"THE IMPACT OF LANGUAGE THEORIES ON DSS DIALOG"

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ABSTRACT

Dialog forms the primary avenue to prevent mismatches between the needs of a computer-user and his/her ability to communicate them to the information system being employed. Using this perspective, user-computer interfaces can be thought of as "linguistic communication systems" that are only technically implemented. Such interfaces are especially important for decision support systems (DSS) where "in the eyes of the user, the dialog _is_ the system".

This paper suggests a linguistic framework for the design of the DSS user interface. First, it presents the historical foundations and perspectives of five major approaches based on language theories. These are the Fregean Core, Chomskyan Grammar, Skinnerian Response, Piaget's Schema, and Ordinary Speaking. Then, it discusses how current and potential DSS interface research are related to these multiple theories and provides illustrative examples of each type of DSS dialog.

KEY WORDS AND EXPRESSIONS:

Decision Support Systems; Language Theory; Human-Computer Interaction; User Interface; Dialog Design; Human Factors; Artificial Intelligence.

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1.0 INTRODUCTION

Many researchers in the decision support systems (DSS) field have addressed the need to understand the characteristics of user-computer interaction when designing the system. The dialog establishes the framework in which outputs are presented as well as the context of user inputs (Ariav and Ginzberg, 1985). According to Sprague and Carlson (1982), "much of the power, flexibility and usability characteristics of a DSS derive from capabilities in the interaction between the system and the user which we call the dialog system" (page 29). From a study of DSS critical success factors, Liang (1986) extends this concept by proposing that the DSS representation format is the most critical factor affecting user attitude.

DSS users are many and varied. They may be expert or novice, routine or ad-hoc, frequent or occasional users. Their tasks may be in a variety of application areas and require different processing capabilities. Users may make requests for data retrieval, direct numerical computations, model execution, and reports generation. They may also be the source of information that the DSS needs in order to structure problems and propose solutions.

The aforementioned diversity suggests a wide variety of "language systems" specifications (Bonczek, et al., 1984). These specifications manifest themselves in the form of user-computer (U-C) dialog. In developing the DSS U-C interface, there is often a trade-off between flexibility and ease of use by a non-technical decision maker or staff member (Bonczek, et al., 1981). There is also the issue of active versus passive style. Active style refers to a dialog in which users state requests in a command mode. These requests may be database queries, step-by-step model formulation, data manipulation, or procedural code. Passive style, on the other hand, refers to a dialog which presents possibilities to the user for selection. User requests may be in the form of questions, fill-in-the-blanks, menus, or hyperCard "hot spots".

Effective U-C interface goes beyond the vague notion of "user friendliness". The evaluation of U-C dialog should be based upon the following criteria:

(1) Functionality:
- Must allow the user to carry out tasks rapidly.
- Must be compatible with other computer and non-computer systems that users may be using.

(2) Reliability:
- Must be highly available.
- Must be consistent and accurate.
- Must ensure privacy and security.

(3) Learning/Ease:
- Must support short learning times and ease of retention.
- Must assist in reducing errors.
- Must provide understandable feedback.
- Must minimize user effort.

While no dialog can successfully satisfy all the above criteria to the fullest extent, DSS dialog design must still strive to attain these goals. In the eyes of the user, the dialog _is_ the system (Bennett, 1983). The most powerful DSS, with sophisticated modelling and data management capabilities, may not be used if the U-C interface is inadequate. The dialog forms the primary avenue to prevent mismatches between the needs of the user and his or her ability to communicate these needs to the DSS. Using this perspective, dialog interfaces can be thought of as "linguistic communication systems" that are only technically implemented (Goldkuhl and Lyytinen, 1982). DSS dialog performs a linguistic function, and its development should be based upon linguistic theory. The study of the DSS U-C interface should have its roots in language development and formalizations.

The objective of this paper is to demonstrate that understanding linguistics can help focus and structure the research on U-C dialog. The application of this research should provide better and more functional DSS dialog capabilities that can effectively support managers in their decision-making activities. Section 2 of this paper first identifies five main approaches of linguistic theory. It then reviews their historical foundations and discusses their perspectives. Section 3 presents a linguistic framework for the study of the U-C dialog. Sections 4.1 through 4.5 investigate in detail each of the linguistic approaches. They also present examples of each type of the U-C dialog and discuss future research directions. Section 5 concludes the paper with a summary of its content.

2.0 LINGUISTIC APPROACHES

Lyytinen (1985) proposes five major approaches which incorporate the "theories of linguistic phenomena consisting of notions, statements, conjectures, and empirical data". These approaches are:

(1) Fregean Core is a descriptive study of language within the context of its relationship with the world; its primary function is to identify the structural characteristics of language (Frege, 1952).

(2) Chomskyan Grammar is a generative or productive study of the

structural relationships between language elements and the manner in which they can be generated; it is concerned with the underlying structure of sentences and their associated meanings (Chomsky, 1957 and 1968).

