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Representational styles and the psychological attributes of potential computer command names

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REPRESENTATIONAL STYLES AND THE PSYCHOLOGICAL ATTRIBUTES OF POTENTIAL COMPUTER COMMAND NAMES

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Abstract

Many studies have focused on strategies to devise computer commands which are easy to use and learn. The present study investigated how representational styles and the psychological attributes of command names affect users' choice of commands.

Experiment 1 showed that novice and intermediate users have more metaphorical representations of computers, while experienced users have more realistic representations.

Experiment 2 identified the psychological attributes of concreteness, imagery, familiarity, and understanding for a set of potential command names. These names were used in Experiment 3 to assess the relationship between the psychological attributes of the names and the frequency with which they are chosen by subjects with different representational styles.

The results demonstrated that all users, irrespective of their particular representational style, chose the same command names, with high levels of rated imagery. The implications of these findings for the design of computer interfaces and the standardisation of command names across products and user groups are discussed.

Declaration

I declare that this thesis is my own, unaided work. It is being submitted for the degree of Master of Arts in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any other degree or examination in any other University.

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____ day of_____, 19___

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Sincere thanks to James Fisher, my supervisor, for his invaluable guidance and support.

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Introduction

A human-machine system can be considered as a combination of one or more human beings and one or more physical components of a machine interacting to bring about, from given inputs, some desired output (McCormick & Sanders, 1983). In pre-industrial society a human-machine system consisted of a simple tool such as a hoe or a sickle, operated manually and in a single, physical mode of information transfer with the user. The system was cheap, easy to learn, and easy to maintain. Allocation of the function between the human and machine was axiomatic.

Over the years, the complexity of human-machine systems has increased. Significantly, the shift in recent years has been away from a physical workload toward a cognitive workload. This is largely due to the increasingly prominent and direct role that computers are playing in the conduct of human affairs. Individuals in a vast range of circumstances and for a wide variety of tasks are using computers as tools. The interaction between human and computer can be considered a human-machine system, where the interface between the human and the machine is both physical and cognitive.

The design of interactive computer systems must be efficient and easy to use for society to realise the full potential of computer-based tools. This view is now clearly acknowledged in the computer industry. Where new computer systems were once developed to store and retrieve more information faster, they are now marketed as "easy to use."

To address this issue of human-computer interaction, the traditional scope of human-machine studies needs to be extended to include the study of human cognitive interaction with computers. Also, recent advances in cognitive psychology and related sciences have resulted in sufficient knowledge of human cognitive behaviour to enable applications in computer science and other domains. This means that psychology will play an increasing role in the design and evaluation of interactive computer systems. To this end, it is increasingly necessary to explore and identify the complex cognitive skills, constraints, and other variables associated with making the interface more user compatible.

It is widely accepted that peoples ability to use an interactive device depends in part on their particular representational styles. Representational style refers to the particular way in which an individual processes and makes use of images or representations. Usually these representations are described as providing predictive and explanatory power for understanding an

interuction. When appropriate, representations can be helpful or even necessary for dealing with a system, but when inappropriate or inadequate, can lead to misconceptions or errors. Although not many would dispute the existence of images, the concept remains relatively obscure, and there are probably as many *different ideas about the nature of representational* styles as there are people writing about them.

Research on representational style is fundamentally concerned with understanding human knowledge of the world. In contemplating representations, four different aspects need to be considered. The first aspect is the target system, that is, the system the person is learning or using. The second aspect is the conceptual model of that target system, which is invented by teachers, designers, scientists and engineers to provide an appropriate representation of the target system. The third aspect is the users' actual representation, which are formulated by users through interaction with the target system. The last aspect to be considered is the scientists' conceptualisation of the users' representation. These are concepts about which cognitive psychologists have very strong opinions but little good evidence.

The notion that people represent things to themselves has also been considered in the memory literature. Word imagery, the ability of a word to arouse sensory images, has been found to be an important variable in learning

and memory literature, but does not appear to have been considered extensively in human-computer dialogue as a factor for choosing between potential computer command *names*. As yet, the way in which command names are internally represented is unknown.

Cognitive representation is exceedingly complex. It is difficult to study, predict and measure. The problem of defining representational styles is compounded by the fundamental existence of individual differences. Individuals differ in their ability to use representations and in their preference for using representations for various cognitive tasks. Their subjective experiences, educational levels, attitudes, abilities, etc., affect their internal representation of the real world. It is not surprising that the investigation of individual differences is one of the oldest approaches to understanding representational style. In order to minimise this problem of individual differences, groups need to be formed along criteria based upon some common denominator.

This thesis is divided into two parts. The first part (Chapters 2, 3, and 4) provides the theoretical and conceptual base for the study. The second part (Chapters 5 through 9) presents the method, results and discussion of the actual research.

Chapter 2 discusses the scientists' conceptualisation of representations. Representation is such a vague, intangible notion that there is little consensus of the

form it takes. Generally, two modes of internal representation are reported. One is a more abstract, propositional mode, and the other, a more visual or concrete mode. Both of these are presented in this chapter to provide an understanding of the scientists' conceptualisation of actual representations, which are used in human-computer interaction and form the basis of the present research.

Chapter 3 presents Paivio's Dual Code theory. The basic premise of this theory is that representational style is comprised of two distinguishable codes associated with different classes of information. The coding systems are verbal representations, which correspond to words, and imaginal representations, which correspond to non-verbal elements of experience. The implications of this theory for the role of imagery in memory is discussed. An understanding of the theory will help establish which are the most salient command name variables.

In Chapter 4 the importance and relevance of research on cognitive representation for human-computer interaction is discussed, as is the need to establish the underlying psychological variables that contribute to the language used between the human and the computer.

In the second part, the three sections of the study are presented. Chapter 5 presents an overview of the rationale and procedure of the present research. Chapter 6 describes the first experiment which is an attempt to

determine whether different levels of cognitive representation of computer systems are formed by different types of users. Chapter 7 discusses the second experiment in which a database of computer command names and their associated psychological attributes is created. Chapter 8 describes an experiment designed to assess whether the semantic associations made by people with different representational styles are similar or different. Also whether the associations made are related to the psychological attributes of the words measured in Experiment 2. Chapter 9 presents a general discussion of the results obtained in all three experiments and the implications for user interface design.

Theories of representational style

Individuals' views of the world, of themselves, of their own capabilities, and of the tasks they perform, depend heavily on the conceptualisations that they bring to the task. In interacting with the environment, with others, and with the artifacts of technology, people form internal representations of themselves and of the things with which they interact.

The nature of these representations in cognitive psychology is extremely controversial. It is one of the oldest and most difficult problems investigated by psychologists (e.g., Eysenck, 1984; Johnson-Laird, 1980; Marks, 1972). Over 2000 years ago, Aristotle regarded imagery as the major medium of thought. Many of the *mnemonic systems devised by the ancient Greeks* involved images in some form (Yates, 1966). The phenomenon has been studied *empirically for a century, dating from* Galton's questionnaire on his correspondents' ability to imagine their breakfast tables (Galton, *1928, originally* published 1880).

More recent studies have examined a variety of aspects of representations, including their use as mnemonics (Bower, 1972; Paivio, 1971a), their mental rotation and transformation (Cooper, 1975; Shepard,

1975), their suppression by other tasks (Brooks, 1967; 1968; Byrne, 1974), and their use in retrieving information about objects (Hayes, 1973; Holyoak, 1977; Moyer, 1973; Paivio, 1975). It has been claimed that cognitive representation plays an important role in memory (Richardson, 1980), that it facilitates learning (Paivio, 1971a), and that it is involved in problem solving (Huttenlocher, 1968).

Few cognitive scientists are likely to doubt the existence of the psychological phenomenon of imagery. However, substantial disagreement exists about the way in which images are mentally represented and the use of these representations in cognition (Johnson-Laird, 1980). The major thrust of most discussions usually concerns the particular case of holistic visual imagery as opposed to propositional representation. In other words, the debate is concerned with whether or not images are a distinct form of representation with a distinctive format and structure.

This chapter presents the two sides of the imagery debate to provide an understanding of the scientists' conceptualisation of representational style. It is not an attempt to resolve the imagery debate. Rather, it presents the salient points of the debate to provide background material for the empirical research described in the second part of this study, which considers the users' actual representational style.

Palmer (1978) provides a basic set of assumptions about the nature of representation and how representations can differ from one another at different levels. Palmer (1978) describes a representation as follows:

> A world X, is a representation of another world, Y, if at least some of the relations for objects of X are preserved by corresponding objects of Y (p.267).

In terms of the above, two representations can differ with respects to the objects and/or the relations they represent. Representations can be non-equivalent, informationally equivalent, completely equivalent, or complex (Palmer, 1978).

Non-equivalent representations are those that do not preserve the same information about the same objects. These representations reflect qualitatively different dimensions, for example, length or breadth. Informationally equivalent representations are indistinguishable in terms of the information they preserve about the represented world. This does not necessarily imply that the representations must look identical. For example, the representation of "taller than" could be modelled by "shorter than" or "larger than". Completely equivalent representations are simply informationally equivalent representations in which the same relations are modelled in the same way.

The above discussion concerns "simple" representations that model a single dimension in their referent world. In the real world, the situation is more complex. Many different dimensions of the represented world can be modelled in the same system. For example, a map representing the location of cities by the location of dots, the condition of roads by different colour lines, and the population of cities by the size of the dot, constitutes a complex representation because such a map is not representationally homogeneous.

However, first efforts to determine the level of isomorphism between internal representations and the outside world must necessarily center on the simplest domains. In these domains there exist some normative knowledge that is relatively easy to detail explicitly. For this reason most internal representational research concentrates on the representation of physical objects (Gentner & Stevens, 1983).

Furthermore, following Neisser's (1967) classical statement, the goal of cognitive psychology is to describe the "software" rather than the "hardware" of the mind. Cognitive theories should not be neuropsychological explanations of the anatomical structures and electrochemical changes causing a subjective image experience, although the theories should be consistent with neurobiological possibilities (Horowitz, 1972).

The object of study in the present discussion is mental representation of the world. Palmer's (1978) view of how cognitive theories and models relate to mental representation and its referent, the real world, is as follows:

The "mental world" is some kind of a representation of the "real world." A cognitive model of this mental world (the "mental model") is, in turn, a representation of that mental world. Thus, the mental model is a representation of a representation of the real world. Therefore, according to Palmer (1978), both the mental model and the mental world are representations of the same represented world--the real world (see Figure 1).

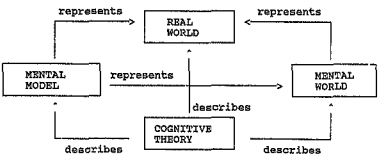

Figure 1. A View Of Cognitive Representation
Relationships among constructs are indicated by labelled arrows.

Cognitive theories and experiments are concerned with the nature of the information represented about the *external* world. In other words, *what the present* discussion considers *is the scientists'* conceptualisation of the mental model of the real world. The mental world and the hypothetical cognitive model of the world should be as equivalent as is meaningful for the goals and methods of cognitive psychology (Palmer, 1978). Current ideas of representation are presented within this *framework of* cognitive representation.

One of the most hotly debated issues of cognition is whether representations are "propositional" or "analog" in nature (e.g. Anderson, 1975; Kosslyn, 1975; Kosslyn & Pomerantz, 1977; Palmer, 1975; Pylyshyn, 1973; 1975). Since one of the present research objectives is to investigate representational style, both positions will be presented, along with the major arguments for and against *each approach*. The discussion is not intended to be either exhaustive or conclusive. Rather the arguments are presented at a level of abstraction appropriate for the present research goals. Empirical research is included where it illustrates one or other of the positions. The theories illustrating the *two sides of* the debate are discussed *first, followed* by the arguments *against* and *for each* theory.

The idea that information is represented in terms of propositions is at present the most popular concept of how meaning is represented in memory. The propositional

approach assumes that the subjective experience of an image is epiphenomenal and that its underlying representation *is propositional in form* (Anderson & Bower, 1973; Baylor, 1971; Chase & Clarke, 1972; Kieras, 1978; Palmer, 1975; Pylyshyn, 1973). These propositional theorists maintain that any information, *regardless of* its original form (e.g., pictorial, verbal, etc.) can be represented by a discrete code, like the binary system employed in contemporary computers.

The *functional* form of knowledge representation is proposed to be in the form of a propositional network. An image in such a network can be represented as a set of *propositions concerning the information* contained in the original image and a set of connections reflecting the relationships among the propositional nodes. In a propositional analysis, only the *meaning of an event* is represented. The unimportant details that humans tend not to remember are not represented. A proposition is the smallest unit of knowledge that can stand as a separate assertion, that is, the smallest unit about which it makes sense to make the judgement true or false (Pylyshyn, 1973). The group of theorists supporting this *view propose* that propositions can embody the complex knowledge used to comprehend prose, carry on conversations, form images, and so on (Pylyshyn, 1973).

Language is the *paradigmatic case of* propositional representation. Words related to objects are related in syntactically ordered strings through relational words

(verbs, propositions and the like). The sentence "the ball is under the table" specifies a relationship between the ball and the table that can only be understood by virtue of the syntactic relationships to the relational construction "is under."

On the other side of the debate, proponents of the analog or imagery position argue that some aspects of knowledge, images in particular because they resemble the objects they represent, are distinct from mere representations of propositions and are, in fact, analog representations (Bugelski, 1977; Kosslyn, 1975; Kosslyn & Pomerantz, 1977; Paivio, 1971b; Shepard, 1975; Sloman, 1971).

The nature of the image is unclear and controversial. Johnson-Laird (1980) outlines the main properties of such a representation, as far as there is consensus. First, the mental processes underlying an image are similar to those underlying perception of an object or picture. Second, an image is a coherent and integrated representation in which each element of a represented object occurs only once with all its relations to other elements readily accessible. Third, an image is amenable to apparently continuous mental transformations, such as rotations or expansions, in which intermediate states correspond to intermediate states (or views) of an actual object undergoing the corresponding physical transformation. Fourth, images represent objects. They are analogical in that the structural relations between

their parts correspond to those between the parts of the object represented.

The arguments against the imagery position have two major thrusts: first, that image representation is inadequate; second, that propositional representation is not only more adequate but is actually essential on independent grounds. In other words, image or analog representations are unnecessary. These arguments are described in the following paragraphs.

The most extensive critique of mental imagery as an explanatory construct for representational style has been given by Pylyshyn (1973). His ideas are discussed a great deal by Kosslyn and Pomerantz (1977) and by Anderson (1978). Most of these and other arguments purporting that image representation is inadequate are based on the "picture in the head" metaphor, whereby visual images are stored in memory much as a photograph is stored in an album, and experiencing an image consists of retrieving and examining one of these mental photographs. However, Kosslyn and Pomerantz (1977) purport that no serious student of imagery actually holds this view. Thus, the critical question is whether the arguments against the imagery position bear with equal force on other conceptualisations of imagery. The five major arguments and their counter arguments are summarised below.

One of the frequent criticisms of imagery theories is that images behave as if they were interpreted, whereas

pictures--just arrays of light information--do not (e.g., Anderson & Bower, 1973; Pylyshyn, 1973). For instance, there is no awareness of having to interpret images as sometimes percepts have to be interpreted. In addition, when a part of an image is forgotten, it is not a random part. It is not as if a corner has been torn from a photographic picture in the head. If an image of a room were incomplete, for example, it would not be missing half a lamp or half a table. Rather, images seem to be organised into meaningful parts, which in turn are remembered in terms of spatial relations among them.

Kosslyn and Pomerantz (1977) do not believe that it is fruitful to suppose that images are simply reembodiments of stored sensations. Rather, perceptual processes result in perceptions being structured into units corresponding to objects and properties of objects. It is these larger units that are stored and later assembled into images that are experienced as quasi-pictorial, spatial entities resembling those evoked during perception itself (cf Neisser, 1967). In terms of the above, equating image representations with mental photographs is erroneous, since this would overlook the structure present within the system (Kosslyn & Pomerantz, 1977).

Second, Pylyshyn (1973) argues that the storage demands to encode these pictures would be enormous and exceed the capacity of the brain. The imagery proponents response is two-fold. First, given the current ignorance

about the capacity of the brain and the fact that there is currently no good measure of the amount of information contained in an image, this remark has virtually no force. Second, storage demands of alternatives to a picture model should be considered. For instance, consider the Baylor (1971) model where enormous numbers of propositions are needed to represent even relatively simple objects. Kosslyn and Pomerantz (1977) conclude that capacity arguments levied against imagery can be applied to propositions with equal force (Kosslyn & Pomerantz, 1977).

Third, although information can be represented vaguely in a picture, it is claimed that the *character* of this vagueness does not match the character of vagueness in introspective reports of images. For instance, Pylyshyn (1973) points out that it is possible to recall what objects were in the room without recalling their exact location. A poor resolution picture of the room is more likely to preserve spatial information than to preserve object identity. Anderson (1978) argues that this is not an insurmountable problem with the picture metaphor, that it is possible to encode two subpictures without encoding their relative spatial location.

