satisfied, the task cannot be completed at all or it must be reformulated. If further information is still needed, new seeking actions are initiated. The process may be interrupted at any time if the worker sees no way to proceed.

2.5. The Research Problem

The specific research problem studied was what types of information (i.e. PI, DI, PSI) are sought for through which types of channels (i.e. external, internal) from what kinds of sources (e.g. experts, literature, official documents) in which kinds of tasks (i.e. automatic information processing tasks, genuine decision tasks). The study was qualitative and no formal testing of hypotheses was attempted.

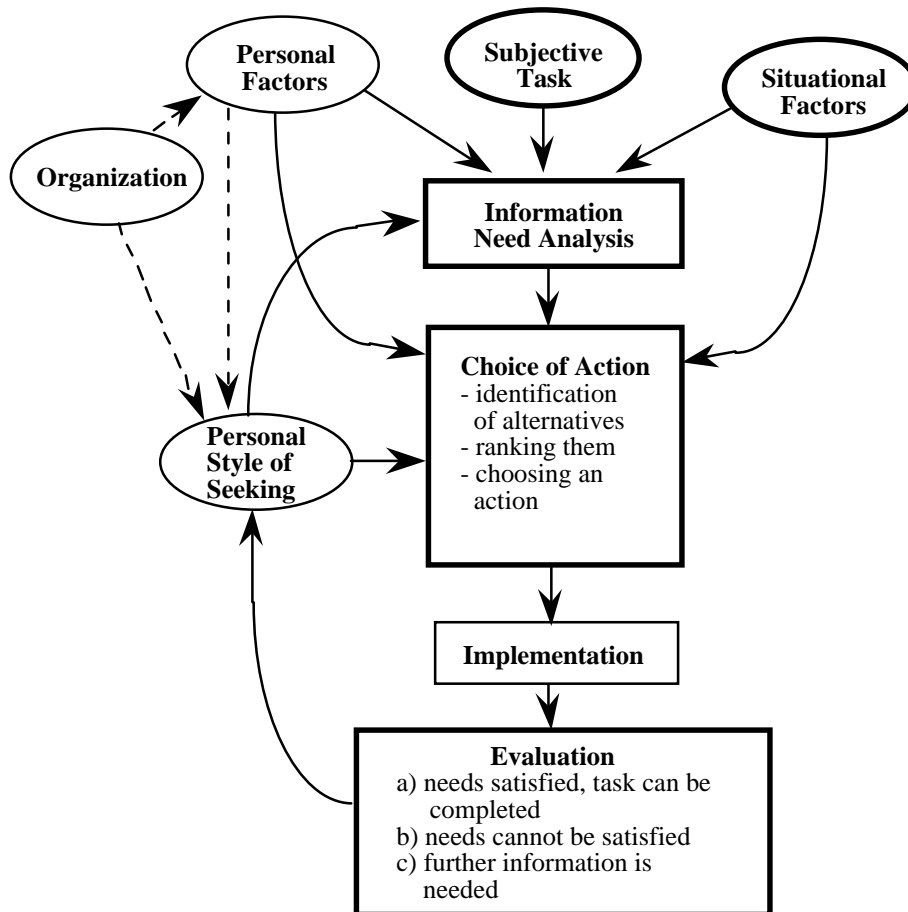


Fig. 2.2. The information seeking model

The empirical research setting was the city secretarial office of Pori (population : 76 344 on Jan 1st, 1991), Finland. The function of the city secretarial office is to prepare and implement the decisions of the city council, the city government, and some other city officials. Fourteen civil servants (here briefly workers) from the city secretarial office performing independent and information-centered work participated in the study. These workers had either a university degree or a polytechnic degree.

In this setting the *types of information sources* were classified as (1) the people concerned (e.g. people proposing, or affected by, administrative actions), (2) experts (including knowledgeable colleagues), (3) literature (e.g. books, reports, journals, newspapers), (4)

official documents (e.g. agendas, meeting minutes, letters, applications, memoranda, maps, unpublished planning documents), (5) personal collections (personal notes, calculations, etc.), (6) registers (manual and computerized catalogues and files), and (7) commercial databases.

The use of acquired information was not considered neither were the details of implementation of information seeking actions. Personal traits of workers as well as their feelings during task performance and information seeking were excluded.

3. Methodology and Data

3.1. Data Collection Methods in Information Seeking Research

Quantitative surveys based on structured questionnaires and interviews have been the most frequent data collection methods in information seeking research despite their known insufficiency and often superficial results (Brittain, 1982 ; Dervin & Nilan, 1986). Their popularity is due to their ease of use, low cost and support to quantitative analysis. Theoretical development in information seeking research in the 1980's (e.g. Dervin & Nilan, 1986) has made other data collection methods necessary. Qualitative methods are often seen as a solution but they suffer from the difficulty in generalizing the results.

Interviewing requires more effort than questionnaires but provides better possibilities for thorough analysis of information needs and seeking. Dervin (1992 ; Dervin & Dewdney, 1986) has developed an interviewing method for her sense-making approach which focuses on a person's situation, the gap preventing progress and the helps looked for. This method is promising in the support to thoroughness of analysis and generalization of result. Even this method, however, and questionnaires and interviews in general, have problems of reliability and completeness when data collection occurs long after the activities being described.

Observation allows real time data collection. Wilson and Streatfield (1977 ; 1981) used it in the INISS-project to collect data on some 6.000 communication events of social workers. They noted that observation is not well-suited to collecting data on desk-based work. In general, observation cannot produce data on thinking processes. The presence of an observer may also interfere adversely the phenomena observed.

Diaries have long, but not often, been used for data collection in information seeking research. They are kept by the participants of the study and also allow real time data collection. This enhances reliability and completeness of the data. According to Allen (1978), however, the laboriousness of diaries requires that the participants are motivated and willing to cooperate.

In general, structured data collection methods support data analysis but also entail presuppositions about the phenomena studied. This may be fatal if it leads to neglecting essential data in

data collection. Less structured methods may collect such data but require tedious interpretation on behalf of the researcher.

