ABSTRACT

A NOVELL APPROACH TOWARDS USABILITY STUDIES FOR VISUAL SEARCH TASKS IN GRAPHICAL USER INTERFACE APPLICATIONS USING THE ACTIVITY THEORY APPROACH

by
Tirthankar Sengupta

The field of Human Computer Interaction still strives for a generalized model of visual search tasks (icon search, menu search, text search, label search, search through hypertext and feature recognition). The existing models of visual search, in spite of being impressive, are limited under certain perspectives due to lack of generality. The thesis tries to provide a holistic approach for the modeling of visual search tasks in graphical user interfaces from the Activity Theory (AT) perspective with the aim of rendering a theoretical bridge between HCI and Psychology. A detailed review of literature from the variegated discipline contributing to the study of Visual Search revealed the presence of gray areas, which can be partially addressed by the Activity Theory approach. The case study uses thinking aloud Protocol Analysis technique for analyzing the complex interaction of behavior, cognition and motor action, which manifest in these tasks. The results have been analyzed and possible modifications have been identified. Interestingly, it is observed that Activity Theory can provide substantial theoretical support to aid Usability Testing Techniques.

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A thesis
Submitted to the Faculty of
New Jersey Institute of Technology
In Partial Fulfillment of the Requirements for the Degree of
Master of Science in Industrial Engineering

Department of Industrial and Manufacturing Engineering

May 2001

APPROVAL PAGE

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To my beloved parents

ACKNOWLEDGEMENT

I would like to thank my advisor Dr. One-Jang Jeng for his constant support and guidance to identify the research area and explaining the intricacies involved. At every stage you have asked me the right questions and provided the correct tips for improvement. I further express my gratitude for the financial support you provided without which I would not have been at the position where I am at present.

I am grateful to Dr. Gregory Bedny for his guidance. Without your guidance getting a grasp on Activity Theory would have been impossible. You almost built my theoretical foundation for the subject. This thesis would have been incomplete without you.

Thank you Dr. Bladikas for your support in all aspects and solving my problems whether it being academic or administrative.

Thanks to Graduate Studies for their continuous financial support and guidance. Thanks to the Department of Industrial Engineering for support in the form of Graduate Assistantship.

Thank you to all my Professors in the Industrial Engineering department for their advice in my general intellectual growth.

Thank you to my parents for their continuous support and encouragement. Thanks to Satya Vallepalli for his continuous insights regarding human computer interactions and usability testing. Thanks to Ivan Siguencia, Laticia and Vatsal Sheth for their help in setting up the experiment and conducting the protocol analysis.

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CHAPTER 1

INTRODUCTION

Graphical User Interface (GUI) has been the most pervasive among all the interfaces that have been developed for the users to communicate with computing machines as well as other similar systems. To mention a few areas of application, GUI exists in software development, financial functions, day-to-day operations in organizations, educational, medical and defense applications. The previous decade witnessed the proliferation of graphical user interface in terms of hypermedia and advanced graphics. The Internet has been the most frequent place for observing innovations in this field.

1.1 Background

In general, most of the communication in a Graphical User Interface (GUI) takes place through the eye as a medium of input to the user and motor and cognitive actions as a medium of input from the user. This demand of the GUI has necessitated the use of visual search processes as a primary cognitive overload on most of the users. GUIs, which assist these cognitive functions of the users' interaction, are better and have substantial place in the market. User centered design is the only key to offer usable and useful software to the myriad of the user community ranging from novice to expert users. Even then we see failures in software, websites, wireless devices due to lack of User Centered Design. Is it due to lack of research or due to exclusion of certain variables that we are facing this discrepancy?

One of the most prominent among these variables is the environment in which the user is working. Environmental variables may affect the users' needs. Users interact with a certain objective, and these objectives might change under different conditions thereby rendering the particular interface unsuitable for use. Design principles can be introduced to cater to these external influences. A proper study of the user population and their subsequent possible activities can give us the different tasks, which a user might require of the system. The cognitive approach to the design of the GUI fails to address these needs as the GUI gets designed from only the point of view of the user under information processing perspective. Taking the example of the web enabled cell phones most of the users find it difficult to undergo certain tasks due to lack of interface design.

The objective is to investigate whether the available guidelines do address these issues or are somewhat limited from catering the user interface professionals. The exclusion of behavior in the study of human computer interactions limits cognitive psychology from addressing these issues when a combination of these processes is in operation.

However, the prominent field, which can contribute substantially to the study of visual search task, is Activity Theory. Activity Theory, developed in Soviet Union from the 1930's, has evolved to a strong psychological theory and has already been effectively involved in the design of Human Computer Interfaces. One basic principle is the unity of cognition and behavior, introduced by Rubinshtein (1959)-the first scientist who paid attention on interdependence of internal cognitive and external behavior. He introduced one of the basic principles of activity- “unity of cognition and behavior”. This unique approach can explain why Activity Theory always pays lot of attention to eye movements during the performance of perceptual and thinking task (problem solving). The first psychologist, who introduced method of registration of eye movement to the field of visual search, was Yarbus (1965). He proved that eye movements play essential role in the formation of visual image. Later Pushkin (1978), Tikhomirov (1984) and others demonstrated the importance of eye movements not only in visual search task but also in problem solving and thinking tasks. Research was also done in the US to address issues regarding the influence of eye movements on cognitive processes.

Activity Theory embraces cognitive Psychology but as a subset of the processes involved in the tasks that conjure up to complex object oriented, goal oriented tasks involved in HCI. The thesis identifies the prospect of Activity Theory in generating novel models for HCI related tasks such as the visual search, where not only cognitive and motor processes will be involved but also the unconscious nature of interaction can be predicted, thereby giving an exact measure of the cognitive complexity involved.

1.2 Objective

The objective of this thesis is to establish Activity theory as a prime theoretical lens in the study of HCI. Studies have already been done in this regard and empirical validation has been provided thereafter, with positive results.

However, Activity theory has been successful in addressing a superficial level of implementation due to its theoretical approach. This thesis introduces the analytical approach to the micro-structural analysis of the HCI tasks and identifies components from the point of view of economy of time, motion and effort. The functional analysis approach is an efficient tool in determining the various components in a particular HCI task. The basic aim is to address the empirical results and the heuristics developed thereafter, so that Usability Testing gets the theoretical backup, which it has been lacking.

CHAPTER 2

LITERATURE SURVEY

The past two decades witnessed immense study in the Visual Search tasks with respect to computing interfaces. Models have been proposed for understanding the cognitive, perceptual and motor skills required for the different visual search tasks for user involved in interaction with computing interfaces. Based on the research in different areas of cognitive psychology, models have been proposed for identifying the Human Computer Interaction parameters. HCI research received a major uplift with the seminal work of Card, Moran and Newell with their historical GOMS model and the later modifications that followed. Design guidelines have been proposed by lot of researchers for efficient Visual Search task performance in GUI environments (Smith and Mosier, 1986; Tufte, 1993; Shneiderman, 1998) and experimenters have come up with experimental data to validate these principles.

This triggered the use of design approaches, which tried replacing the user for the enticing economy of the method. Our knowledge of understanding of these processes in the HCI context, however, suffers some limitations. Before discussing these constraints, it is customary to chart the chronology of research in visual search from the three prominent fields- Cognitive Psychology, Eye Movement and Human Factors.

The high level theories of HCI thus developed and then empirically validated are discussed with a section on Usability Testing methods. This is because HCI models are developed for providing theoretical substitutes of user testing of systems. The literature review will elaborate the findings from these fields and then discuss the limitation of the results of these researches in terms of addressing important issues pertaining to user interface design and usability testing.

2.1 Visual Search

The initiation of the scientific study of search commenced during the World War II (Smith, 1985). Koopman did the first scientific study of search for a naval document. Study of search involving menu selection and interfaces was done by Card (1982,1983), who proposed various mathematical models for computer based menu selection. Study of search involving icons on the interface was reported by studying eye movements during Visual Search Task performance. This was also widely used in cognitive psychology (Kieras, Meyer, 1997; Hornof, 1999).

However, these studies consider cognitive and motor activity in separately and sequentially. Over the past two decades there has been a lot of research to formulate visual search models for improving human machine interactions. Cognitive psychology has proposed models involving the perceptual, motor and cognitive processes involved in the visual search tasks. Studies have also been done on eye movement registration for identifying the strategies used by users while performing search. On the other hand Human Factors studied different industrial situations to come out with effective data as an input to the different search strategies used by a subject. The contributions from each of these fields are discussed in detail in the following sections.

2.1.1 Visual Search in Cognitive Psychology:

A phenomenal number of empirical studies (cf. Brogan, Gale & Carr, 1993) have attempted at investigating the cognitive processes involved in visual search The standard method of designing the task for subjects in visual search experiments is to state whether or not a display contains an item of interest, which differs from the others with respect to a identificative feature such as color or shape (feature search) or color and shape (conjunctive search).

Basic studies deal with the data that represent error rates and, more importantly, reaction times—the times subjects typically take to respond "yes" when a target is present or "no" when it is absent (the classical information processing approach). In general searches of visual displays are held to embrace an ensemble of perceptive processes which expose parallel as well as serial characteristics and which involve dynamic shifts of attention (Pomplun *et.al.*). The key observation is that with feature search, reaction time is usually independent of the size of the item set while with conjunctive search, reaction time increases linearly with the number of distracters in the visual field.

This pattern of findings has been taken as suggesting two modes of visual processing which correspond to consecutive stages: an initial, pre-attentive stage during which many items are analyzed in parallel with respect to only few specific features, and a subsequent stage during which the set of items is analyzed sequentially with respect to feature combinations. The relevant theories are the "feature inhibition theory" (Treisman & Sato, 1990), which maintains that during early processing likely distracter items are eliminated from the search set by means of inhibition based on the analysis of single features, and the "guided search model" (Wolfe & Cave, 1989), which claims that during early processing, a likely target region or likely target items are activated a priori on the basis of feature similarity.

Yet another theory emphasizes the role of perceptual grouping in visual search. Following Pashler (1987), who suggests that conjunctive search proceeds on a cluster-by-cluster basis, processing within clusters of items being exhaustive and parallel but processing between clusters being sequential, this approach maintains that visual search is guided by the global similarities that hold within the item set.

Of these there a three models, which stand out as they have empirically provided results for most of the inferences from the host of experiments that have been undertaken. These are

The Simple Search Model by Neisser's (1963)

This model assumes that people search for the target item in a serial fashion and terminate the search as soon as the item is detected. Therefore the model predicts the increase in response times as the number of items in the list increases.

The Feature Integration Theory by Treisman (1986)

This theory addresses the pre attentive visual processing is placed in the working memory and is available to the search strategy. Thus it asserts that initially there will be a parallel search in which specific identifiable features preprocessed in the human memory will be used for quick detection. This will then be followed by a serial search provided there is a failure in detecting the target item in the initial search.

<u>The Guided Search Model by Cave and Wolfe (1990)</u>

This model adds to the Treisman's theory with the fact that the target item will contain an activation score. Depending upon the activation score computed the search strategy will take place. This activation score is computed very early in the parallel processing stage and then these items are serially searched in order of their activation scores.

There has been a lot of study for search strategies of different interface elements. However these studies have addressed only elements in separation. To elaborate, these studies have either dealt with menus or hierarchies of menus, icons or groups of icons. Research needs to be done in terms of the interface itself in a holistic perspective, which consists of a combination of these elements and how the interaction and relation between these elements affect search strategies under different work situations. This study tries to explore the methods offered by activity theory to study the combined search strategies and task completion strategies by individuals in front of the computer interface.

