
Information Utilisation: A Cognitive Analysis of how Girls Utilise Drug Information Based on Brookes' Fundamental Equation $K(S) + \Delta I = K(S + \Delta S)$

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ABSTRACT

This paper posits Bertram Brookes' Fundamental Equation of Information Science $K(S) + \Delta I = K(S + \Delta S)$ as an expression of cognitive information utilisation. It acknowledges Brookes as one of the founders of information science, and presents the exploration of this equation as still one of the greatest challenges for the discipline of information science, particularly in light of user-centred developments in information retrieval, human-computer interaction, organisation of information, and product and service development. This paper explores some of the conceptual issues related to understanding cognitive information utilisation in the framework of Brookes' equation, and presents an overview of one approach to operationalisation, based on a quasi-experimental study of girls and their interaction with information about the drug heroin.

BACKGROUND

In an examination of the foundations of information science, the late Laurence Heilprin spoke of the 20th century as the "Age of Information", an era characterised by the exponential growth, organisation and global distribution of information. He asserted that since the 1960's the study of the channels of information between people has become the locus of the development of theories, generalisations and speculations that are the foundations of an information science. In his analysis, Heilprin foreshadowed an "Age of the Mind" as a probable successor to the "Age of Information", an age of investigation of the minds bounding the channels. He claimed that "all discovery, investigation and technological adaptation takes place in those mental terminals, not in the nonliving connecting channels" (1989, 346), and saw the need for increasing attention to be directed to understanding these "mental terminals" as a prelude to the effective organisation and provision of information.

It is curiosity about this interaction of mind and information, about how people do something with information to enable them to get on with their lives, that is currently shaping information science. Two important developments have contributed to this. The first is the shift in the last two decades from a system-oriented paradigm to a user-oriented paradigm as a conceptual orientation of, and approach to research in information science (Dervin & Nilan 1986). The second is the emergence of a cognitive view in information science (Belkin 1990) where the primary theoretical object is structures of knowledge, or models of the world, which control the perception and processing of external information. While it is acknowledged that an increasing amount of user-centred and cognition-centred research is taking place in the field, much of this focuses on macro-level interactions between generators, intermediaries and users of information systems, a focus that Heilprin would identify as part of the "Age of Information" rather than the "Age of the Mind".

It is the intersection of these developments with the contribution made by Bertram Brookes to the then emerging discipline of information science that is the central concern of this paper. Today, with the perspective of two decades as hindsight, Brookes is regarded as one of the founders of information science. For some years he claimed:

"Information Science operates busily on an ocean of commonsense practical applications which increasingly involve the computer. ... Information science floats in a philosophical limbo. It has no theoretical foundations" (1980, 125).

His writings sought to "find the grounds of information science" (1980, 126). Brookes recognised that the concepts of information and knowledge are critical concepts in the discourse of the cognitive viewpoint. He considered that while the "practical" pursuit of information science is the collection and organisation of "the exosomatic stores of knowledge which have an existence independent of those who created them", the "theoretical" pursuit of information science is the cognitive interaction between the private, inaccessible thoughts and mental images of people, each unique, and objective documented artefacts of knowledge (1980, 127).

THE FUNDAMENTAL EQUATION OF INFORMATION SCIENCE

Brookes posited this interactive process of what people know, how what they know changes, and the effect of these changes as an abstract "Fundamental Equation of Information Science", most commonly expressed in his writings as $K[S] + \Delta I = K[S + \Delta S]$ (1980, 131). This equation, expressed in pseudo-mathematical form, suggests that in the process of doing something with information,

a person's existing knowledge structure $K[S]$ is changed by an increment of information ΔI , and this modification has some effect, a changed knowledge structure $K[S + \Delta S]$ where ΔS indicates the effect of the modification. Brookes asserted that the change was not accretive but rather, some adjustment to the structure.