A fourth criticism that Pylyshyn (1973) levels against the picture metaphor is that it is misleading in that it causes people to postulate mental processes by analogy to operations they can carry out on pictures. Anderson (1978) claims that it is an open question

whether the metaphor is in fact misleading. For example, the fact that mobile eyeballs are not available for viewing images poses no insurmountable problem. Sperling (1960) reports that eye movements are irrelevant when scanning afterimages. Rather, a shift of attention from one part of the image to another, is required for scanning an image. Furthermore, results such as those of Kosslyn (1973) on scanning; or Shepard (1975) on mental rotation of images would seem to imply that the metaphors used in theorising about imagery are not as ill-conceived as it might seem (Anderson, 1978; Kosslyn & Pomerantz, 1977).

Last, Pylyshyn (1973) argues that even if all the unanalysed images could be stored, it would be virtually impossible to search for one particular image among them. This claim assumes that images are uninterpreted and thus cannot be "content addressed" and that there is no other information associated with them in memory which could be used to "look them up". It seems possible that verbal labels or other codes associated with images could serve this purpose (Kosslyn & Pomerantz, 1977). In addition, it remains possible that all images are in fact randomly searched, as Pylyshyn (1973) suggests, whenever a particular one is sought (Kosslyn & Pomerantz, 1977). There is no way of knowing what the speed of such a search might be and one need not assume that the search would be apparent to consciousness (Sternberg, 1966).

The above arguments have not provided any reason to discard imagery as an explanatory construct in psychology. However, an independent line of argument against them is that picture representations are unnecessary (Pylyshyn, 1973). This argument has two subclaims. First, it is argued that a propositional representation is essential on independent grounds. Second, it is argued that a propositional representation can handle all the phenomena ascribed to a pictorial representation. Therefore, on grounds of parsimony, it is unnecessary to assume a pictorial representational style in addition to a propositional representational style. These arguments are described in the following paragraphs.

Pylyshyn (1973) argues that it is necessary to propose a propositional code to explain how it is that people can describe pictures in words or create pictures to illustrate verbal material. Similar proposals for an interlingua have been made by Chase and Clarke (1972), by Anderson and Bower (1973) and by Fodor (1975). The abstract propositional code would serve as a neutral format into which and out of which pictorial and verbal information could be translated. It serves as a "half-way house" for the process of translating between the two peripheral codes.

However, this argument is flawed by a serious inconsistency. To translate from code I to code II, it is necessary to translate code I into a new code, code

III, and from code III to code II. This argument leads to an infinite regress. To translate from I to III, a new code IV would be needed and so on (Anderson, 1978). It is simply not necessary to have a proposition or any other intermediate code for translation. To solve the translation problem, one must have a set of transformational rules that specify how one format is represented or mapped in terms of another. These rules would not represent information about the world, but only about codes between which translation is required. These rules would take the form of processes or routines, which, when applied to information coded in one format, produce a corresponding representation in another format. No intermediate third form of representation need be involved (Kosslyn & Pomerantz, 1977).

Further, Anderson and Bower (1973) argue that a propositional code is needed to deal with the considerable evidence that subjects tend to remember only the meaning of sentences and not their exact wording. For instance, subjects show confusion about whether they heard an active sentence or a passive equivalent (Sachs, 1967). However, Anderson (1978) has proposed several explanations of the phenomena that do not require a propositional code. For instance, one could propose that subjects represent these sentences in memory by pictures (for example, a boy hitting a girl). Such pictures would represent meaning but not in the original form. Another possibility is that the exact string is heard in memory,

but the processor does not pay attention to the differences between active and passive sentences because normally this is not important.

Pylyshyn (1973) argues that a propositional format is appropriate for representing knowledge, since what is known about the world is a set of facts or assertions that are necessarily true or false. Mental pictures on the other hand do not have this property. Pictures do not assert anything and, hence, are neither true nor false; they merely exist with no truth value. Thus, images are inadequate for representing world knowledge (Pylyshyn, 1973). Rather, propositions, because of their abstract truth-bearing character, are better suited to represent world knowledge.

Kosslyn and Pomerantz (1977), on the other hand, argue that propositions need not be the only way of modeling mental processes and structures. People do not have to have knowledge when they have a mental image any more that a camera has knowledge when it contains an exposed film (e.g., Wittgenstein, 1953). Nevertheless, images may contain information from which knowledge is derived. If images are sensory patterns that have been partially processed and stored, the question of how knowledge can be derived from images is quite similar to the question of how knowledge is derived from ongoing sensory activity. Knowledge is obviously derived from perceptual representation and there seems to be no reason why it should not also be gleaned from mental images.

Furthermore, the mere possession of representations does not constitute knowledge either, any more than a page has knowledge because a sentence is written on it (Kosslyn & Pomerantz, 1977). If knowledge is viewed in terms of active processes performed on data structures rather than in terms of the static structures themselves, then using propositions instead of images as the format for these structures does not necessarily have advantages. In either case, processors must be postulated that operate on the data structures. The power of any representational format can only be assessed by considering its compatibility with these processes (Kosslyn & Pomerantz, 1977).

It is a generally well accepted claim that any well specified set of information can be represented by a set of propositions (Anderson, 1978). Thus, propositions can represent any information in an image, a sentence, or any other source. The power of propositional representations has been used by Kosslyn and Pomerantz (1977) to argue against them. The human representation system is limited while a propositional representation system in principle may not be limited. Thus, one must find some way of introducing constraints into a propositionally based model to account for the constraints so apparent in human memory (Kosslyn & Pomerantz, 1977).

The arguments thus far, namely, arguments against imagery theories and arguments for propositional representations, constitute the anti-imagery position.

The following section considers arguments made for imagery theories. It is important to consider some of the classes of data presented and to evaluate their ability to decide issues of representation. The discussion will not attempt to review all the relevant experiments, but will be restricted to a few representative ones. Further details can be obtained in other sources (e.g., Paivio, 1971c).

One of the most influential phenomena supporting imagery theory uncovered in recent research has been that of mental rotation. If images resemble the external objects they represent, then it should be possible to rotate mental images continuously so that the image passes through the intermediate positions in a rotation.

Shepard and Metzler (1971) presented subjects with pairs of drawings that showed objects rotated in various planes from zero to 180 degrees (see Figure 2). The subjects' task was to determine whether the two drawings illustrated the same objects or different objects. The objects could be the same although differing in angular rotation (bottom pair in Figure 2) or they may be different by virtue of one being a mirror image of the other, while still varying in rotational position (top pair in Figure 2). The greater the degree of rotation separating the pairs of objects, the longer the subjects' reaction times were. The subjects stated that they performed the task by forming an image of one drawing, then rotating it mentally to the same position as the

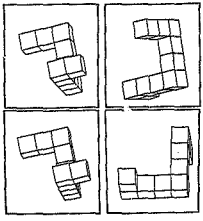

Figure 2. Stimuli in the Shepard and Metzler (1971) study

other. They then compared the objects mentally to determine whether they matched.

From these data Shepard (1975) concluded that the linear function relating action time and angular disparity reflects the time required to mentally rotate an image. Thus the experimental evidence showed that mental images can be rotated in the same way that physical objects can be rotated. In this respect, images resemble the things they represent. As such, this experiment provides evidence for the imagery position.

However, Anderson (1978) argues that it is a simple matter to propose a propositional model that mimics this image model. The model would involve a propositional

description of an object and its orientation in space. Small changes can be computed in an image, so a series of small changes could be computed in the propositional representation.

Brooks (1968) reports an important series of experiments on the scanning of visual images. These experiments showed that imaging and perceiving in the same modality interfere with each other more than when two distinct modalities are involved. He had subjects scan around an imagined block "F" (see Figure 3) from a prescribed starting point and in a prescribed direction, categorising each corner as a point in the extreme top or bottom (assigned a "yes" response) or as a point between (assigned a "no" response). For a non-visual contrast task, Brooks (1968) also gave subjects sentences such as "a bird in the hand is not in the bush". Subjects had to scan through such a sentence while holding it in memory, classifying each word as a noun or not. A second experimental variable was how subjects made their responses. Subjects either said "yes" or "no"; tapped with the left hand for "yes" and the right hand for "no"; or pointed to successive "Y"s or "N"s on a sheet such as Figure 4. Output mode was crossed to yield six conditions.

The most relevant result is that subjects took much longer in the pointing condition than in any other condition. This was not the case for sentences. Segal and Fusella (1970) and Byrne (1974) have reported

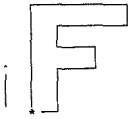

Figure 3. Example of a diagram used by Brooks (1968) The asterisk and arrow show the subject the starting point and direction of scanning the image

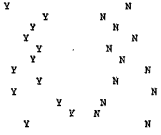

Figure 4. A sample output sheet for the pointing condition used by Brooks (1968)

corroborative findings. Apparently, scanning a sheet as in Figure 4 conflicted with scanning a mental array.

These results show that requiring the subject to engage in a conflicting scanning action on an external physical array causes great interference with the mental scan (Anderson, 1975). This reinforces the conclusion that *when subjects are scanning a mental array*, they are scanning a representation that is analogous to a physical array.

On the other hand, propositional theorists may argue that visual images are represented by propositions that incorporate *various spatial relations (e.g., above, left of)*. These same relations appear in the descriptions generated by the perceptual apparatus. Because the propositions describing the images are similar in form to those describing perceptions, they are difficult to distinguish from each other. Here, *a person might* mistakenly interpret a percept to be an image, and thus fail to perceive the stimulus as such. If propositions representing material encoded in different modalities use different relations, then it is easier to distinguish these propositions from each other than if propositions encode material in the same modality (Kosslyn & Pomerantz, 1977). Kosslyn and Pomerantz (1977) maintain that the two explanations are based on confusion and misclassification of source of origin, and seem indistinguishable.

Kosslyn (1975) has found that subjects take longer to verify that an imaged object has a certain property if they are instructed to make the image of the object small. Kosslyn (1975) relates this to the supposed perceptual fact that it is difficult to discriminate details of small objects when presented. Kosslyn (1975) has also shown that there is a complexity limitation on an image--that it takes longer to verify that an object has a certain property when it is imaged along with a more complex object.

These results can be accounted for by a propositional modal that assumes that a subject activates less propositions to represent an object when instructed to image it small and can activate less propositions when another complex object must be represented (Anderson, 1978). According to Anderson (1978) there is no justifiable basis for calling one set of assumptions more arbitrary than the other.

A number of experiments (Cooper, 1975; Nielson & Smith, 1973; Smith & Nielson, 1970) lead to the conclusion that images can be matched to perceptual objects as templates in an unlimited-capacity parallel manner. For instance, Smith and Nielson (1970) have found subjects to be unaffected by complexity in recognising faces when they have encoded the faces as whole units, but not when they have encoded the faces as verbal strings. This finding has been used as evidence for image over propositional representations (e.g.,

Kosslyn (1975) has found that subjects take longer to verify that an imaged object has a certain property if they are instructed to make the image of the object *small*. Kosslyn (1975) relates this to the supposed perceptual fact that it is difficult to discriminate details of small objects when presented. Kosslyn (1975) has also shown that there is a complexity limitation on an image--that it takes longer to verify that an object has a certain property when it is imaged along with a more complex object.

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Paivio, 1977; Kosslyn and Pomerantz, 1977). However, there is nothing at all incompatible between propositional representations and parallel processes. The ACT Model (Anderson, 1976) is an example of a propositional system in which all basic processes are parallel and some are of effectively unlimited capacity.

The above discussion has shown that the many examples proposed by imagery theorists do not provide greater evidence for an image or analog representational style than they do for a propositional representational style. Furthermore, the nature of propositions and images remain unclear and controversial.

Some theorists believe the propositional-analog debate is, in principle, not capable of resolution since it is not possible for behavioural data to uniquely decide issues of internal representation (Anderson, 1978). Others, such as Kosslyn (1981), believe that it is very optimistic to expect a speedy resolution to such a difficult problem, given the complexity of the issues involved. Therefore, researchers should continue to work out the empirical implications of the respective positions and continue to collect new data that supports one view while putting strain on the other. Yuille (1983) posits that the current crisis in imagery research stems from the weak theoretical concepts which characterise the field. For the most part, definitions of imagery seem to be based on intuitive notions of mental processes, and the interpretation of research

results appears to originate from the same intuitive source (Yuille, 1983).

Given the present state of the debate, Palmer (1978) concludes that it is beyond the scope of cognitive psychology to concern itself with the physical embodiment of a representation. Rather, the representational assumptions and processes that embody the representing world, is the proper level of discourse for cognitive theory (Palmer, 1978). This is the approach adopted in the present research. While there is no consensus of the scientists' exact conceptualisation of the nature of peoples' internal representational styles, "imagery" in cognitive activity remains a useful component and phenomenon for research. Researchers are not precluded from studying the effect that these representations have on the way in which individuals interact with their environments and the way in which they learn and remember.

Before the actual research is presented, Paivio's Dual Coding model is discussed. The model is worth considering since it has potential for application in the field of cognitive human-computer interaction. Furthermore, it is an exemplar in the field as far as precision of definition is concerned. Paivio clearly demonstrates that a variety of experimental findings have been predicted from Dual Coding theory, whereas no other approach can make this claim (Yuille, 1983; Paivio 1983).

Paivio's Dual Code Theory

As illustrated in the previous chapter, the nature of representational style in cognitive psychology is controversial. The debate between propositional and imagery theorists has by no means been resolved. The use of imagery as a particular form of mental representation is vague and unclear, and its role in learning and memory has not been clearly defined. In spite of this, Paivio and his colleagues have repeatedly implicated imagery as an important variable in memory and learning tasks. Paivio has, in a succession of experiments, systematically demonstrated that concrete words which readily invoked mental imagery, are easier to learn and recall than abstract or low-imagery words. In the course of this research, Paivio developed norms to measure the image-arousing ability of words, as well as their concreteness, familiarity and meaningfulness values.

The implications of these findings for human-computer interaction are very important. There is a need to apply psychological theories to identify the underlying variables that determine which computer command names will be easier to learn and remember than others. While Paivio's theories provide for such a possibility, they also provide the methodology to

determine the norms for these words. Thus, the potential for Paivio's work to be applied to research in human-computer interaction is great. For this reason, the present chapter will provide an overview of Paivio's Dual Code Theory.

The core of dual-code theory is described as follows by Paivio and Lambert (1981):

> Dual code theory... is based on the assumption that memory and cognition are served by two separate *symbolic systems*, one specialised for dealing with verbal information and the other for non-verbal information. The two systems are presumed to be inter-connected, but capable of functioning *independently*. Interconnectedness means that representations in one system can activate those in the other, so that for example, pictures can be named and images can occur to words. Independence implies, amongst other things, that non-verbal (imaginal) and verbal memory codes, aroused directly by pictures and words or indirectly by imagery and verbal encoding tasks, should have additive effects on recall (p.532 -533).

Essentially, the model postulates a separation in memory which parallels an intuitively plausible distinction between linguistic and non-linguistic events (Clark, 1983). A child gains knowledge about the world, and learns the meanings of things long before he or she

understands language or is able to speak. If knowledge and meaning are acquired before language, then epistemological and *semantic information* initially must be, and subsequently may remain, essentially nonverbal (Bleasedale, 1983). The major theoretical assumption here is that language is closely linked to *two basic* coding systems or cognitive modes. One mode is related directly to speech itself; that is, thinking can be in terms of words and their interrelations and these *implicit verbal processes* can mediate language behaviour. The other code is nonverbal and is presumably tied closely to the private experience that is referred to as imagery (Paivio, 1971a, 1971b).

The view that the comprehension and production of language can be mediated by nonverbal imagery seems perfectly reasonable at a *common sense level*, but the notion has been repeatedly opposed in psychology (Paivio, 1971c). The grounds for the negative attitude towards imagery theorists have been outlined in the previous chapter and will not be presented here. It is important to note however, that Paivio does not suggest that meaning is an image, since he recognises that the term "meaning" *has broader significance* than that (Paivio, 1979). Rather, he claims that imagery can and does occur as an associative reaction to words, and that it plays a part in memory and *comprehension of language.*

In addition to two separate codes, Paivio (1971b) has identified three levels of processes that are

theoretically and operationally linked to meaning. These are referred to as representational, referential, and associative levels of meaning. Each level involves either imaginal or verbal symbolic processes, or both. The analysis applies to nonverbal as well as verbal stimuli, although for the purposes of this paper, the concern is only with verbal stimuli.

The representational level refers to hypothetical symbolic representations that are stored in long-term memory as concrete images in the case of stimulus objects, and as implicit auditory-motor representations in the case of verbal stimuli. At this level, objects and words act as stimuli to activate the corresponding representational processes within the individual. In this manner, words activate verbal representations and perceptual experiences activate imaginal representations. This level of meaning corresponds intuitively to familiarity in the most elementary sense of "knowing" the stimulus (Paivio, 1971b). Familiarity implies that some organismic representation of a stimulus is "available". Further associative connections may be lacking, however, in which case the stimulus has no higher order (referential or associative) meaning (Paivio, 1979).

The second level, referential meaning, assumes associative connections between imaginal and verbal representations, such that an object or picture can be named and the name can evoke an image. The reactions in each case are referential or denotative in nature.

The third level, associative meaning, refers to sequences or patterns of associations involving words, images, or both. It includes associative meaning in the traditional sense of intraverbal associations and, in addition, incorporates the assumption of imaginal associative chains or structures.