2.1.2 Visual Search in Human Factors

Human Factors is an established field in the study of man machine interactions. Human Factors has its roots from the Second World War when some of the air force pilots were unable to operate the aircrafts due to improper addressing of the display properties and thus were victims of fatal outcomes. The field of

Human factors has been applied to a host of disciplines from industrial design, medical equipment design, nuclear reactors and every conceivable system where human element plays a crucial role in its operation. Computing interface is no exception.

The formal introduction of Human Factors to the field of computers is credited to Ben Shneiderman. Donald Norman had previously structured the high level theories for interface design from classical experimental psychology and redefined Human Computer Interaction. After these studies, the field of HCI has identified Human Factors and psychology as the key approach to the study and design of these interfaces. Contributions, in terms of data and the theories based on them, came in from variegated fields of Industrial inspection, defense, aviation and a host of other application areas.

Complex models of visual search have addressed motor and cognitive processes involved in a gamut of activities. These models have conclusively proved that better research into fields like visual search, auditory search can lead to usable and useful interfaces. The Display Analysis Program developed by Tullis (1988) provided some basic predictions regarding the time involved. However, it did not account for the underlying processes involved. The system developed by Lohse (1993)— Understanding Cognitive Information Engineering went a further step ahead by predicting the time required for the basic cognitive, perceptual and motor processes involved in the tasks. However the system had the limitation of addressing only eye fixations and movements involved in search of graphs, tables and charts.

Sears (1993) developed a system known as the link analysis program which involved a Human factors technique in Industrial Engineering whereby the different search items were linked under certain specific tasks and the search times were calculated to figure out the optimum search time involved. Study of visual search in industrial inspection by Drury (1990) and others provide significant findings for modeling of visual search under different conditions of stimulus, nature of work and work setting (paced, un-paced and self paced). Human factors of display devices have contributed substantially to the field of visual search.

2.1.3 Visual Search in Eye Movement Research

Eye movement research involved areas such as foveae fixations, concentration of rods and cone cells and the use of eye tracking devices to observe the eye movements and thereby, somewhat neglected the cognition component involved in the processes.

More recently, several studies have gone beyond reaction time measurement. They have analyzed eye movements in visual search, with results that corroborate the guided search model. Also, some current models of visual search are based on oculomotor data, rather than on reaction times (e.g., Rao & Ballard, 1995). These and other studies demonstrate that eye-movement measurement is eminently suited for investigating visual perception. Making eye movements while viewing a scene is absolutely natural.

Eye-movement measurement has major advantages over reaction time measurement. First, eye-tracking systems yield information not only about the duration but also about the time course of search. Second, researchers are able to analyze the subjects' trajectory of gaze and hence have access to spatial data rather than only resorting to temporal detail. Third, due to the abundance of spatio-temporal data empirical validation and more precise modeling can be achieved using eye movement studies. After all, eye movements may be an even more direct overt manifestation of cognitive processes in vision than are latencies.

Low-level factors such as item size or item density as well as high-level factors such as item gestalt or item function influence both the length of saccades and the duration of fixations (Rayner, 1998). According to findings in reading research (Just & Carpenter, 1987), the total fixation time spent on any single item or item cluster can generally be considered a valid measure of the processing time for that particular object.

Despite the promising results of eye-movement recording in visual search, relying solely on the standard visual search paradigm can trigger unnecessary and inappropriate limitations for complete research endeavor. Standard visual search tasks usually require only a small number of eye movements; large parts of the display can be processed within a single fixation. Therefore, gaze trajectories yield only coarse information about a subject's strategy to find the target. It is virtually impossible, for instance, to test the hypothesized distinction between two successive stages in visual search on the basis of eye movements alone. Moreover, not all of the important components of visual perception are involved in a standard visual search task. Perhaps the most important element that is neglected is memory, behavior and working conditions both physical and psychological. In visual search, people have to keep in memory some representation of a particular object in order to be able to identify the target item among non-target items.

The standard visual search paradigm thus mirrors a situation in which somebody is looking for a well-known object. The memory structures that are relevant in such situations must include information about the designated target object and its features, experience and information about the actual scene. Unfortunately, the standard visual search paradigm is not particularly well suited to deepen our understanding of the role of memory in visual perception since the designated target is hardly ever systematically varied within experiments. In everyday life there are other—not necessarily less common—situations that require purposeful search.

A common example of the kind of visual search addressed here is the "original and fake" kind of picture-picture comparisons occasionally found in magazines. Such matching tasks resemble many real-world situations that arise from a discrepancy between an actual state and a target state. Construction, for instance, requires that the current situation continually be compared to (and adjusted according to) the goal. While the standard visual search task requires the viewer to hold in mind a representation of a single target item, a matching task requires the viewer to keep two structured sets of items in memory at once.

Consequently, the representations that are functionally relevant in matching tasks are rather complex since both the actual and the target scenes have to be memorized for comparison.

The review would be incomplete without a brief explanation of the physiological processes that occur during visual search phenomenon. The visual environment is an enormously rich source of information. Any approach to understanding visual perception must recognize that only a small part of this potential information is actually used. The visual axis of the eye is directed to a series of locations in the visual field, resulting in a continually changing sequence of images falling on the fovea. This sequence is the main, although not the only, way in which visual input is selected for cognitive visual tasks.

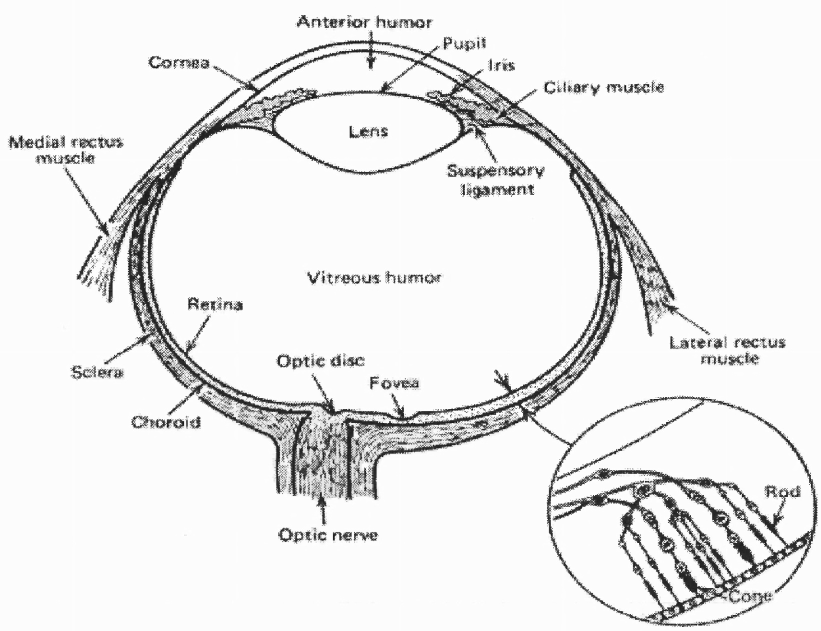

Figure 2.1 Structure of the Human Eye

Active saccadic scanning is a fundamental feature of vision. It is not so much dependent on the organization of the occulomotor system as upon the organization of the visual system. Saccades are necessitated by the rapid decline in resolution away from the fovea. Thus we can see that both Eye movement and Cognitive psychology research had its own limitations in terms of conclusively explaining the phenomenon of Visual Search Tasks. Research attempts were then involved in the process of developing models, which could cater to all the observed phenomena in visual search tasks. Researchers have developed models, which had automated techniques for predicting visual search tasks in computing interfaces.

2.1.4 Cognitive Modeling of Visual Search tasks

Cognitive Modeling represents the latest approach to research in the field of Human Computer Interaction. Two types of Cognitive Modeling – one involving the use GOMS analysis techniques and the other by using cognitive architecture were proposed. The first involved GOMS (Card, *et. al.*1983) analysis techniques, such as the GLEAN. The next one was developed at the University of Michigan by David Kieras and Meyer known as the Executive Process Interactive Control (EPIC). EPIC specifically possesses a better model, Hornof (1999), for providing a more or less complete picture of the general visual search task and accounted for all the processes and also the eye movements involved in Visual Search tasks.

2.2 Human Computer Interaction

This field has been gaining popularity in the past decade and its implementation has been widespread in the areas of graphical user interface design, information visualization and recent spate of integrated devices which include cell phones, palm pilots, hand held pcs, digital assistants- the list is growing.

Human Computer interaction resides on certain fundamental principles. The thesis only deals with aspects where the end user is interacting with the product through an interface. Other forms of human computer interaction include end-user programming, code structuring, programming styles, which have a direct influence on the performance of the operator. However this study only addresses the user interface design principles that have been derived from high-level theories. The review is necessary for understanding the basic nature of human computer interaction and identifying similarities between the activity theory approach and the other methods, which have given the foundation for this significant subject.

Various theories are in practice for identifying effective user interfaces. However, Shneiderman gives the best and most comprehensive one in his book – " Designing the User Interface". The theories are briefly mentioned to make the user familiar with the aspects considered while developing theories for human computer interactions.

The first one is the conceptual, semantic, syntactic and lexical model. Here the conceptual level is the user's mental model of the interactive system. The semantic level describes the meanings conveyed by the users command input and the computer display as the output. The syntactic level identifies the process of combining the semantics into a comprehensible code for the particular computer system. The lexical level defines the precision with which the user has to specify the syntax. It is a top down approach.

The second one is the historical GOMS (goals, operators, methods and selection rules developed by Card, Moran and Newell (1980,1983). Later Kieras and Polson (1985) developed on the Goms approach and came up with a refined version known as the NGOMSL. There are four different versions of GOMS in use today, all based on the same GOMS concept. These are described below.

CMN-GOMS: The fundamental formulation proposed in Card Moran and Newell was a loosely defined demonstration of how to express a goal and sub-goals in a hierarchy, methods and operators, and how to formulate selection rules.

KLM: A simplified version Card, Moran and Newell called the Keystroke-Level Model uses only keystroke-level operators—no goals, methods, or selection rules. The analyst simply lists the keystrokes and mouse movements a user must perform to accomplish a task and then uses a few simple heuristics to place "mental operators."

NGOMSL is a more rigorously defined version called NGOMSL presents a procedure for identifying all the GOMS components, expressed in a form similar to an ordinary computer programming language. NGOMSL includes rules-of-thumb about how many steps can be in a method, how goals are set and terminated, and what information needs to be remembered by the user while doing the task.

CPM-GOMS: A parallel-activity version called CPM-GOMS (John, 1990) uses cognitive, perceptual, and motor operators in a critical-path method schedule chart (PERT chart) to show how activities can be performed in parallel.

The third set of theories analyses the users in stages in the operation. Norman (1988) defines seven stages of action as a model of human computer interaction.

1. Forming the goal.
2. Forming the intention.
3. Specifying the action.
4. Executing the action.
5. Perceiving the system state.
6. Interpreting the system state.
7. Evaluating the outcome.

These seven-stages leads to the identification of the gulf of execution (the mismatch between the user' intentions and the allowable actions and the gulf of evaluation (the mismatch between the system's representation and the users' expectation).