Brookes appears to use the term "effects" at two levels. First, in a general sense there is an effect when people interact with information. Secondly and more specifically, a changed knowledge structure $K[S]$ is one effect, and ΔS is another. At a concrete level, the evidence of cognitive information utilisation is found in the component of the equation $K[S + \Delta S]$. This part of the equation identifies two potential sets of indicators: modifications to structures and the effects of the modification. The use of the brackets [] in the equation suggests that the modification to structure and effects are not separate but interrelated entities. He also claimed that the fundamental equation can also be considered as a sequence. Each successive information inputs $I_1, I_2 \dots$ in sequence changes the person's knowledge structure from $(S)_0$ to $(S)_1$, from $(S)_1$ to $(S)_2$ and so on, corresponding to the successive inputs:

$$\begin{array}{l} I_1 + (S)_0 \longrightarrow (S)_1 \\ I_2 + (S)_1 \longrightarrow (S)_2 \\ I_n + (S)_{n-1} \longrightarrow (S)_n \\ \text{Overall sum of these sequences} \\ \Sigma I + (S)_0 \longrightarrow (S)_n \end{array} \quad (\text{Brookes, 1974, 148})$$

Brookes' equation is a conceptualisation of the fundamental transformation that characterises information and its effects in the mind. It is an expression of what happens in the mind when people are exposed to information and do something with this information. In this sense, the equation can be regarded as an expression of cognitive information utilisation. While Brookes consistently asserted that the interpretation of the fundamental equation is the basis research task of information science, he was aware of the difficulty of exploring these knowledge structures because of their complexity, the difficulty of direct observation and no agreed upon analytical techniques, and because their structural forms may be modified by input questions applied to them to establish their form. He thus turned his interest to public or objective knowledge, claiming

"we do not need to peer into other people's minds but only to study the interaction between humans and their exosomatic stores of knowledge. ... The practical program is to organise mankind's untidy inheritance of exosomatic knowledge for more effective social use" (1974, 149).

To date, the challenge of exploring Brookes' Fundamental Equation remains an open one. Indeed, this gap is evident when the broader field of information utilisation is examined.

INFORMATION UTILISATION AS A FIELD OF STUDY

While a substantial literature of this field has been developed, there are major gaps, particularly in relation to its cognitive dimensions. The study of information utilisation has emerged from several different traditions, and at present, the multiple theoretic perspectives, while contributing to the richness of the field, have generated terminological inconsistency and confusion, diverse methodological approaches, conflicting findings and generalisations.

The question of what constitutes information utilisation has been one of the most salient issues in the field. The studies are dispersed in the multidisciplinary literature, and they are characterised by multiple, often ambiguous and not at all comparable meanings attached to the term utilisation. Labels such as information use, knowledge use, information utilisation, and knowledge utilisation are employed interchangeably, with often little clarification of meaning. In a review of the field, Karapin notes

“‘utilization’ contains eight more letters and four more syllables than ‘use’, and means almost exactly the same thing. Its extra bulk may lend ‘utilization’ a kind of scientific authority. At any rate, most of the writers reviewed here use the longer word, particularly those trying to develop a more precise, technical definition”
(*Karapin in Heller 1986, 261*).

At a broad level, information utilisation is primarily portrayed in two ways, firstly as end-state, itself being seen as the problem, and secondly as an interactive change process. These conceptions have generated and have been reinforced by categorising indicators of information utilisation in terms of instrumental, conceptual and symbolic. The context of these types is primarily organisational; their information base is the findings of wide-ranging social science research; and their focus is the adoption, implementation and institutionalisation of this information in tangible, immediate and direct ways. Comparatively less attention has been given to developing an empirical base for better understanding information utilisation as an interactive change process, particularly as it relates to individuals, and almost no attention has been given to understanding the cognitive dimensions of this interactivity.

An important aspect of the information utilisation literature is the acknowledgement of the role of a person's model of the world in the relevance assessment of information to be acted upon. This contribution is often expressed in terms of frames of reference, defined as basic elements of a situation which govern a person's involvement in the situation enabling people to assess what

the situation ought to be for them, to shape judgements and to determine when action is acceptable and act accordingly. An extensive range of frames of reference considered to contribute to information utilisation have been identified in the information utilisation and information seeking literature. These include attitudes, values and norms; goals and commitments; dimensions of the information concern; cognitive style; motivations, assumptions, conventions, and premises; personalities and dispositions towards certain rules such as truth tests and tests of relevance; situationality; qualities of information and characteristics of sources of information such as credibility of source, authority, or tradition; and relationship of information to established attitudes and situations.

Primary attention has been given to exploring external frames. The question of how internal frames of reference such as existing knowledge, styles of information processing and attitudes and values shape information utilisation is an open one. Conceptualising information utilisation as a type of organisational change or end-state has tended to mask the complex cognitive exchanges that occur, and has limited explorations into the contexts of human information processing and the cognitive and social processes that structure them. With a transmission of information focus that assumes that information has an existence apart from human construction, people are attributed a role as mere receivers and reactors, rather than as initiators and manipulators of knowledge. Indeed, information utilisation is seen as the problem, not as a process of responding to another problem.