3.2. Data Collection

In this study, we combined questionnaires and diaries for data collection. Diaries were suited for collecting data on performance of individual tasks while questionnaires were useful tools for data on the workers studied and their organization. The diaries were semistructured so that the subjects could relatively freely describe relevant aspects of their tasks but were forced to choose among alternatives when necessary. In addition, the subjects had afterwards the opportunity to comment on their thoughts emerged during task performance.

The questionnaire elicits information on the participants (e.g. education, experience), their jobs, their attitudes toward their jobs, situational factors affecting their work, their views on the kind of information needed in their jobs, and the channels and sources providing such information. The diaries describe workers' tasks, perceived information needs, channels and sources, and actual channels and sources utilized as well as an evaluation of the information obtained. The questionnaires formed the first phase and the diaries the second phase in data collection. The questionnaire form is given in the Appendix. The diary structure, based on the model of Fig. 2.2, is given in Fig. 3.1. The users were given instructions on keeping the diaries, e.g. the terms were explained. The diary items are referred to by D1 - D8 below, and the questionnaire items by Q1 - Q7.

A task consisted of one or more work sessions which may be interrupted by breaks. Each filled-out diary form described one work session. Also work sessions were sometimes interrupted. The diaries were kept during the process, not afterwards — some of the questions were considered at the end of each work session. The participants were instructed to choose among their tasks which to describe in the diaries with the objective of describing a sample which represents the variety of their tasks as well as possible.

Altogether 94 task descriptions were collected through the diaries during a two-week period. In these descriptions, the diaries of the work session of each task were combined. Out of them, 25 were selected for qualitative analysis. This selection was performed in three steps :

1. Tasks where the role of information was too marginal, and incompletely described tasks, altogether 18, were excluded.
2. After a preliminary analysis, tasks of each worker similar to each other with respect to content and procedure were identified, and duplicate examples were eliminated. 30 tasks were eliminated.
3. Finally the tasks of all workers were pooled and the criteria of step 2 were used to eliminate additional 21 tasks. Thus 25 tasks remained for further analysis.

- DIARY** Date : Time started :
1. Describe your task in detail :
 2. Describe the situational factors affecting the task :
 3. What is the ambition level you aim at in the task : good, nearly good or satisfactory ?
 4. Describe in detail what kind of information you think you need in order to perform the task
 - (a) thoughts in the beginning of the task :
 - (b) thoughts emerged later during the task :
 5. Which channels and sources do you consider (mention also those you won't use)
 - (a) thoughts in the beginning of the task :
 - (b) thoughts emerged later during the task :
 6. How much time did you use in planning information seeking ?
 7. Which channels and sources did you use ? (Include yourself ; mention the names of any colleagues consulted ; mention channels used no matter whether or not you obtained the sources) :

Source	Why chosen	Channel	Why chosen	Success	Applicability†††††
					†††††
					†††††

Success : you got the information (a) wholly, (b) partly, (c) not at all
 Applicability : the information was (a) well-applicable, (b) partially applicable, (c) not applicable at all

8. Was the whole of the information obtained (a) sufficient for the task or (b) insufficient for the task ?
9. Estimate the time spent (a) on information seeking (b) on the whole task.

Fig. 3.1. Diary structure

Task Category	No. of workers	No. of Tasks
I	4	6
II	5	6
III	5	8
IV	3	5

Table 3.1. Number of workers supplying diaries and number of tasks per task category

Table 3.1 shows how the final 25 tasks were distributed over task categories and the number of workers supplying at least one diary in each task category. These 25 tasks were performed by altogether 10 different workers each yielding 1 - 6 diaries.

3.3. Data Analysis

The task category of each task was identified by considering the diary items D1 (task description and how it evolved between work sessions) and D4a (information needs in the beginning

of the task). The clarity, specificity, sufficiency and extent of description was judged in both cases. The items D1 provided the basis for judging the apriori determinability of task outcome and process while the items D4a provided the basis for judging the apriori determinability of the information needed. In some cases the information for D1 and D4a had to be identified under other headings in the diaries. The type of information was not considered in this phase. This was a time-consuming interpretation and classification task. None of the tasks was analyzed into the class "new, genuine decision task". Therefore there are only four task categories in the analysis below. The intra-classifier reliability (one classifier, 3 years in between) of the task classification was 0.91 (Pearson's coefficient). The inter-classifier reliability (two classifiers) was 0.75 (Pearson's coefficient). In the latter case, the 7 tasks of 25 classified inconsistently were classified into neighbouring classes.

The information needed, looked for and obtained was classified into PI, DI and PSI (items D4a & b). Because each task may belong only to one task category but may require several types of information, the tasks' information categories were extended by four classes representing combinations of the basic classes : PI&DI, PI&PSI, DI&PSI, and PI&DI&PSI. Here the intra-classifier reliability was 0.83 (percentage of agreement) and the inter-classifier reliability (two classifiers) was 0.8 for PI and DI but only 0.53 for PSI (percentage of agreement).

The channels considered and used were classified as external / internal, and the sources considered and used as external / internal as well as in the seven classes introduced in Section 2.5, i.e. (1) the people concerned (abbreviated pcon), (2) experts (exp), (3) literature (lit), (4) official documents (doc), (5) personal collections (pers), (6) registers (reg), and (7) commercial databases (db) (items D5a & b, D7). The internality of channels and sources was judged on the basis of where the channel or source was available, not where it was produced. The channel and source classifications did not require interpretation and their reliability is thus 1.0.

The basis for the situation and worker-specific factors were the items Q2-4 and D2-3. The workers' experience was classified into the classes university degree (briefly uni) and poly-technic degree (poly) (items Q4). The workers' experience was classified into the classes <5 years, 6-10 years, 11-15 years, and >15 years (items Q3a-b). There was further information collected through the questionnaires and diaries (Q5-7, D6, D8, D9). These are not analyzed explicitly below.