These models provide usability personnel with economical alternatives in the design phase for task analysis and then evaluating the tasks in terms of the heuristics. This has resulted in development of non-user based techniques for affordability. However we should take care of the fact that when the user is not taken into account we should provide a suitable alternative, which is capable of surrogating the user population intended. Therefore the ideal aim is to provide these models with proper theoretical and empirical bakup.

2.3 Usability Testing

2.3.1 Introduction

ISO 9241-11:1998 is a set of standards by the International Standardization organization, which defines usability as-

"The extent to which a product can be used by specified users to achieve specific goals with effectiveness, efficiency, and satisfaction in a specified context of use."

The standard elaborates with the definitions for "effectiveness", "efficiency" and "satisfaction".

Effectiveness is the extent to which a goal, or task, is achieved.

Efficiency is the amount of effort required to accomplish a goal.

Satisfaction is the level of comfort that the user feels when using a product and how acceptable the product is to users as vehicle for achieving their goals.

A product or service is highly usable if it can be used as a tool for accomplishing a set of defined and expected tasks easily with minimum frustration and maximum subjective satisfaction. Ideally, frustration should not exist at all, which is impossible to achieve as a particular product or service can be used by a variety of users under a variety of situations.

Usability has been embraced under the rubric of ergonomics (tools and devices), user centered design (UCD) (systems and services), and human-computer interaction (HCI). The last one represents the toughest challenge to usability professionals till date. Throughout its development, usability has always been associated with the interaction between a user and a system. Therefore, understanding usability is a combination of understanding the user's needs, desires, abilities, knowledge and goals, combined with the functions, and limitations of the product or service. To understand the user, usability must take into account things like experience, domain of knowledge, cultural background, disabilities, as well as age and gender. To understand the product or service, usability addresses the product or service's ability to be learned, experimented with, and even re-used after periods of non-use. It addresses the limitations of the product and service itself as well as the limitations of experienced user of the product or service.

Hence, user analysis is an important aspect of user-centered systems design. However, Human-Computer Interaction (HCI) has yet to formulate reliable and valid models of behavior rather than identifying distinctions based on task and experience. The hundred years of evolution of research on individual differences has identified a set of characteristics that can represent potential application in the HCI arena. But problems of theoretical status and applicability are still left to be encountered. Dillon, *et.al.*(1996), identified the relationship between work in cognitive and differential psychology and current analysis of users in HCI. They concluded that HCI could gain significant predictive power if individual differences research was related to the analysis of users in contemporary systems design.

These recent findings obviously conclude that usability testing and HCI research requires proper formulation of user behavior for accurate prediction of the usability problems in the HCI context. A short description of the different usability methods has been given in order to familiarize the reader to its dependency on user experience, behavior and motivational aspects. Later it is explained how activity theory uses a holistic approach to model both cognitive and behavioral processes in order to model a HCI related task.

2.3.2 Usability Methods in Practice

Various methods have been developed through the ages for identifying usability. Some of them are done at the beginning of the product development or system development phase while others find importance in iterative design as well as the final design stage. However the most effective ones are those, which take into account the user and study the product in the context of its use. The following definitions are quoted from website of Hom (1998) due to their comprehensiveness and clarity. For other details please refer to his website at http://www.best.com/~jthom/usability/

Contextual inquiry is basically a structured field interviewing method. It is different from plain, journalistic interviewing due to its foundation on a few core principles. These include understanding the context in which a product is used (the work being performed) is essential for elegant design, that the user is a partner in the design process, and that the usability design process, including assessment methods like contextual inquiry and usability testing, must have a focus. Contextual inquiry is more a discovery process than an evaluative process; more like learning than testing.

Ethnographic Study / Field Observation is observing users in the field is often the best way to determine their usability requirements. Traditional usability testing, while providing a laboratory environment that makes data collection and recording easy, also removes the user and the product from the context of the workplace. Sometimes, it's best to see exactly how things are done in the real world.

Surveys are ad hoc interviews with users, where a set list of questions is asked and the users' responses recorded. Surveys differ from questionnaires in that they are interactive interviews, although not structured like contextual inquiries nor formally scheduled and organized like focus groups.

Interviews and focus groups let you query users about their experiences and preferences with your product. Both are formal, structured events where you directly interact with users, asking them to voice their opinions and experiences regarding your product.

Questionnaires are written lists of questions that you distribute to your users. Questionnaires differ from surveys in that they are written lists, not ad hoc interviews, and as such require more effort on the part of your users to fill out the questionnaire and return it to you.

Journaled sessions bridges usability inquiry, where you ask people about their experiences with a product, and usability testing, where you observe people experiencing the product's user interface.

Heuristic evaluation is a variation of usability inspection where usability specialists judge whether each element of a user interface follows established usability principles. Basically, heuristic evaluation is a fancy name for having a bunch of experts scrutinize the interface and evaluate each element of the interface against a list of commonly accepted principles--heuristics.

Cognitive walkthrough is a review technique where expert evaluators construct task scenarios from a specification or early prototype and then role play the part of a user working with that interface--"walking through" the interface. They act as if the interface was actually built and they (in the role of a typical user) was working through the tasks. Each step the user would take is scrutinized: impasses where the interface blocks the "user" from completing the task indicate that the interface is missing something.

Formal Usability Inspection takes the software inspection methodology and adapts it to usability evaluation. Software inspections, more commonly known as code inspections, started at IBM as a way to formalize the discovery and recording of software problems ("defects" in quality jargon, "bugs" in the vernacular). The technique also provided quantitative measurements that could be tracked using statistical process control methods. Code inspections were also adapted to check and track documentation defects, and usability defects were a logical next step.

Pluralistic walkthroughs are meetings where users, developers, and usability professionals step through a task scenario, discussing and evaluating each element of interaction. Group walkthroughs have the advantage of providing a diverse range of skills and perspectives to bear on usability problems. As with any inspection, the more people are looking for problems, the higher the probability of finding them. Also, the interaction between the team during the walkthrough helps to resolve usability issues faster.

Feature inspections analyze only the feature set of a product, usually given end user scenarios for the end result to be obtained from the use of the product. For example, a common user scenario for the use of a word processor is to produce a letter. The features that would be used include entering text, formatting text, spell checking, saving the text to a file, and printing the letter. Each set of features used to produce the required output (a letter) is analyzed for its availability, understandability, and general usefulness.

Consistency inspections ensure consistency across multiple products from the same development effort. For example, in a suite of office productivity applications, common functions should look and work the same whether the user is using the word processor, spreadsheet, presentation, or database program.

Standards inspections ensure compliance with industry standards. In such inspections, usability professional with extensive knowledge of the standard analyzes the elements of the product for their use of the industry standard. For example, software products designed for the Windows environment should have common elements, such as the same functions on the File menu, a Help menu, etc.

Guidelines and checklists help ensure that usability principles will be considered in a design. Usually, checklists are used in conjunction with a usability inspection method--the checklist gives the inspectors a basis by which to compare the product. Nielsen, in the book Usability Inspection Methods, lists a small set of usability guidelines as follows.

- Visibility of system status
- Match between system and the real world
- User control and freedom
- Consistency and standards
- Error prevention
- Recognition rather than recall
- Flexibility and efficiency of use
- Aesthetic and minimalist design
- Help users recognize, diagnose, and recover from errors
- Help and documentation

Thinking Aloud protocol is a popular technique used during usability testing. During the course of a test, where the participant is performing a task as part of a user scenario, you ask the participant to vocalize his or her thoughts, feelings, and opinions while interacting with the product.

Co-discovery is a type of usability testing where two participants attempt to perform tasks together while being observed.

The question-asking protocol simply takes thinking aloud one step further in that instead of waiting for users to vocalize their thoughts, you prompt them by asking direct questions about the product. Their ability (or lack of) to answer your questions can help you see what parts of the product interface were obvious, and which were obtuse.

Some usability tests are targeted at determining hard, quantitative data. Most of the time this data is in the form of performance metrics--how long does it take to select a block of text with a mouse, touch pad, or trackball? How does the placement of the backspace key influence the error rate?

In the above description it is clearly evident that Usability testing is not only time consuming but also expensive when done with real effectiveness. Research needs to be more comprehensive in identifying the user behavior classification so that Usability testing can become cheaper for the manufacturers. Usability suffers this negligence from small business firms due to their incapability of investment in user studies and surveys. As a result a proper behavior modeling approach will equip them to offer better products and market share. The various usability metrics we try to gather during these studies are all ephemeral for the same set of users under a different circumstance. And it is important to pay heed to the parameters that can influence the results of these metrics for the same product. A sample list may include the following.

- Time-- to perform a given set of tasks
- Errors-- number and seriousness
- Learning-- by measuring the time necessary to accomplish a given set of tasks.
- Recall-- can the task be done without relearning?
- Concentration-- how many items can be remembered?
- Fatigue—a measure how pleasant the interface is to the user.
- Acceptability-- a subjective evaluation of the user
- Functionality-- breadth of tasks that can be completed

2.3.3 The Gap

The current methods do not properly take into account user behavior as an important factor in the study of HCI and usability. It is not only behavior, which is important, but also the situation awareness or the subjectively relevant task conditions and other factors, described later, that matter. The goal is to achieve a model, which can closely represent the actual scenario in a human computer interaction situation.

The sequential approach to study of HCI tasks is itself a limitation. As a result, certain variables are regularly overlooked while drawing out expert reviews and heuristic evaluations and problems are encountered in the active stage of the product life cycle. This gap cannot be nullified, as user behavior seems to be the most complicated and difficult to model due to the phenomenal differences in their characters, background, experience and approach. However this gap can be minimized to hone up the usability testing methods like heuristic evaluations, expert reviews, which are cheaper to conduct for the organizations. This will not only empower these techniques but also provide important feedback while designing user interface guidelines and style guides. The only work, which is left is to modify the approaches of activity theory, so that it can be applied to HCI practice and thereby can render added efficacy to the techniques and principles, which has developed through the ages.

CHAPTER 3

THE RUSSIAN THEORY OF ACTIVITY

3.1 Background

Activity Theory derives its roots from the Marxian theory of "dialectical materialism". Founder of Activity Theory were Russian scientists Rubenshtein (1959), Vygotsky (1962) and Leontev (1978).Basic research from Activity Theory perspective in HCI- related field include Information Systems (Hasan, 1995), Computer Mediated Communications (Kuutti, 1991), Human Computer Interaction (Kaptelinin, 1994), Computer Science, (Boedker, 1991), Activity Theory is defined as a goal directed, artifact mediated set of actions for accomplishing a certain objective. Recent research has defined Activity (Deyatel'nost') as a coherent system of internal mental processes, external behavior and motivation that are combined and directed to achieve conscious goal (Bedny, Meister, 1997). Basically Activity Theory promotes system structural approach in study of human performance.

Activity is described as multidimensional system (Bedny, 2000.). Hence Activity can be studied from cognitive perspective when major concept is process, morphological analysis when major concept is actions and operation, functional analysis when the basic unit is function blocks. One important feature of system-structural analysis is that the hierarchical description of activity embraces certain principles, which involve both conscious and unconscious processing of information, study of cognitive and motor actions, self regulated for the objective of accomplishing a desired goal. In the process it involves several feed forward and feedback loops influenced by the nature of the task situation.

A fundamental theoretical concept in Activity Theory is of internalization. According to Vygotsky (1962), internalization is the transformation into an internal mental plane of external performance in social interactions. According to Bedny (1981), object practical actions emerge as a basis for the formation of the internal mental actions external actions are not transformed into internal plane but are an important precondition for the formation of internal cognitive actions based on mechanisms of self-regulation. Mental actions begin internally with external support. At the first step internal plane of activity evolve with the support of external activity. Only later mental plane of activity becomes independent.