Rich (1991) acknowledges that there little attention has been given to the cognitive interactions of people and information. While some of the empirical investigations regard information utilisation as a process rather than an end-state, the primary purpose appears to be to observe behaviour, not to understand it.

In summary, the current status of information utilisation research highlights the following general propositions:

- (a) Information has the potential to make a difference, and that individuals involved in utilising information would have acted differently or thought differently in the absence of information;
- (b) Information needs to be known in order to be utilised and this involves a communication process;
- (c) information utilisation is interpretative, interpreted by various stakeholders in terms of their own frames of reference;
- (d) information utilisation is socially constrained by frames of references and the situated realities they engender;
- (e) information utilisation is systemic, rarely decomposable into discrete parts;
- (f) information utilisation is transactive, rather than exchanged or transmitted in toto;

- (g) information utilisation involves cognitions and behaviours in relation to taking in information that result in cognitive effects as preludes to resolution of the information problem or need;
- (h) information does not always evoke a discernible response; simply making information available is not sufficient to ensure its utilisation.

CONCEPTUAL ISSUES

In order to understand cognitive information in the framework of Brookes' Fundamental Equation, it is necessary to understand the relationships between information, knowledge, effects and action as Brookes saw them. Brookes' Fundamental Equation raises a number of key questions that are essential to examining cognitive information utilisation. They are indeed difficult questions to answer:

- what is information?
- what is knowledge?
- what is the relationship between information and knowledge?
- what is a knowledge structure?
- how is a knowledge structure represented?
- how can knowledge structures be measured?
- what is known about the relationship between information and knowledge structures?
- what are the effects of exposure to information?
- how does a knowledge structure change over different exposures?

Brookes spoke of the equation in terms of equilibrium rather than equality:

"A knowledge structure must be regarded as a live information-seeking ('emmorphotropic') entity striving always to modify itself to be in dynamic equilibrium with the information it is receiving. Some of the incoming information adds nothing new to what we already know; the corresponding parts of the structure are strengthened but not consciously. Some of the information may be new and help to resolve some anomaly or reduce some stress in the structure; such information is of interest and we may become conscious of it"

(Brookes 1978, 22)

and claimed:

"crudely interpreted, it says that whatever 'goes' in depends on what is already 'there'. The private world of subjective knowledge is literally *meta*-physical"

(1974, 148).

WHAT IS INFORMATION AND KNOWLEDGE?

Brookes took a wide view of information. His notion was of a continuous spectrum of information processes involving physical, biological and cognitive information:

"All information which modifies a knowledge structure is the result of an information process. The knower sees, hears, tastes, smells or feels something. Sometimes the information is consciously sought, sometimes information is imposed upon us, but any information we gain is the result of a process in which our neural system is activated by some source outside our brain"

(1978, 21).

According to Brookes, all human communication processes rest on transmission of purely physical signals, patterns of sound or light or some other form of electromagnetic transmission. He argued that the point at which people become conscious of the incoming physical information, selection occurs, and that in this process of selection, the senses play an important part. Within the person, neural systems are activated by input energy, that is, physical information, and the information signals are transmitted along its neural pathways. Brookes equated this process with perception. The incoming stream or patterns are detected by the sensory organs and are transduced into electrical signals which pass from the sensory organs along neural pathways to the central nervous system. This is the biological phase. These signals may or may not be transduced once again into the signals that people recognise and interpret cognitively. Cognition, according to Brookes, is the mental awareness of any signals received and the resultant the subjective interpretation of these signals

Brookes regarded information and knowledge as the fundamental entities of the cognitive world where knowledge is structured integrated information and information is fragmented knowledge. He recognised two concepts of knowledge: subjective, private, cognitive knowledge, and objective, public, social knowledge. Subjective knowledge is the summative construction of cognitive information, selectively absorbed and ordered. It is interpreted, organised, and has patterns imposed on it. It is also a basis for creating objective knowledge which is expressed in publicly observable ways and which may attract the cognitive attention of other people.

One crucial difference according to Brookes between information and knowledge is that knowledge is cognitively structured. Any bit of information in a knowledge structure is related cognitively through the structure to all other bits in the structure. These cognitive relationships are synthesised into a structure which, in spatial terms, may have any number of dimensions (1978, 23).