A process analysis method was developed by Murtonen (1992 ; 1994) for final data analysis. In this method, the sample tasks were first abstracted into *work charts* (Fig. 3.2) based on the information seeking model (Fig. 2.2). These were then combined in *process tables* (Table 3.2 a-b) for each task category.

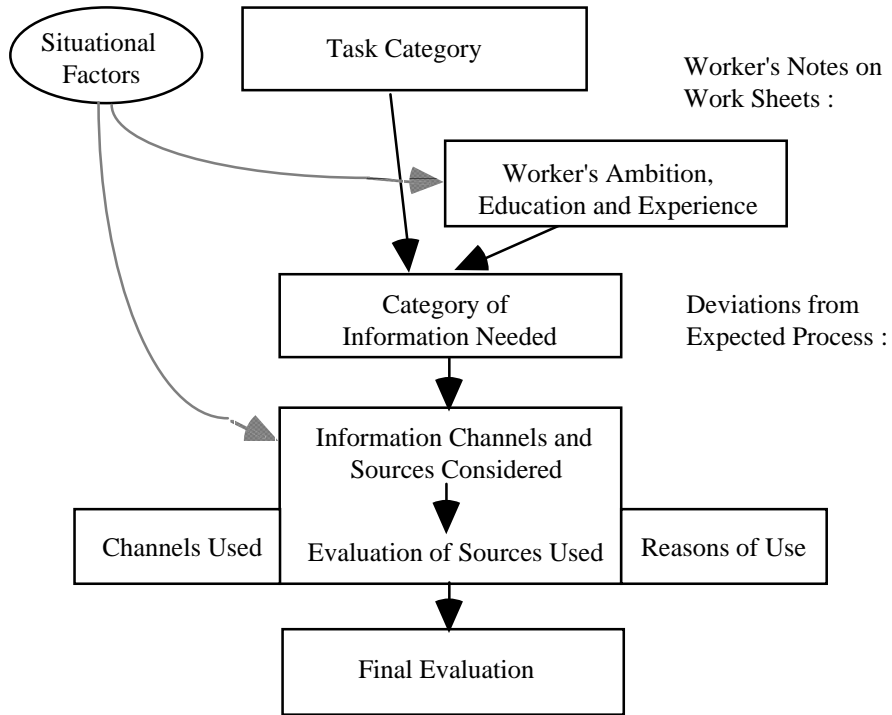


Fig. 3.2. The work chart structure

Task description : Examination of the statutes of a society

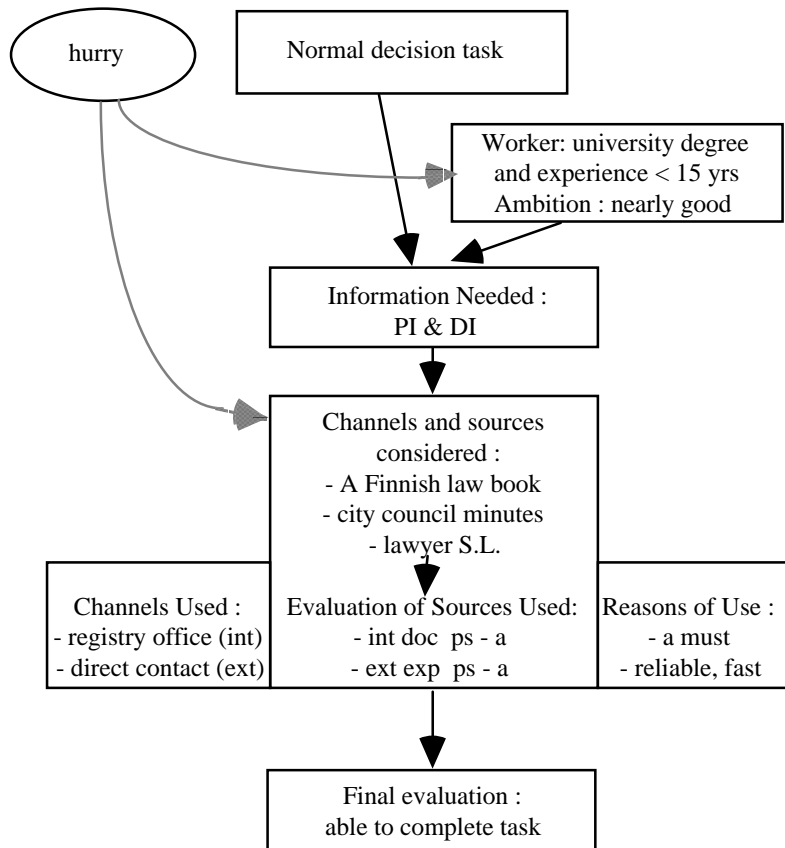


Fig. 3.3. A sample work chart

Work charts do not only allow generalization of task characteristics but also support recognition of any deviations from the expected information seeking process. A sample work chart is presented in Fig. 3.3. The task in question is a normal decision task which must be performed in hurry. The worker in this case was a lawyer (i.e. a university degree) with 12 years experience and had the ambition level "nearly good". Both problem and domain information were needed.

The worker did not consider any channels in the beginning but rather three sources : a standard Finnish law book, the city council meeting minutes and the lawyer S.L. The evaluation of channels and sources used is coded. The code "int doc ps - a" describes the search and use of the city council minutes, i.e. that an internal (official) document was used. The code "ps - a" denotes that information seeking was partially successful (ps — partial information was obtained) and that the information obtained was well-applicable (a, cf. the diary form, item D7). On the right, the reason for using this document is given as a must, and on the left the channel for this document is given as the city registry office, which is an internal channel. Similarly, the contact to the lawyer is coded as external expert yielding partial and well-applicable information. He was contacted directly due to known reliability and fast response.

The lowest box gives the final evaluation (cf. the diary form, item D8). In this case the outcome was positive, the worker was able to complete the task. The situational factor hurry may have had influence on the ambition level and the choice of sources (e.g. neglecting the law book). The workers' thoughts about the task, channels and sources which could not be fitted into the boxes of the work charts were recorded beside the work charts (cf. Fig 3.2).