Whether the processes at any of these three "levels of processing" or "levels of meaning" are involved in a given psychological task is assumed to depend upon particular characteristics of the task. This assumption gives rise to various empirical hypotheses concerning the effects of imaginal and linguistic variables in different experimental situations (Paivio, 1971c, 1972). Paivio (1971a) has specified various defining operations for each level, but has assumed that latency measures or their analogs are the most appropriate indices of the availability of the underlying processes. Accordingly, representational meaning would be indexed by the speed of perceptual recognition as reflected in reaction time measures. Duration thresholds, familiarity ratings, and frequency counts would be appropriate correlates.

Referential meaning would be measured by latency of labelling an object, or the latency of image arousal to words or sentences. Ratings of ease of imagery or concreteness would be correlated analogs of image latency. Associative meaning should be similarly indexed by measures of associative latency.

The theory was originally suggested on the basis of experimental research carried out during the 1960's, but Paivio's position on the role of mental imagery in human memory has remained essentially unchanged over the years (for example, Paivio, 1979; 1983). Paivio (1971a) obtained data in support of dual coding by showing, among other things, that presentation of a pictorial representation of an item and presentation of a verbal representation of the same item have independent and additive effects on recall.

The ramifications of dual-coding theory extend far beyond what is covered in the present discussion. Only those aspects of the theory that bear on the explanation of learning and remembering of words, and as such have implications for human-computer interaction, will be discussed.

Within the context of the preceding theory, the major assertion is that concrete and abstract language differ primarily in referential meaning. Concrete words readily evoke images of the concrete languages and events to which the concrete language refers, whereas abstract words or passages do not evoke images as readily. In other words, the theory asserts that concrete events can be dually coded, both as images and as words, whereas abstract events are more likely to be coded only in verbal form. This theory suggests that concepts rated high in imagery value are likely to be dually coded, whereas concepts rated low in imagery value are likely to

be represented primarily as words. It follows that concepts rated high on the imagery scale should be more readily attained than concepts rated low on the imagery scale because, in the former case, subjects can make use of both a verbal and an imagery system (Katz & Paivio, 1975). Note that concrete and abstract language, however, need not differ in representational meaning (familiarity), nor in their capacity to arouse other words as associative reactions (Paivio, 1971b).

Some direct evidence that people have two distinct types of information (semantic and perceptual) available from the lexicon has appeared in the normative ratings collected by Paivio, Yuille, and Madigan (1968). Paivio et al. (1968) obtained imagery and concreteness ratings by instructing subjects to base imagery ratings on the ease of forming an image and to base concreteness ratings on the basis of whether the word denoted an object that could be experienced by the senses. That these two types of information are distinct and independent is shown by the fact that the correlation between imagery and concreteness ratings is not perfect even though the reliability is quite high, and the consideration results that show the subjects' ability to distinguish imagery and concreteness values for a word, is evident in the norms.

For example, as pointed out by Paivio et al. (1968), words like "ghost" are rated as abstract, since ghosts are not generally considered to be real things, but

everyone knows from movies and stories what a ghost is supposed to look like. Thus, the abstract word "ghost" is rated high in imagery value. Also, words for emotions, such as "anger" were similarly rated as abstract and high in imagery. On the other hand, subjects rated the word "armadillo", which denotes an actual object, to be highly concrete but relatively low in imagery value. Lack of visual experience with armadillos entails a poor perceptual representation of the animal. Hence, rated concreteness and imagery of words are based on distinct types of knowledge people have about the denoted concepts, thus supporting the psychological validity of the distinction between semantic and perceptual knowledge about words (Kieras, 1978).

Richardson (1975a, 1975b, 1976) attempted to distinguish between these two constructs empirically. Richardson (1976) had different groups of subjects rate 244 phrases on their concreteness and imageability. The results showed a highly significant interaction between the two scales and the various stimulus items. This implies that imageability and concreteness do deviate from one another, and that it is legitimate to distinguish between the two scales (Richardson, 1980).

It is now well established that word imagery or imageability is positively correlated with performance in a wide variety of learning tasks (Paivio, 1971c). This effect has been demonstrated with free recall (Paivio,

1968; Paivio, Yuille & Rogers, 1969; Richardson, 1974; 1978a), with serial recall (Paivio, et al., 1969; Rubin, 1980), with paired associate learning (Paivio, Smythe & Yuille, 1968; Richardson, 1978b), and with recognition memory (Olver, described by Paivio, 1971c, p184). Imageability has been found to affect both the accuracy with which material is retrieved from memory, and the speed with which it is retrieved (Bleasedale, 1983; Macht & Scheirer, 1975). It has also been shown to have a selective effect on long-term or secondary memory to total performance (Paivio, 1975; Richardson, 1974, 1978a).

Many researchers have also investigated the dimension of concreteness of words. Concreteness has been found to correlate positively with performance in experiments on free recall (Dukes & Bastian, 1966; Paivio, 1967), recognition memory (Gorman, 1961), short-term memory (Yorkowski & Eisner, 1968), paired associate learning (Epstein, Rock & Zuckerman, 1960; Paivio, 1965; Winnick & Kressel, 1965), associative speed (Paivio, 1966; Yuille & Paivio, 1967), and perceptual selectivity and recognition speed (Reigel & Reigel, 1961). Begg and Paivio (1969) presented abstract and concrete sentences to subjects and found that in subsequent recognition testing, changes in meaning of the input sentences were detected better in concrete sentences than in abstract sentences. Richardson (1975c) describes two experiments designed to demonstrate the effects of concreteness in

experimental tasks. In the first, subjects were asked to categorise individual nouns on the basis of their *meaning*. A majority sorted the words in a manner related to their concreteness. In the second, subjects were asked to produce a discrete free associate to each of these words. The concreteness of a word correlated positively with the average speed with which the associate was given. In neither experiment was imageability related to the subjects' performance, which implied that neither task was *influenced* by imaginal processing. On the other hand, significant effects of concreteness in these tasks implied that this variable was not merely an index of the image arousing potential of verbal material (Richardson, *1980*).

The relative importance of imageability and concreteness in verbal learning has also been investigated. For example, Richarson (1975b) considered the free recall of *individual words* and produced an interactive relationship, such that imageability had a positive effect on the recall of items of low concreteness, but no effect upon the recall of items of high concreteness. A *subsequent* experiment (Richardson, 1975a) showed that imageability affected the recall of items of high concreteness if the subjects were instructed to use mental imagery in learning. Under these *circumstances*, the memorability of the stimulus items varied with their imageability, but not their concreteness. The results confirmed that concreteness

should not be regarded as an index of the image-arousing capacity of verbal material (Richardson, 1980).

Concrete concepts have also been found to be more easily attained than abstract concepts (Katz & Denny, 1977; Katz & Paivio, 1975). In an extensive unit-analysis of verbal behaviour, Rubin (1980) demonstrated that out of 51 properties of a set of words, imagery was one of the main factors which emerged as being important in verbal processing. Furthermore, it had a significant effect on what words subjects were able to recall.

There was a concern that the effects described above could be explained in terms of some other confounding attribute, but by 1971, more than twenty alternatives had been ruled out (Paivio, 1983). Additional possibilities have been proposed from time to time, for example, Anderson and Bower (1973) suggested that the differences could be due to the greater number of dictionary meanings or greater lexical complexity of abstract words, either of which might create uncertainty and confusion, hence poorer recall of abstract words. Neither interpretation has stood up to empirical tests (e.g., Peterson & McGee, 1974; Richardson, 1980) (Paivio, 1983). Thus, imagery value remains the best single predictor of memorability of items within the range of meaningful verbal material.

An implication from these findings for human-computer dialogue is that problems in both learning and remembering command names may be related to the abstract-concreteness and imageability of the words selected for

the name sets (Rogers & Oborne, 1985). Some command names may have a richer mental representation than others, and this might be a variable which can serve to differentiate between command verbs which are easier or more difficult to learn or remember. This possibility is discussed further in the chapters which describe the present research.

Representational style and command name variables in human-computer interaction

The previous chapters have provided the background necessary to investigate representational style and the psychological attributes of potential computer command names within the context of human-computer interaction.

A recent direction of cognitive psychological research, and cognitive representation, in particular, concerns human-computer interaction (e.g., Carey, 1982; Douglas & Moran, 1983; Long, Hammond, Barnard, Morton, & Clark, 1983; Kieras & Polson, 1985). Human-computer interaction, and text editors in particular, offer an ideal medium for studying human cognitive processes (Wickens & Kramer, 1985). The editing of a manuscript includes a wide variety of information processing activities from the encoding of text on the screen, through the retrieval of information from memory and its integration of new materials, to the selection and execution of data entry and modification commands.

Another important reason for studying interaction with text editors is that inferences can be made from such studies to general human-computer interaction. Since computers are playing an increasingly prominent and direct role in the conduct of human affairs, human-

computer interaction is rapidly becoming one of the most active new research areas in cognitive science.

Recently, it has been recognised that a user's representational style is of paramount design importance (e.g., Carey, 1982; Manketelow & Jones, 1987; Van der Veer, Tauber, Waern, & Van Muylwijk, 1985). Any design implicitly incorporates terminology, apparatus, operations, ideas and relationships that the user must deal with when using the system. Whether designers plan for it or not, the user comes to understand the system in terms of these things, which collectively form the user interface.

Van der Veer et al. (1985) defines the interface for the user as his/her knowledge about the "virtual" machine. In other words, the interface is the user's representation of the system (see Figure 5). This is in contrast to the usual definition of the interface as the part of the system which is visible to the user and/or where the action is located. According to Van der Veer et al. (1985), this latter part is only the perceptual component of the system. The perceptual component is the part that has traditionally been considered by designers. It includes such aspects as character legibility (Vartabedian, 1971), keyboard layout (Siebel, 1972), and system responsiveness (Long, 1976). The overall architectural issues, which include the cognitive compatibility of the software interface, have largely been avoided (Long, et al., 1983).

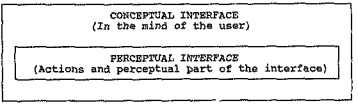

Figure 5. The conceptual human-computer interface
Source: (Van der Veer et al., 1985, p.292)

The impact of the concept of a "virtual" machine is that designers are challenged to work out a specification of the conceptual model aiming at the intended model of the user (Rohr & Tauber, 1984). The closer a user's conceptual model, or representation, is to the designers intended model, the better the user's performance would become. Modelling the conceptual world of an intended representation is the cognitive aspect of the definition of a human-machine interface. In other words, the system designers must build a conceptual model of the target system in order to provide an appropriate representation of the target system to the users of that system. Only after this process has been completed is the perceptual world and action component of the interface defined (Van der Veer et al., 1985).

An appropriate design of the target system should encourage users to form accurate and useful representations of the target system. There are many

benefits associated with having these types of representations. For instance, representations permit users to acquire meaningful explanations of various device functions (Kieras & Polson, 1985); facilitate the users' initial interactions with the device, by enabling them to correctly anticipate the proper sequence and effects of actions (Rubenstein & Hersch, 1984); tie together otherwise apparently separate procedures; enable users to diagnose an error condition; enhance the users' ability to deal with novel situations and to invent new methods (Myers, 1980). In general, a developed and accurate representation of a system contributes to overall user productivity with the system.

Thus, the whole conceptual organisation of the computer system from the user's point of view is an integral part of the user interface (Moran, 1981). The designer needs to distinguish between his or her own conceptualisation of the representation and the actual representation that a particular user type may have.

Discovering a person's representational style is not easily accomplished (Norman, 1983). At the moment, there are no satisfactory tools that let designers experience a proposed system from inside the user's cognitive world (Carey, 1982). One cannot *simply look into the user's* head. The methodologies used are eclectic. They include verbal reports, protocol analysis, traditional cognitive psychology experiments, developmental studies, expert-novice studies, simulation of possible psychological

models and comparison of the simulation results with what humans actually do, comparisons across cultures, historical comparisons, and field observations in which an artificial domain is constructed that has interesting relevance to the real domain under study (Stevens & Gentner, 1983).

One way to learn about the user's representational style is to ask the users. This technique is used in the present study. By asking users questions about their conceptions of "what goes on inside a computer," useful information can be gathered. This information about the user's representational style could assist designers of interactive systems in developing a conceptual model.

This questioning methodology is well suited to the abstract nature of representations. Consider Norman's (1983) conclusion, based on extensive observations of people's interactions with a number of technological devices, that "most people's understanding of the devices they interact with are surprisingly meager, imprecisely specified, full of inconsistencies, gaps and idiosyncratic quirks," (Norman, 1983; p.8). The nature of the cognitive representation renders it very difficult to study using other more structured methods.

This methodology has been used in previous studies of mental models in related areas. For example, Norman (1983) questioned subjects about their understanding of a calculator which they had used to perform a series of arithmetic problems. Mayer and Bayman (1981) made

similar analyses. Myers (1980) describes an experiment where secretaries were asked questions about what kind of a *internal* representation they had of a word processor's inner workings, and how they had organised their knowledge about the system. Landeweerd (1979) assessed the mental model of a process control situation by means of a questionnaire, consisting of "*what leads to what*" questions e.g., "What is the effect of ____?", or "What *is the effect of control action* ____ *on* output ____?".

The present study is broader than most of the previous studies concerning representations (e.g., Billingsley, 1982; Jamar, 1986; Kieras & Bovair, 1983; Mayer, 1975, 1980) in that it explores the qualitative nature of the user's representational style. As such, this study is exploratory in nature, and represents an attempt to determine whether groups of people with different representations can be identified, and whether key aspects or ways in which these representations differ can be distinguished.

One of the more important variables that a designer can manipulate in forming a conceptual model of the system, is the *command language*. An interactive command language is viewed as a crucial component of the *conceptual framework* presented to the user. It represents a very basic means for potentially enabling compatibility in user-computer interaction (Treu, 1975). The objective is to design a "computer-understood" command language that is conducive to the users'

representation (Treu, 1975) and to be able to convey an implicit model of system actions and relationships to the user (Rosenberg, 1982). The crucial factor in developing such a language is the names given to entities and operations in the system by the command language. If those names are not appropriate, performance will be *impaired just as with poorly designed syntax or dialogue* structure (Rosenberg, 1982). Users need to be able to infer a semantic association between an external symbol, the command, and an internal symbol, the users' internal representation of the concept.

In almost all computer applications, users must enter or select correct words for the desired objects or actions. If everyone *always agreed on what to call* things the users' word, the designers' word, and the systems' word would be the same: what the user typed or pointed to would be mutually understood. Unfortunately, people often disagree on the words they use for things. Furnas, Landauer, Gomez, and Dumais (1987) studied word choice for objects in five application-related domains and found that in every case, people favoured the same term with probability less than .20.

Awareness of these factors has given rise to a considerable amount of behavioural research on the properties of command names (e.g., Carroll, 1980). Studies have considered the relationship between attributes of computer command name sets and such human performance features as the learning and recall of

computer-oriented words (Scapin, 1981), the suggestiveness of command names (Rosenberg, 1982), the characteristics of the relationship between command names within a set such as congruence and hierarchy (Carroll, 1980), and the extent to which computer command languages should resemble the terminology and structure of natural languages (Landauer, Galotti, & Hartwell, 1983; Scapin, 1982; Treu, 1975). Findings from theses studies, however, have been varied and inconsistent. For instance, Landauer et al. (1983) were unable to show that "naturalness" has a demonstrated effect on ease of use and concluded that choice of vocabulary made very little difference. However, other studies have shown that names do influence ease of use. For example, Carroll (1980) has shown that command sets that include congruent terms were rated as being preferred and were also better learned than were sets including noncongruent terms. Also, Scapin (1981) found that user-generated commands were easier to recall than computer language-imposed commands when learning a text-editing task.

Particular disparities in evidence concerning the usability of name sets are unlikely to be resolved until more systematic knowledge is obtained concerning both the range of factors influencing the acquisition and ure of name sets and the precise ways in which performance is affected in initial learning and long term use (Grudin & Barnard, 1984). Central to this is the fundamental issue of establishing which are the most salient command name

variables in relation to their ease of learning and remembering (Rogers & Oborne, 1985).

There is a need, therefore, for a more systematic approach in which the evaluation of command name variables is considered in relation to the underlying psychological processes and representational styles involved in users' behaviour. Furthermore, the scientific knowledge and theoretical models which have been developed in the field of psycholinguistics and cognitive psychology ought, wherever possible, to be applied (Rogers & Oborne, 1985).

Rogers and Oborne (1985) investigated various semantic attributes of a set of verbs in relation to the underlying psychological processes involved in a naming task. Specifically, they examined the role of imagery, concreteness, familiarity, and understanding--variables which do not appear to have been considered in human-computer dialogue but which have been suggested in the memory literature as playing an important role in the mental representation of word meaning and memory (e.g., Paivio, 1971a; Richardson, 1980). For further discussion of the relevance of these psychological concepts to human-computer dialogue, see Chapter 3.

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variables in relation to their ease of learning and remembering (Rogers & Oborne, 1985).

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the factors of imagery and word frequency as a function of the ease with which command names were elicited from an appropriate verbal description. These studies are important since the hypotheses were based on empirical research of memory tasks.

In the first experiment they conducted, Rogers and Oborne (1985) obtained a wide range of ratings for tho imagery and concreteness scales, indicating that, for a set of words, there are some words which can be classified as highly concrete and associated with high imagery, whilst there are others which are classified as highly abstract and associated with low imagery. The results for the understanding and familiarity scales were biased in that the majority of ratings were at the extreme end of the "good understanding" and "highly familiar" scales respectively. These results suggest that a words linguistic concreteness and imagery association may have functional properties for verbal behaviour (Rogers and Oborne, 1985).