In essence, Brookes saw a complementary relationship between information and knowledge in the information process continuum: "I regard knowledge as a structure of concepts linked by their relations and information as a small part of such a structure"; a "summation of many bits of information which have been organised into some sort of coherent entity" (1974, 48). Since information is a small bit of knowledge, and therefore is the same kind of thing as knowledge, in the equation $K(S) + \Delta I = K[S + \Delta S]$ he used ΔI instead of ΔK because the same information might have different effects on different structures.

WHAT IS A KNOWLEDGE STRUCTURE?

Brookes characterised knowledge as a structure of concepts linked by their relations. He saw their role as subjectively interpreting sense data from outside world and transforming it into information, and then transforming knowledge structures (1980, 131). Brookes identified two types of knowledge structures, consistent with his notions of objective and subjective knowledge. These are objective maps of the exosomatic stores of knowledge, and cognitive maps. Brookes did not elaborate on what the dimensions of a private knowledge structure might be, except to say that it is a n -dimensional structure composed of concepts and their interrelationships. He speculated that when people communicate, the relevant parts of the knowledge structure are expressed in words and the n -dimensions are squeezed into a linear verbal stream. Linear processes such as sound waves transmit these words. Within the physical channels the information transmissions have no cognitive structure. But as the transmissions reach the mind of another, the stream of physical information filters through that person's n -dimensional knowledge structure and, in a successful communication, modifies that structure as the bits find their proper place (1978, 22-23). This is the essence of his fundamental equation.

It is against this background that the following methodology is presented to investigate cognitive information utilisation in the framework of Brookes' Fundamental Equation. Brookes acknowledged that to test these speculations about the development of private knowledge structures in any direct empirical way would be very difficult:

"I cannot believe that it would be possible to make intrusive observations inside other minds without seriously affecting the phenomena we hope to observe. Nor can we rely on introspection. ... So the direct investigation of subjective knowledge structures does not look any more promising now than it has done for many centuries" (1978, 22-23). "Research in this problem has already attracted so many lines of research - in psychology, neuro-physiology, robotics, and so on - that I doubt whether information science could find a foot-hold or that it could offer anything if it did" (Brookes 1980, 49).

AIMS OF THE STUDY

The specific focus of this study is on the cognitive effects of exposures to information and how these effects are manifested in changes to a person's knowledge structure. In the context of Brookes' Fundamental Equation, the study sought to:

- (a) establish the processes of change operating on knowledge structures;
- (b) establish the perceived effects of exposure to information;
- (c) establish how the perceived effects are manifested in changes to a person's knowledge structure; and
- (d) examine patterns within and between respondents in relation to changes in knowledge structures and perceived effects

RESPONDENTS

The data for this study was obtained from four girls in their final year of high school at a Catholic college in Sydney. All girls were nominally Catholic. A key criteria in the selection of the girls was their fluency in written and spoken English. Consequently, the girls were selected on the basis of having a high level of English fluency in both written and oral communication.

DESIGN

Brookes regarded his equation only as a skeleton, and in stating that the interpretation of the equation is the basic research task of information science, he saw the major task of information science was to elaborate this by analysing examples of knowledge structures and by observing how they respond to the received information. In doing so, Brookes claimed that

"it would be necessary to be able to describe, in suitable terms and with suitable precision, the state of knowledge (S)₀ of the reader at the beginning of his reading. Any such reader will already have a complex knowledge structure, complex enough to make us consider whether we could not begin at some earlier, simpler state" (Brookes 1974, 148).

Brookes also recognised the need for the investigation of:

"experimental or observational knowledge structures and information inputs. We then have to observe what happens, measuring the effects as well as possible, at first in simple cases and then in more complex cases as we develop skill on our technique and confidence in our theories" (Brookes 1974, 48-49).

A quasi-experimental approach was employed where the effects of the manipulated variable, exposure to pre-determined amounts of information, was

assessed by looking at changes in the girls knowledge structures established prior to and after the information exposure. While Brookes suggested an experimental approach, experiments are relatively uncommon in the information utilisation literature, and in the broader area of information seeking behaviour. In the main, the classic laboratory approach has not been seen as appropriate for the study of conceptual utilisation or utilisation for enlightenment.

The design was an Experimental Repeated A – B design, where the A phase involved measures of existing knowledge structures and the B phase involved the information exposure being introduced and changes (or not) in knowledge structures noted. This A – B pattern was repeated three times, with no variation of treatment procedure. An integral part of the process were interviews probing the effects of the exposures.