3.4. Process Analysis Tables and Quantitative Indicators

In the second phase of analysis, work charts in each task category were combined in *process tables* (Table 3.2). The practical work processes (Table 3.2a) and the associated thinking processes (Table 3.2b) were considered in separate tables. The practical process tables summarized the tasks and their information seeking actions. The thinking process tables summarized the channels and sources considered and actually used, as well as any situational factors and worker's thoughts concerning the task and information seeking (as given in the diaries). The meaning of columns in the tables and their coding is easily understood by comparison with the work charts. In both process tables, different work sessions are identified by roman numbers. In the practical process tables, the items in the Channel and Source columns are adjusted so that the channel of each source is on the same line. Thus, in Table 3.2a, in the second work session of task 7 yet one more internal expert was consulted with negative results. The channels and sources considered and actually used are arranged similarly in the thinking process tables. Thus, in Table 3.2b, in task 6 a personal register was considered and used

while the Labour Office register or city departments were not used despite of being considered.

Automatic Information Processing Tasks

Task No	Ambition	Worker	Info Type	Channel	Source	Success	Reason	Evaluat.
...
5	good	poly, •10	PI	-	int reg	s - a	available	positive
6 I	good	poly, •15	PI&PSI	none	int exp	ps - pa	-	negative
				none	int pers	ps - pa		
				pcon	int reg	ps - pa		
				pcon	int doc	ps - pa		
6 II				none	int exp	ps - na		negative

Legend : The coding of the columns is as in the work charts. In the Success-column, s = successful, ps = partially successful, ns = not successful, a = applicable, pa = partially applicable, and na = not applicable. Positive in the Evaluat -column means that the worker was able to complete the task (otherwise negative).

Table 3.2a. Sample practical process table

Automatic Information Processing Tasks

Task No	Sources / Channels Considered	Sources / Channels Used	Situational Factors	Thoughts Emerged
...
5	<ul style="list-style-type: none"> • personal register • Labor Office register • Other intern branches of administration 	int reg - -	Done in hurry, but this had no effect because the register provided complete information	-
6	<ul style="list-style-type: none"> • diary • a card file 	- - int exp int pers int reg int doc int exp	Unusually unclear starting information -> extra effort in information seeking	Task depends on memory and ability to think in accord with those having dealt with the case earlier.

Legend : The coding of the columns is as in the work charts.

Table 3.2b. Sample thinking process table

The tabular form of process tables allowed comparisons across tasks in each category to identify their common as well as divergent features. Thus we were able to find out in each task category, what types of information was needed, which, and how many, sources and channels were considered and used, why they were used and with what success and effect on the tasks. We were also able to refine the findings on the basis of worker (ambition, education, experience) and situation-related factors. In Section 4, the thinking process tables are presented in a condensed form, without the columns for Situational Factors and Thoughts Emerged.

In order to support further summary analysis, several summary indicators were computed in order to identify any emerging patterns. The following indicators were computed :

- In order to characterize roughly the complexity of information needed in each task category, the *Information Complexity Index* was constructed. For it, the information category of each task was quantified as follows : PI = 1, DI = 1, PSI = 2, PI & DI = 2, PI & PSI = 3, DI & PSI = 3, and PI & DI & PSI = 4. The mean of these quantifications was then computed in each task category. This quantification is motivated as follows : PI and DI can most often be presented in the form of simple factual statements — either descriptive in the case of DI or prescriptive in the case of PI. Thus the value 1. PSI, on the contrary, is more complex and not simply factual : it is often in the form of frameworks and procedures in relation to PI and DI — thus the value 2. The quantifications for the combined classes follow in an obvious way. We have probed several quantification schemes (e.g. PI = 1, DI = 2, PSI = 4, PI & DI = 3, PI & PSI = 5, DI & PSI = 6, and PI & DI & PSI = 7). They yield different index values but always the same clear differences when considered across the task categories (see Section 5).
- The *PSI-percentage*, the percentage of tasks where PSI was needed.
- To characterize the patterns among the sources and channels supplying them, they were classified into fact-oriented (registers, databases), problem-oriented sources (people concerned, documents), and general-purpose sources (experts, literature, personal collections). The percentage shares of these classes were computed among sources considered and actually used as the indicators *Fact-oriented %*, *Problem-oriented %* and *General-purpose %*.
- To characterize information seeking successfulness, the indicators *Seeking Success Rate* and *Information Applicability Rate* were computed. For the former, source success in providing the requested information was weighted as : ns = 0, ps = 1, and s = 2. The mean of these over all sources used in each task category was calculated. The latter was similar, but information applicability was weighted as : na = 0, pa = 1, and a = 2.
- To characterize the use of channels in each task category, two indicators were used. The *Channel Rate per Seeking Action* -index indicates, how many channels were used, on the average, for each seeking action. The *Channel Internality* -index reports the percentage of internal channels among the channels used.
- To characterize the use of sources in each task category, two indices were calculated. The *Source Count per Task* -index indicates, how many sources were used, on the average, for each task. In 7 diaries some source type was indicated in plural (e.g. decisions). They were counted as three sources of this type. The *Source Internality* -index reports the percentage of internal sources among the sources used.

4. Findings

The main findings are reported below in the practical process and thinking process tables for each task category (Tables 4.1 - 4.4). We shall interpret the findings in this section and summarise the emerging patterns in Section 5.

4.1. Automatic Information Processing Tasks

In automatic information processing tasks, analyzed in Tables 4.1a and b, the level of ambition is typically high. In simple tasks there may not be much choice other than between do-well or don't-do-at-all. Almost all information needed is problem information (PI). This information is obtained in one half of the cases without any channels and almost always through internal channels. The registrar's office is a standard means to get hold of internal documents. Thus the channels are either not needed or known standard channels (see also the column Reason). Also the ultimate sources are almost always internal and either documents or registers — one to two sources are typically sufficient for each task. Information seeking is typically successful and the resulting information is well-applicable. One work session is sufficient for tasks in this category. Only task 6, which has a negative result, is an exception from the general trend. It is obvious that when dead-ends are encountered, more sources are attempted with marginally successful results. Also different strategies in the task may be tried resulting in a need of PSI.