However, in their second experiment, no main effect was found for imagery. A complex interaction between imagery and frequency was found whereby high-frequency words were modified by imagery whilst the effect of imagery on low frequency words was minimal. Furthermore, the modifying effect of imagery on high-frequency words was contrary to expectations based on research in the field of cognitive psychology, in that low-imagery rather than high-imagery words were derived more easily. There

are a number of variables which may have *influenced* subjects' responses and hence the nature of the results *obtained by Rogers and Oborne (1985).* These are described in the following paragraphs. In the next chapter, Rationale and procedure, the way in which these variables were considered in the present research will be described.

One factor which may have influenced the results that Rogers and Oborne (1985) obtained is the type of definition used in the task. There are a number of issues here. First, according to Johnson-Laird and Quinn (1976), the simpler the semantic content of a verb, the more difficult it is to define. Also, the easier the word is to define, the easier it would be to *correctly* guess the word. This implies that the frequency of correct *responses could have been due* to the semantic content of the verbs, and not a function of their frequency or imagery values.

A second related issue is that some of the definitions of the words were more general and others were more specific. The pattern of correct responses could have been influenced by the specificity/ generality of the definition used in the task.

A third related issue is that the type of definitions used in the task could influence the subjects' responses. By making use of definitions from the Concise Oxford Dictionary, it is implied that subjects think about the semantic content of any word in the same way as the

dictionary def[illegible], it. This is not necessarily the case and the use of dictionary definitions could affect the semantic association that the subject is required to make between an external symbol (the definition) and the internal representation (the word they select).

A second factor which may have influenced the results obtained by Rogers and Oborne (1985) is the context in which the experimental task was performed. Rogers and Oborne (1985) kept their subjects naive as to the nature of the target words. However, it has been established that the particular meaning aroused by a stimulus is not fixed, but may vary from time to time depending on the *situational context (Paivio, 1971c). For instance,* Bransford and Johnson (1972) dramatically increased recall of the propositions contained in a passage merely by providing beforehand a two-word title of abstract sentences. Shwaneflugel and Shoben (1983) measured comprehension time in a reading task and showed that, in context, abstract sentences were read as rapidly as concrete sentences. More recently, Scapin (1981) investigated the learning and recall of computer command definitions that differed in context connotation and showed that inexperienced users tended to remember words which were computer oriented more easily than more usual words used as computer commands. This implies that the context in which the words are presented could impinge on the results obtained. Hence, in order to determine the semantic association between the definitions and the

potential computer command names, the task should be carried out in a computer context whereby the target words are specified as being computer commands.

A third factor which could explain why Rogers and Oborne's (1985) results were inconsistent with previous research is the nature of the subjects who participated in their study. In any study concerned with semantic representation, it is important to consider individual differences. Individuals differ in their ability to use mental imagery and their preferences for using mental *imagery* for various cognitive tasks. Their subjective experiences, educational levels, attitudes, abilities etc., all affect their ability and willingness to form accurate representations, and to make semantic associations (e.g., *Van der Veer* et al., 1985). As such, it is important that the nature of subjects who participate in the task are *as close as possible* to the population to which the results will be generalised.

Rogers and Oborne's (1985) subjects were undergraduate psychology students between 18-22 years old. It is reasonable to assume that the semantic associations that they make may be different from semantic associations made by workers in real work settings and, as such, the generalisability of Rogers and Oborne's (1985) results may be affected. Furthermore, sub-cultural socio-linguistic effects need to be considered. The acceptability of a particular word as a computer command name with a specific meaning in one

country or culture does not necessarily generalise to another country or culture. For instance, the word "zap" was rated as having a "good understanding" value by the British subjects in Rogers and Oborne's (1985) but it is unlikely that it would be given the same rating by South African subjects. Rubenstein and Hersch (1984) stress that if computer commands are to be used cross culturally, assessment procedures should be conducted across the entire range of appropriate subjects.

Also, only ten subjects participated in Rogers and Oborne's (1985) study on semantic association. Future studies should use a larger number of representative subjects.

Furthermore, the difference between experts and novices appears to be an important variable to consider when investigating individual differences in representational style and semantic associations. Experts and novices differ both qualitatively and quantitatively in their abilities to process large amounts of meaningful information (e.g., Adelson, 1984; McKeithen, Reitman, Reuter, & Hirtle, 1981). This difference has been seen in the domains of chess, Go, electronics, bridge, music, and physics (Charness, 1976; Chase & Simon, 1973a, 1973b; Egden & Schwartz, 1979; Engel & Buckstell, 1978; Larkin, McDermott, Simon & Simon, 1980; Reitman, 1976; Sloboda, 1976). A common explanation for this difference is that experts have not only more information, but they have information better

organised into useful categories. Instead of remembering and perceiving individual pieces of information, they process meaningful groups of information, making their perception more efficient and their recall performance much higher (McKeithen et al., 1981).

There is also literature on the varying experiences of different user types on interactive computer systems. For example, a user who is a programmer might have a very different understanding of a piece of software than a person with no programming experience (Carrol & Olson, 1987). Novice users' knowledge appears fragmentary, may involve false inferences about system operation and can be *resistant* to subsequent change (Lewis & Mack, 1982). Likewise there is a significant body of literature which characterises *and models* smooth, error free, expert performance, most notably for text editing tasks (Card, Moran, & Newell, 1983; *Kieras & Polson*, 1985). Considering these factors, Rogers and Oborne's (1985) results could be contaminated and their *generalisability* constrained by not having controlled for the level of experience in the subjects.

The first section of this paper has considered the conceptual and theoretical issues underlying the present research. In the following chapters, the rationale and procedure, and the actual research conducted for this thesis, is presented and discussed.

Rationale and procedure

There were two main objectives for the present study. One is to further the understanding of the nature of representation of computer systems. The second, which encompasses the first, was to investigate the psychological variables involved in the selection of computer command names. Both of these objectives are important considerations for the design of human-computer interfaces. In order to achieve these goals, three experiments were conducted.

The discussion of cognitive theories of representational styles, presented in the first part of this paper, illustrated that the debate about whether representations are propositional or analog in nature has not been resolved. In spite of this, representation remains an important variable to consider when studying the nature of the interaction between people and computers. Chapter 4 discussed the benefits of a complete and accurate mental model for computer users.

The aim of the first experiment conducted in the present study was to address the qualitative nature of users' representations of computer systems and to explore individual differences in representational style. Structured interviews were conducted with expert,

intermediate, and novice computer users to gain insight into users' perceptions of the internal dynamics of computers, and to investigate qualitative differences between the user groups.

The discussion in Chapter 4, indicated that the distinction between different user types is important when considering representational styles and semantic associations. The division of subjects into expert, intermediate, and novice user groups was based on the expectation that different user types would form qualitatively different mental models and make different semantic associations. This division was based on a priori variables such as formal computer training and experience, the range of tasks the users typically perform with computers, and the length of time they have been using computers. Failure to distinguish between user types would result in findings contaminated by user differences and the generalisability of the study would be reduced.

Paivio's (1971c) Dual Code Theory, presented in Chapter 3, has implications for choosing computer command names. Paivio (1971c) suggests that more concrete and highly imageable words convey more meaning, and hence show better results on learning and memory tasks, than abstract or low imagery words. These findings provide potential guidelines for selecting the most appropriate names for computer commands.

The second experiment conducted in the present study was designed to obtain ratings on concreteness, imagery, familiarity, and understanding for a set of potential computer command names, so that the applicability of Paivio's Dual Code Theory can be tested. As yet, there appear to be no published data for these attributes for the equivalent names, for South African subjects. The attributes of the words were assessed using a seven point Likert type rating scale. The rating technique was based on that used by Paivio et al. (1968). From these data inferences can be made about the way in which names are internally represented in terms of imagery and concreteness. Once these values are known, the psychological characteristics of the words chosen by subjects in the semantic association task could be analysed. This helped to identify the most salient computer command name variables.

The third experiment investigated whether semantic associations between computer commands and functional descriptions made by the subjects, were related to the psychological attributes of the words or to the experimental group. The semantic association task for the third experiment was designed so that users had to select a command from the list that was provided. This allowed the direct assessment of names for which a normative data base has been established. Also, it was similar to the actual situation in some computer systems, where a user sees a menu list of all commands available

in a given context and must decide which command name will result in the system performing the desired task. The semantic association task was not designed so that subjects used an actual computer because of methodological problems; learning and using a text-editor involves many more variables than the semantic properties of its computer command names. A more ecologically valid, but less specific and controlled test would complicate the investigation of semantic associations (Rosenberg, 1982).

Also, this task facilitated the investigation of whether different types of users with qualitatively different representational styles would select different responses to the same functional descriptions. This would have implications for the types of words which could be used most optimally as computer commands, depending on the nature of the intended users.

Previous research in this area, conducted by Rogers and Oborne (1985) was very important since their hypotheses were based on empirical research of memory tasks. The present study is an attempt to expand on their findings. Many of the problems facing Rogers and Oborne's (1985) research (see Chapter 4) were carefully considered in the present study. The steps taken to overcome these problems are as follows:

First, the definitions used in the semantic association task (in Experiment 3) consisted of statements defined by computer users. This ensured that

the definitions were stated as closely as possible to subjects' concepts of the functions. This would not necessarily be true if dictionary definitions were used. The association task investigated the users' selection of command words for five different definitions of the same word processing function. Both strategies reduced the impact that definitions could have had on the results, providing a clearer investigation of semantic associations.

Second, the personal history of the subjects was considered. Subjects were chosen to ensure that the results could be generalisable to a wide population of computer users. All of the subjects involved in the semantic association task used a computer as part of their job. They were recruited from ten different organisations to represent a wide range of industries. This resulted in a broad spectrum of computer users, in contrast to the psychology students who participated in Rogers and Oborne's (1985) study. Ninety-nine subjects participated in the semantic association task, compared to the ten subjects participating in Rogers and Oborne's (1985) study. The nature and number of subjects participating in the present study inevitably increases the validity and generalisability of the results.

Third, subjects in all stages of the study were informed that the words were potential computer commands. This provided a more realistic context for the study than

in Rogers and Oborne's (1985) study, in which subjects were not informed of the nature of the target words.

Fourth, the relative contribution of word frequency to the task of mapping a description to a name was not considered in the present study. Rogers and Oborne (1985) used Thorndike and Lorge's (1944) book on word frequencies. Today, and particularly in the computer context, this work is of limited value since the lists are based on texts which are at least forty years old (Johansson, 1983).

To summarise, the following questions were addressed in this study:

- Are different levels of user characteristics reflected in the nature of the users' internal representation of the computer system?
- *Do different user types make different semantic* associations?
- Is the choice of word in the semantic association task related to its concrete-abstractness, imageability, familiarity, or understanding rating?
- For a set of potential computer command names, is it useful to differentiate between them in terms of their values for concrete-abstractness, imageability, familiarity, or understanding?

The method, results, and discussion of each of the three experiments are presented in the following chapters.

Experiment 1

The Investigation of Representational Style

Introduction

Experiment 1 was conducted for two purposes. First, this experiment was conducted to investigate qualitative differences in the representational style of users with varying levels of computer literacy. To achieve this, structured interviews were conducted with three types of users: "expert," "intermediate," and "novice." Inferences about differences between subjects' representational styles were formed after analysis of the interviews. It was hypothesised that each type of user group would construct qualitatively different representational styles.

The second purpose was to obtain stimuli for Experiment 3, the semantic association task. The stimuli were derived from the transcripts of the interviews. The derivation of these stimuli are described in Chapter 8, which describes the semantic association task.

Method

Subjects

Three groups of computer users participated in the study, each representing a different category of user.

There were seven "novice," eight "intermediate," and ten "expert" computer users. Each group was classified according to three criteria: level of experience with computer applications, the tasks for which they used computers, the length of time they had been using computers, and the formal knowledge that they have acquired about computers.

The expert group consisted of business information systems students at the University of the Witwatersrand, Johannesburg. These subjects used computers in all their work. All of the subjects in this group used a wide range of computer applications including word processing, data base management, programming, spreadsheets, and statistical packages. All had taken computer science courses as part of their academic studies.

The intermediate group consisted of five industrial psychology students at the University of the Witwatersrand, Johannesburg, and three staff members of a large building society. These subjects used the computer primarily for word processing and data analysis. None of these subjects had any formal education in computer science. All had used computers for longer than six months.

The novice group consisted of industrial psychology students at the University of the Witwatersrand, Johannesburg, and also staff at a large building society. They used computers for word processing only, thus performing a limited range of computer tasks. None of

the subjects had any formal education in computer science, and all had used computers for less than six months.

Procedure

Ten different functions typically performed with a word processor were identified. These were delete, edit, start, end, replace, insert, list, save, and print. The interviews were structured around these functions. For each of the ten functions, an open ended question, such as, "What do you think happens when you DELETE something on the computer?", or "What do you think happens when you SAVE something on a computer?" was asked. Subjects were probed with the question, "What do you think is going on inside the computer to make this happen?" (see Appendix 1 for experimenter control sheet).

Each interview was conducted on a one-to-one basis, and was completed in approximately 20 minutes. Answers were given verbally and tape recorded. The recordings constituted the raw data for the experiment. The role of the experimenter was to ask the questions and probe for responses. At no time did the experimenter attempt to influence or direct subjects' responses.

Analysis of Data

Content analysis was performed on the data with the aim of exploring the mental models of computer dynamics constructed by different user classes, and identifying

the general set of variables underlying these mental models. The analysis was also intended to enable the identification of descriptive statements for each of the word processor functions, to be used in Experiment 3, the semantic association task.

In the first step of the *content* analysis, the *recorded* tapes were typed verbatim, regardless of syntactic or semantic errors. The experimenter checked the transcript against the tapes, and attempted to fill in passages which the typist had found inaudible. Passages which the experimenter failed to recognise were marked "(?)." In this way, everything on the tapes was preserved in the *transcripts*.

Each transcript was analysed in the same way. For each question about a word processing function, each new concept the subject expressed about the internal dynamics of the computer was extracted. If the subjects repeated or rephrased an idea within the same question, that idea was noted only once. If repetition occurred across questions, then that same idea was noted for each question in which it occurred. A table was drawn up consisting of all the phrases. Each phrase represented a single expression of an idea, in response to each of the ten questions in the interview. Each statement thus generated by independent respondents was assigned a frequency value that represented the number of times that concept was expressed in the complete series of

interviews across all respondents for each user group. Appendix 3 contains the table of statements.

Inspection of the table revealed a number of categories into which the statements could be sorted. These include statements that referenced physical components of the computer, such as "disc head moves across the disc," statements that made use of metaphors such as "storage is like a filing cabinet," and statements that acknowledged the electronic nature of the computer, such as "bits and bytes are transferred electronically to the printer."

Statements made within each subject group that fit into any of the categories identified above were counted and then expressed as a percentage of the total amount of statements generated for that group. Proportions were used to account for the differences in total number of statements generated by the three sample groups.

In order to compare the observed distribution of the scores with a normal distribution, the Kolmogorov-Smirnov (K-S) one-sample test for goodness of fit was conducted. This test is appropriate for the ordinal scale used for this data. The K-S test is more powerful than Chi Squares test since the K-S test treats individual observations separately, and thus does not lose information though the combining of categories. Also, this test is applicable for small sample sizes (Siegel, 1956).

The K-S one-sample test compares the cumulative distribution function for a variable with a specified theoretical distribution (normal distribution in this experiment) and tests whether the distributions are homogenous (Norusis, 1988). The point at which the theoretical and normal distribution diverge is determined and the sampling distribution indicates whether such a large divergence is likely only on the basis of chance (Siegel, 1956).

The significance level for all the statistical procedures conducted all three experiments for the present research, will be set at the .05 significance level. By selecting a significance level, it is possible to control the size of a Type 1 error, and as such increase the power of the tests. A .05 significance level implies that the probability of a Type 1 error occurring, that is, rejecting a hypothesis when in fact it is true, is 5 in 100. This is a value acceptable to most researchers (Keppel, 1973). The power of the experiments are also increased by controlling the sample size and by reducing uncontrolled variance.

Results

The results show differences in the representation of the internal dynamics of computer systems between user groups. Table 1 is a summary of the data obtained by grouping subjects' responses into different categories. The K-S test was conducted for each category of

Table 1

Classification of statements into meaningful categories

Categories	Subject Group: Novice (n = 7)	Intermediate (n = 8)	Expert (n = 7)	K-S
Metaphors	17.0%	11.8%	5.1%	1.73**
Physical Components	3.7%	2.2%	6.7%	1.26
Electronics	5.7%	7.5%	13.1%	1.69**

* $p < .05$
** $p < .01$
*** $p < .001$

% Percentages represent the proportion of responses in that *category* to the total number of responses in that group.

responses. From the results of the K-S test it can be seen that the differences in scores for the metaphorical and electronic categories were significant. For both of these categories *the frequency* with which a particular type of statement was made depended on whether the subjects who made the statements were expert, intermediate, or novice users. The K-S score for the physical category was not significant at the .05 level.