RESEARCH ENVIRONMENT

The research investigation was placed within the context of the established school curriculum in NSW, Australia. The specific topic of the research was information related to the drug heroin, an important life concern of adolescents (Edwards and Poston-Anderson 1994). The focus problem was a hypothetical research task in which the girls would normally actively seek out information to develop their responses to the task:

Your local council is concerned about the increase in drug usage in the area, and has approached high schools to participate in a public forum. The public forum will focus on factors associated with harm from drug use, and consequences of harmful drug use on the individual, and making health-related decisions. You have been selected by your school to present a talk, accompanied by a written guide, at the forum that specifically deals with heroin. Your topic will focus on nature and incidence of the drug, implications for the individual, and implications for the community.

PROCEDURE Information

In Brookes' equation, ΔI refers to an increment of information, or information input that has been selected from information available in the physical world such as in documents, or selected by observation through the senses. It is the information received, selected from the "totality of physical information", and then is transduced into private thoughts. For the purposes of this study, the "totality of physical information" was operationalised as a print-based document.

Exposure to information was manipulated in terms of pre-determined amounts of different, publicly available information presented to the girls at predetermined stages during the research process. "Exposure" was defined as purposeful

consideration of information, as contrasted with rejection of information without any effort to read it. These pre-determined amounts of information formed the basis for ΔI to be selected by each girl. The information was derived from three sources: (a) Liz Byrski. Pills, potions, people: understanding the drug problem. Blackburn, Victoria: Dove Communications, 1986; (b) Heroin: depressant. Sydney: CEIDA, 1989; and (c) Drugs and the law. Sydney: CEIDA, 1990. The sequence of exposures was: (a) nature of drug heroin: what it is, how derived, and use throughout history; (b) implications for the individual: effects of heroin use; and (c) implications for the community: emphasis on community control, approaches to treatment, and recovery.

KNOWLEDGE STRUCTURES

Judgements about changes in knowledge structures are based on operationalisations of knowledge structures. The question of operationalising knowledge structures is a complex and vexed one, and many approaches to representation have been developed across many disciplines. Central to the operationalisation are two procedural questions: how is knowledge acquired, and, how is this knowledge then presented as a structure.

A number of key assumptions underpinning knowledge representation are embedded in this research:

- (a) human knowing can be adequately modelled by representational systems;
- (b) humans handle complexity by finding patterns and grouping things into categories and units;
- (c) knowledge about a single state or event is organised together in one functional unit, that is, an associative nature of knowledge as knowledge "units" or "packages"; and
- (d) information known for one unit can be applied to other units, and that inconsistent knowledge can exist.

The literature presents inconsistent advice about approaches to knowledge elicitation and acquisition, acknowledging incomplete theory and limited repertoire of approaches. A number of ways in which information is acquired for knowledge representation purposes are commonly presented. These include interviews, familiar-task methods, limited information tasks, constrained processing tasks, and tough-cases methods. Two approaches were chosen to elicit the knowledge of the girls about the drug heroin. These were: free generation written discourse, and question answering protocols through a semi-structured interview. These approaches are a popular method for exposing and analysing the content of a person's knowledge (Graesser & Clark 1985).

The first step in uncovering and exploring content of a knowledge base was the free generation phase for content extraction. In this phase, the girls were asked to write down what ever they knew about the drug heroin, in the context

of the hypothetical task provided, with minimum of instructions or rules for writing. In the second stage of the knowledge acquisition process, they answered a set of questions based on the individual written responses in the free generation stage. This was undertaken in a semi-structured interview, with questions such as: why did X occur? how did X occur? When did X occur? What enabled X to occur? What are the consequences of X occurring? What is the significance of X occurring?

FRAMEWORKS FOR KNOWLEDGE REPRESENTATION

The question of how a person's knowledge structure is represented is critical to resolving how knowledge structures will be measured in this research. A considerable amount has already been written in many disciplines about knowledge structures, with many names given to them: semantic networks, frames, scripts, schemata, plans, productions, themes, memory organisation packages, thematic abstraction units, mental models, cognitive models, and cognitive structures. Yet the field is far from being settled on a general theory of representation.