Automatic Information Processing Tasks

Task No	Ambition	Worker	Info Type	Channel	Source	Success	Reason*	Evaluat.
1	good	uni, >15	PI	none	int db	s - pa	-	positive
2	good	poly,•15	PI	reg.office (int) int reg	int reg int doc	ps - pa s - a	indisp, fast indisp	positive
3	good	uni, >15	PI	none ext pcon	int doc ext doc	s - pa s - pa	available necessary	positive
4	good	uni, >15	PI	reg.office	int doc	s - a	-	positive
5	good	poly,<10	PI	none	int reg	s - a	availabe	positive
6 I	good	poly,•15	PI&PSI	none	int exp	ps - pa	-	negative
6 II				none int pcon int pcon none	int pers int reg int doc int exp	ps - pa ps - pa ps - pa ps - na		negative

* indisp = indispensable

Table 4.1a. The practical process table for Automatic Information Processing Tasks

Table 4.1b shows that the channels and sources considered are also used. More channels may be considered than used (cf. task 5), but additional sources become redundant if the first ones

supply the information needed. There were situational factors which may have complicated the tasks tasks 4 and 5 (hurry) and especially 2 and 6 (unclear starting information).

4.2. Normal Information Processing Tasks

The level of ambition in normal information processing tasks is also high, but exceptions are possible (Table 4.2a). The information needed is almost exclusively problem information (PI). Task 1 is an exception, but this is explained by lack of experience of the worker. The information needed is obtained almost exclusively directly, without any channels. This means that the workers know how to get hold of relevant sources. The column Reason supports this conclusion. Three or more sources are typically needed. The sources are more varied than in automatic information processing tasks. Half of the sources are internal. Half of them are also human expert sources. These seem to be flexible alternatives to direct consultation of registers and documents. Whether the experts used *their* registers, documents etc. was not recorded, but this is possible due to the information type PI needed and the division of work in public administration. Information seeking is almost always successful and yields applicable results. One work session is typically sufficient.

Automatic Information Processing Tasks

Task No	Sources and Channels		Task No	Sources and Channels	
	Considered	Used		Considered	Used
1	• "ALTIKA" -database	int db	4	none	int doc
2	• computer-diary • city government minutes	int reg int doc	5	• personal register • Labour Office register • Other intern branches of administration	int reg - -
3 *	• existing proposals →	int doc ext doc	6	• diary • a card file	- - int exp int pers int reg int doc int exp

* The arrows indicate that a set of sources of a given type were identified in the beginning.

Table 4.1b. The thinking process table for Automatic Information Processing Tasks

The channels and sources considered are also used (Table 4.2b), but novel sources are often identified (and used) during the work process more often than in automatic information processing tasks. Deficiencies in information systems may complicate tasks which are expected to be simple (task 4) where the worker complained the situation.

Normal Information Processing Tasks

Task No	Ambition	Worker	Info Type	Channel	Source	Success [#]	Reason [*]	Evaluat.
1	near good	poly,•5+	PI&DI&PSI	none none none	int pers int doc int pcon int pcon int pcon	ps - a s - a ↓ ↓ s - a	confirm	positive
2	good	uni, >15	PI	none	ext exp	s - a	known	positive
3	good	uni, >15	PI	none none int exp int exp none none	ext exp ext exp ext exp ext exp ext exp ext exp	↓ ↓ ↓ ↓ ↓ s - a	convent. convent. wg-prop wg-prop	positive
4 I	good	poly,•15	PI	none none none none	int exp int exp ext exp ext	ps - a ps - a s - a ps - a	-	negative
4 II				none none	pcon int exp	s - a		continue d
5	satisfact	poly,•15	PI	none none	int doc ext lit	s - a ps - pa	fast available	positive
6	good	poly,•10	PI	none none none none	int pers int reg int reg int doc	s - a s - a s - a s - a	↓ availab & fast & exact	positive

* confirm = to confirm ; convent = convention ; wg-prop = work-group proposal ; case hist = collected history of the case + only 3 months experience in his current job # Downward arrows denote a combined judgement for several sources

Table 4.2a. The practical process table for Normal Information Processing Tasks*Normal Information Processing Tasks*

Task No	Sources and Channels		Task No	Sources and Channels	
	Considered	Used		Considered	Used
1	<ul style="list-style-type: none"> • personal notes • a map • people concerned <ul style="list-style-type: none"> → → • address register 	int pers int doc int pcon int pcon int pcon -	4 I	<ul style="list-style-type: none"> • city personnel dept. • minutes of the occupational safety council 	int exp - int exp ext exp ext pcon int exp
			4 II	<ul style="list-style-type: none"> • occupational safety manager • minutes of the occupational safety council 	-
2	<ul style="list-style-type: none"> • personnel manager of the RR company 	ext exp	5	<ul style="list-style-type: none"> • city government minutes • a guide to educational institutes 	int doc int lit
3	<ul style="list-style-type: none"> • personnel manager of a large company 	ext exp ext exp ext exp ext exp ext exp ext exp	6	<ul style="list-style-type: none"> • personal notes • personal register • personal statistics • city government agenda 	int pers int reg int reg int doc