(3) Skinnerian Response is a behavioristic study of language and its relationships with observable behavior; it is concerned with how language promotes operand learning and surface associations (Skinner, 1953 and 1957).

(4) Piaget's Schema is a cognitive study of language; it focuses on the relationships between the mind and linguistic behavior (Piaget, 1952 and 1970).

(5) Ordinary Speaking is an interactional study of the relationships between language and human action; it focuses on the conversational aspects of language (Austin, 1962; Searle, 1969).

Table 1 reviews some of the unique characteristics of each of the five approaches listed above. These characteristics are now described. Fregean Core and Chomskyan Grammar are both founded in the linguistics school. Advocates of the former approach surfaced in the 1940's and 50's, while the supporters of the latter emerged in the 60's. Skinnerian Response and Piaget's Schema both have foundations in the field of psychology with the former becoming popular in the 40's and 50's and the latter in the 60's and 70's. Ordinary Speaking has become recognized in the 1960's.

Insert Table 1 about here

The primary linguistic functions focus on the purpose that language serves in human life. These are:

(1) The Descriptive Function: It implies that the language denotes tangible entities, truth-values, structures, and logic.

(2) The Generative Function: It suggests that, in addition to being descriptive, language also has an explanatory level for grammar, meanings, and sense relations.

(3) The Behavioral Function: It focuses on publicly observable responses to stimulus and to conditioning and learning.

(4) The Cognitive Function: It emphasizes the organzing role of language in human cognition and memory.

(5) The Interactionist Function: It stresses the social and expressive aspects of language use. People employ language to express feelings and attitudes and to establish, coordinate, and control relationships with others. The interactionist function also emphasizes the role of language when making sense of intentions, perceptions, and experiences.

The nature of knowledge reveals the properties of knowledge obtained during a linguistic study. In this context, we distinguish the following alternatives:

(1) The mathematical nature of knowledge shares properties with axomatic knowledge.

(2) The conceptual nature of knowledge uncovers features of mental acts and objects.

(3) The empirical nature of knowledge explains human empirical behavior in causal terms.

(4) The psychological nature of knowledge deals with facts and laws of

psychological reality.

(5) The rule-based nature of knowledge expresses rules and norms that underlie human practice.

Each language approach provides a different level for a linguistic study. The individual level concentrates on the analysis of language as an individually-based phenomenon. It is founded primarily on an individual's skills and competence. The group level concentrates on the analysis of language as it is anchored to social context.

3.0 THE LINGUISTIC FRAMEWORK

Studying linguistics can provide an invaluable framework for the investigation of the U-C dialog. Each approach to language has its unique set of characteristics and selective attributes. These characteristics can be summarized by three linguistic components: (1) style, (2) structure, and (3) content. Style is the mode, manner, or appearance of the language. Structure deals with the syntactic arrangements of the linguistic elements. Content incorporates the semantic attributes of linguistics. Table 2 compares the linguistic components of the five approaches introduced in the previous section.

Insert Table 2 about here

The five linguistic approaches are based upon theory that traverses the extremes from description to explanation, repetition to analysis, learning to acquisition, public response to states of consciousness, surface structure to deep structure, and performance to competence. While no one theory can dominate this framework, together they can form a strong foundation for research and development of the DSS user-computer dialog. Table 2 and the remaining sections of this paper list some implications for adopting this framework.

4.0 THE IMPACT OF LANGUAGE THEORIES ON DSS DIALOG

4.1 Fregean Core

The Fregean Core approach rests on the assumption that natural language sentences correspond to logically true and false facts in the world. Its basic structure is built upon a rigorous application of the scientific principle of observation of human languages. Only the "publicly observable responses" are subject to investigation. The linguist's task is to describe human languages and to identify the structural characteristics of those languages. They believe that every fact in the world corresponds to a structure in the formal language, and a systematic approach can be applied to translating sentences into a formal language that corresponds to these facts. Operations can be performed on the language structures to produce new structures that preserve the truth value of the facts.
The initial rise in the popularity of the Fregean Core approach led to an unchecked rush of linguists worldwide to write the grammars of exotic languages (Brown, 1980). They believed that the languages of the world differed considerably in style and that no preconceptions could be used to infer their correspondences to the facts. Sapir (1933) stated: "It is best to admit that language is primarily a vocal actualization of the tendency to

see reality symbolically".

The Fregean Core approach can make its greatest contribution to the DSS U-C dialog in the study of command languages, punctuation, naming, abbreviations, and syntax. Since the Fregean Core approach focuses on the structural elements, operational mechanisms, and formal notations of language, it views dialog in terms of the sequencing of words, the mapping of words or names to facts, the relationships of names to other names and abbreviations, the logical operators within sentence structures, and those aspects of language that effect truthfulness and correctness. The following presents some examples of dialog research based upon the Fregean Core approach.