Intermediate and novice subjects showed preferences for using metaphorical statements. Novices used metaphors to explain computer functions over three times more often than did the experienced users. The biggest category of response for the expert group were statements related to the electronic nature of computers.

The pattern of scores for the intermediate group were consistently closer to the novice groups' scores than to the expert groups' scores. This suggests that the representational styles of the intermediate group were qualitatively more similar to the novice group than to the expert group.

Discussion

The results of the structured interviews indicate statistically significant trends in formulating different styles of representation. Within the context of the interviews, the statements indicate that different conceptualisations between the groups do exist. Expert subjects speak frankly about the way computers function, expressing no mysticism about "bits and bytes." A typical sentence from an expert subject's interview is "each time you press a button on your keyboard it sends electronic impulses which are converted to a magnetic format, which is bits and bytes, and stored on something that will retain magnetism." A typical novice response was "it uses some kind electric circuitry, or whatever is instructing it." An intermediate subject stated, "maybe

the letters are in some sort of code like naughts and ones, and all it has to do is recognise the sequence of numbers." These quotes illustrate that while the novice and intermediate users do not have any clear understanding about the technicalities of a computer, they do acknowledge that it is electronic and do not have illusions of, for instance, little men running around inside the computer writing on huge sheets of paper.

The results do show however, that more subjects from the novice and intermediate groups, than from the expert group, used analogies to explain and interprat how a computer works. A number of different analogies were used. For instance, "the screen is like a scrabble board. What is being recorded is that little piece of wood that is your scrabble block," or "there are different boxes in storage. Edit is one box, FLIST is another etc. Each button is connected to a certain box and when you press that button, it gives you that box."

These observations imply that novice and intermediate users would be more responsive to analogies or metaphors in user interface design. These users appear to be more willing than the expert group to accept an analogy, for instance, a filing draw analogy, as an explanation of how a computer works. Over-simplified metaphors might be ineffective in reaching expert users. Expert users might not internalise the metaphorical concepts because they would conflict with their prior computer knowledge and experience.

The representational styles of the intermediate and novice groups seem to be more similar to each other than to the representational styles of the experienced group. The main differentiating factor between the novice and intermediate group was the length of time that th y had been using a word processor. Thus, it appears that this is not an important variable to consider when attempting to differentiate between user classes on the basis of their representational styles.

The differences between the expert group and the other two groups were more marked in terms of the computer applications which the different groups used and the formal education which they had received regarding computers. These variables appear to be more important for distinguishing representational styles. Because expert users perform so many different tasks on the computer with many different types of software, the user interface becomes more transparent to the expert users. They come to understand that different software packages can accomplish the same functions using techniques that appear to be different on the surface.

For instance, consider the following statement made by an expert user: "A word processor is just an extension of a normal program. The thing about computers is that everything is on one level. Everything is stored and interpreted as bits and bytes." This view is generally reinforced by the formal computer education expert users have received in the past. Also, because of the

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diversity of tasks performed by expert users, they have more opportunity for low-level interaction with computers, and sometimes even become involved in hardware.

On the other hand, the novice and intermediate subjects in this study typically formulated their mental models of computers based on interaction with a single word processing package. Today, word processors are relatively easy to use. Their user interfaces do not encourage users to conceptualise the computers in terms of bits and bytes.

Thus, it appears that range of tasks performed and formal computer education, are more important than duration of use on a computer, and should to be considered in any further research on group differences in representational styles.

In conclusion, results from the first experiment indicate that there are qualitative differences in representational styles between user types. This finding appears to be consistent with results from previous research which differentiates between types of users. Adelson (1984) found that the mental representations of experts are abstract conceptualisations of the original problem statement, whereas those of novices were less abstract and focused more on surface features of the problem.

A similar pattern emerged in the present study. Expert users had a more sound knowledge of computers and

their ideas about the internal dynamics of computers were more abstract and they had a wider range of explanations than the novices. Novices with little or no computer knowledge, offered more concrete, but more limited explanations. Their representations consisted largely of analogies or surface features to which prior knowledge could be applied. Other investigators have observed that new, inexperienced users spontaneously refer to a typewriter analogy when learning about word processors (Douglas & Moran, 1983; Mack, Lewis & Carroll, 1983).

This finding is related to other research which attributes different representational styles to the way in which knowledge is organised (*cf. Chase & Simon*, 1973a; McKeithen et al., 1981). These studies have shown that experts have more information better organised on an abstract level than novices whose representations are more concrete, but not always accurate, and less generalisable to novel situations.

The present research has helped to further the understanding of mental models, and the results have also suggested user characteristics which may potentially be used as a basis of inferring the nature any particular users' mental model. It would be worthwhile to investigate this topic further. The next experiment will determine values for the psychological attributes for the group of computer command words.

Experiment 2

The establishment of a normative data base of a set of potential computer command names and their semantic correlates

Introduction

The aim of this experiment was to obtain data for a set of computer command names on the variables of concreteness, imagery, familiarity, and understanding. The data collected was used in the third experiment, the semantic association task where the psychological attributes of potential computer command names were assessed in relation to the frequency with which subjects made associations between these words and the definitions generated from the first experiment.

Method

Subjects

Forty subjects were tested, five people from each of eight different commercial companies. The companies covered a broad spectrum of industries including manufacturers, retailers, and banks. At the time of the study, all of the subjects used computers as a part of their jobs.

Apparatus

For each of the 10 word processing functions identified in Experiment 1, five possible command names were chosen. This resulted in a set of fifty command names; five words for each of the ten word processing functions. The commands were obtained from reference guides written for a variety of software applications available for personal computers. The applications included word processing packages, statistical packages, data base management systems, and high-level languages.

The words were rated on each of the following variables: "concrete-abstractness" (high concrete-high abstract), "imagery" (high imagery-low imagery), "familiarity" (very familiar-not familiar), and "understanding" (good understanding-not good understanding).

Likert type rating scales were used for all four variables (Likert, 1932). The rating technique was introduced by Paivio, Yuille, and Madigan (1968) to assess the imagery value of words. This scale has high inter- and intra-subject reliability, correlates highly with other measures of imagery, and the imagery scores have been found to correlate with performance on a wide assortment of tasks (Paivio, 1971b).

Procedure

A cover letter was included in the questionnaire stating the purpose of the study. The instructions

included an explanation for each of the variables as well as examples of how to complete each question (see Appendix 4). Subjects were asked not to think too long about each word and not to refer back to words which they had previously rated. No time limit was set.

Questionnaires were distributed at participating companies. Completed questionnaires were collected two weeks later. No additional verbal instructions were given.

Analysis of Data

Pearson product-moment correlations (r) were conducted to determine the degree of linear correlation between each of the psychological attributes of the words. This information was used to determine whether useful predictions of one of the psychological attributes of a word could be made if another is known. The data in the present experiment satisfies the requirements for this statistic since the scores are measured on an equal interval scale.

Results

The words are presented in alphabetical order in Table 2, together with the means and standard deviations of the imagery, concrete-abstractness, familiarity, and understanding ratings. The range of imagery ratings (1, low imagery; 7, high imagery) for the mean scores was 3.32 to 5.75. For concrete-abstractness ratings (1, high

abstract; 7, high concrete), the mean scores ranged from 2.25 to 6.27. The frequency distributions of the two attributes exhibited slightly different patterns. As shown in Figure 6 and Figure 7, the modal imagery ratings lie in the range of 4 to 5 (n = 30), whereas most concrete-abstract ratings are 3 to 4 (n = 20), and 4 to 5 (n = 18).

The frequency distributions for familiarity and understanding were found to be extremely negatively skewed, with the majority of mean scores for both being in the range 6 to 7. The full range of mean scores for understanding was between 4.42 and 6.97, with 82.4 per cent of the words falling in the 6 to 7 range. For the familiarity scale the range of mean scores was between 4.50 and 6.97, with 76.5 per cent of the words falling between 6 and 7. Table 3 contains a summary of the Pearson product-moment correlation coefficients (r) between each of the variables. The correlation between imagery and concrete attributes for all words was significant ($r = .70$, $p < .0001$). In other words, if a subject rated a word high on imagery then that word would receive a similarly high score for concreteness, and vice versa. The same applies for low concreteness or imagery values.

An extremely high correlation was found between familiarity and understanding ($r = .98$; $p < .0001$). This means that subjects gave almost identical familiarity and understanding scores to the words in the task.

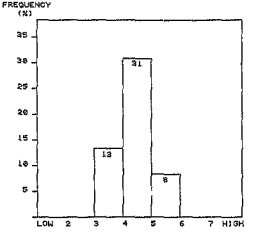

Figure 6. Frequency distributions for imagery means

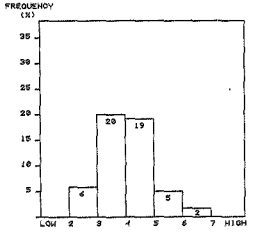

Figure 7. Frequency distributions for concrete-abstractness means

Table 2

Psychological Attributes of Potential Computer Command Names

	Concreteness		Imagery		Familiarity		Understanding	
Name	M	SD	M	SD	M	SD	M	SD
Add	3.92	2.26	4.77	1.93	6.90	0.30	6.92	0.27
Amend	3.67	2.03	3.55	1.95	6.15	1.35	6.27	1.30
Append	2.77	1.87	3.22	1.70	4.92	2.32	4.97	2.31
Begin	3.88	2.31	4.15	2.15	6.80	0.55	6.82	0.56
Cancel	3.45	2.31	4.02	1.98	6.75	0.74	6.82	0.45
Change	4.25	2.43	4.90	2.04	6.80	0.69	6.77	0.02
Clear	2.63	2.20	4.07	2.15	6.63	0.90	6.75	0.90
Close	3.67	2.35	4.35	2.13	6.77	0.70	6.88	0.46
Delete	3.60	2.20	4.80	1.87	6.92	0.27	6.92	0.27
Demolish	4.52	2.28	5.40	1.96	5.80	1.75	6.72	1.55
Directory	5.88	1.87	5.42	1.77	6.65	0.80	6.72	0.82
Download	2.25	1.85	3.40	2.01	4.75	2.27	4.90	2.02
Edit	3.88	2.41	3.63	2.16	6.70	0.88	6.85	0.43
End	3.57	2.53	4.60	2.24	6.72	0.60	6.85	0.43
Exchange	4.32	2.31	4.15	2.14	6.20	1.44	6.35	1.35
Execute	3.42	2.44	4.38	2.39	6.65	0.83	6.75	0.93
File	6.27	1.38	5.52	2.08	6.82	0.84	6.88	0.60
Finish	4.17	2.31	4.40	2.20	6.22	1.66	6.38	1.50
Give	3.77	2.35	3.88	1.99	6.00	1.80	6.02	1.72
Insert	4.00	2.14	4.63	1.66	6.60	1.10	6.63	1.15
Inset	2.92	1.94	3.32	2.18	4.65	2.29	4.52	2.45
Introduce	3.02	2.06	3.92	2.18	5.90	1.84	5.90	1.84
List	5.85	1.78	5.57	1.92	6.88	0.40	6.90	0.30
Load	4.63	2.43	4.63	2.28	6.75	1.01	6.60	1.35
Look	3.38	2.24	4.40	2.31	6.55	1.18	6.57	1.13
Output	4.92	2.09	4.72	1.95	6.60	0.84	6.65	0.77
Preserve	3.02	2.04	3.55	2.16	5.35	1.93	5.67	1.82
Print	5.25	2.27	5.70	1.76	6.97	0.16	6.97	0.16
Quit	3.32	2.32	4.63	1.94	6.80	1.28	6.82	1.20
Replace	4.57	2.29	4.95	1.74	6.70	0.76	6.80	0.69
Report	5.77	1.62	5.75	1.39	6.63	1.10	6.67	1.05
Retain	3.55	2.18	3.63	2.17	5.97	1.58	6.10	1.50
Revise	3.47	2.17	3.92	2.18	5.90	1.58	6.10	1.50
Run	4.07	2.39	4.70	2.34	6.77	0.83	6.77	0.70
Save	4.07	2.41	5.15	1.96	6.95	0.32	6.95	0.32
Scan	3.45	2.11	3.75	1.96	5.90	1.84	5.55	1.92
Search	3.88	2.28	4.82	2.12	6.75	0.54	6.82	0.45
Seek	3.42	2.21	3.97	2.00	6.10	1.48	6.38	0.98
Spot	4.45	2.18	4.02	2.01	5.22	1.99	5.20	2.08
Start	4.52	2.31	4.10	2.36	6.85	0.48	6.68	0.40
Store	4.72	2.34	4.88	2.24	6.72	0.91	6.77	0.73
Strikeout	2.75	1.84	3.52	2.24	4.52	2.11	4.50	2.28
Substitute	4.00	2.28	4.35	2.19	6.22	1.59	6.42	1.32
Switch	4.52	2.36	4.77	2.02	6.10	1.61	6.15	1.67
Table	6.25	1.53	4.95	2.33	6.72	0.85	6.55	1.34
Terminate	3.70	2.46	4.80	2.27	6.55	0.81	6.65	0.74
Transfer	4.02	2.26	4.40	2.17	6.45	1.01	6.50	0.99
Type	4.45	2.33	4.57	2.32	6.65	0.77	6.85	0.48
View	4.13	2.45	4.77	2.12	6.13	1.62	6.47	1.32
Write	5.27	2.20	5.32	2.02	6.92	0.27	6.95	0.32
Zap	2.88	2.32	4.22	2.70	4.50	2.60	4.42	2.65

Table 3

Pearson product-moment correlation coefficients between concreteness, imagery, familiarity, and understanding

Psychological Attribute	r
Concreteness and Imagery	0.70 ***
Understanding and Familiarity	0.98 ***
Understanding and Imagery	-0.02
Imagery and Familiarity	-0.04
Concreteness and Understanding	-0.02
Concreteness and Familiarity	-0.01

* $p < .05$
** $p < .01$
*** $p < .001$

The correlations between understanding and concrete-abstractness (r=-0.02) and understanding and imagery (r=-0.02) and those between familiarity and concrete-abstractness (r=-0.01) and familiarity and imagery (r=0.04) were all non-significant at the .05 level. This means that neither the imagery nor the concrete-abstractness scores could predict either the familiarity or the understanding scores and visa versa.

Discussion

The wide range of ratings obtained for the imagery and concrete-abstractness scales indicate that, for a set of names, some can be classified as highly concrete and associated with high imagery, while others can be classified as highly abstract and associated with low imagery. The implications of these observations suggest that systematic normative rating data of imagery and concrete-abstractness can be produced for a set of names (Rogers & Oborne, 1985). The results for the understanding and familiarity scales, conversely, were biased in that the majority of ratings were at the extreme end of the scales for understanding (82.4 per cent of the words were rated between six and seven on the seven-point Likert scale), and familiarity (76.5 per cent of the words were rated between six and seven on the seven-point Likert scale). A very similar pattern of results was obtained by Rogers and Oborne (1985).

The results show that there is a group of potential computer command names that exhibit contrasting patterns for imagery and concrete-abstractness. There was a difference of more than one point on the Likert scale for almost 20 per cent of these words. Futhermore, for 80 per cent of these words the nature of the relationship was such that imagery ratings were higher than concrete ratings. This seems to suggest that these words aroused sensory images even though they were considered relatively abstract. The direction of this relationship

is opposite to the relationship found by Rogers and Oborne (1985). This may be due to the different contexts in which the subjects completed the questionnaires and the history of the subjects participating in the present study. Subjects in the present study were aware that the words were potential computer commands, while in the Rogers and Oborne (1985) study, the subjects were not. As such, subjects in the present study could form images of these abstract words in terms of their ideas of computer dynamics. Without such a context, it is more difficult to form images of such abstract words, hence Rogers and Oborne's (1985) findings that abstract names were unable to arouse sensory images. This result is supported by the findings in the first experiment, that users do use analogies and images to understand computer dynamics. Also, since these subjects were computer users and not first year undergraduate students, it may have been easier for them to form images of the words in this context.

The validity of imagery and concreteness as two measures that define a common dimension of word meaning, in terms of the words' associations with concrete objects and events, was evaluated. This was achieved by examining the correlations between imagery and concreteness, and also between familarity and imagery and concreteness, respectively (Rogers & Oborne, 1985). Rogers and Oborne (1985) found that all the correlations were highly significant and hence suggested that there is

is opposite to the relationship found by Rogers and Oborne (1985). This may be due to the different contexts in which the subjects completed the questionnaires and the history of the subjects participating in the present study. Subjects in the present study were aware that the words were potential computer commands, while in the Rogers and Oborne (1985) study, the subjects were not. As such, subjects in the present study could form images of these abstract words in terms of their ideas of computer dynamics. Without such a context, it is more difficult to form images of such abstract words, hence Rogers and Oborne's (1985) findings that abstract names were unable to arouse sensory images. This result is supported by the findings in the first experiment, that users do use analogies and images to understand computer dynamics. Also, since these subjects were computer users and not first year undergraduate students, it may have been easier for them to form images of the words in this context.

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a general unifying dimension and that future research in this area may use either the imagery or the concreteness measure.

In the present study, however, a different pattern of results was found. First, familiarity was not significantly correlated with concreteness or imagery. Second, while the correlation between concreteness and imagery was highly significant, it was not perfect. As such it seems to suggest that concreteness and imagery are, in the more carefully defined context of computer dynamics and command words, independent attributes of the words tested in this experiment. Thus, following Richardson (1980), and for reasons described in Chapter 3, in the present study, imagery and concreteness were considered as two separate, independent variables.