From the discussion above we can bring to conclusion that cognitive psychology, which is the primary tool for studying human-computer-interactions possess one serious drawback- to study cognition in separation from behavior. Cognition and behavior must be studied in unity. Thus Activity Theory can mitigate the limitation of Cognitive Psychology, which separates cognition and behavior while addressing the various issues in interface design. Activity approach definitely leads to more general and precise concepts of subjects, tools, object, goal, task, and mental and behavioral actions, self- regulations, which become important in the study of HCI.

3.2 Overview of Activity Theory

The concept of activity (deyatelnost) plays a key role in Russian psychology and ergonomics, which is a coherent system of internal mental processes and external mental behavior and motivation that are combined and directed to achieve a conscious goal.

Goal is the second important feature. The concept of goal formulation (see figure 3.1) manifests as the image of the desired result in the future. Awareness of the goal is of prime importance as the kind of goal influences and determines the other activity aspects. The other different parameters of work activity consist of the actual output, the strategies used, the individual style, the prescribed method for the particular work and several internal and external attributes of human performance, which permit the organization of human activity to achieve the desired goal. However the goal reached as a result of the actual output, more specifically identified as outcome, may vary from the desired one and interestingly is subjected to changes during the performance of work.

This is addressed by the concept of self-regulation. Self-regulation postulates that an operator, during task performance, can compare the desired goal with the actual outcome and adjust behavior after evaluating any discrepancy. A fundamental component of Activity Theory is the task. The tasks described in Activity Theory can be divided in two basic types of components- the cognitive component and the motor component, which can then be divided into further subdivisions based on the type of task involved. In visual search tasks, the cognitive processes during visual search can be identified as the cognitive component and the eye movements as the motor component.

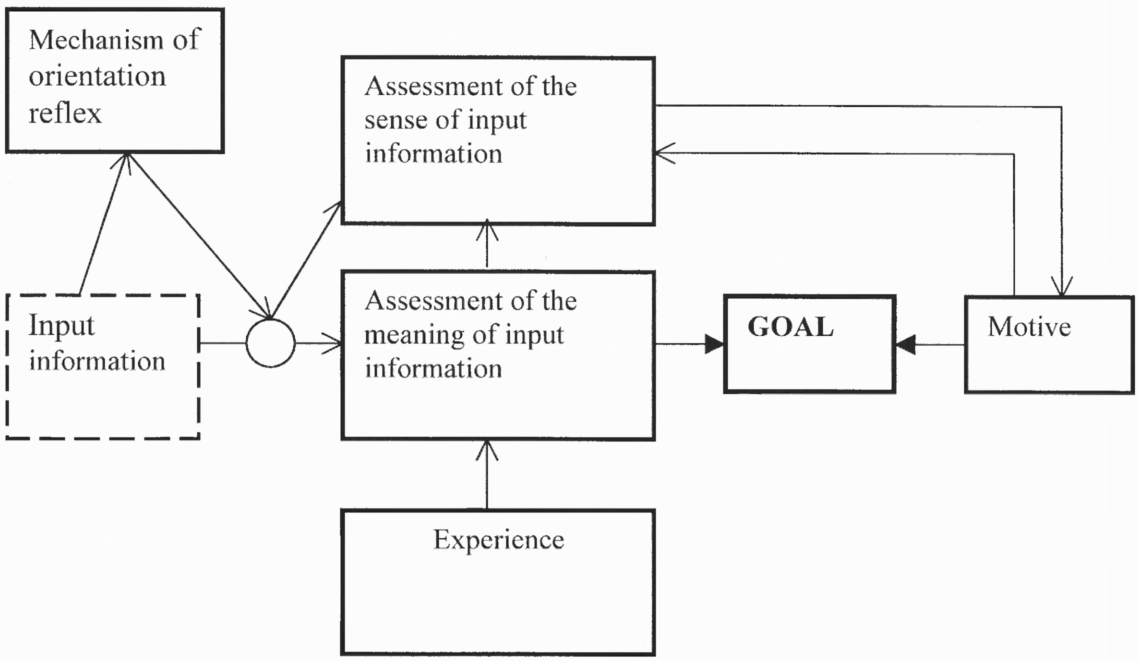

Figure 3.1 Model of Goal Formation

These processes from the Activity Theory point of view are interrelated. This unique feature of Activity Theory empowers it to identify a relationship between the cognitive and the motor component of Visual Search and thereby develop a more general model. This will not only involve the task situation (situation awareness) but also address the phenomena as an interrelation and interaction of the various components. In the experiment Activity Theory is used as a theoretical lens to understand a very simple interaction of users with one of the most widely used software. In the following sections a brief discussion on the different tools offered by Activity Theory has been illustrated.

3.3 Systemic Structural analysis

Activity is multidimensional as it involves various aspects of user and the nature of task under consideration. The reason for this is that during any activity the operator might change strategies due to influence of a factor or a combination of factors. These factors include knowledge, experience, situation awareness, motivation, external and internal constraints and dynamic sub-goal formulation. The change may be attributed to the individual subjective evaluation in terms of the long-term goal. Hence any activity, especially computer related task, cannot be studied under a single model. The alternative approach is to address it with a hierarchy of models (figure 3.2) that describe activity related to design with different methods and various levels of detail. Bedny identifies four basic stages of design in what is termed as Systemic Structural Analysis. The design analysis commences with the functional description of the most important tasks as identified as functional analysis, the main focus of this study.

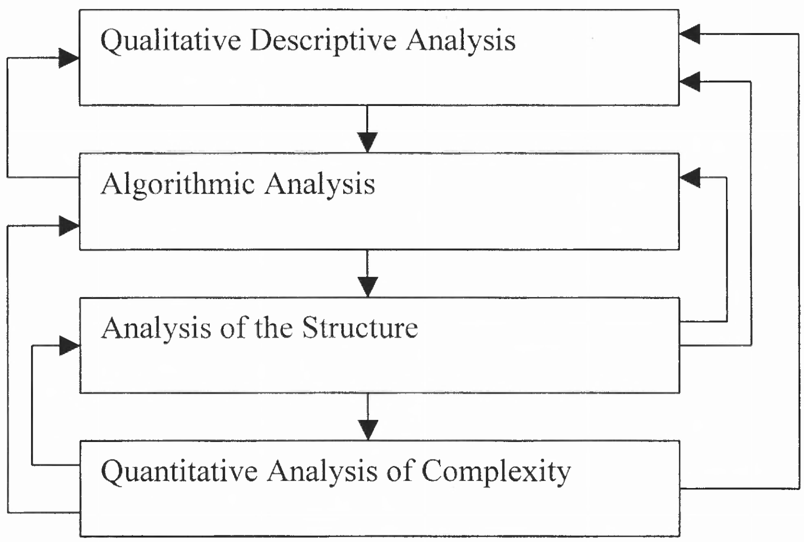

Figure 3.2 General Scheme of systemic structural analysis and design of work activity. adapted from Bedny (1987)

3.3.1 Functional Analysis

During functional analysis, importance is first given to the most crucial components of activity. Based on expert opinion and prototypes, the goal of the activity and its significance is specified. Thereafter, an estimate of the possible motivational and emotional state of the operator is carried out for the particular task concerned. Examples of factors considered include repetitiveness, potentials for variability. In human computer related tasks, both of these factors demand user attention and hence become significant in the analysis. Next, a qualitative analysis of the cognitive aspects is done. This is more or less similar to the information processing approach but includes extra features such as the stimuli characteristics, memory requirements, feedback information and the operators' motivational state.

After the overall analysis is done, the activity is then divided into subsections and each section is then analyzed for the specific sub-goals and the ideal operation expected. The different subtasks are described in terms of types of action to be performed such as motor, sensory, perceptual, cognitive processes, the psychological specificity, the potential difficulties in performing the action and the consequences of failure in achieving the sub-goals. Functional analysis reveals that for the same task different strategies might provide the same goal thus initiating different cognitive complexities in different individuals.

Thus, a simple cognitive task analysis is insufficient to describe the complex structure of activity. This is primarily observed in computer tasks as almost all the software designed has different methods to obtain the same result due to inclusion of the feature of flexibility. Analysis of potential errors and their types are also considered in this stage as errors might differ in nature. Some of them may result in hazardous situations (system crash) while some of them may delay the achievement process, thus resulting in inefficient operation.

3.3.2 Algorithmic Analysis

This is the second stage of design analysis where the ergonomist involves in breaking down the activity elements into algorithmic elements like the operators and logical conditions. Operators are characterized by motor and mental actions, whereas logical conditions relate to the decision-making processes. The basic structure of the algorithm cannot be identified in advance and may need modification in the subsequent stages of analysis. Algorithms can turn out to be stochastic or deterministic. In deterministic cases only two outputs are encountered (1 or 0). For example a yes no situation in a dialog box, or using the num lock key.

3.3.3 Morphological Analysis

The third stage of behavioral analysis involves the development of the time structure. All the activity elements are transferred to their temporal indices that indicate the duration and distribution over the total time. This helps us to identify, which of the activities can be performed in real time and in parallel.

3.3.4 Quantitative Analysis of Complexity

Basically, there are two general approaches to the evaluation of task complexity. The first one involves the use of external criteria in relation to the internal plane of activity. The second approach uses the internal cognitive actions and operations and the motor actions. GOMS is a typical application of the first approach to human computer interaction tasks. Therefore, the second approach uses typical elements of task to derive the complexity by breaking it into the working of the three different processors, the perceptual processor, the cognitive processor and the motor processor.

However, task complexity also depends upon the nature of task. Task analysis methods take into account the microelements of operation. For example, a computer-oriented task is having three operations and the other one is having only one operation. However, the first one results in minor changes in formatting. The second one, if done improperly, can result in system crash and loss of data. So, the keystroke level model and the GOMS model cannot address this situation.

Activity theory uses a comparison of different elements and transfers the different elements to one surface plane. Hence, it takes into account the possibility of simultaneous or parallel occurrence as well as the situation in the whole time structure of the activity. It is, therefore, important to study the activity elements instead of the task elements for having a true measure of the complexity.

3.4 Self- Regulation of Activity

The second important aspect, which Activity Theory corroborates, is the self-regulation of activity. Generally, physical self-regulation of the human body is studied during and after stress. However this concept of self-regulation addresses the balance and adjustment of the psychological processes during an activity. Thus according to the activity approach, any activity possesses a structured organization. All the corresponding components can influence the other component in the dynamic structure. As a result any activity possesses a self-regulation system particular to the individual and the different components are self-regulated towards the specific goal. Any component in the self-regulation system can have an effect on the other due to changes in the internal as well as the external environment.

Norman explained the terms gulf of execution and gulf of evaluation as the relation between the user and the computer interface. The self-regulation system analyses the processes taking place in these gulfs, whereby it can identify areas to reduce these gaps improving human computer interaction. Since activity theory applies to any kind of activity all the CHI related tasks can be identified through activity theory.

However, cognitive psychology is important for activity theory due to its time-tested approach of identifying the cognitive load on the user. On the other hand, behavioral analysis using Activity theory gives more comprehensive results. Thus the concept of self-regulation is significant when functional analysis of the activity is undertaken. The case study here uses functional analysis of a simple activity on the computer using a common software. Hence a detailed description of the concept of self-regulation is given for the readers' convenience (see figure 3.3).