Many studies have been made in the area of the structure of command languages. Barnard, et al. (1981) performed an experiment to determine whether order and consistency had any effect on user speed. Their results suggest that command languages should consistently allow users to enter the simple, more familiar, and well-understood terms first, and then let them consider the more variable terms, e.g., "OPEN FILEA" rather than "FILEA OPEN".

Further studies by Carroll and Thomas (1982) have suggested that users also prefer commands and congruent pairings. Hierarchical commands build upon other commands such as "MOVE heading-name UP" and "MOVE heading-name DOWN". Corresponding non-hierarchical commands would require two unique commands to perform these same tasks. Congruence pairings represent the semantic oppositions in the definitions of the commands to which they refer, for example, "OPEN" and "CLOSE".

Punctuation has been studied. Radin (1984) conducted an experiment comparing different punctuation commands with the use of the space-bar. His subjects experienced higher entry speed, accuracy, and readability using the space-bar instead of punctuation keys. Much discussion has resulted from the study of naming and abbreviations. Thomas and Carroll (1981) suggest names of referents stand for, or abbreviate, their descriptions. Users tend to name the "things" they create by referring to their defining properties. One naming rule debate revolves around the question of specificity versus generality. Specific terms can be more descriptive and may be more memorable. On the other hand, general terms may be more familiar to users and therefore easier to accept. Black and Moran (1982) compared learning speed and recall of commands using a paper and pencil test. Their results indicated that infrequent, specific command sets (e.g., "INSERT", "DELETE") were easier and faster to recall than general words (such as "ALTER" and "CORRECT"). Even nonsense words ("GAK", "MIK") did surprisingly well since they were specific.

A number of studies support the notion that abbreviations should be made using a consistent strategy [See for example (Benbasat and Wand, 1984) and (Schneider, 1984)]. Some of the various methods that can be applied are: truncation, vowel dropping, keeping the first and last letters, standard abbreviations from other contexts, and phonics (example "XOT" for execute). Truncation (using the first, second, third, etc. letters of each command) appears to be the most effective mechanism overall, but it has problems (Schneider, 1984). Conflicting abbreviations appear often; e.g., "PR" for "PRINT" and "PROTECT". Congruency of pairs of names may be violated, for example using "U" for "UP" and "D" for "DELETE" instead of "DOWN". Minimal distinguishing identifiers may be lost ("OUT" for "OUTPUT-A" or "OUTPUT-B"). Moreover, decoding an unfamiliar abbreviation is not as good as with vowel dropping.

Fregean Core also lends itself to studies of syntactic knowledge of users. Syntax refers to the way words or commands are assembled into a complete sentence that instructs the computer to perform a task. Syntax knowledge is usually device dependent, acquired by rote memorization, and easily forgotten (Schneiderman, 1987). An example is the use of delete, backspace, CTR-H, or escape to erase a character. The choice of the appropriate key depends on the layout of the specific keyboard being used.

SOPHIE (Fox, 1984) is an example of an expert system designed utilizing principles based upon the Fregean Core approach. The system was developed for the U.S. Air Force to assist technicians in learning about electronic trouble-shooting. The interface which took approximately two years to develop, is able to deal with abbreviations, misspellings, context-dependent deletions, paraphrases, and ambiguities.

Mittra (1986) reports on a mainframe-based DSS, called REVEAL, which was designed to offer a natural language syntax. This DSS, which is marketed by InfoTym, assists users in developing business models. Not only does the system provide a natural language vocabulary, it allows users to define their own words and write their own rules. Each rule contains a linguistic representation of what can be imprecise data or approximate statements. By using what is called "fuzzy sets", users can create mathematical models representing imprecise concepts, intuition, experience, and policy statements. For example, a user can define mathematically what is meant by a "low" price or a "high" margin.

In summary, Fregean Core linguistics can assist in building the U-C dialog by establishing a strong foundation in language structure and formal logic. This foundation should be utilized to its fullest in supporting DSS users. Decision makers should not be expected to be proficient at using a keyboard or remembering commands and punctuation from one session to the next. The U-C interface should make DSS users as productive as possible by assisting with syntax and structuring the dialog in a way that enables them to concentrate on the decision task at hand and not on the dialog. Future research in the Fregean Core approach could, for example, explore the effectiveness of dialog that automatically inserts right parentheses and quotes when the user forgets to do so. In the case where the insertion point is not obvious, the dialog could alert the user to manually insert it.

4.2 Chomskyan Grammar

Chomskyan Grammar rests on the assumption that sentences in natural language express both syntactic and semantic regularities. Chomskyan Grammar differs from Fregean Core in its attempt to derive meaning from sentence structure. The meanings of sentences are more closely related to the underlying structures rather than surface characteristics. Within the underlying structures are elements common to all languages, and these may reflect innate organizing principles of grammar. When grammatical rules are concerned with meanings, these are said to be based on sense relations (Lyons, 1977). This approach is instrumental, not only in describing language, but also in arriving at an explanatory level of adequacy in the study of language. "Linguistic theory is concerned primarily with an ideal speaker-listener in a completely homogeneous speech community, who knows his language perfectly and is unaffected by such grammatically-irrelevant conditions as memory limitations, distractions, shifts of attention and interest, and errors (random or characteristic) in applying his knowledge of the language in actual performance" (Chomsky, 1965).