Table 4.2b. The thinking process table for Normal Information Processing Tasks

Normal Decision Tasks

Task No	Ambition	Worker	Info Type	Channel	Source	Success	Reason	Evaluat.
1	good	uni, •15	PI&DI&PSI	none none none none none none none	int lit int lit int exp int exp int exp int exp int exp ext exp	↓ ↓ ↓ ↓ ↓ ↓ ↓ s - pa	-	positive
2 I	satisfact	uni, >15	PI&DI&PSI PI	none	int exp	s - a	indisp	negative
2 II	good			none none none none	int lit ext pcon ext pcon ext pcon	s - a ↓ ↓ s - a		positive
3	good	poly, •5	DI	none none none none	int lit int lit int lit int pers	ps - na ps - pa ps - a ps - a	-	positive
4	satisfact	uni, •15	PI&DI	none	ext exp	s - a	-	positive
5	satisfact	poly,•15	PI	none none none none none	int doc int doc int pers int pers int exp	ps - a ps - a ps - a ps - a ps - a	indisp indisp indisp indisp necessary	positive
6	good	uni, •5	DI	none none none none none none	int lit int lit int lit int lit int exp int exp	↓ ↓ ↓ ↓ ↓ s - a	-	positive
7	near good	uni, •15	PI&DI	none none none	int doc int exp int pers	ps - a ps - a ps - a	casehist ⁺	positive
8	good	uni, •15	PI	library ⁺ int exp none	ext lit ext exp int exp	ps - a ps - a ps - a	-	positive

⁺ library = external library, case hist = collected history of the case

Table 4.3a. The practical process table for Normal Decision Tasks

4.3. Normal Decision Tasks

In normal decision tasks (Table 4.3a), the information needed is more complex than in the former categories. The need to formulate the task is reflected in the more frequent appearance of PSI among the information needed (2/8). Also DI was needed in most tasks. Most typically, at least PI & DI are needed. Note also the change of information types between the two work sessions of task 2 where also the ambition level changed as the worker has gained more confidence. What is very important is that hardly any channels are used for the information (2 channels in 35 seeking episodes) — i.e. the locations of the sources are well-known — and

almost all sources are internal (28/35). Information seeking is quite successful (although often only partially) and yields applicable information. On the average, 4-5 sources are needed per task.

In normal decision tasks, the channels and sources considered are also used (Table 4.3b), and novel sources are often identified (and used) during the work process as in normal information processing tasks. However, there is a marked difference in the type of the sources considered between these two task categories. While documents, registers and people concerned are the most frequent source type considered in normal information processing tasks, here the more general purpose sources (experts, literature) are clearly the most frequent group considered. The same pattern is seen in the sources actually used although in both task categories the more general purpose sources (experts, literature) are the most frequent group (12/23 vs. 25/35). Only a few situational factors were present in the data (hurry in tasks 2, 7, 8 and interruptions in task 6) which may have reduced the level of ambition.

Normal Decision Tasks

Task No	Sources and Channels		Task No	Sources and Channels	
	Considered	Used		Considered	Used
1	<ul style="list-style-type: none"> • literature • documents • experts → → → → →	int lit int lit - int exp int exp int exp int exp ext exp	5	<ul style="list-style-type: none"> • documents • employment decisions • personal calculation • personal notes • a colleague • other branches of city administration 	int doc int doc int pers int pers int exp -
2 I	<ul style="list-style-type: none"> • municipality directors 	- int exp int lit	6	<ul style="list-style-type: none"> • literature 	int lit int lit int lit int lit int exp int exp
2 II	<ul style="list-style-type: none"> • municipality directors → →	ext pcon ext pcon ext pcon			
3	<ul style="list-style-type: none"> • personal seminar speeches • journals 	int lit int lit int lit int pers	7	<ul style="list-style-type: none"> • earlier plans & population forecasts 	int doc int exp int pers
4	<ul style="list-style-type: none"> • expert • literature 	ext exp -	8	<ul style="list-style-type: none"> • library • expert A • expert B 	ext lit ext exp int exp

Table 4.3b. The thinking process table for Normal Decision Tasks

4.4. Known, Genuine Decision Tasks

In known, genuine decision tasks (Table 4.4a), the ambition level is high (good or nearly good). Due to task complexity, a lower level could be expected. However the workers are all highly educated and experienced. This makes the self-reported ambitions more reasonable. Task complexity is reflected clearly in the information types needed. PSI is needed in three of the five tasks in this category. Note also that highly educated and experienced workers possess themselves lots of PSI. Again, typically no channels are used to locate the mostly human sources (14/20 experts). Three experts and additional sources are typically needed for the tasks. A vast majority of the sources are internal. They are only partially successful in providing the information needed and provided only partially applicable information. This is also compatible with task complexity.

Known, Genuine Decision Tasks

Task No	Ambition	Worker	Info Type	Channel	Source	Success	Reason	Evaluat.
1	good	uni, •15	PI&DI&PSI	none none none none	int lit int exp int exp int exp	s - a s - a s - a s - a	-	positive
2	near good	uni, •15	PI&DI&PSI	library library library none none none	ext lit ext lit ext lit int exp int exp int exp	↓ ↓ ps - pa ↓ ↓ ps - pa	-	negative
3	good	uni, >15	PI&DI	none	int exp	s - a	necessary	positive
4	near good	uni, •15	PI&DI&PSI	int. office none none none	int doc int exp int exp int exp	ps - a ps - a ps - a ps - a	-	positive
5	good	uni, •15	PI&DI	none ext pcon ext pcon ext pcon ext pcon	int pers ext exp ext exp ext exp ext exp	ps - pa ps - pa ps - pa ps - pa ps - pa	-	negative

Table 4.4a. The practical process table for Known, Genuine Decision Tasks

In known, genuine decision tasks, the match between the sources considered and actually used is similar as in the preceding task category (Table 4.4b). That is, some sources considered are not used, and new sources are identified on the way. The main difference between this and the preceding task category is in the type of the sources. In known, genuine decision tasks the sources considered and used are even more concentrated in the expert and literature source types (use : 18/20 vs. 25/35 in the previous category). Situational factors are present (hurry in tasks 1, 2 and 5) but no clear effects can be recognized in the data. For example, experts are used heavily, no matter whether or not the task is done in hurry.