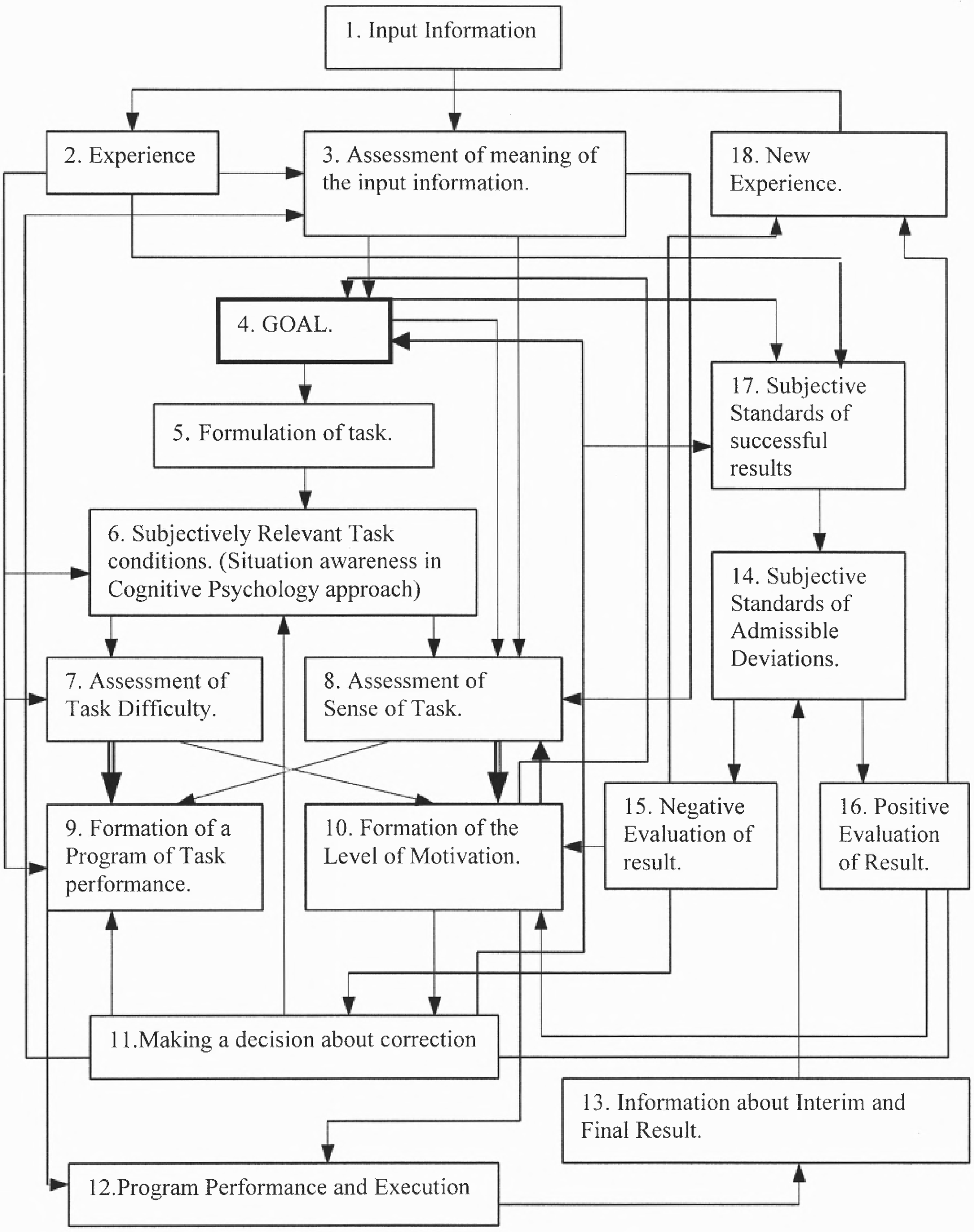

Figure 3.3 Model of self-regulation of activity from Activity Theory point of view: adapted from Bedny (1997)

Figure 3.3 gives the complete picture of the self-regulation system for an activity. It is represented by function blocks, which are dynamic in nature and are continuously evaluated and changed in response to the external change of conditions. The most crucial concept is that of a function block, which is Each function block includes different cognitive processes for achieving a specific purpose in regulation of activity. Function blocks integrate into a self-regulative system with feed forward and feedback connections between them. The major function blocks in the current study evolved into a goal or goals, past experience, subjectively relevant task conditions, motivation and function blocks involved in evaluative components of the self-evaluation of the task.

3.5 Current Activity Theory research in HCI

Situation Awareness as introduced by Endslay (1995) holds absolute similarity to subjectively relevant task conditions. However it is only a function block in the self- regulation system. Subjectively relevant task conditions however offer some additional clues. Due to its existence in a dynamical structure it has been given the flexibility of changing although the user may be in a particular task.

Recent research in Human Computer interactions from the perspectives of Activity Theory has substantiated its robustness. An overview of the various research work is dealt here just to comprehend the universality of the approach and its relationship to hci studies.

Kuutti (1992) has been working on Computer mediated communications and CSCW work in an Activity Theory framework. Cooperative applications have the typical characteristic of emerging through time and the development needed at every stage is difficult to chart. He has shown that Activity Theory concepts can identify the opportunities at the predetermined, active and expansive phases of the system.

Hasan's (1997) research involves the information systems and human computer interactions paradigm. She has effectively pointed out that using Activity Theory as a philosophical and theoretical basis the alienation between thought and action can be mitigated. This results in comprehensive outcomes as indicated in her case study.

Nardi (1996) an evangelist and activity theory preacher has shown the way how computer science can benefit from activity theory. Her book Context and Conscious represents the latest study in the approach of activity theory to HCI.

The latest developments in Activity Theory in Russia have focused more on practical aspects rather than theoretical and philosophical grounds. Gregory Bedny (1997) has charted out with intimate details, the recent approaches. This thesis is an attempt to visualize human computer tasks from the viewpoint of the current developments.

CHAPTER 4

CASE STUDY

4.1 Procedure

The experiment involved the use of Microsoft Word to perform a relatively moderate task of converting a set of text into a table. The task is quite frequent and is evident (as observed later) from the protocol analysis (Newell and Simon, 1978) of the expert user. In AT the same as cognitive psychology, during studying problem solving tasks, the terminology of verbal protocol analysis is used. There are similarities and differences in the different flavors. A significant difference is that in AT verbal speech can be considered as a system of verbal actions (Bedny, *et. al.* 2000). Verbal performance of task differs from communication and explanation. Due to this, verbal protocol can be organized in different ways.

With a verbal protocol approach, speech can emerge as a system of verbal actions, which to some extent correspond to actual performance. The verbal protocol can also be organized as an explanation of actions being performed. And these two methods can be combined. In one case the subject speaks aloud what he did and in another case subject speak aloud how he did. Furthermore, AT embraces the fact that verbal speech and thought overlap but do not exactly match each other. Thus verbal protocol in AT should be combined with observation of task performance by different subjects with different backgrounds and different levels of experience, with respect to the system.

The differences between verbal protocol analysis and real performance can be used as sources of information to find of relationships between conscious and unconscious processes (Bedny, Meister, 1997). This is due to the AT view of verbal protocol as a result of thought and not as an exact match of the thought process, which guides the subjects' actual actions. In this study a combination of verbal actions as a system of actions performed by subjects with explanation of the subjects' action has been used. The obtained data were interpreted from a functional analysis point of view. The functional analysis describes the strategies of human performance through analysis of different function blocks in the self-regulation system. (Bedny, *et.al.* 2000). (Refer to figure 3.3 for the different function blocks).

Data obtained from observations and the verbal protocol analysis was assigned to different function blocks (a coordinated system of sub-functions with a specific purpose within the structure of activities). Each function block includes different cognitive processes for achieving a specific purpose in regulation of activity. Function blocks integrate into a self-regulative system with feed forward and feedback connections between them. The major function blocks in the current study evolved into a goal or goals, past experience, subjectively relevant task conditions, motivation and function blocks involved in evaluative components of the self-evaluation of the task.

4.1.1 Task

The task required the conversion of a piece of text into a table. The desired sequence of intermediate operations is shown in the figures 4.2-4.5. The final product or desired result is shown in figure 4.1. An ideal operation involves the use of the following steps.

1. Select the text to be converted by using the mouse. (figure 4.2)
2. Go to "Table" menu option and then to open the submenu of the "Convert" option. (figure 4.3)
3. Click open the "Text to Table option" (figure 4.4)
4. Mark the desired options in the dialog box to obtain the final result. (figure 4.5).

(please see figures 4.2 to 4.5 on the next two pages)

Cognitive Walkthrough:	Cognitive walkthrough is a review technique where usability specialists
Heuristic Evaluation:	It is a variation of usability inspection where expert evaluators construct
On-field Observation:	Observing users in the field is often the best way to determine
Protocol Analysis:	Protocol Analysis is a popular technique used during usability
Questionnaires:	Questionnaires are written lists of questions that you distribute to users.

Figure 4.1 The desired result or product set as a task for the subjects

4.1.2 Subjects

Experiments were conducted with three users. All the users were observed and went through a protocol analysis of the task. All of them are regular users of Microsoft Word®. However, one of them reported superior skills. The second one had a moderate level of experience. The third also was a regular user but was not acquainted with the intricate aspects and were hence considered inexperienced.

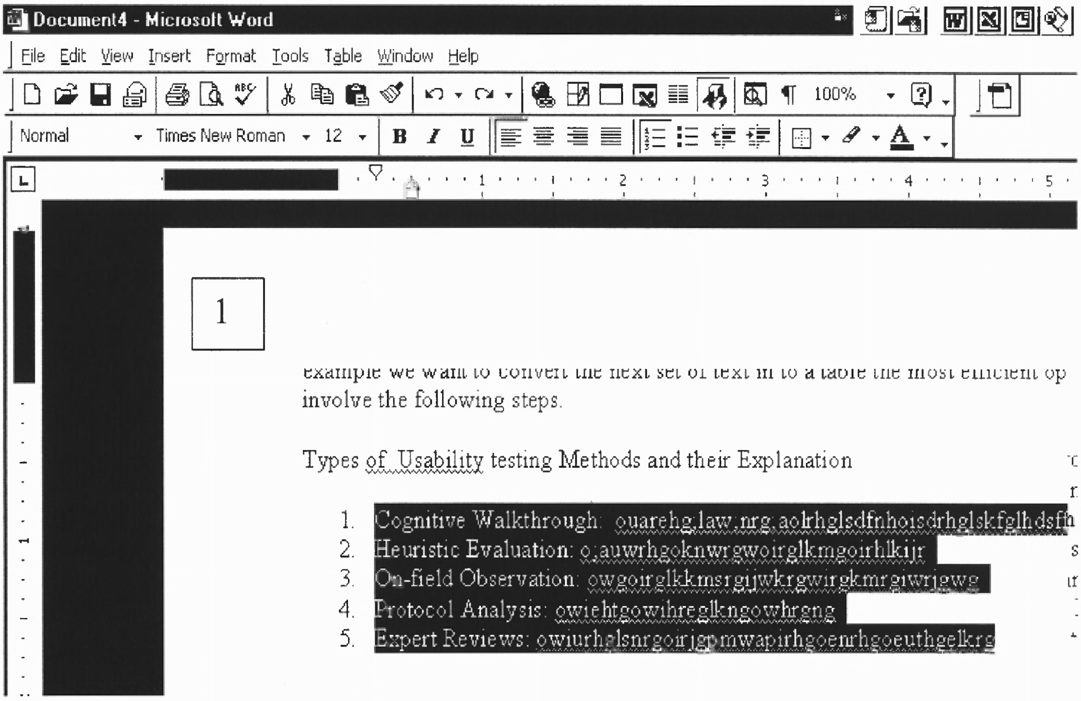

Figure 4.2 First screen for the ideal operation for the task as expected under the given functionalities of the system