Familiarity and understanding were not considered in the next part of the study, since almost all of the words had near perfect familiarity ($\bar{m}$ = 6.95, sd = .75) and understanding ($\bar{m}$=7.0, sd=.69) ratings. In fact, only 10 per cent of the words had ratings less than 5 (1, low; 7, high) for both familiarity and understanding.

The inspection of the data suggests that the linguistic concrete-abstractness and imagery associations of a name may have functional properties that have an effect on verbal behaviour. The aim of the next experiment, therefore, was to evaluate the properties of the set of words chosen in response to verbal descriptions, and to determine the nature of the

relationship between the attributes of concreteness and imagery and the semantic associations made by the subjects.

Experiment 3

Semantic associations between verbal descriptions and words with known concreteness and imagery scores, by different subject groups

Introduction

Semantic association made by different groups of computer users were investigated in relation to the representational styles of the user groups and the psychological attributes of the words in the association task. Two hypotheses were formulated. First, it was hypothesised that the frequency with which words were chosen in the semantic association task would be positively related to both the imagery and concreteness values of the words determined in Experiment 2. Second, it was hypothesised that the different representational styles of computer users, identified in Experiment 1, would manifest in a different set of command words chosen by the three different user groups in the semantic association task.

Method

Subjects

The subjects were 99 computer users from 10 different organisations. Subjects were divided into three groups

corresponding to the novice, intermediate, and expert user groups defined in Experiment 1, on the basis of their responses to demographic questions included in the questionnaire.

The novice group (n = 26) had some or very little word processing experience and the computer tasks they performed were only related to word processing. All the novices had less than six months of experience with computers. The intermediate group (n = 25) mainly used word processing packages, although some of them had wider task domains since they had also used data analysis packages. All had longer than six months experience with computers. The expert group (n = 48) were proficient with more than one type of computer package, such as database management systems, spreadsheet, statistical packages, and word processors. The tasks they used the computer for were diverse and incorporated more than word processing and data analysis functions.

Apparatus

The experimental task was designed as a questionnaire and consisted of a sequence of definitions or action descriptions and a list of potential computer command names (see Appendix 5). Subjects were asked which computer command name on the list they would choose to invoke the action described in each of the definitions.

The definitions were derived from the subjects' responses to open-ended questions in Experiment 1, which

addressed the issue of how a user perceives a computer to achieve a particular objective. Appendix 3 contains a complete list of these definitions. For each of the ten questions about a particular word processing function, described in Experiment 1, the five most frequently expressed ideas were chosen as representative to be used as definitions in the experimental task. In this manner, five statements were collected for each of the ten functions.

If any of the five most frequently occurring statements was too general--that is, expressed a concept not directly related to the particular word processing function in question--then it was not used as a definition. The next highest frequency statement was used in its place. For instance, for the function "delete", the most frequently occurring response was, "it depends on the program" (n=14). Such a definition was too vague to convey meaningful information in terms of its role as a stimulus in the present semantic association task. Therefore, the next frequently expressed idea, "words disappear off the screen" (n=4) was used instead.

The selected statements were formed into descriptive sentences and listed in a random fashion.

The target names were those in the data base described in Experiment 2. The words were presented on a separate page in the questionnaire, listed in functional groups. The fact that there were several appropriate

names from which to choose was brought to the attention of the subjects by listing the names in functional groups. This would discourage subjects from choosing the first name perceived to be in the appropriate target category that they encountered on the list.

One name from each group was chosen to identify that group of commands, resulting in ten group names. These were delete, edit, start, end, replace, insert, search, list, save, and print. For clarity, in the following discussion, the group name is in quotation marks to distinguish it from the actual words in that group. For instance, "delete" consisted of the names delete, strike out, clear, demolish, and cancel (see Appendix 1 for a complete list of names).

Subjects were informed that the names were all potential computer commands in a cover letter. The instructions given at the beginning of the questionnaire were as follows:

> "For each statement below, please write down the number of the most appropriate command verb in the box provided. The numbers corresponding to each of the command verbs are presented below. There are no correct or incorrect answers. The best response describes what you feel to be the most suitable command verb for each particular definition. In other words, which command verb would you use to invoke each of the actions described in the statements?"

Procedure

The questionnaires were distributed to computer users in the various organisations and collected one week later. No additional verbal instructions were given.

Analysis of data

For each statement, subjects selected one potential computer command name. The frequency of subjects who chose each computer command name for each statement was calculated for the three user groups. The frequencies with which each of the names were chosen were summed across all of the definitions corresponding to each of the ten word processing functions. The frequency scores for each word, converted to percentages for easier comparison, are shown for each word processing function in Tables 6 to 15. For example, for the five definitions that referred to the functional word group "delete", delete was chosen by 54 per cent of the novice group, 60 per cent of the intermediate groups, and 62 per cent of the expert group.

For each of the functional groups, all names chosen from the appropriate group of names (marked with an asterisk) were included in the table irrespective of the frequency with which they were chosen. Words chosen from outside the appropriate functional group of words were listed separately if they were chosen by two percent or more of the total subject group and listed collectively

under "other" if chosen by less than two percent of the subjects.

The Kendall rank correlation coefficient (tau) was used to measure the strength of the association between the frequencies with which the words were chosen and the concreteness and imagery values of the words. This test is appropriate since the requirement that both variables be measured on at least an ordinal scale has been achieved (Siegel, 1956).

The tau measure of association is based on the comparison of values of both variables in every case. Each pair of cases can be concordant, discordant or tied. A pair of cases is concordant if the values of both variables for one case are higher (or both are lower) than the corresponding values for the other case. The pair is discordant if the value for one variable for a case is larger than the corresponding variable for the other case and the direction is reversed for the second variable. When the two cases have identical values on one or both variables, they are tied. If the preponderance of pairs is concordant, the association is positive: as ranks of one variable increase (or decrease) so do ranks of the other variable. If the majority of pairs is discordant, the association is negative: as ranks of one variable increase, those of the other tend to decrease. If concordant and discordant pairs are equally likely, no association exists (Norusis, 1988).

A qualitative analysis was conducted in order to determine whether the different representational styles of computer users, identified in Experiment 1, would manifest in a different set of command names chosen by the three different user groups. It was felt that a qualitative analysis would be most suitable because of the hybrid data yielded in the analysis. The nature of the data collected from the questionnaires, consisted of non-independent scores. The reason why the scores were not independent is that the frequency with which a subject chose a particular command name was summed for all of the definitions referring to each of the ten functional groups.

This was done to reduce the problem of induction--the risk of influencing a subjects' answers--which is a major methodological difficulty with naming experiments (Scapin, 1982). By using many definitions for each functional group of words, the impact of the nature of the definitions on subjects' answers and hence the outcome of the present research could be reduced. The implications of this is that the rows of the table were independent (user groups), but the columns were not (command names).

In such a case the results of a non-parametric test such as a Chi Squares analysis would be more of a reflection of the differences of scores across words, rather than differences of scores between groups. As such, an analyses using non-parametric statistical

methods such as Chi Squares would be inappropriate since such tests require that scores are independent (Siegel, 1956).

Results

Each group of definitions was intended to describe functionality which could be invoked by a corresponding group of command names. The percentage of people who chose command names from the intended category reflects the number of people who thought about the statements in t o manner intended. Table 4 shows the average percentage of all subjects who chose names from the intended category.

The high percentage of subjects who chose words from the intended category implies that the definitions derived from the first experiment and used as stimuli here were close to the way subjects conceptualise the tasks. In this study, the frequency of a correct responses greater than 70% for 7 out of 10 groups of words, and the lowest score was 59% for "insert" and "replace". Rogers and Oborne (1985), found correct response to a definition less than 40% for 11 out of 32 instances.

Kendall's tau for the frequencies with which words were chosen by each group of subjects and the words' concreteness and imagery ratings are presented in Table 5. The pattern of results was similar for all three groups of users. Tau for imagery and the frequency with

Table 4

Average percentages for all subjects selecting names from the intended functional group

Function	Percentage	Function	Percentage
"delete"	88%	"search"	83%
"edit"	73%	"replace"	59%
"start"	69%	"insert"	59%
"save"	70%	"list"	69%
"end"	73%	"print"	79%

Table 5

Kendall's Tau for the psychological attributes of the words and the frequency with which they was chosen by each subject group

Psychological Attribute	Frequency with which the words were chosen		
	Novice	Intermediate	Expert
Concreteness	.21*	.08	.09
Imagery	.28**	.24**	.21**

* $p < .05$
** $p < .01$
*** $p < .001$

which words were chosen, was significant at the .01 level for all three user groups. This implies that the more imageable the word, the more likely it was to be chosen in response to the definitions.

The correlation between concreteness and frequency with which novice subjects chose words was significant at the .05 level. The correlation between concreteness and frequency with which intermediate and expert subjects chose words did not reach statistical significance. In other words, for intermediate and expert subjects, the concreteness value of a word could not predict the frequency with which it was selected. These results confirm the earlier statement that imagery and concreteness were not necessarily defining the same underlying dimensions of a word in the context of computer dynamics and control words. Moreover, the results indicate that imagery may be an important variable to consider when choosing between potential computer command names, for all three subject groups. Concreteness may only be important when designing for novice computer users.

Inspection of the summary data in Tables 6 through 15 reveals an extremely similar pattern of command name choice by all three user groups for each of the ten word processing functions. Typically, a few names, with high imagery scores, account for the majority of responses in each functional group. Also, in every functional group,

the two most frequently chosen names were the same for all three subject groups.

For "delete" (see Table 6), delete and clear account for an average of 76 percent of the names chosen. The imagery value for delete ($\bar{m}$ = 4.08) and clear ($\bar{m}$ = 4.07) were the highest imagery values in that group. Demolish which has the highest concreteness score ($\bar{m}$ = 4.52) was chosen by 8 percent of the novices, but only 2 and 1 percent of the intermediate and expert groups respectively. This is in line with the overall pattern of the relationship between concreteness and imagery and name choice described above.

For the "search" functional group (see Table 7), search and scan together account for an average of 65 percent of the names chosen. Both these command names had high imagery values relative to those in the rest of that functional group (for search rated imagery $\bar{m}$ = 4.8; for scan rated imagery $\bar{m}$ = 3.8). The average total frequency with which novices selected search and scan was 12 percent lower than the total group average. Novices' responses were spread out more to include spot and seek. The rated concreteness values of spot ($\bar{m}$ = 4.45) and seek ($\bar{m}$ = 4.42) were both high. However, their imagery values were less than those of search and scan ($\bar{m}$ = 4.02 and $\bar{m}$ = 3.42 respectively). Two other names with very high imagery values also chosen in the "search" group were directory ($\bar{m}$ = 5.42) and list ($\bar{m}$ = 5.57). Although these words have high imagery values they were chosen with low

frequency in the "search" group (average = 2) since they have relatively little meaning for the definitions corresponding to the "search" functional group.

For "edit" (see Table 8) the overall pattern of results is similar to the pattern in the other groups, although there appears to be a wider distribution among the names selected by the subjects. Change, again the name with the highest imagery value in that functional set ($\bar{m}$ = 4.9), alone accounted for 26 percent of the names selected. Together, four of the five words in the group account for an average of 73 percent of the words chosen. "Edit" is a relatively general function and may apply to a number of different tasks a user may perform with a word processing package. It is possible that the spread of responses across target names reflects this generality as well as the higher number of other names chosen.

For "replace" (see Table 9), replace, change, and substitute together account for an average of 70 percent of the names chosen. The rated imagery values for replace ($\bar{m}$ = 4.95) and change ($\bar{m}$ = 4.90) have the highest imagery values for names selected in the "replace" functional set. Change was not included as a target name for the *"replace" group by the experimenter, rather,* it was included with "edit." It appears that this word could apply to both functions although it was associated with "edit" by an average of 25 percent of the subjects, and with "replace" by only 16 percent. This is an

indication that change is more readily semantically associated with "edit" than with "replace."

For "start" (see Table 10), three names, load, start, and begin, account for an average of 60 percent of the names associated with the "start" definitions. The name choice pattern for "start' was unusual in that the word in the group with the highest imagery value, namely run ($\bar{m}$ = 4.70) was chosen by an average of only three percent of the subjects. This may be so because run is an easily imaged word, however, it is unlikely that the image formed of run is semantically consistent with the image of starting a computer program. Load, which has the next highest imagery value after run ($\bar{m}$ = 4.63) was the most frequently chosen name.

For "insert" (see Table 11), insert was selected by an average of 40 percent of all the subjects. Insert has the second highest imagery rating ($\bar{m}$ = 4.63), while add has the highest ($\bar{m}$ = 4.77). However, insert has a higher concreteness value ($\bar{m}$ = 4.00 and $\bar{m}$ = 3.92 respectively). This may explain the why insert was chosen by many more subjects than add was. However, it is more likely that insert was chosen more frequently because images formed of insert are possibly more easily associated with computers applications than images formed of add. This is because insert frequently appears in computer applications and documentation and also, it is one of the labelled function keys on most personal computers. This makes it a name which is easily associated with the

"insert" definitions, and explains why one name accounts for an average of 40 percent of all choices, unlike most of the other functional groups where two or three words account for a large proportion of names chosen.

For "print" (see Table 12), print was overwhelmingly the most popular choice. Print has a very high imagery score and the highest in the group ($\bar{m}$ = 5.70), and the highest concreteness score ($\bar{m}$ = 5.25). It was selected by an average of 60 percent of the subjects. Print and output together account for 74 percent of the responses.

For "list" (see Table 13), the pattern of responses was similar to those for "insert." Directory was the most frequently chosen name, and directory and list together accounted for an average of 60 percent of all the responses. These two names have high imagery scores ($\bar{m}$ = 5.42 and $\bar{m}$ = 5.47 respectively), however, these scores are both lower than the imagery value for report ($\bar{m}$ = 5.77) which was only associated with "list" definitions by one percent of the group. It appears that even though report is an easily imageable word, it is not successfully associated with the "list" function in word processing packages, in fact, it was selected more frequently in response to "print."

For the "save" functional group (see Table 14), save and store account for an average of 64 percent of all the names chosen. Save and store have the two highest imagery scores in the "save" functional group ($\bar{m}$ = 5.15

and $\bar{m}$ = 4.88 respectively). This is typical of the patterns of name choice in the other functional groups.

For "end" (see Table 15) four words, namely, end, close, quit, and terminate account for 70 percent of all the names chosen in response to the "end" definitions. The range of imagery scores for these words is very small ($4.35 < \bar{m} < 4.80$). *Given the similarity of these imagery* scores for these command names, and the equal distribution of choices between the names in all three user groups, it appears that all four names have similar semantic meaning and are equally successfully associated with the "end" definitions. Since these four names were easily associated, the number of other choice made were relatively few.

From the results of the semantic association task, it can be seen that a pattern of computer command name choice is emerging. Typically, a few words account for the majority of all users choices. The words chosen all have high imagery values. Furthermore, the pattern of choice is the same for the novice, intermediate, and expert user groups. The implications of these findings are discussed in the following section.

Table 6

Percentages of command names chosen for "delete"

Name	Subjects			
	Novice	Intermediate	Expert	Average
*Delete	54	60	62	59
*Clear	15	12	21	17
*Strike Out	5	8	4	5
*Cancel	5	2	4	4
Zap	3	9	2	4
*Demolish	8	2	1	3
Other	10	7	10	8

* Denotes names in the target functional group

Table 7

Percentages of command names chosen for "search"

Name	Subjects			
	Novice	Intermediate	Expert	Average
*Search	28	32	37	34
*Scan	25	31	33	31
*Spot	10	8	3	6
*Seek	10	6	5	6
*Look	7	7	5	6
View	9	7	4	6
Edit	3	3	1	2
Directory	2	0	2	2
List	1	1	3	2
Other	5	3	6	5

* Denotes names in the target functional group

Table 8

Percentages of command names chosen for "edit"

Name	Subjects			
	Novice	Intermediate	Expert	Average
*Change	37	22	22	26
*Edit	14	22	31	25
*Amend	12	12	12	12
*Revise	13	14	8	10
Replace	2	10	2	4
Switch	3	4	3	3
Exchange	0	2	2	2
Substitute	1	2	2	2
Load	2	1	2	2
Save	2	2	2	2
*Append	0	0	0	0
Other	14	9	14	12

* Denotes names in the target functional group

Table 9

Percentages of command names chosen for "replace"

Name	Subjects			
	Novice	Intermediate	Expert	Average
*Replace	40	46	45	44
Change	19	11	16	16
*Substitute	5	11	11	10
Edit	8	10	7	8
Amend	4	7	8	7
*Exchange	5	3	3	3
Store	3	2	1	2
Revise	2	1	2	2
*Switch	4	0	1	1
*Transfer	0	1	0	1
Other	10	8	6	6

* Denotes names in the target functional group

Table 10

Percentages of command names chosen for "start"

Name	Subjects			
	Novice	Intermediate	Expert	Average
*Load	22	34	31	29
*Start	18	17	18	18
*Begin	17	15	10	13
*Execute	4	7	6	6
Seek	5	3	5	5
*Run	2	3	5	3
Scan	1	3	5	3
Search	2	5	2	3
Directory	5	3	2	3
Store	5	1	1	2
Transfer	2	2	1	2
Other	17	7	14	13

* Denotes names in the target functional group

Table 11

Percentages of command names chosen for "insert"

Name	Subjects			
	Novice	Intermediate	Expert	Average
*Insert	43	45	35	40
*Add	11	6	8	8
*Inset	8	10	6	8
Append	10	6	5	6
Delete	5	6	4	5
Clear	6	2	4	4
Edit	4	4	4	4
Transfer	2	2	2	2
Amend	2	2	2	2
*Introduce	0	4	2	2
*Give	0	2	1	1
Other	9	11	17	16

* Denotes names in the target functional group

Table 12

Percentages of command names chosen for "print"

Name	Subjects			
	Novice	Intermediate	Expert	Average
*Print	52	69	60	60
*Output	13	11	16	14
*Download	8	2	3	4
Report	0	1	2	2
Switch	2	2	2	2
List	1	1	3	2
Replace	4	1	4	2
Substitute	1	2	3	2
*Type	0	1	1	1
*Zap	1	0	0	0
Other	17	10	6	11

* Denotes names in the target functional group.