Known, Genuine Decision Tasks

Task No	Sources and Channels		Task No	Sources and Channels	
	Considered	Used		Considered	Used
1	<ul style="list-style-type: none"> • literature • experts <p style="text-align: right;">→ →</p>	<ul style="list-style-type: none"> int lit int exp int exp int exp 	4	<ul style="list-style-type: none"> • documents • experts <p style="text-align: right;">→ →</p>	<ul style="list-style-type: none"> int doc int exp int exp int exp
2*	<ul style="list-style-type: none"> • library : earlier plans • libr : nation-wide plans • libr : future scenarios • work group opinion <p style="text-align: right;">→ → →</p>	<ul style="list-style-type: none"> ext lit ext lit ext lit int exp int exp int exp 	5*	<ul style="list-style-type: none"> • universities • research institutes <p style="text-align: right;">→ →</p> <ul style="list-style-type: none"> • library 	<ul style="list-style-type: none"> int pers ext exp ext exp ext exp ext exp -
3	<ul style="list-style-type: none"> • expert • documents 	<ul style="list-style-type: none"> int exp - 			

Table 4.4b. The thinking process table for Known, Genuine Decision Tasks**5. Discussion**

Our data sample, 25 qualitatively selected tasks, allows qualitative analysis and supports development of novel analysis methods like our process analysis method relating task complexity and information seeking. It also allows testing of quantitative indicators for working with larger data and provides suggestive quantitative evidence on the relationships of task complexity and information seeking. Although the data do not allow testing for statistical significance, almost all quantitative indicators are systematically and logically related to task complexity. The main findings of Section 4 are summarized statistically in Table 5.1.

The three information category indicators show invariably, that as the tasks grow more complicated, also their information needs become more complicated. The variety of information increases, the share of PSI increases and the values of the information complexity index increase from task category I to category IV.

The orientations of channels and sources considered also give systematic trends. The share of general-purpose sources and channels considered increases markedly from task category I to IV, and the share of fact-oriented sources and channels considered decrease equally markedly. The former is related to increased needs for PSI and digested information and the latter to problem solving based on digests and vision rather than hard facts in the higher task categories. The behaviour of the problem-oriented sources, supplying mainly PI, fits this picture : in the simplest cases hard (PI) facts are needed most whereas problem-oriented channels and sources become critical in the middle categories due to case-based discretion. The fall of problem-oriented channels and sources in complex tasks is due to efforts in problem structuring and understanding — a few qualitative digests of PI may be sufficient.

The concentration of fact-oriented sources and channels in the simplest tasks is logical, because facts lend themselves most easily to rule-based processing. The orientations of sources actually used support exactly the same conclusions.

Task Property	Task Category			
	I	II	III	IV
Information Category Indicators				
• Typical Information Needed	PI	PI	PI&DI	PI&DI&PSI
• Information Complexity Index	1.33	1.5	2.0	3.2
• PSI %	17	17	25	60
Orientations of Channels & Sources Considered				
• General-purpose %	19	54	77	91
• Problem-oriented %	37	35	23	9
• Fact-oriented %	44	11	0	0
Orientations of Sources Used				
• General-purpose %	25	61	83	95
• Problem-oriented %	42	30	17	5
• Fact-oriented %	33	9	0	0
Seeking Success				
• Seeking Success Rate	1.5	1.78	1.57	1.25
• Information Applicability Rate	1.17	1.96	1.67	1.45
Channel Related ...				
• Channel Rate per Seeking Action	0.5	0.09	0.06	0.4
• Channel Internality *	83	(100)	(50)	13
Source Related ...				
• Source Count per Task	2.0	3.8	4.4	4.0
• Source Internality	92	57	80	65
• Typical Sources	doc & reg	exp	exp & lit	exp

* The figures in parentheses are based on two channels each

Table 5.1. Statistical summary of main information seeking patterns in the data

The indicators of successfulness of information seeking actions give a downward trend (i.e. less success) toward the higher task categories after the increase between the first two categories. It is understandable that finding applicable information is more difficult in complex situations. In them, the need is often unclear and the information obtained should be fitted to the task situation and this takes effort. It is also generally known that this is a major cause for neglecting research-based information in decision-making. That the applicability index in category IV is not lower may be due to worker's unclear needs which result in welcoming much of what is found in trying to understand and formulate the task. The peak of

applicability at task category II may be explained by little data and the occasion of the dead-end task (No. 6) in category I : without it, the seeking success rate in category I would be 1.86 and applicability rate 1.43.

The channel rate index exhibits low channel use in the middle task categories. A possible explanation is as follows : In simple tasks the channels are well-formed and well-known, and therefore used. In the middle range-tasks this is not the case but the sources are well-known and obvious. Thus no channels are needed. Finally, in complex tasks, no obvious sources exist so general-purpose channels must be exploited. The index also reveals that little use is made of channels : information is most often located without any channels and channel use is low even in complex tasks. The second index is based on little data especially in the middle range of task categories. The figures for categories I and IV are as expected, i.e. in simple tasks internal channels are sufficient whereas in complex tasks external channels must be used.

It is not surprising that the number of sources consulted increases toward the complex task categories (cf. e.g. Tiarniyu, 1992). With the exception of task category II, the source internality index decreases from task category I to IV. The low in category II is due to one task requiring 6 external experts. The rise of the share of external sources toward high task complexity categories is as expected (Allen, 1978). However, the source internality index values are throughout rather high, especially in the high complexity categories. This finding is counter to common expectations (e.g. Tiarniyu, 1992). It is particularly interesting because the diaries providing our data were written during task performance — they are not opinions based on hind-sight and should therefore be more valid than ex post facto opinions. However, administrative workers tend to use internal sources (Tiarniyu, 1992 ; Wilson, 1988). It is also possible that high source internality depends also on factors we have not explicitly considered, e.g. the size of the organization (Fischer, 1979), planning-type tasks rather than research or management type tasks (Allen, 1978 ; Rosenbloom & Wolek, 1967) or source accessibility (Cyert & March, 1963 ; Culnan, 1983 ; Hardy, 1982 ; O'Reilly, 1982). Internal sources tend to be better accessible. Culnan (1983) pointed out that task complexity increases the use of less accessible (often external) sources.