Since the Chomsky view conceives of language as conceptual ideas and meanings arranged by grammar, its primary application is in user-computer dialogs based on selection prompts and natural language interactions. Semantics describe the meanings conveyed by the user's input commands and by the computer messages. Chomsky's approach views the U-C interface in the context of its grammar and assumes that the dialog is anchored to familiar concepts. Moreover, dialog is hierarchically organized, acquired by meaningful learning or analogy, and is independent of the syntactic details.

One of the applications of Chomskyan Grammar is in the coaching of users through menus, programmed function keys, touch panels, picking of icons, and ordinary question-and-answer text. By interactively decomposing a task into subtasks and prompting the user through the selection of functions, operands, and options, the system can assist the user in building a command string. The users' intentions or meanings are conveyed to the DSS while the syntax of the commands is not as apparent. Dialog systems that decompose tasks through the use of menus have been the subject of much research. Liebelt, et al. (1982) demonstrated the importance of meaningful menu organization in a study comparing simple menu trees with three levels and 16 target items. Two trees, one of which was meaningfully organized and the other disorganized, were used by the subjects. Error rates were nearly halved and user think-time was reduced for the meaningfully organized menu form. In a later menu search study, McDonald, et al. (1983) found that semantically meaningful categories, such as food, animals, minerals, and cities, led to shorter response times that do random or alphabetic organizations.

IBM's TREND ANALYSIS software is an example of a system designed to replace all user commands with menu selections. This DSS package lets the user select from a menu of alternatives that include report names and computation commands. Selection is accomplished with a keyboard or a "picking" device such as a light pen. The menu-based dialog seems to be quite effective for inexperienced or infrequent users who are familiar with the problem domain.

Perhaps the most publicized area where Chomskyan Grammar can best be utilized is artificial intelligence, especially dialog employing natural language processing. Within this realm, a dialog representation is considered to be a set of syntactic and semantic conventions that make it possible to describe "things" (or objects). The syntax of a representation specifies the symbols that may be used and the ways those symbols may be arranged. The semantics of a representation specify how meaning is embodied in the symbols and the symbol arrangements allowed by the syntax. Figure 1 shows a semantic net representation of the statement: "The boat is a toy ship, and it is blue". Or semantically speaking: "The boat has three links that together constitute two slots, one slot having just one value and the other slot having two. The color slot is filled with blue and the IS-A slots are filled with SHIP and TOY".

Insert Figure 1 about here

In addition to the semantic net construct, Chomskyan Grammar can assist in the understanding of parse trees. Parsing is the act of applying grammar rules in order to determine how the words are combined. A parse tree shows how the grammatical categories are related to the words. Figure 2 shows an example of a parse tree. The words "time", "flies", "like", "an", and "arrow", at the endpoints of the tree, are all terminal symbols. The words at the higher levels in the tree are called nonterminal symbols. Each of them is a name for some grammatical category: S represents a sentence, NP a noun phrase, N-MOD a noun modifier, VP a verb phrase, NP a string of noun modifiers, and DET a determiner.

Insert Figure 2 about here

Parsing applies rules of a phrase structure to compute a parse tree. The objective is to determine the function of each word in a sentence and thereby facilitate U-C dialog. This relieves the user of the task of learning new syntactic rules when communicating with an unfamiliar system.

Biswas, et al., (1988) report the development of an expert system, called OASES, which utilizes natural language to emulate a consultant and aid in trouble shooting manufacturing processes. OASES employs a direct question and answer technique for evidence gathering. User responses are not restricted to the context of the query. But when users are unable to understand the query, the system displays a list of meaningful responses. OASES parses using an augmented transition tree. However, when unable, it resorts to a "pattern-matching" approach and finds evidence which is then submitted to the user for verification. An example of the dialog with pattern-matching is now provided.

OASES - On which shifts have you observed the problem?

USER - We have been experiencing a gradual decrease in efficiency over all shifts.

OASES - OASES has extracted the following evidence. Confirm (y.) or disconfirm (n.).

((trouble occurs) (all shifts))?

USER - y.

OASES - ((problem symptom) (decrease in efficiency))?

USER - y.