Information science, linguistics, education, and artificial intelligence have contributed a substantial theoretic input to the knowledge representation field. Information science has developed many general approaches to representing knowledge, particularly classification schemes. Such schemes are used to describe collections in information agencies rather than an individual's structure of knowledge, and tend to present knowledge as isolated descriptors of document aboutness with relations not particularised and remaining implicit. Farradane's contribution in terms of relational indexing (1980) has made an important contribution to knowledge representation. Farradane based his approach on the notion that any analysis of information for storage and effective retrieval must be in terms of the concepts and relations between them. He developed a taxonomy of categories and explicit relations which permitted full representation of any type of complex subject, and enabled subtleties of meaning to be exhibited reproducibly. However, it is not simple to apply, and its application seems to be limited to describing multiconcept subjects, rather than propositions.

A number of notations and mapping schemas have been developed in the area of artificial intelligence and education, with considerable input by Quillian (Rumelhart 1984). Most other formalisms/notations are considered as variants and extensions of Quillian's basic format. The approach selected for this study to represent a person's structure of knowledge was based on Graesser and Clark (1985). In their research the structure of knowledge is operationalised as a Conceptual Graph Structure, a graphical representation consisting of self-contained units called statement nodes, which are interrelated by a network of arcs, thereby enabling both the basic ideas units within a knowledge structure

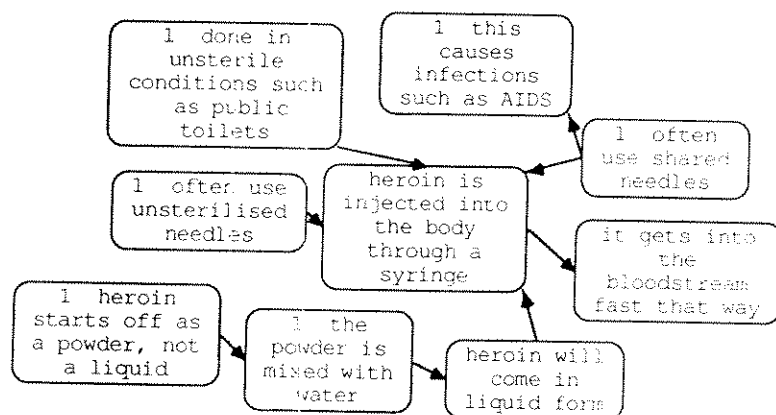
to be isolated, and interrelated, thereby generating an interrelated set of nodes and relations to form a conceptual graph structure.

An important decision at the outset of constructing the conceptual graph structures was the nature of the unit of knowledge: the form of the content of the node. This was a decision about the extent of breaking down the ideas derived from the acquisition approaches into generic units, so that the structure could be constructed. For the purposes of this research, the basic unit of a node was a description that is similar to a proposition, in a coherent form, and generally expressed as a sentence. Propositional representations as the basic unit of a knowledge structure are prominent in the literature, and many of the comprehensive theories of knowledge representation use propositions to represent knowledge. This study thus assumed that the surface structure of knowledge representation is a set of propositions that are ordered and related by various relations integrated as a meaningful whole.

The decision was made to retain the propositions as expressed in the natural language of the girls. Most representational systems recognise that the inconsistencies of language present formidable barriers to understanding meaning, and present alinguistic formalisms as the unit of structure. In this study, meaning *per se* was not the focus, and it was felt that it was not necessary to translate natural expressions into an alinguistic form of propositional logic. All empirically extracted propositions through written and verbal responses were then translated into conceptual graph structures which were assumed to represent the true knowledge structures under consideration. While it may not have captured all the knowledge that the girls had about some topic, it did capture a sufficient amount of knowledge for considering how knowledge structures participate and interact in the information process, and what the impact of this interaction was in terms of cognitive information utilisation.

Figure 1 shows a simple conceptual graph structure:

FIGURE 1
Conceptual graph structure



STEPS IN THE DATA COLLECTION PROCEDURE

The equation and its sequence suggested the following procedure for data collection which was employed throughout this study:

- (a) acquire and map base line knowledge structure (S_0) of respondents
- (b) exposure to Information I_1
- (c) acquire and map base knowledge structure (S_1)
- (d) exposure to Information I_2
- (e) acquire and map base knowledge structure (S_2)
- (f) exposure to information I_3
- (g) acquire and map base knowledge structure (S_3)
- (h) debriefing and discussion

DATA ANALYSIS

The data analysis consisted of three phases. Phase 1 focused on identifying changes to knowledge structures. Phase 2 focused on establishing the perceived effects ΔS . Phase 3 focused on establishing how the perceived effects were manifested in changes to the girls knowledge structures.