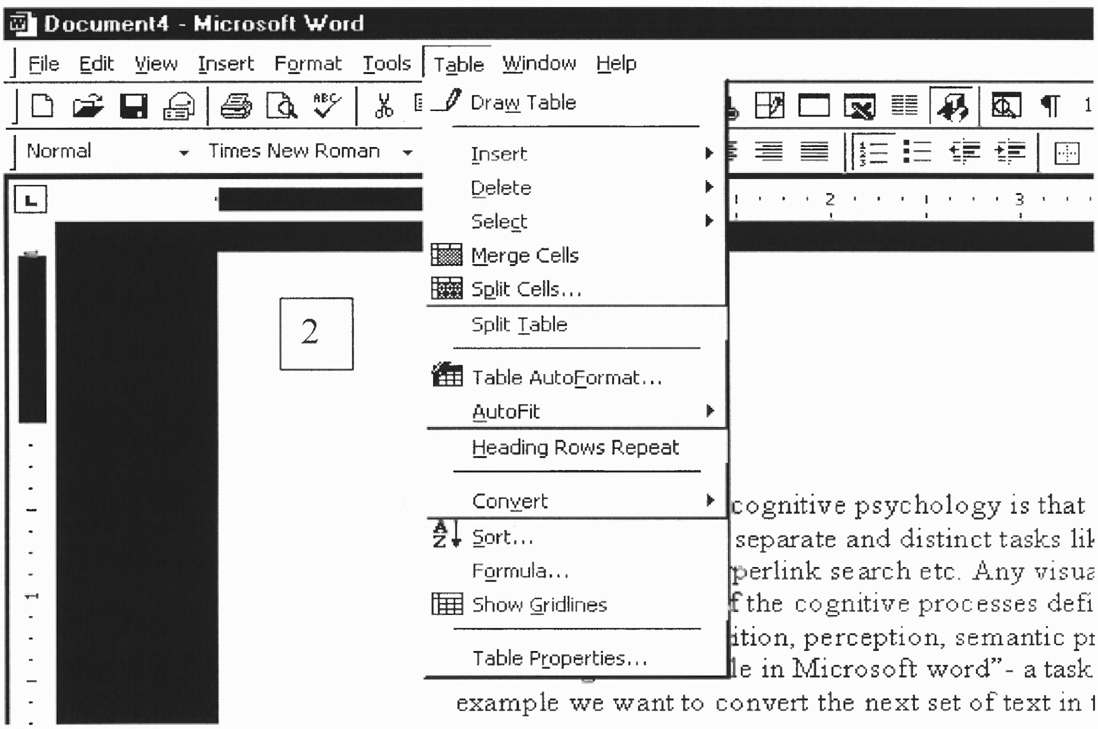

Figure 4.3 Second screen for the ideal operation for the task as expected under the given functionalities of the system.

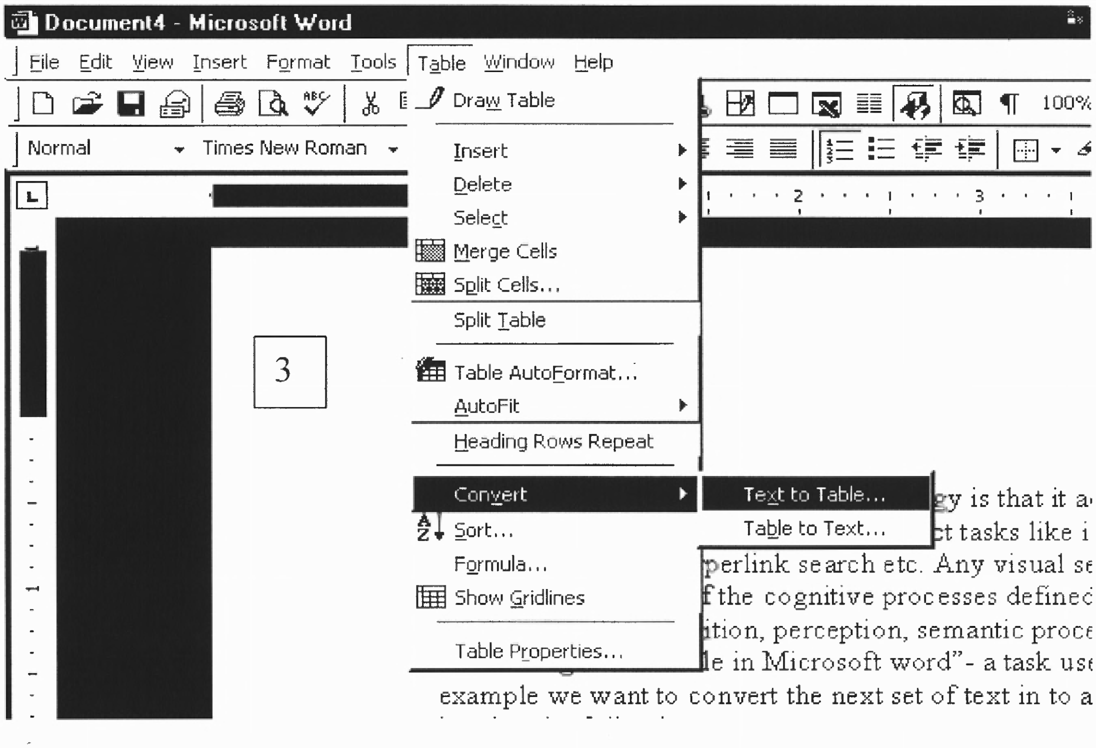

Figure 4.4 Third screen for the ideal operation for the task as expected under the given functionalities of the system 3rd screen

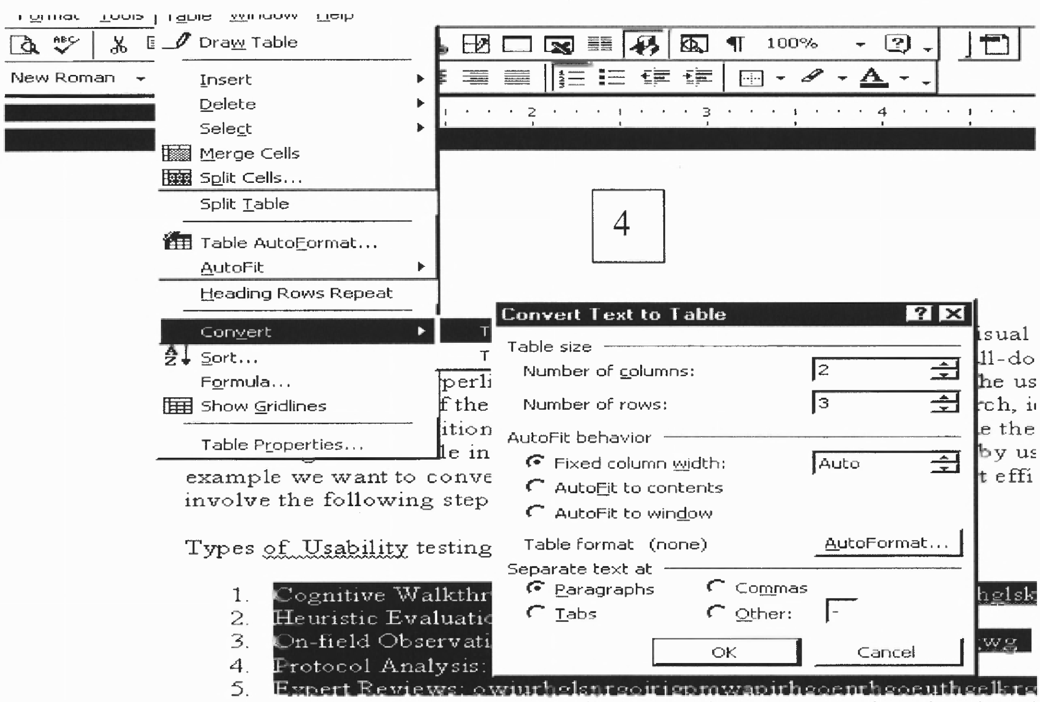

Figure 4.5 Fourth screen for the ideal operation for the task as expected under the given functionalities of the system.

4.1.3 Method

All the users were experimented at different times so that no user could learn from the other one. The explanation of the task given in section 4.1.2 was not stated but end result or goal (figure 4.1) was shown to them. The goal of activity was not only stated verbally but also presented in material form (printed paper) (see figure 4.1). The subjects had to achieve the required future state through the set of actions, operations and sub-tasks. They were not only asked to speak aloud what they were doing, but also what they were thinking at each step and why they were doing the particular operation (thinking aloud protocol).

The three users each with different levels of proficiency in Microsoft Word performed the task with the protocol analysis. A post-task self analysis was also carried out by the subjects themselves and feedback about the interface was taken. All the subjects used the same computer (Dell Dimension XPS T700r with Pentium III microprocessor at 700 mega hertz and MS Windows 98 operating system) at different times.

4.2 Results

Subject 1, presumably the more experienced, had really no difficulty at all. However he faced confusion at the last screen (figure 4.5) in selecting the options. However, his experience led him through the rest of the process easily due to his confidence, which he later reported in the post interview.

Subject 2 formulates his goal according to his past experience regarding text editing. He correctly identifies the menu option but has difficulties in applying the alternatives in the dialog box. This is not a limitation of his cognitive skills but a deviation from his expectation, which created confusion. His mental image about the task was previously generated through similar interactions and he was expecting that this would work the same way. He had applied numbering or bullets in almost a similar set of operations and expecting the software to automate the process which did not happen. The limitation of the software to convey the meaning of "separate text by" had created this error. The other option, which he was expecting would work fine sounded a bell (wrong feedback) even though he was correct in putting the option. Previous experience had reorganized his behavior to judge that as an error and made him quite unsure about the result. As a result wrong feedback lead to the repetition of the task.

Subject three, the most inexperienced of the group, had a totally different approach about the task. He created a table and put the text inside the cells by a simple cut and paste method. This reflects the subject's less knowledge about the software. So interaction does not depend upon merely the design of the software components according to specific principles but also on the progressive knowledge and scaffolding. Designing software with usability techniques definitely provides a better approach but individual differences, dynamic situation, possible change in goals, user experience can also be taken into account. This will increase the efficacy of the design and more importantly of the usability testing methods.

4.3 Inferences

Based on the protocol analysis, observation and post-task interview eight areas were identified as areas of the prime focus by the subjects. These areas have been shown in the figures 4.6-4.9 with dotted lines. Each of these areas affects the self-regulation system of the individual and renders one or more function blocks to be more significant than the others during the performance of that task. Problems associated with these areas and their inability to generate effective interactions is explained below.