Several proponents of natural language interaction now acknowledge that current system interfaces cannot understand language in a significant sense (Winograd and Flores, 1986). This does not preclude the use of natural language interfaces in DSS because many practical applications do not require deep understanding. Natural language has been successfully applied to such diverse areas as tutoring, foreign language translation, naval logistics, city government question and answering, text generation, and even check book balancing. Most studies have focused on the issue of whether natural language can assist a user in meeting his or her goals. However, some laboratory experiments have attempted to investigate usability of a restricted natural language for database queries. Schneiderman (1980) briefly trained subjects in SQL and then tested them in an experiment to determine whether they asked more valid queries in English than in SQL. Half the subjects queried in English first and then in SQL. The other half queried in SQL first and then in English. There was no significant difference in the number of valid queries asked, but an order effect in the English-to-SQL group having more errors than the SQL-to-English group was apparent. Similarly, a field trial conducted by Vassiliou, et al. (1983) demonstrated that there was no significant difference in the performance of

SQL and natural language users; however, the former group required more query-formulation time.

In summary, Chomskyan Grammar has a limited but interesting research future in the field of artificial intelligence and especially in the area of natural language processing. Its emphasis on grammar, semantics, and meanings hold the possibility to free the user from learning dialog rules. Future DSS will have built-in selection prompts to guide the user through grammatical structure or natural language interfaces that parse the decision maker commands. The user will no longer be required to learn software- and hardware-dependent dialog and can spend more time concentrating on the decision task at hand.

4.3 Skinnerian Response

The Skinnerian Response approach rests on the assumption that language is a mechanism that causes and controls observable behavior (Skinner, 1957). The meaning of natural sentences lies in the behavior they have caused by serving as a stimulus. Skinner is best known for his experiments with animal stimulus-response behavior in "Skinner's boxes", but he has also gained recognition for his contributions to education through teaching machines and programmed learning. The Skinnerian Response view has best been utilized in assisting users in the learning process by utilizing repetition and reinforcement and also in developing dialog that specifically illicits responses such as system messages, error handling, and help screens.

The Skinnerian Response view emphasizes a "means-end" relationship between linguistic stimuli and DSS effectiveness. It focuses on a mix of variables in the decision maker's environment. These variables influence the resulting behavior of the decision maker and the effectiveness of the decision itself. Unlike the application of Chomskyan Grammar to natural language interfaces, Skinnerian Response views DSS dialog in terms of the computer as the speaker and the user as the listener. This listener's role is to understand the problem and determine the decision that must be made. The speaker must provide the appropriate cues in the form of suggestions, messages, windows, menus, help facilities, etc. which allow the user's intelligence to keep choosing the next step. Only through the use of consistent and understandable dialog can the DSS produce sufficient <u>stimulus</u> to help users appropriately <u>respond</u> by changing or reversing their actions.

Kobashi (1985) used dialog in the form of suggestions in developing a multicriteria decision-making tool. Based upon the assumption that aiding does not mean structuring of a DSS environment, he developed a table-oriented decision aid, called TODA, that displays such messages as "Today's Suggestion: You May Sort The Items Now". No empirical studies were conducted to determine to what extent users have accepted the system suggestions.

Jarke, et al. (1987) took advantage of the concept of learning by example, which they refer to as "Selection-by-Example", in their group DSS software, called MEDIATOR. In the initial setup of this system, users select a subset of data from one or more mainframe databases by following a DSS example for identifying and naming the data fields.

Cohill and Williges (1982) compared the impact of on-line help facilities on 72 novice users. A control group receiving no on-line help was compared with 8 experimental conditions formed from all combinations of initiation (user- vs. computer-invocation of the help session), presentation (printed vs. on-line), and of topics (user vs. computer selection of display material). The control group with no on-line help facilities did significantly worse than the experimental groups. Of all the groups, the best performance was achieved by the user-initiated, user-selected, and printed manual group.

The Skinnerian view of learning emphasizes repetition and reinforcement. One interesting study in this area utilizes a feedback mechanism with a natural language interface (Slator, et al., 1986). Subjects were given a task of creating a graph on a screen by entering natural language commands. The commands were then interpreted into corresponding computer language and executed. Half the subjects could view the associated computer command on the screen, and the other half could not. The group that could see the computer commands made more semantically complete natural language commands than the group that was not provided this feedback.

In summary, the Skinnerian Response school of linguistics has much to offer research in DSS dialog. How the user learns and responds while formulating a decision can assist in developing a new DSS dialog that concentrates on the user as the problem-solver. As an example of a possible research area, Weber (1986) suggests the use of "automated listing and brainstorming tools" for DSS applications. Theory suggests that insight into solving a problem is often triggered by a clue that the solver often never consciously notices. DSS Dialog could provide lists of relevant factors which could be used as triggers.

4.4 Piaget's Schema

Piaget's Schema rests on the assumption that natural language sentences are generated by human cognitive structures and processes. The meaning of sentences lie in the properties of cognitive processes and structures that generate and interpret them. In this view, language allows discovery of underlying motivations and deeper structures of human behavior (Brown, 1980). Unlike other linguistic views, Piaget's Schema supports the notion that DSS U-C dialog cannot treat users as a collective entity but as individuals with separate cognitive needs. U-C dialog should be developed to recognize and support the uniqueness of each user in the task of making a decision.