The approach taken to identifying and conceptualising the change processes operating on knowledge structures was deduced from the actual structures generated through the graphing procedures. A change in structure was defined as an alteration to the initial structure. Data analysis was undertaken employing the following steps:

1. Identify and isolate propositions. As a result, large macrostructures were generated to represent the declarative knowledge of each girl.
2. Establish working substructures. Given the large size of these structures, with each containing more than 150 nodes and relations, they were broken down into 3 smaller structures based on the organising concepts embedded in the hypothetical task.
3. Systematic comparison of structures. This was to isolate all instances of changes in structure based on the organising concepts, and to derive generic change processes.
4. Document all instances of changes to structure.

To operationalise the perceived effects ΔS , an analytical framework was deduced from an extensive range of indicators (some 150) of the effects of the exposure to information on their knowledge base as evidence of information utilisation. These indicators were derived from written and verbal responses and the debriefing session. Particularly in the question answering sessions, the girls were encouraged to talk in conversational style, and to make comment as they wished, thus supplying a rich collection of effects indicators. The following steps were undertaken to organise and interpret these indicators:

1. examination of transcripts to isolate and extract the indicators of the effects of doing something with the information.
2. formal clustering of indicators to conceptualise similar patterns or characteristics using "constant comparative method" (Glaser 1978)
3. plausibility testing and comparison, so as to test the adequacy and completeness of the constructs embracing all the indicators.
4. generating appropriate metaphors for the constructs that give meaning to the particulars and provide a richer basis for exploring theoretical possibilities.

The analytical procedure for establishing how the perceived effects of the exposure to information were manifested in changes to a person's knowledge structure involved:

1. identifying the content areas linked to each specific indicator of an effect.
2. isolating the conceptual graph structures for these content areas at each of the stages of the exposure, resulting in a sequence of conceptual graph structures. Extensive analyses were then compiled.

PERCEIVED EFFECTS: INFORMATION UTILISATION

This section will briefly document some of the findings of this study. In the initial comparison of pre- and post-exposure knowledge structures, three generic change processes were established: appending, where a new node or structure of nodes and relations is attached to an existing node in the structure; inserting, when a new node is adjoined in between two nodes in the structure; and deleting, when there is the removal of a node in the structure. These change processes represent the cognitive mechanisms for making alterations to knowledge structures.

The study identified five types of cognitive information utilisation. These were:

- Get a complete picture;
- Get a clearer picture;
- Get a changed picture;
- Get a verified picture; and
- Get a position in a picture.

This paper will briefly discuss one major effect, that of "Get a clearer picture". Get a clearer picture happens when new information enables people to see existing ideas and their relationships with greater understanding and clarity. The new information sheds more light on ideas and their relations so that ideas are seen more clearly. Get a clearer picture is often enabled by the sorting out and organising (sequencing) of ideas more meaningfully, or through the resolution of confusions and indistinctions, thereby providing clarification.

The written and verbal responses, and the debriefing session provided a substantial number of indicators of this perceived effect. Some of the indicators included:

- "it explains things"
- "it helps to clarify things I didn't understand before"
- "I could sort out my fuzzy ideas"
- "elaborates an idea. For example, explaining why the criminal network in Australia grew"
- "I realise that I was confused before when I got all the effects mixed up. I could group my ideas better. It made sense"
- "you can explain things, you can give reasons like why the community reject addicts"