Table 13

Percentages of command names chosen for "list"

Name	Subjects			
	Novice	Intermediate	Expert	Average
*Directory	25	39	42	37
*List	28	19	22	23
*View	6	7	2	5
Retain	3	5	7	5
Search	1	4	5	4
Preserve	4	3	4	4
*Table	5	3	2	3
Scan	3	2	3	3
Spot	4	2	2	2
Save	3	2	1	2
File	5	3	1	2
Store	3	3	0	2
*Report	1	1	0	1
Other	12	7	9	7

* Denotes names in the target functional group.

Table 14

Percentages of command names chosen for "save"

Name	Subjects			
	Novice	Intermediate	Expert	Average
*Save	47	38	50	46
*Store	20	14	19	18
Load	6	13	14	12
Download	9	5	9	8
*File	3	7	2	4
Start	0	8	0	2
Output	1	3	1	2
*Preserve	3	1	0	1
*Retain	3	0	0	1
Other	8	11	5	6

* Denotes names in the target functional group

Table 15

Percentages of command names chosen for "end"

Name	Subjects			
	Novice	Intermediate	Expert	Average
*End	12	22	19	18
*Close	15	19	19	18
*Quit	12	20	19	17
*Terminate	19	13	12	14
*Finish	9	3	5	6
Switch	5	5	7	6
Execute	2	2	8	5
Download	6	4	2	4
Transfer	3	3	3	3
Cancel	2	1	2	2
Other	15	8	11	4

* Denotes names in the target functional group

Discussion

The frequency of "correct" responses to the definitions was very high ($\bar{m}$ = 72.2%). This means that the descriptive statements, generated in Experiment 1, were accurate in that they expressed the function in a manner very close to the way subjects conceptualised it. This was possible since the definitions were derived directly from subjects' descriptions of their own representations of computer dynamics. As such many of the possible biases, due to the nature of the definitions inherent in Rogers and Oborne's (1985) study, were controlled in the present experiment.

The results of the semantic association task are therefore more specific to the purposes of this study in that the differences in the subjects' choice of words can be more safely attributed to the psychological attributes of the words rather than the nature of the definitions.

The results of this experiment show that imagery was significantly correlated with the frequency with which words were chosen for all three user groups, while the correlation between concreteness and frequency reached significance for only the novice users, and not for the intermediate and expert users. This reinforces the idea expressed earlier in this paper that imagery and concreteness are distinct and independent types of information. Although many experiments have demonstrated that concreteness and imagery are significantly related to each other and that both have the same effect in

certain experimental tasks, Richardson (1975a; 1975b; 1976) demonstrated that it is valid to distinguish between the two constructs. The present results reinforce those obtained by Richardson (1975a; 1975b; 1976).

It has been shown that a lack of visual experience does not necessarily entail a poor perceptual representation of the concept (Kieras, 1978). It seems as if for intermediate and expert users' representations of computers, perceptual representation (imagery) is more important than visual experience (concreteness) since most of the workings of the computer are not visible to the user. In other words, whether the user can form an internal representation of the function is more important than whether they perceive the function to be a concrete object; whereas perceptual representation and visual experience are equally important for novices. Therefore, concreteness does not appear to be one of the psychological attributes of potential computer command words that warrant consideration when deriving computer command words for intermediate and expert computer users.

For novice users however, a more concrete word may help to construct analogies that, as was shown in the first experiment, this group of users formulate in order to understand the dynamics of a computer. Thus when selecting a command word, for novice users, the concreteness value of the command is an important variable to consider.

Rogers and Oborne (1985) found no significant main effect for imagery and thus rejected their hypotheses that high-imagery words would show a superior performance to low-imagery words. This was not the case in the present study and the hypothesis was accepted. As Rogers and Oborne (1985) point out there were a number of reasons why the results they obtained were not significant. For instance, the context within which the task was performed, the nature of the definitions, and the small number of subjects. These factors were controlled in the present study and are sufficient to account for the different results obtained.

The implication of this finding is that imagery, one particular psychological attribute of computer command names, is an important variable for designers of user interfaces to consider when choosing between potential computer command names. It appears that high-imagery words, in a semantic association task, facilitate users ability to make better assumptions about the meaning of the words than low-imagery words do. This observation considered together with the literature linking imagery as a important variable in learning and memory tasks (e.g., Paivio, 1971c), makes the psychological attribute of imagery an important variable to consider when choosing between various words to be implemented as computer commands.

The most interesting finding from this study has been the pattern with which command names were selected in the

experimental task. Regardless of the level of expertise, all users tended to select the same commands names, with high levels of rated imagery, for each of the word processing functions. This is counter to many pointifications in the literature that no single computer command name, however well chosen, can be expected to cover more than a small proportion of users expectations (e.g., Card, Moran, & Newell, 1983; Furnas et al., 1987; Landauer et al., 1983). Furnas et al. (1987) suggest that unlimited aliasing is the solution to the problem. Other authors such as Landauer et al., (1983) and Scapin (1981) have determined that experienced and inexperienced computer users have different needs for command names. Scapin (1981) found that inexperienced users tended to recall computer oriented (thus more specific) names than more common or general ones.

In the present study the appropriateness of command names was considered in relation to the underlying psychological processes and representational styles involved in users' behaviour. Also, scientific knowledge and theoretical models developed in the field of psycholinguistics and cognitive psychology were applied. Particulary, the role of imagery and concreteness of a name was investigated. These variables have been suggested in the memory literature as playing an important role in the mental representation of word meaning and memory (cf Paivio, 1971a; Richardson, 1980).

This approach appears to have been successful since the rated imagery value of the names was significantly related at the .01 level, to frequency of choice for command names, for all user groups. Thus, this study has identified an underlying psychological attribute of command names which is applicable across a range of subjects with varying levels of expertise. This implies that different levels of metaphorical representation may be successfully associated with the same words because of the vagaries of word meanings.

This finding is important because it has implications for the standardisation of computer command names across products. Standardisation would be extremely beneficial since ease of use and efficient learning would be encouraged through positive transfer of semantic knowledge from product to product. Also, users could gain expertise and grow with an existing system without having to relearn command names.

The implications of the results of this experiment for the standardisation of computer commands are explored further in the following chapter which is an overview of the all three experiments and a general discussion.

Overview and Conclusions

The empirical research conducted in the *present* study was designed to test a number of hypotheses. This chapter represents a general overview of the most salient results and their implications for software user interface design.

The motivation for the investigation of users' representational styles of computer systems is grounded in the belief that a person's ability to use *a system is* related to their conception or representation of that system. An understanding of this relationship and of the nature of representational styles applies to the problem of designing computer system so that they are easy to use and *learning is efficient* (e.g, Carey, 1932; Manketelow and Jones, 1987; Van der Veer et al., 1985).

As suggested in the introduction to this thesis, there are four different aspects of representations which are involved in the relationship between a user and a computer. First, the target system, that is, the system the person is interacting with. Second, the users' actual representation *which is formulated* by users through interaction with the target system. Third, the scientists conceptualisation of the users' representation. Fourth, the conceptual model of the

target system which is presented by designers to provide an appropriate representation of the target system.

Ultimately, research in this area is aimed at acquiring an understanding of the relationship between a user and a computer so as to be in a position to provide practical guidelines for designing the actual target system, the first aspect of representations, and for the theoretical importance of understanding people as they generally perform complex cognitive tasks (Carroll & Olson, 1987). In order to achieve this goal however, an understanding of all aspects of representations must be achieved. This study has contributed towards furthering the understanding of the different aspects of representations.

The nature of the users' actual representational style, the second aspect of representation, was directly addressed in Experiment 1. The hypothesis that different types of computer users would have qualitatively different representational styles of computer systems was generally supported by the results from Experiment 1.

Experiment 1 was explorative in nature. The results from Experiment 1 indicated that there are a general set of variables which underlie the formation of representations of computer systems. The emphasis of these underlying variables were different for the three types of user groups. While novice and intermediate users use metaphors and analogies more often, the expert group had more realistic concepts and explained their

representations in terms more closely approximating the physical and electronic nature of computers. This is consistent with previous research which attributes different representational styles of novices and experts to the way in which knowledge is organised (cf Chase and Simon, 1973a; McKeithen et al., 1981), and with Adelson (1984) who identified different types of representations formed by novices and experts.

The implications of these results for user interface design are that designers must take user types into consideration, and in order to maximise user performance, different conceptual user interfaces should be constructed for different user types. The results suggest that novice and intermediate users would be more responsive to analogies or metaphors in user interface design. Expert users might not internalise the metaphorical concepts because they would conflict with their existing knowledge and experience with computers, and therefore, result in a less than optimum match between the actual system and the users' representation of the system.

The results obtained in Experiment 1 also have implications for understanding the scientists' *conceptualisation* of these representations, the third dimension of representation. As illustrated in Chapter 2, the nature of representations and the way in which they are used in cognition is not clearly defined and certainly not agreed on by all theorists (cf Anderson,

1975; Kosslyn & Pomerantz, 1977). The two major schools of thought on the subject are held by propositional and analog theorists. Both, or either, of these theories could be used to explain the observed results.

The results from the present research do not provide evidence in support of either one of the theories. It appears that both types of representation are being used. Expert users' representational styles appear to be more abstract and propositional than those of novice and intermediate users', whose representational styles seem to be more analog in nature. Thus, propositional theorists such as Anderson or Pylyshyn may argue that the nature of the experts' representational styles provide evidence for a propositional representation. On the other hand, proponents of the imagery position such as Kosslyn and Pomerantz may argue that the nature of the novices' representational styles provide evidence in support of their own particular viewpoint. These arguments are concerned with the scientists' conceptualisation of the users' representations, and this issue is still far from resolution.

As indicated earlier in this paper one of the most important variables that a designer can manipulate in forming the conceptual representation of the target system for users, the fourth dimension of representation, is the command language and specifically the names attributed to the commands in the language (e.g., Treu, 1975; Rosenberg, 1982). In designing commands, designers

should try to invoke a representation in the user that fits the system; they should try to get the user to build a representation of the system that fits what the users have to do to operate the system (Carroll & Olson, 1987).

Command names are often the most visible part of a system and are likely to influence the representation of the system that they form. In discussing command names, Schneider (1984) quotes from Shakespeare's Romeo and Juliet "A rose by any other name would smell as sweet." Schneider (1984) points out that the lively debate in design circles suggests that this concept does not apply to command names (Shneiderman, 1987). Critics (e.g., Norman, 1981) focus on strange names in *UNIX*, such as MKDIR (make directory), CD (change directory), or RM (remove file); or in IBM's CMS, such as GENDIRT (generate directory). Part of the concern is consistency within and across products. The present study uncovered some important findings in this regard. Primarily, it was concerned with the relationship between potential computer command names and users' representational styles, and the psychological attributes of the command names.

The hypothesis that the different representational styles of novice and experienced users would manifest in a different set of command words chosen in the semantic association task was not supported. This has important implications. Earlier in this chapter the results of Experiment 1 were discussed. Experiment 1 showed that

meaningful distinctions could be drawn between the types of representational styles formed by different groups of computer users. It was expected that these differences would *manifest* in different sets of command names being generated in the semantic association task. However, this was not the case. For each of the ten word processing functions, the two *command names chosen* most frequently were the same for all three user groups. This finding has exciting ramifications for command naming conventions.

The interpretation of this finding is that the vagaries of word meanings, and the associated high imagery values of the potential computer command names were such that it allowed each of the user groups to identify the name with their own particular representational style. In other words, the findings suggest that different levels of metaphors across groups can be successfully associated with the same words because of the vagaries of interpretation that are so much a feature of natural language word meanings (see Bobrow, 1967; Thomas, 1978). Furthermore, since the same words were chosen by all the groups in response to the functional definitions, the findings suggest that the robustness of the name meanings is enough to ensure that the semantic association is maintained even though representational styles change as users acquire more *expertise.*

This implies that a single name could be used (in conjunction with other design criteria) to invoke in users with different representational styles a model that fits the system. This finding serves to justify the standardisation of command names across products. People with varying backgrounds and familiarity with many different software packages, for the most part, chose the same command names. Standardisation across and within software products would encourage, on the whole, efficient learning and ease of use across products. The positive transfer of semantic and syntactic knowledge from one system to another would be optimised. Also as users progress from one level of expertise to the next, their short-term memory will not be burdened by a new set of commands with potentially conflicting meanings. Conversely, users will not be confused by similar words with the same mapping to a function. Osgood (1949) showed that learning a new response was hindered when the to-be-learned response is similar but not identical to the already learned response. If standardisation was successfully adopted, command names would become transparent to users of all software products adhering to the standards, and the memory of users of these products would be freed, allowing full concentration on the task, not the interface.

Another important focus of this study was on the psychological attributes of the command names, which is an important variable to consider before the names of

commands to be used in standardised products are decided (e.g., Rogers & Oborne, 1985). The psychological attributes considered in relation to choice of command word were concreteness and imagery. Results from Experiment 2 suggest that the *linguistic imagery and* concrete-abstractness values of a set of potential *computer command names* may have functional properties that have an effect on verbal behaviour.

The hypothesis that the frequency with which words would be chosen in the semantic association task would be positively related to the imagery value of the words, was supported by the results. The results suggest that for all three user groups imagery is a powerful variable to consider when selecting between potential computer command names for a system. The higher the imagery value of the word, the more likely it was to be chosen. A highly imageable word conveys more meaning than a command word that has a low imagery value. *These high imagery* words thus promote the formation of internal *representations which facilitate* the interaction between the user and the computer. For designers of user interface systems, the results of the study suggest that where there is a choice, a word with higher imagery should be chosen over a word with lower imagery.

This study was useful since it has begun to explore the nature of the a users' representation of a computer system. Also, scientific principles studied in the area of cognitive psychology have been successfully

incorporated into a study of human-computer interaction. To summarise, the results obtained in the experiments carried out in the present study indicate that there are qualitative differences between the representational styles of users with varying levels of expertise. Nevertheless, the vagaries of word meanings in natural language are such that the same pattern of words was selected in a semantic association task by users with qualitatively different representational styles. Also, there was a statistically significant positive relationship between the frequency with which a word was chosen and the words' rated imagery value.

The implications for user interface design are that different conceptual interfaces should be considered with different user types in mind. However, the same high imagery words should be used as command names across products to facilitate the acquisition of expertise and transfer of knowledge.

Future research should be done to expand on patterns emerging here and also to focus on ways in which accurate and useful representations can be encouraged though the design of the conceptual interface for the target system.

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APPENDIX 1

Computer command names used in the present study.

"Delete"	Delete	"Insert"	Insert
	Clear		Give
	Strike		Add
	Cancel		Inset
	Demolish		Introduce
"Search"	Search	"Print"	Print
	Scan		Output
	Spot		Download
	Seek		Type
	Spot		Zap
"Edit"	Edit	"List"	Directory
	Change		List
	Amend		View
	Revise		Table
	Append		Report
"Replace"	Replace	"Save"	Save
	Substitute		Store
	Exchange		File
	Switch		Preserve
	Transfer		Retain
"Start"	Load	"End"	End
	Start		Close
	Begin		Quit
	Execute		Terminate
	Run		Finish

APPENDIX 2

Experiment Control Sheet

1. What experience have you had with computer software?

2. What experience have you had with computer hardware?

3. What is your general attitude towards computer? and the people in organisations who use them?

4. What do you think happens when you perform .... function on the computer?

- delete (delete consecutive characters at the cursor)
- insert (insert successive characters into existing text)
- search (to find a word or character in a document)
- replace (to replace one string of characters with another)
- start (to start a work session, begin word processing)
- edit (to recall a previously entered document for revision)
- list files (to list all file in a specified directory)
- print (to print a document)
- save (to save a document you are working on)
- end (to complete work session, exit word processor to DOS)

5. What is happening inside the computer to make this happen?

6. Do you have any other comments to make about the way in which you represent the internal dynamics of the computer to yourself? Do you think it would be useful to know more about what is going on?