Every individual using a DSS has a different mental model. Much controversy has centered around whether or not the DSS U-C dialog should be tailored to the user's cognitive skills or preferences (Huber, 1983). Although the controversy focuses on the relative impact of the user's cognitive style and how much consideration should be given for this in the development of DSS dialog, few would argue that the user cannot be completely ignored. Even users have a feeling of self-awareness. In a relatively recent survey of 34 different DSS users, "sensitivity of user's needs" was rated highest in importance (Meador, et al., 1984).

DSS dialog implications for the Piaget's Schema are in the areas of user preferences, experience, and usage patterns. Sign-on procedures are an example of where Piaget's Schema can have an impact. Sprague and Carlson (1982) recommend that since most DSS users interact with their systems infrequently, sign-on procedures should be customized according to user preferences. Schneiderman (1987) proposes that infrequent users maintain only the semantic knowledge and computer concepts related to a task and have difficulty maintaining the syntactic knowledge. He recommends that the user's burden of memory be lightened by simple and consistent structure in the command language, menus, and terminology employed, and by the use of recognition rather than recall. Turban and Watkins (1986) suggest the use of familiar terms and natural language interfaces for both expert system and DSS users in order to "improve the interaction between managers and computers".

As an example of a direct application of user preferences, it has been reported that expert systems are being developed for financial service organizations for the purpose of establishing and maintaining financial plans for customers (Bond, 1987). The expert system retains in memory the expectations, commitments, goals, and preferences of each customer, along with the previous history of financial services. Changes to the customer profile and all financial purchases automatically update the database and thus provide individualized decision support for each customer's purchase options.

Liang (1987) reports on a DSS developed with a self-adaptive U-C interface. The interface adjusts itself according to anticipated user behavior. Users are divided into three groups: consistent, systematic, and random. Users who always prefer the same presentation mode are referred to as consistent users. Those who change their preferences in a partially predictable way are called systematic users. Users who change their preferences unpredictably in a given situation are categorized as random users. The DSS tracks user preference patterns and then adjusts its default presentation mode accordingly.

Another example of a system that was designed around user experience is IPMA (Integrated Pest Management Assistant). This expert system was created for the Department of Entomology at Oregon State University (Goul and Tonge, 1987). IPMA is used by extension agents to help orchard owners make decisions regarding pear tree infestations. Since the orchard owners were familiar with manuals, the U-C interface was designed to look like an "electronic" manual, complete with table of contents and chapters discussing tree phenology stages. In addition, a dictionary containing words and phrases and a scratchpad were added to allow users to record personal insights and observations.

Some of the research in cognitive style indicates how the U-C dialog can more effectively support DSS users. Zmud (1979) reported that systematic/analytic thinkers prefer more quantitative information and require more decision time than heuristics. Dialog with systematics would consequently be more quantitative and contain less narrative.

Fowler, et al. (1985) constructed an exploratory study with field dependent/independent types. Field-independent cognitive styles tend to be manifested in the ability to analyze and restructure information according to situational demands and personal needs. On the other hand, a field-dependent cognitive style is manifested in the acceptance of, and reliance on, the inherent organization of overcoming an embedding context influence. The researchers wanted to determine if there was a correlation between cognitive styles and the command structures of the U-C dialog. In the study, one of the two types of commands was given to subjects to allow them to retrieve and edit files. The first type was the linear structured command which requires the user to enter both command and argument together. The second type was the substructured command which provided a set of prompts for the arguments. The results suggested that field-dependent users tended to prefer substructured command language. Field-independent individuals showed a general preference for linear commands. More interestingly, they requested more help screens than the field-dependent subjects.

In summary, Piaget's Schema approach to U-C dialog has the potential to allow the computer to communicate more meaningfully with the user. The effects of cognitive structure on dialog require more empirical study before our knowledge can be expanded in this area. However, until that time, it has been recommended that future DSS be designed with dialog options that provide users with the flexibility to select their most preferred "interface" style (Mann et al., 1986).

4.5 Ordinary Speaking

The underlying assumption of Ordinary Speaking is that natural language sentences correspond to performances of speech or social acts. Speech acts are minimal units of verbal and non-verbal communication. They obey rules that are conventional and constitutive. These rules govern successful performance of acts and allow a systematic study of meaning. In the Ordinary Speaking view, one can only explain the meaning of words or sentences by examining "the whole of language and the actions into which it is interwoven" (Wittgenstein, 1958). Thus, language can be studied as an open collection of speech acts. It is a social fact and its primary function is to promote social interaction. Meaning is the result of a rule-following behavior that manifests itself in speech acts. This leads to the conception of meaning which goes beyond speech itself. The study of language now includes the investigation of oral and visual clues. Oral clues include hesitations, pauses, backtracking, social feedback, murmers, voice pitch, and projection. Examples of visual clues are head nodding, posture, and facial expressions.