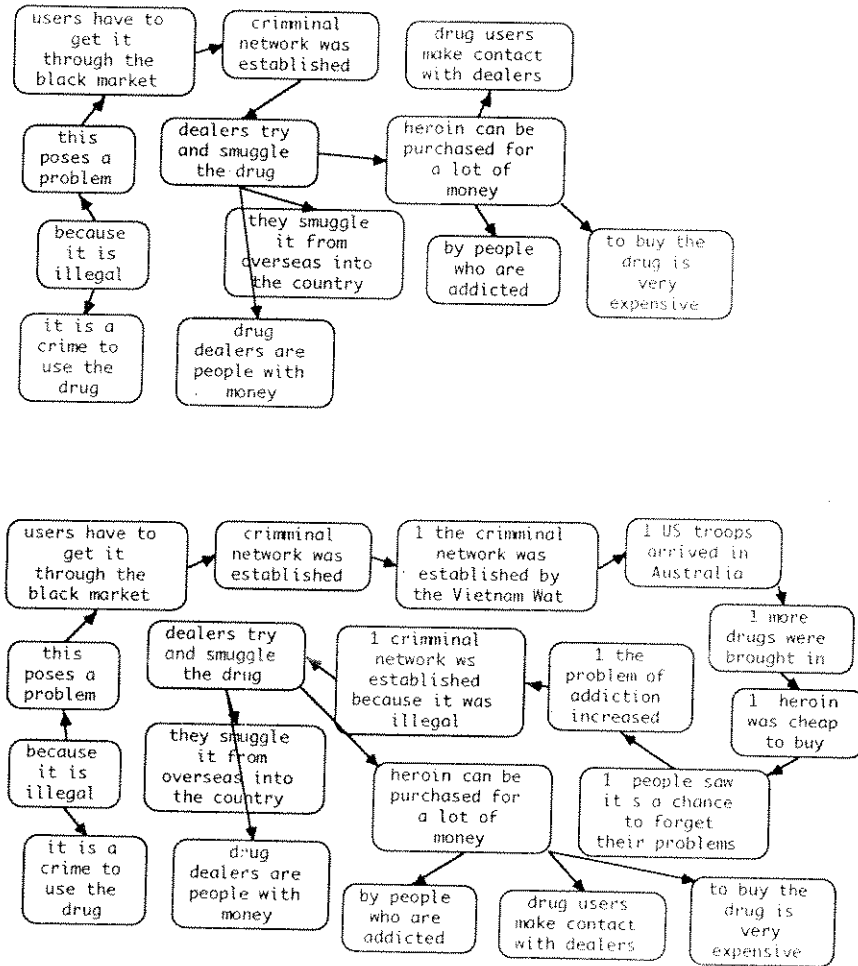
The study showed that all the girls interacted with the information provided in the information exposures in order to get a clearer picture. There was considerable variation in the total number of indicators of getting a clearer

picture provided by each girl, as well as some variation in the number of indicators of the perceived effect from each of the different exposures. Inserting appears to be the predominant change process to enable the girls to get a clearer picture, although there is a substantial number of appendings. In some instances, appending is a necessary prelude to inserting.

A distinctive pattern emerged in the character of the changed knowledge structures as a result of the insertings and appendings. Insertings are used consistently to tell "how" or "why" a relationship exists. Insertings are explanatory. They add greater clarification and understanding through explanation. "How" explanations result in cause-oriented substructures being inserted. These substructures tend to present a linear sequence of intermediate events or states linked by "results in", "enables" or "leads to". "Why" explanations result in goal-oriented substructures being inserted. These sequences show desired states or events, and reasons for them. Appendings appear to serve two purposes in relation to getting a clearer picture. The first purpose is to add precision of detail. Clarity of thought comes with precision and specificity of ideas through building up set membership details or specific property/attribute details. This is the most predominant outcome of appending. Consequently, appended substructures tend to be set membership or property substructures. The second purpose is to provide explanation by telling "how". The appending substructure is a cause-oriented substructure, providing a sequence of intermediate events and states and consequence relations.

The following example in Figure 2 illustrates changes to one girl's knowledge structure in order to get a clearer picture. The example is part of the girl's structure on the nature and origin of heroin, and focuses on the development of the criminal drug smuggling network in Australia. The inserting takes place between the propositions "criminal network was established" and "dealers try and smuggle the drug". The inserted sequence provides an explanation of how, why, and when the criminal network was established in Australia. It provides both background and argument, with some factual evidence for the initial proposition, with "dealers try and smuggle the drug" as the conclusion to the argument.

FIGURE 2
Get a clearer picture



CONCLUSION

To the layperson, this investigation might seem as an exploration of what is already common sense. Intuitively it is accepted that information makes a difference to what people know; that it has some effect. This idea underpins every aspect of information provision. It is the very reason for the multitude of information agencies; it is at the heart of every educational system around the world. At a broad level, this study makes a contribution to understanding the cognitive processes and cognitive effects of exposure to information at a more abstract level, and from the perspective of the individual. In the context of the purposes of this specific paper to explore methodological aspects, the study does present a workable methodology for observing human information processes by measuring information and knowledge in human terms. Modelling of such information processes and the effects of information exposure is seen as critical to making the design and development of information systems more responsive to people. This study is seen to contribute to the development of a research technique from the perspective of information science for the representation of knowledge structures and for examining how these knowledge structures change with exposures to information. The methodology employed in this study was shown to be workable. While it was time consuming, with an intensive time commitment of up to five hours per girl, it was successful in obtaining rich data to enable confident analysis. While its experimental nature and external validity limitations are acknowledged, the further development and testing of such a tool should enable researchers to empirically develop this important field.

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