The typical source types in task category I are administrative documents and registers whereas in category IV they are experts and literature. This is in line with the findings by Tiarniyu (1992) and Daft *et al.* (1988). The latter reported that oral sources are preferred in unclear situations which correspond to our task category IV.

By comparing the task categories I and IV one may generalize that in simple tasks simple information (typically PI) is needed and it is obtained from problem and fact-oriented sources (typically administrative documents and registers) residing almost totally within the organization. Information seeking is quite successful from well-known sources and the resulting infor-

mation is moderately applicable. On the contrary, in complex tasks complex information (typically PSI) is needed and it is obtained almost totally from general-purpose sources (typically experts and literature) residing often within the organization. Information seeking is partially successful and the resulting information is quite applicable. This contrast between the categories underlines the importance and consequences of task complexity : in complex tasks understanding and problem formulation are essential and require different types and more complex of information through somewhat different types of channels from different types of sources.

In general, Tiamiyu's findings (1992) on the number and type of sources used in tasks of varying complexity, degree of discretion and duration are compatible with our results. There is, however, difficulty in comparing the findings : although Tiamiyu has considered tasks of different complexity it is difficult to judge how they relate to our complexity categories because whole jobs instead of individual tasks are considered. This difficulty is increased by his choice to focus on his respondents' major work activities (those performed most often). Frequent activities are not likely to belong to high complexity categories in our task categorisation because their outcomes, inputs and processes tend to be known the better the more frequent they are.

We consider Kuhlthau's (1991) findings and arguments on the affective dimension in task performance, information seeking and use convincing. Although we did not study this dimension, there are some indications in the data on its influence. For example, the dead-ends in tasks I.6 and II.4 (category.task-number) led to many information seeking actions with probable anxiety. Also the change of level of ambition and type of information needed in task III.2 reflects a gain in the worker's confidence. However, Kuhlthau's findings are based on imposed assignments in a library context. In particular, we presume that the tasks assigned were all relatively similar and of about the same, quite high complexity level (e.g. normal decision tasks or known, genuine decision tasks). In complex tasks there always is a problem formulation step followed the problem solving step whereas in simple tasks only the latter step is present. We hypothesize that, due to these differences, the affective dimension is often not as marked in simple tasks as in complex tasks and that it influences simple tasks only indirectly (cf. Locke *et al.*, 1981 ; Huber, 1985). For example, feelings like lack of motivation, being angry, etc. might have an overall effect on performance and not form an integral part of the process itself in simple tasks. In particular, in simple tasks anxiety is not likely to arise from the tasks themselves but might rather be due to situational factors.

Saunders and Jones (1990) developed a general model relating information acquisition to complex organizational decision-making processes. The model is based on contextual, information acquisition and decisional components and suggests that the selection of information source and medium at a particular point in time is affected by the various phases

and associated routines comprising decision processes as well as many contextual factors. Saunders and Jones derived six propositions from the model focusing on the use of media and sources. Our data relate only to recognized decisions, not directed or undirected viewing ; moreover, we have analyzed only single tasks, not simultaneous working on several tasks ; further, our diaries do not track the use of sources in defined phases of decision processes. While Saunders and Jones consider complex decision-making, we have analyzed information seeking in simple to complex tasks. Therefore our data cannot be used either to support or to refute the Saunder-Jones propositions. However, we think that the Saunders' and Jones' view that particular sources and media are more appropriate at different points in the decision process is well-founded. It matches our view that particular sources and media are more appropriate at tasks of different complexity because they supply different types of information. We think that information, source, media and task categorization deserve further detailed attention in studies relating decision-making and information seeking.

The methods employed in this study were qualitative and time-consuming on behalf of both the participants (workers) and the researchers and required motivated participants — a usual problem in qualitative study methodologies (cf. Allen, 1978). The participants need to be well-informed about the purpose and structure of diaries and the concepts employed in the diary forms. However, this approach is very beneficial when the validity of the data is considered. The diaries were written when the tasks were actually performed. Therefore the likelihood of forgetting or neglecting pieces of information needed, information seeking actions taken or the usefulness of various sources consulted is much less than in survey-based approaches.

The process analysis method developed for diary data analysis allows examination of relationships between task complexity, the types of information needed, the number and types of sources and channels considered and used, as well as reasons, successfulness and effects of their use. The analyses can be done at the level of individual tasks which is necessary if the effects of task complexity on information seeking are to be identified. The analyses can also be refined on the basis of worker and situation -related factors. We shall utilize this method and develop it further in subsequent studies on information seeking and use with larger samples in various contexts.

6. Conclusions

We have developed a qualitative method for task-level analysis of the effects of task complexity on information seeking and found in a public administration context that these effects are systematic and logical. As task complexity increases, so

- the complexity of information needed increases,
- the needs for domain information and problem solving information increase,

- the share of general-purpose sources increase and that of problem and fact-oriented sources decrease,
- the successfulness of information seeking decreases,
- the internality of channels decrease, and
- the number of sources increase.

The contrast between simple vs. complex tasks underlines the importance and consequences of task complexity : in the latter understanding, sense-making and problem formulation are essential and require different types and more complex of information through somewhat different types of channels from different types of sources. The other findings include that, in general, very few channels are used to locate the sources used in all task complexity categories. The internality/externality dimension of sources indicates a large share of internal sources even in complex tasks. Our findings suggest that both the task complexity and the information type -dimensions are indispensable to an holistic general model of information seeking and use. They also suggest that it would be useful to explore the task complexity concept and its dimensions more thoroughly (e.g. Campbell, 1988 ; Wood, 1986). Moreover, our methods and findings should be valuable in charting the information seeking actions in organizations in order to provide a sound basis for information management.

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Appendix : The Questionnaire Form

The questions are open-ended

1. Name :
2. Job title :
3. (a) Length of experience in this job :
(b) Length of experience in similar jobs :
4. Education :
5. What kind of information do you need in your job in general ?
6. What kinds of information channels and sources do you have at your disposal.
Please, tick those you use regularly. Explain reasons of use or non-use.
7. What kinds of situational factors affect your work, in general ?