The linguistic approach of Ordinary Speaking can be best studied in dialog that is used by group decision support systems (GDSS) and computer-supported collaborative work (CSCW). Here the dialog no longer takes the form of "user-computer" interaction but "user-computer-user" (U-C-U) exchange. GDSS are designed to help groups of people make faster, more satisfying, and "better" decisions with the assistance of computer and communication technologies [for details see, e.g., (DeSanctis and Gallupe, 1985) and (Jelassi and Beauclair, 1987)].

GDSS significantly alter the user language since written texts is the primary channel available to the decision maker. The dialog lacks significant oral and visual clues as well as social context information that is normally present in face-to-face or telephone conversations. Kraut, et al. (1982) argued that inhibiting the flow of social feedback, especially "back channel" feedback, feelings, and social meanings, decreases the efficiency of interpersonal communication. An example of "back channel" feedback is nodding one's head or murmuring "hmm". User-computer dialog may also interfere with regulating turn-taking, intentions to speak further, and controlling other procedural aspects of participation. Thus the study of the U-C-U dialog focuses attention on text and the associated methods used for feedback and relating feelings as well as social meanings.

GDSS research is still in its infancy and much more is hoped to be learned in the future (DeSanctis and Gallupe, 1987). However, some studies conducted to date have made some interesting observations. Siegel, et al.

(1984) compared groups making decisions in a face-to-face manner versus using a GDSS with no verbal communication. Their results suggest that GDSS users are capable of communicating to make decisions but require more time than face-to-face groups. They also observed an "uninhibited" dialog by the GDSS users and none by the face-to-face groups. This included swearing, insulting, and name-calling. This phenomena has been termed "flaming" and is thought to be the result of reduced social context and the additional freedom of expression that computing provides (Kiesler, 1986).

Siegal, et al.'s results (1984) also indicated that GDSS users prefer to use more numerical data and make fewer suggestions to compromise and fewer feedback remarks. They also prefer simultaneous conversations, where each member has a designated window on the computer screen for displaying his or her messages, as opposed to asynchronous conversations where only one person at-a-time can send a message.

Research in computer-supported collaborative work investigated multi-user interfaces for computational meeting tools. These tools are being designed and used for a range of informal and formal meeting processes at Xerox PARC [their description can be found in (Stefik et al., 1987a)]. An important abstraction that guided the design of multi-user interfaces is WYSIWIS (What You See Is What I See). It expresses many of the characteristics of a chalk board in face-to-face meetings. Every group member sees exactly the same image of the written information and can see where anyone else is pointing. Some shortcomings of the WYSIWIS concept are due to the inherent conflicts between the needs of a group and those of individuals, since user interfaces compete for the same display space and meeting time. To help minimize the effect of these conflicts, constraints were relaxed along four dimensions of WYSIWIS: display space, time of display, subgroup population, and congruence of view [for details, see (Stefik et al., 1987b)]. Meeting tools and their associated user interface must be designed to support the changing needs of information sharing during process transitions, as subgroups are formed and dissolved, as individuals change their focus of activity, and as the the group shifts from multiple parallel activities to single focused activity and back.

As previously stated, the U-C-U dialog is ripe for studying and much can be learned about the meanings of messages within the context of Ordinary Speaking. For example, future research could explore in more depth how users compensate for lack of oral and visual clues. Flaming has already been observed. Will users also rely more on repetition, verbose messages, "too-prompt" responses, shunning, etc.? In addition, there are possibilities for the system to take a more dominant part in this dialog. Someday computers may sense when users are making too many mistakes, are not responding fast enough, or do not understand the issues. They may also be able to detect the force of the user's fingers on the keyboard and the heat and perspiration levels of the hands. When voice recognition technology can more adequately support research that uses the Ordinary Speaking approach, computers will be able to detect changes in pitch, speed, emphasis, and inflection. A GDSS may be able to inform its users as to which members in the group are tired, angry, or upset. Based upon its understanding of the members, it may even be able to recommend a tactic or a comment that might assist in moving the group toward a consensus.

5.0 PAPER SUMMARY

The framework for the study of DSS dialog, proposed in this paper, suggests viewing user-computer interface within the context of our knowledge of linguistics. The five major approaches to linguistic theory were identified; these are Fregean Core, Chomskyan Grammar, Skinnerian Response, Piaget's Schema, and Ordinary Speaking. Examples of research issues that need to be addressed in each of these approaches were presented. Because language is so complex and the various theories overlap and contradict each other in some instances, it is impossible to isolate any one of these issues within a single theory. Most of the research questions have implications in more than one linguistic approach. They were identified and classified based on the area in which they made the largest contribution.

The Fregean Core approach helps establish a strong foundation in language structure and formal logic which can be used in DSS dialog to assist with syntax constructs and errors correction. The Chomskyan Grammar, by deriving meaning from sentence structure, may serve as a basis for developing natural language interfaces for DSS, coaching users through grammatical representations, and parsing their commands. The Skinnerian Response, in which user learning is enhanced through repetition and reinforcement, produces stimulus to help decision makers appropriately respond to the system. Piaget's Schema depends on users' cognitive style and therefore can be used to support the individual needs of DSS users. Ordinary Speaking, which is based on social rules, can effectively contribute to the dialog design of emerging applications such as Group DSS and Computer-Supported Collaborative Work.