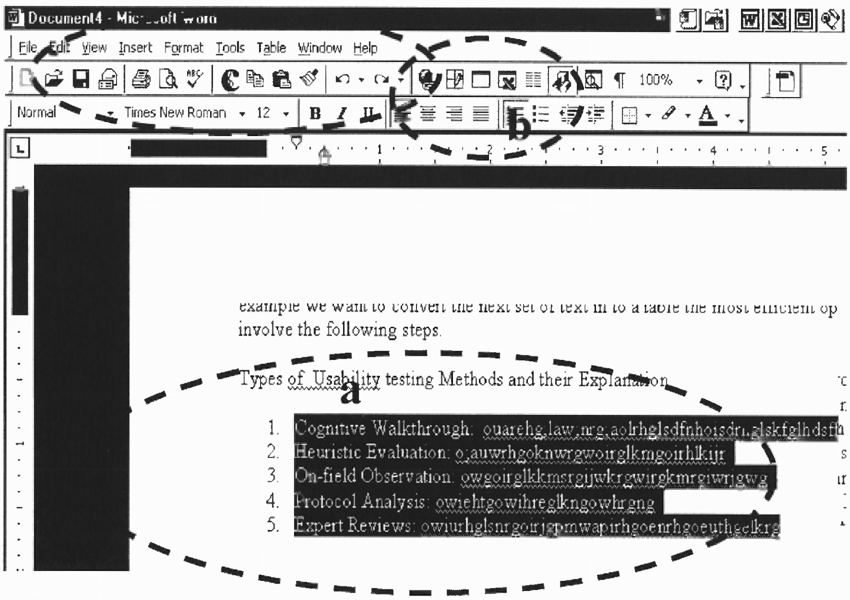

Figure 4.6 Search areas in the first screen of operation according to verbal protocol.

The text body, which needs to be converted, is identified by "a" in stage 1(see figure 4.6). This area of interactions on the screen had no significant interaction problem. All the three users quickly identified the strategy to select the text for converting it to a table. Let us consider how the function blocks of experience influences the subjects' strategy formulation, and that of subjectively relevant task conditions and sub-goal formulation matched the requirements of task execution. It is worth mentioning that Subject 3 developed a subjective goal that deviated significantly from the objectively given goal. Subjectively relevant task conditions also differed for him and thus reformulated his goal to produce different and inefficient strategies of execution. For example, he created a separate blank table and put the texts one by one in the respective cells. However, according to instructions he must convert the given text by using the particular software feature which the other two followed. As a result orientational components involved in the strategies became totally inadequate. Reformulation of goal resulted in a change on all the other function blocks of self-regulation. Goal reformulated by subject intermittently, can influence all other mechanisms. This interaction can be viewed as a game of chess where external information becomes an input for developing subjectively relevant task conditions, which are dynamical models of the situation. Subjects can develop totally different mental representations of task from the same screen. The strategy though incorrect from the expectation did meet the requirements but required more time to execute.

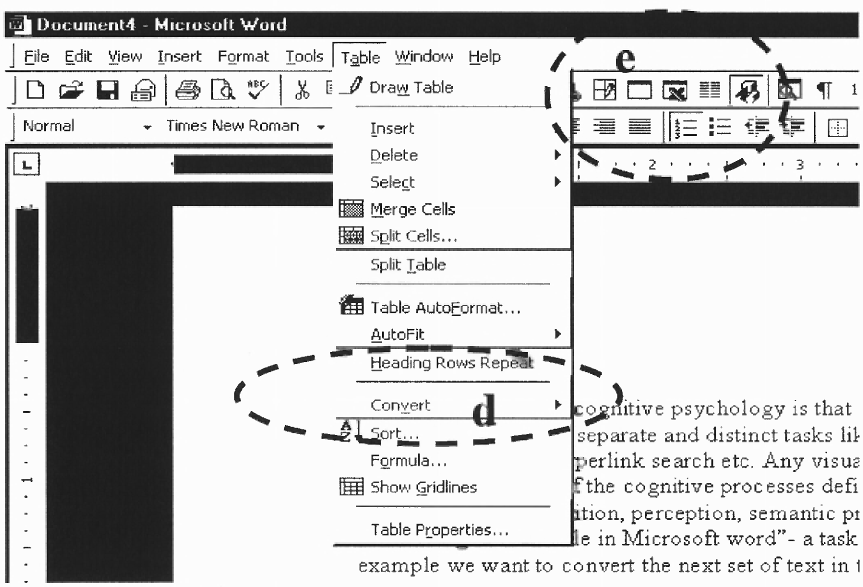

Figure 4.7 Search areas in the second screen according to verbal protocol

Problems were observed in the next stage of task performance when subjects used visual search processes for manipulation of icons, menus and text in combination (see figure 4.7). Here subjects 2 and 3 were constantly referring to the areas "b" and "c" as the more important components of task at this stage, but the only thing they were needed to identify was the table menu option. As a result, subject's image of task developed by the analysis of function block of subjectively relevant task conditions become inadequate at this stage of performance. This produced complex decision-making processes, complicated mental operations and actions, and increased search times.

At this stage, subjectively relevant task elements were only in the table menu option. However, due to irrelevant task elements the function blocks used up much of the cognitive resources. Complexities of the task were further increased when the subjects clicked a wrong option and were introduced to a completely different situation. This was mostly due to the icons in area "b" and "e", which continuously deviated the subject from obtaining the correct strategy of choosing the "Convert" menu option, marked by area "d".

The failure occurred because identificative features of icons matched the image of task worked as a filter for eliminating objectively important elements of the task and extracting irrelevant components of the objectively presented situation. As a result, formation of intermittent goals in an incorrect way, lead to the generation of negative motivational states. This affected the Goal, motivation and subjectively relevant task conditions and thereby increased the task time.

In some cases the subjects rejected the task by opting out. In other cases when subjects overcome negative motivational states and continue to reach the goal the time of task performance was significantly increased. The option of rejecting or not rejecting the task depends on the relationship between the function blocks of sense of the task and difficulty of the task. If the task is perceived as very difficult but not sufficiently significant for subject then they will reject the task performance. Thus the level of motivation, which determines the acceptance or rejection of task, depends on the relationship between the significance and difficulty of task.

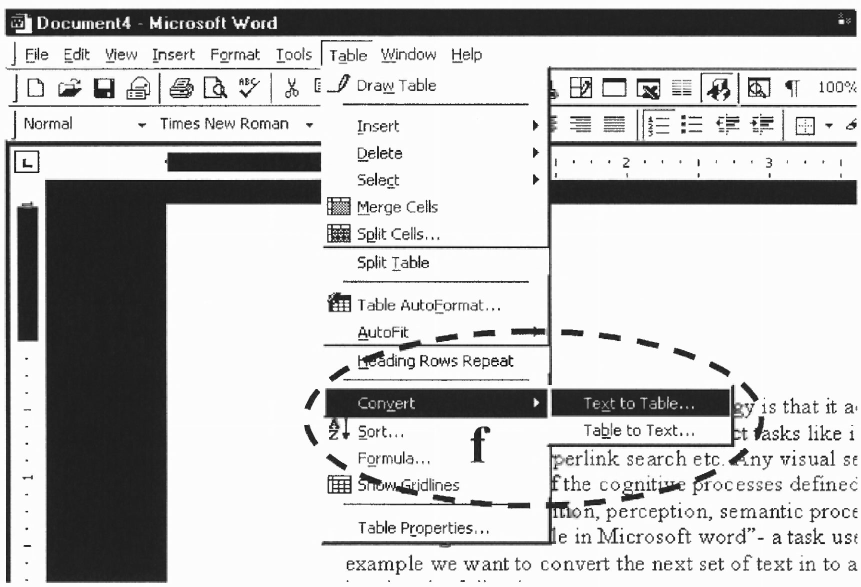

Figure 4.8 Search areas in the third screen according to verbal protocol

As soon as the third stage (figure 4.8) came up the subjects had no problem in identifying the option as the semantics completely matched the verbal-logical processes- subjects were encountering (area “f”). The function blocks of evaluation and experience rendered a match between the subjective and objective image of the subtask and the execution took no time for opening the dialog box as shown in the fourth stage. Interestingly the inexperienced user could not understand what the two options, "Text to Table" and "Table to Text", in the convert submenu meant, a fact supporting the importance of experience function block.

The fourth stage had most of the problems and even with the experienced user. The dialogue box had given no clue to the subjects in terms of the result.

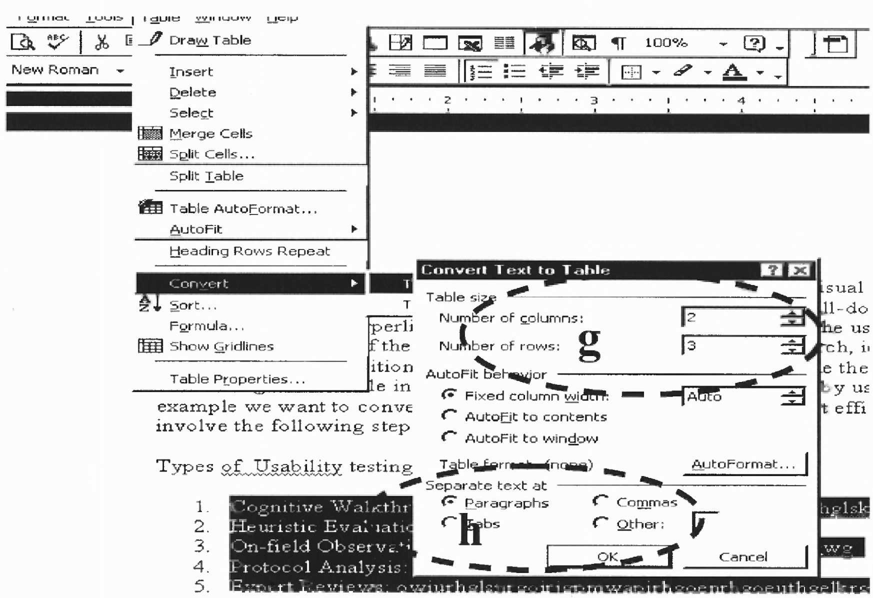

Figure 4.9 Search areas in the final screen and areas of decision-making.

Only the number of rows and columns (area "g") attracted subjects' attention. The second set of choices, a subjectively relevant task component was never paid attention by most of the subjects. On the other hand all the subjects who reached this stage could make out that any option in the area "h" (the dialogue box) would have an effect over the results and thereby had developed an adequate representation of the task. But not how to perform the same? Here discrepancies were between orientational components and executive components of activity. The area “h” does not possess identificative features to let the subject select a correct program of performance.

The experienced user tried all the options sequentially to satisfy the criteria developed by evaluation blocks. This reflected a development of trial and error strategies through a sequence of executive and evaluative steps thereby complicating the interactions between the executive and evaluative blocks of self-regulation. As a result, the complexity of the task noticeably increased. Subjects 2 and 3 were still using visual processes to search the screen, specifically areas “c”, “b” and “e”, for identifying options, which were relevant to the task.

From the observations, it is clear that at each stage of interaction the function blocks of the self-regulation system either were reconstructed or reoriented in terms of the feedback influences. Cognitive processes were mostly dominated by visual search tasks and a fair amount of time was expended for search of unwanted areas on the screen. This was due to the similar identificative features of the icons and meaning in the text, which rendered an improper state to the users’ mental dynamical model of the image of the task.

Two inferences come out of these observations. First, in any interaction we cannot define the components of the interaction by simply extracting the elements of the task. These elements include icon search, menu search or text search. Rather, these elements are integrated by function blocks into a structural system, which is relevant to the particular stage of the solution. The more experienced the user is the less the time and resources used on these function blocks for proper execution. A highly efficient user of MS Word uses strategies of performance in which evaluative components of activity significantly were almost automatized. Thus, self-regulation of activity achieved a more automated level of functioning.