APPENDIX 3

Table of statements generated in Experiment 1

	Expert	Int	Novice
DELETE			
Depends on the program	8	3	2
Goes to the directory	1		
Marker shows file has been deleted	6	1	
Becomes free space	2		
Written over	2		
Physically been removed	5		
Erases it from file	3	1	
Disappears off the screen	3	1	
Bits change to "off" state	3		
Disc head moves across disc	2		
Locates internal storage number	2		
Moves spaces	1		
Clears the area	1		
Screen is virtual	3		
Remaining bytes linked differently	1		
Reorganises memory locations	1		
Program translated into machine code	1		
Not deleted immediately	1		
Deletions move into buffer	1		
Erases from memory, not disc		1	
Letter by letter sent through wire		1	
Particular tracks deleted from disc		1	
Removes impulses from the discs		1	
Does not appear on disc anymore			1
Erases from memory			1
Space on disc becomes free		1	
Deletes from text and from memory		1	
Text adjusts itself		1	
Wiped of the tape			1
Electromagnetic pulses wiped off disc		1	
Not there anymore		1	
Types over			1
Removes from screen only			1
INSERT			
Moves each character across	6	2	
Physically doing it in primary memory	1		
Saves new one over old one	1		
Nothing happens on disc before saved	1		
Zaps it around	1		1
Bits and bytes transmitted	1		
Like a tape-recorder	3		
Stores either a zero or a one	2		
Laser marks the beginning of a file	1		

	Expert	Int	Novice
Adds space	2	1	
Like a mathematical function	1		
Changes relative co-ords of screen matrix	1		
Pointer marks end of file	1		
Disc drive makes contact *with disc*		1	
Space bar moves words across			4
Searches for 1st letter of each word			1
Built in facility		1	
Flags position where space needed		1	
Scans the actual disc			1
Like a magnetic tape			1
Letters that you put down are movable		1	
Commands not erased, pushed along		1	
Shifts across in screen and storage			1

SAVE

Creates new entry	2		
Overwrites existing file	4		
Looks on the disc	3		
Finds space to store the file	4		
Physically converts text	1		
Dumps bits and bytes onto disc	2		
Primary memory on the screen	1		
Secondary memory on the disc	1		
Takes it to memory	1		
File from main memory stored on disc	3		
Bits compressed onto disc	1		
Reads document letter by letter into space	1		
Stores with electromagnetic pulses	1	1	
Floats over surface of disc	1		
Conversion has certain rules	1		
Like a magnetic tape	1		
Changes charges of magnetic field on disc	1		
Like a photograph of memory	1		
Stores impulses	1		
Like a calculator memory	1		
Memory shoots along valve to storage	1		
Becomes permanently stored on disc		1	
Wires control process		1	
Electronic messages b/n console and mframe		1	
Like a library		1	
Like a record			2
Instrument makes grooves			1
Seals work on hard disc			1
File moved from temp memory to large storage section			1
Copies from screen to disc			1
Machine code = dots, dashes, stars etc		1	1
Save onto empty tracks		1	
Head doesn't touch disc		1	
Head transposes info onto disc		1	
Terminal does not have storage capacity		1	
Copies from disc into fixed memory in computer		1	

	Expert	Int	Novice
Electromagnetic imprint		1	
Stored in codes			1
Storage like a cupboard			1

SEARCH

Brings it up on the screen		1	
Characters converted to argument of bytes		4	
Goes through the whole thing		5	1
Find the matching one		10	6
Searches for each letter		6	
Uses elimination process		2	
Searches through memory on disc		2	
Like linking terminal to mainframe		1	
Like a filing cabinet		1	
Chips speak to the screen		1	
Cannot view search process		1	
Searches for exact combination		2	
Sequence of characters form each word		1	
Pulls string of characters from text		1	
Zooms through looking for internal format		1	
Like an immediate typewriter			2
Electronic eye			1
Paper revolves inside machine			1
Converts to code, searches for code			1
Looks for letters one at a time			1
Goes through line by line			1
Searches for first letter of each word			1
Goes through lines from left to right			1
Compares pattern of word in memory			1
Searches automatically over a range of space			1
Configuration of letters translated to bits			1

REPLACE

Overwrites argument	1		
Bits represent characters	1		
Same as delete and insert	1	1	1
Replaces particular box in matrix	1		
Checks length of words	1		
Stores new word in place of old one	2		
Changing impulses	1		
Adjusts to make words fit within margins		1	
Shunts everything up			1

START

Loads (reads) it from disc into memory	9	2	
Code converts into from disc to memory	2		
Batch file initialises program	1		
Looks for package in storage	2		
Operator makes computer run	2		

	Expert	Int	Novice
Boots up the machine	2		
Initial starting point hardware coded	3		
Heads brush against electric tape	1		
Data transferred through electric current	1		
Heads determine whether pulse pos or neg	1		
Machine checks for autoload file	1		
Interface between floppy and disc drive	1		
Disc like a music record	1		
Checks dir for starting position of file	1		
Heads transfer bits non-destructively	1		
Computer automatically perceives		1	
Each person has own disc		1	
Reads wp file from disc		1	
Information transmitted through cable			1
Electrical pulses			1
wp automatically in machine			1
Loads wp into memory			1
opens file		1	
Contents of file reflected on screen		1	
Accesses certain files		1	
Loads it into memory		1	
Each key connected to a different "box"			1

LIST

Track on each disc	2		
Accessed by operating system	2		
Default (automatic)	1		
Takes the head there	2		
Reads the track	2		
Loads file onto the screen	1		
Filename is identifier for file	2		
Like a key	1		
Allocated space in memory	1		
All new filenames go into directory	2	2	
Directory has "address" for each file	2		
Directory is a DOS function	3		
Storage interacts with software	1		
Like a table	1		
Reads catalogue portion of disc	1		
Like a library	1		
Like another ordinary file	1	1	
Reference page of each file in library		1	
Generated by program		1	
Like a draw			1
discs compared to filing cabinet		2	
Directory is a draw		1	
Files and documents put into draw		1	
Peripheral function of computer			1
Place on list not correlated to place on disc			1
Filenames marked to go to certain files			1

EDIT

	Expert	Int	Novice
Machine picks up (fetches) the file	4		
Goes to the allocated place on the disc	5		
Puts required file into memory	3		
Opens the file	2		
Displays first part of allocated space	1		
Compares filenames with stored files	1		
Looks at directory	2		
Brings up all info from particular file		1	
Searches disc for filename		1	

PRINT

Print card is interface between printer and computer	3	1	
Characters go down the cable	1		
Dump screen onto paper	2		
Sends bytes down the line	5		
Software driven	1		
Spooled to the printer	1		
File to be printed goes into a buffer	5		
Takes file from main memory, not disc	1		
Communication lines b/n computer and prntr	1		
Modum (buffer) decodes electronic bits	3		
Remains in memory til computer switchd off	1		
Prints from the buffer	1		
Printer has own language	2	2	1
Machine code translated into alphabet	3	3	
Sends code, character by charas to printer	1	1	
Actual file sent to the printer		1	
Wires move it across		1	
Electrons activate keys on printer		1	
Prints from floppy			1
Involves a conversion process			4
Electronically transmitted			1
Prints from floppy			1
Like a record			1
Instrument makes grooves			1
Prints from memory		1	
Printer has memory of its own		1	
Electronic			1

END

Control passed from wp back to CPU	1		
Program has ended	2		
DOS (operator) takes over	1		
End statement in source code of program	1		
Close all files	2		
Resets all variables	1		
Goes through terminating procedures	1		
Move from one sub-level to next higher one	2		

	Expert	Int	Novice
Resets pointers			
Disc becomes disengaged from terminal	2		
Must physically remove disc	1		1
Close memory - cupboard			1
Closes documents and discards them	1		
Closes box			1

APPENDIX 4

Questionnaire used for Experiment 2

1 Jan Smuts Avenue
Johannesburg
2001 South Africa

Telegrams 'Universitas'
Telex 4-27125 SA
(011) 716-1111

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

21 October 1986

Dear Sir\ Madam

I am currently involved in a research project to assess the psychological attributes of potential computer commands. Please would you assist me by responding to the following questionnaire. The questionnaire should take no longer than 15 minutes to complete.

Please note that neither your name nor that of your company is required. As such, your anonymity is assured.

Thanking you in anticipation,

Yours sincerely

Behrmann

Jane Behrmann
B.A. (Hons)

INSTRUCTIONS

For each of the words, there are four rating scales. The first scale is CONCRETE-ABSRACTNESS. A word is ABSTRACT in the sense that it does not denote a CONCRETE object, an object having an external reality. For instance, the word, "table", is more concrete (high concrete), and the word "idea", which is more abstract (high abstract).

The second scale is IMAGERY. Some words have higher imagery values than others because they have richer mental representations. For example, the word "religion" commonly evokes an image of a church (high imagery), whereas the word, "thought" does not usually result in a mental image of the word (low imagery).

The third scale is FAMILIARITY. This refers to how familiar the word is to you. The last scale, UNDERSTANDING, refers to how well you think you understand the meaning of the particular wc.d.

For each of the scales below, place an X on the most appropriate portion of the line for the word immediately above each set of scales. There are no correct or incorrect answers. The best response describes how you feel about the particular word.

For example:

CHAIR

HIGH CONCRETE |X|_|_|_|_|_|_| HIGH ABSRACT
HIGH IMAGERY |_|X|_|_|_|_|_| LOW IMAGERY
VERY FAMILIAR |X|_|_|_|_|_|_| NOT FAMILIAR
GOOD UNDERSTANDING |X|_|_|_|_|_|_| NOT GOOD UNDERSTANDING

IDEA

HIGH CONCRETE |_|_|_|_|_|X|_| HIGH ABSRACT
HIGH IMAGERY |_|_|_|_|_|_|X| LOW IMAGERY
VERY FAMILIAR |X|_|_|_|_|_|_| NOT FAMILIAR
GOOD UNDERSTANDING |X|_|_|_|_|_|_| NOT GOOD UNDERSTANDING

There is no time limit. Please do not think too long about each word and do not refer back to words which you have already rated.

INSTRUCTIONS

For each of the words, there are four rating scales. The first scale is CONCRETE-ABSRACTNESS. A word is ABSTRACT in the sense that it does not denote a CONCRETE object; an object having an external reality. For instance, the word, "table", is more concrete (high concrete); and the word "idea", which is more abstract (high abstract).

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For each of the scales below, place an X on the most appropriate portion of the line for the word immediately above each set of scales. There are no correct or incorrect answers. The best response describes how you feel about the particular word.

For example:

CHAIR

HIGH CONCRETE |X|_|_|_|_|_|_| HIGH ABSRACT
HIGH IMAGERY |_|X|_|_|_|_|_| LOW IMAGERY
VERY FAMILIAR |X|_|_|_|_|_|_| NOT FAMILIAR
GOOD UNDERSTANDING |X|_|_|_|_|_|_| NOT GOOD UNDERSTANDING

IDEA

HIGH CONCRETE |_|_|_|_|_|X|_| HIGH ABSRACT
HIGH IMAGERY |_|_|_|_|_|_|X| LOW IMAGERY
VERY FAMILIAR |X|_|_|_|_|_|_| NOT FAMILIAR
GOOD UNDERSTANDING |X|_|_|_|_|_|_| NOT GOOD UNDERSTANDING

There is no time limit. Please do not think too long about each word and do not refer back to words which you have already rated.

DELETE

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

CLEAR

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

DEMOLISH

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

STRIKE OUT

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

CANCEL

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

SEARCH

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

LOOK

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

SCAN

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

SPOT

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

SEEK

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

EDIT

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

APPEND

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

CHANGE

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

REVISE

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

AMEND

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

REPLACE

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

EXCHANGE

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

SUBSTITUTE

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

SWITCH

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

TRANSFER

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

START

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

BEGIN

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

EXECUTE

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

LOAD

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

GIVE

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

INTRODUCE

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

INSET

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

SAVE

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

FILE

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

STORE

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

PRESERVE

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

RETAIN

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

RUN

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

LIST

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

REPORT

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

VIEW

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

DIRECTORY

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

TABLE

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

INSERT

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

ADD

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

END

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

FINISH

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

CLOSE

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

QUIT

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

TERMINATE

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

PRINT

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

WRITE

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

DOWNLOAD

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

OUTPUT

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

TYPE

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

ZAP

HIGH CONCRETE	|_|_|_|_|_|_|_|	HIGH ABSTRACT
HIGH IMAGERY	|_|_|_|_|_|_|_|	LOW IMAGERY
VERY FAMILIAR	|_|_|_|_|_|_|_|	NOT FAMILIAR
GOOD UNDERSTANDING	|_|_|_|_|_|_|_|	NOT GOOD UNDERSTANDING

APPENDIX 5

Questionnaire used for Experiment 3

1 Jan Smuts Avenue
Johannesburg
2001 South Africa

Telegrams 'Univits'
Telex 4-27125 SA
(011) 716-1111

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

19 November 1986

Dear Sir/ Madam

I am currently involved in a research project to assess the psychological attributes of potential computer commands. Please would you assist me by responding to the following questionnaire. The questionnaire should take no longer than 15 minutes to complete.

Please note that neither your name nor that of your company is required. As such, your anonymity is assured.

Thanking you in anticipation,

Yours sincerely

Liana Behrmann
B.A. (Hons)

INSTRUCTIONS

For each of the statements below, please write down the number of the most appropriate command verb in the box provided. The numbers corresponding to each of the command verbs are presented below. There are no correct or incorrect answers. The best response describes what you feel to be the most suitable command verb for each particular definition; in other words, which command verb would you use to invoke each of the actions described in the statements. For example:

To delete characters in a document..... [4]

To transfer information into disc..... [36]

You may find it convenient to detatch this page when completing the questionnaire. There is no time limit. Please do not think too long about each statement.

COMPUTER COMMAND VERBS

1. Strike out	6. Seek
2. Clear	7. Look
3. Demolish	8. Scan
4. Delete	9. Spot
5. Cancel	10. Search
11. Change	16. Replace
12. Append	17. Exchange
13. Edit	18. Substitute
14. Revise	19. Switch
15. Amend	20. Transfer
21. Begin	26. Table
22. Start	27. Report
23. Execute	28. View
24. Load	29. Directory
25. Run	30. List
31. Inset	36. Save
32. Add	37. File
33. Give	38. Store
34. Introduce	39. Preserve
35. Insert	40. Retain
41. Finish	46. Print
42. End	47. Zap
43. Close	48. Download
44. Quit	49. Output
45. Terminate	50. Type

COMMAND ACTION STATEMENTS

1. To change one set of characters to another .....☐
2. To make a list of all your files .....☐
3. To identify a particular file .....☐
4. To get output from the computer .....☐
5. To find a summary of the contents of your disc.....☐
6. To recall a previously entered document for revision☐
7. To make a correction .....☐
8. To store a file from memory onto disc .....☐
9. To make changes in an old document ... .☐
10. To insert successive characters into existing text.☐
11. To overwrite a particular argument of characters...☐
12. To move characters position in storage .....☐
13. To physically remove a file .....☐
14. To complete work session .....☐
15. To load the disc into memory .....☐
16. To keep the location of the file on the disc .....☐
17. To compare patterns of words in memory .....☐
18. To store a new word in place of an old one .....☐
19. To pass control from word processor to CPU .....☐
20. To dump bits and bytes onto a disc .....☐
21. To convert text to machine code .....☐
22. Put required file into memory .....☐
23. To boot up the machine .....☐
24. To disengage disc from the terminal .....☐
25. To reflect contents of file onto screen .....☐

26. t mark a file so that it no longer exists .....☐
27. ' transfer writing on the screen to paper .....☐
28. o change electromagnetic pulses on the disc .....☐
29. T change the relative co-ordinates of the screen.☐
30. T start work session; begin wordprocessing.....☐
31. T use an elimination process to identify words ..☐
32. T make heads check directory for starting point .☐
33. T perform the same as insert and delete .....☐
34. To look for a matching combination of characters .☐
35. To convert machine code to script .....☐
36. To view all filenames .....☐
37. To reset all variable .....☐
38. To search for a particular word .....☐
39. To make words disappear from the screen .....☐
40. T put new words into the text .....☐
41. T send characters to the printer .....☐
42. T close all files .....☐
43. T move words along the screen .....☐
44. To transfer screen information to storage facility☐
45. o dump the screen onto paper .....☐
46. o fetch a particular file .....☐
47. o create more space .....☐
48. To locate a word or character string in the file. ☐
49. To look through the entire memory .....☐
50. To delete consecutive characters at the cursor ...☐
51. To replace one string of characters with another .☐
52. To save the document you are working on .....☐

53. To go *through* terminating procedures ..... ☐
54. To list all files in the *default directory* ..... ☐
55. To access a package from storage ..... ☐
56. To make a space on the disc *become* free ..... ☐

DEMOGRAPHIC QUESTIONS

1. When last did you use a computer?

_____

2. For how long have you *been* using a computer?

_____

3. On *average*, how many hours per day do you use a computer?

_____

4. On average, how many hours per week *do* you use a computer?

_____

5. For what tasks do you use a computer?

_____

_____

53. To go through terminating procedures ..... ☐
54. To list all files in the default directory ..... ☐
55. To access a package from storage ..... ☐
56. To make a space on the disc become free ..... ☐

DEMOGRAPHIC QUESTIONS

1. When last did you use a computer?

_____

2. For how long have you been using a computer?

_____

3. On average, how many hours per day do you use a computer?

_____

4. On average, how many hours per week do you use a computer?

_____

5. For what tasks do you use a computer?

_____

_____

Author Behrmann Ilana
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