The objective of this paper was to suggest a linguistic framework that may facilitate the structuring of research on DSS dialog and provide guidance for future work. Which theories best serve as models for DSS dialog? Each of them exploits many useful attributes and simultaneously clarifies and distorts knowledge. A theory choice is not to select "the best", but rather "the fittest" for those goals that DSS researchers share.

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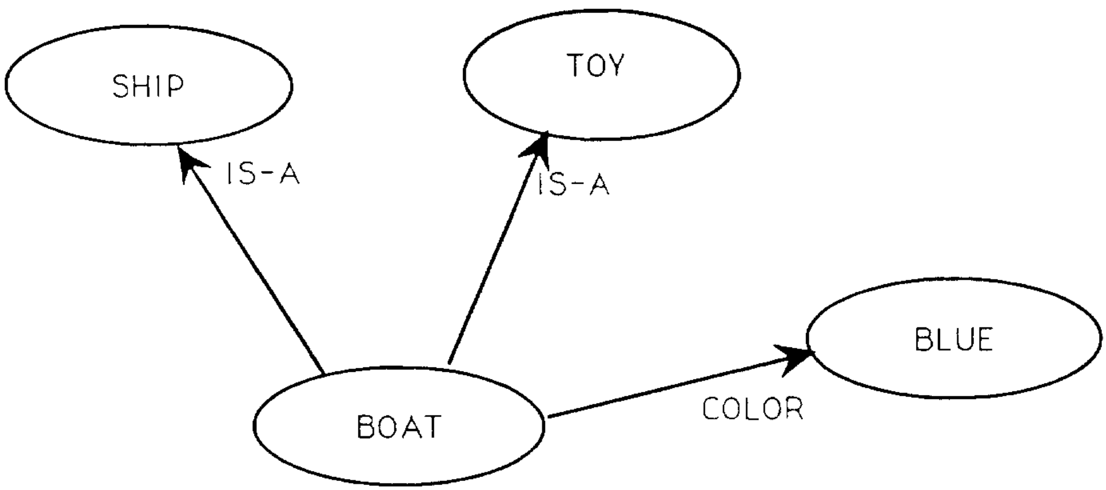
Table 1: Linguistic Theory Characteristics

LANGUAGE STUDY	FOUNDATION	PRIMARY LANGUAGE FUNCTION	NATURE OF KNOWLEDGE	LEVEL	COMPONENTS OF FUNCTIONS	ADVOCATES
FREGEAN CORE	Linguistics Structural School	Descriptive	Mathematical	Not Important	Entities Truth/value Structure Logic	C. Hocket C. Fries C. Frege
CHOMSKYAN GRAMMAR	Generative Linguistics School	Generative	Conceptual	Individual	Grammar Meanings Sense Relations	N. Chomsky J. Lyons
SKINNERIAN RESPONSE	Behavioristic Psychology School	Behavioral	Empirical	Individual	Stimulus/Response Conditioning Learning	B.F. Skinner C. Morris
PIAGET'S SCHEMA	Cognitive Psychology School	Cognitive	Psychological	Individual	Cognitive Maps Memory	J. Piaget P. Lindsay P. Norrman D. Ausubel
ORDINARY SPEAKING	Discourse Linguistics School	Interactional Sense-making	Rule-based	Group	Social Context Speech Acts Intentions	L. Wittgenstein J.L. Austin J.R. Searle

Table 2: Linguistics Impact on DSS dialog

LANGUAGE STUDY	STYLE	STRUCTURE	CONTENT	NATURE OF DSS APPLICATIONS	CONTRIBUTIONS TO DSS DIALOG RESEARCH
FREGEAN CORE	Many, But Not Important	Formal Logic/ Structure Rigorous Mappings of Facts Operations on structure	Truth Value	Command Languages Punctuation Naming Abbreviation Syntax	Assist with structure & syntax Correct Errors
CHOMSKYAN GRAMMAR	Preserves Regularities	Formal Grammar	Correspondence With Observations Meaning representation	Selection Prompts Natural Interfaces	Coach Users Through Grammar Parse Sentences
SKINNERIAN RESPONSE	Consistency Clarity	Repetition and Reinforcement Stimulus/Response	Meaning Lies In Observable Behavior	System Messages Error Handling Help Screens User Learning	Provide Clues
PIAGET'S SCHEMA	Dependent on Users' Cognitive Style	Not Important	Meaning Lies in Cognitive Process	User Preference Experience Usage Patterns	Support Individual Needs
ORDINARY SPEAKING	Promotes Social Interaction	Based on Social Rules	Meaning is the Result of Oral and Visual Clues	GDSS CSCW	Recognize Context Assist with rules and feedback

Figure 1: Semantic Net Representation



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