Second, it is better to use an object-action pair for tool tips. Tool tips should be provided for menu options too with the option of activating and deactivating these features. For example, the use of tool tip "Columns" in one of the icons confused most of the users. It is used for writing text in two columns. Therefore, a better use should be "Columns for Page." Using a tip, like "converts the selected text into a table as specified" at the "convert" menu option, would definitely be helpful for Subjects 2 and 3. Subject 1, who is not comfortable with it, can deactivate the feature. The basic aim is to guide the user through the process in such a way that he identifies the correct sub-strategies most of the time. This will expedite the process of his learning and the self-regulation function blocks will execute with more efficiency. A sample result obtained by the second user in the process is illustrated below in figure 4.10.

Cognitive Walkthrough:Cognitive walkthrough is a review technique where usability specialists	Protocol Analysis: Protocol Analysis is a popular technique used during usability
Heuristic Evaluation: It is a variation of usability inspection where expert evaluators construct	Questionnaires: Questionnaires are written lists of questions that you distribute to users.
On-field Observation: Observing users in the field is often the best way to determine	

Figure 4.10 Final product or result obtained by second subject initially.

CHAPTER 5

CONCLUSIONS

5.1 Activity Theory as a Theoretical Lens for HCI

The functional analysis of HCI related activities reveals the relationship between empirical material and the function blocks of self-regulation, which provides the opportunity to precisely describe users' performance strategy during HCI. Goal formulation and experience are of prime importance, which necessitate memorization and training as important factors for these tasks. The function blocks of goal and subjectively relevant task conditions function as filters, which determine what information is important for a particular stage of task performance. Thus AT promises to shed light not on the tasks as a separate unit but as a component which is affected by related processes and subject behavior.

Usability techniques have been criticized for lack of theoretical backup. This may be due to the fact that usability studies are performed on individuals who have unique behavior phenomenon during interaction. Unless the user behavior is modeled analytically the results of psychological research cannot be applied with efficacy to understanding usability problems, which show up during the stage of actual use. It is difficult to chart the myriad of human behavior but it may be possible to model the interaction of these simultaneous processes to render usability testing as a useful and cost-effective tool for the industry.

Usability aims to render systems to be a pleasant learning experience for the users. AT aims to expedite the learning process through its holistic approach to the cognitive processes involved. The thesis addresses only visual search processes but AT can involve many other processes. As more sensory input channels are used the nature of interaction will become more complex and individual models of these tasks may lead to misleading results. Future research is needed for adopting AT to study different activities in HCI and modification of the established techniques like systemic-structural analysis is needed for efficient implementation.

5.2 Implications for Usability Testing

Usability addresses the relationship between a tool and its user. In order to be effective, it must allow the intended users to accomplish their tasks in the best way possible. The review of usability in chapter 2 can be summarized in the figure 5.1 below

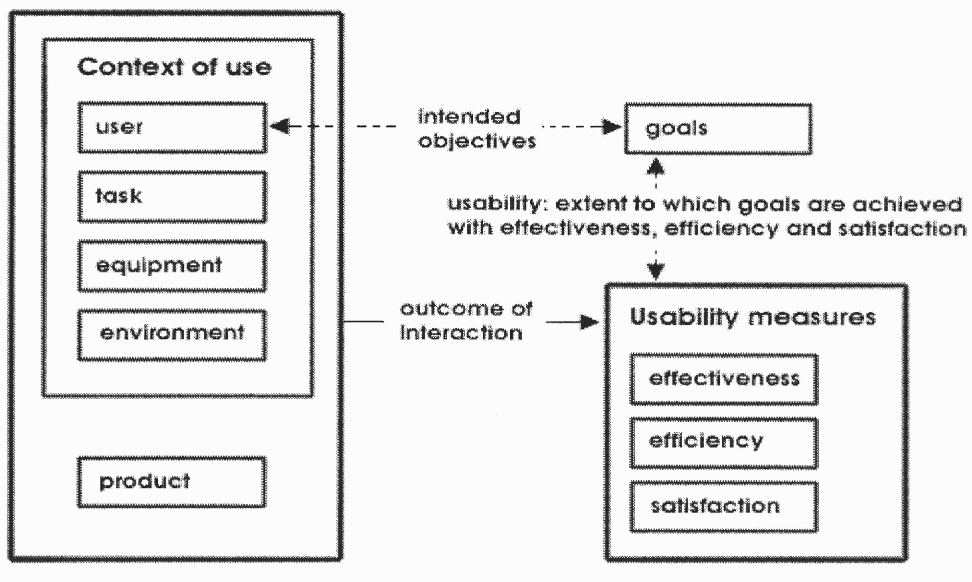

Figure 5.1 Usability framework according to ISO/DIS 9241-11.2.

Activity theory studies the user (subject) relation to the goal (desired result of the tasks) and the tools or equipment (entity for accomplishing the tasks towards the goal). The same principle applies to computers, websites, and other software. Holistically, every system irrespective of its implementation should conform to the user to work and be able to employ its functions effectively. Computer interfaces encompass severe complexities due to the very nature of the dynamically changing goals as well as the related tasks and subtasks due to user behavior, experience, motivational levels and feedback. It has been discussed how every function block is interrelated to each other in the context of a Human Computer Interaction task in chapter 4.

Thus, there is a direct relationship between Usability testing and Activity Theory. The issues, that both of these techniques try to address, are the same. Usability approaches the problem empirically and then tries to identify the gaps in the interaction. On the other hand, Activity Theory uses a classical theoretical approach. The preferred method for ensuring usability is to test actual users on a working system. Achieving a high level of usability requires focusing design efforts on the intended end-user of the system.

There are many ways to determine who the primary users are, how they work, and what tasks they must accomplish. However, clients' schedules and budgets can sometimes prevent this ideal approach. Some alternative methods include user testing on system prototypes, a usability inspection conducted by experts, and cognitive modeling. The key principle for maximizing usability is to employ iterative design, which progressively refines the design through evaluation from the early stages of design. The evaluation steps enable the designers and developers to incorporate user and client feedback until the system reaches an acceptable level of usability.

5.3 Further Research

Activity theory has developed on basic work-study and activity systems involved in social life. The next step is to identify the potential of the other methods offered by the set of tools in systemic structural analysis. Computers offer to be an interesting entity when it influences activity systems in social arena. To study them and the users in relation to these systems, Activity Theory needs to be modified on the basis of relevant parameters. The interactions are not as simple as identifying a sequence of steps. It is a complex dynamic structure where each aspect can influence the other to bring about drastic changes in the interaction and finally the result. Research is also required to classify the different areas of computing applications in terms of conditions they are used, types of tasks they are used for, criticality of the operations, motivational aspects and user population characteristics.

This is not only restricted to the desktop computers but also to various appliances which have found their place in the market due to their specificity of operations. These include palm pilots, hand held pcs, cell phones, ATM machines, vending machines, displays and any other conceivable system, which provides an user interface for reaching the mass. Only then can the vision of universal usability (Shneiderman, 1997) can be realized.

APPENDIX

PROTOCOL ANALYSIS TRANSCRIPTS

Subject 1

- This seems to be fairly easy.
- What I will do is go to the table menu.
- Oh! I forgot. I have to select first and then I am clicking open the table menu.
- In the table menu the convert option will do my job.
- Obviously I have to select the text to table option.
- This is where I always confuse with thos feature.
- Any I will try my luck with all of them.
- Now what did I use to separate the text?.
- I hope its paragraph.
- I choose the paragraph option and click ok
- No this is not what I want.
- I will use the tab option next time.
- Ya this will work definitely.
- I go to convert and use the similar path.
- I choose the tab options in the separate text by group.
- I click ok. Ya that's it. I knew I would get that.

Subject 2

- Reading the titles or rather the text. I am thinking in a way to ordering it.
- Hey I think it is already in sequence so I will stick to what is there.
- Now how do I convert this text to a table?
- May be I have to highlight this as whatever formatting stuff we do we select the text.
- So I take the mouse put the cursor on the start of the text and select the area.
- Its related to table let me go for the menu which shows table. I am going through the options and trying to figure out what each means.
- Convert suits the best so I place the pointer on it and a menu opens with text to table.
- Bingo this option might give me what I am trying to do.
- Now what's this dialog box?
- Oh it gives the options for the table. I am going to use two columns. Why cant I do anything with rows anyway it is fine because I need five rows and it is showing five.
- Now how am going to separate the text to make table?
- This area is confusing. What do these options mean?
- Error-sound on clicking "enter". This is not what I want? (clicks undo)
- Hey I can use paragraphs. As this did not come out the way I wanted.
- I use the same menu options to go to the dialog box and I will click on paragraphs.

- I chose paragraph to separate text as the other option is giving me a error sound.
- I am thinking whether this will give the desired result.
- Anyway let me click on this let's see what happens.
- Hey the titles should be separate from the description.
- I am thinking how to separate this. This is not coming through. I separate them by space.
- I will insert space. Using the keyboard to insert spaces.
- Lets just do it manually by going to each one.
- Now to have two columns. Let me do it by drawing a line between the spaces. I click the straight-line icon and then draw it. I think I should have another row for the heading.
- Looking for icons below the menu bar. The one, which have a table sort of thing.
- Nothing works out here. Let me get back to the table menu option. Oh I think left click might do some trick. So I place the mouse on the text and left click. Damn no such options. Wait the insert table icon could have done it. But ...(thinks)
- Now I click open the insert table. Nothing to help me here. Does not suit what I am trying to do.
- I will go back to the table menu. May be it will give me something.
- Hey there is an insert rows above option, which I think will work.
- So I click it. But oh no it came at the third row. Why?

- I am wrong. I think I have to repeat the procedure but no option is working.
- Let me go to the insert but no menu is available. You know I will give up this and just write the text on the top of the table. Or let me give it a last try by pressing this icon. (Nothing happened).
- Anyway I will just write the text. Just write without inserting the row.
- I will press the space bar to align the Text at the center.
- I should have done the insert part. But the Menus did not give me any clue how to do it and neither did the icons.

Subject 3

- I have to convert this text into a table. That means.. All right.
- I will first create a table and then insert these texts to the respective cells.
- I will have to make a table with two columns and five rows, as there are five items and their description.
- So I point my mouse to the table menu and click the draw table option. But here is no table on the text. Let me use the next option.
- I click on insert table and ok now I have the dialog box, which gives options for filling in the number of rows and columns.
- I am filling the rows text box. It has already given me the columns. That's nice.
- Now I will put in the text inside respective cells. How do I do that? May be I can cut and paste. Or would typing be faster. Who is going to type? I

will cut and paste the text into the cells. I am lazy when it comes to typing.

- Now I am selecting the text to be put in and then I move the mouse to the cut icon.
- Then I come back to the cell and click on it to position the cursor.
- I am now moving the mouse to the paste icon just by the side of the cut icon and click on it to bring the text in the cell.
- (The subject repeats this for the rest of the text and arranges the text in the order desired)
- Now I think I should remove the extra row, as it is looking a bit awkward due to it being empty.
- I left click the mouse and in the pop up menu I find the option of deleting a row.
- Now I will center the title on the first row and I think then it will be done.
- I am selecting the heading in the first row of the table and then I move my mouse to the center-justifying icon and click it to get the desired result

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