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HUMAN USE OF WORLD KNOWLEDGE

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## ABSTRACT

Three experiments are presented to examine how humans use world knowledge in complex situations and to see if people can acquire new knowledge in a formal way (i.e., symbolic and linguistic rather than experience-based knowledge) without a strong semantic understanding of the area of discourse.

These experiments limit the interactions between the new area of discourse and the subject's existing body of world knowledge by translating each of the content words of the new area into a nonsense word, and presenting the subject with a mixture of the original English description and the substituted nonsense words.

The experiments utilized areas of discourse of different size and complexity, and with different experimental environments desired to elicit both the conclusions being drawn and the evidence upon which they were based.

These experiments indicate: that subjects are able to acquire new knowledge expressed in unfamiliar terms; that function words play a central role in this process; that some portion seems to be rule-driven and mechanizable; that world knowledge is extensively utilized to validate the local plausibility of interpretations; and that style is an important aspect of this process, enabling subjects to determine the important sections of a passage and how description flows from one sentence to the next.

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**Human Use of World Knowledge**

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The experiments utilized areas of discourse of different size and complexity, and with different experimental environments designed to elicit both the conclusions being drawn and the evidence upon which they were based.

These experiments indicate that subjects are able to acquire new knowledge expressed in unfamiliar terms; that function words play a crucial role in this process; that some portion seems to be rule-driven and mechanizable; that world knowledge is extensively utilized to validate the local plausibility of interpretations; and that style is an important aspect of this process, enabling subjects to determine the important sections of a passage and how description flows from one sentence to the next.

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## INTRODUCTION

Human use of world knowledge is a concern of artificial intelligence both as an estimate of the amount of world knowledge required to solve particular problems and as a suggestion of techniques for utilizing such world knowledge. However, since this topic is so ill-defined, psychological experiments which deal at interesting levels of complexity have been very hard to define. Therefore, most knowledge of this area is based on our own intuitions.

While we are not psychologists, we would like to present three experiments which deal with complex real-world-type situations and which should shed some light on how humans use world knowledge in complex situations. All of these experiments are based on a common technique, Content Suppression, that, in the hands of professionals, should provide a tool for further investigation of the amount of world knowledge used by human subjects and the mechanisms by which they process such world knowledge.

We were drawn into a study of world knowledge by our investigations into automatic programming systems[1]. It is our view that one important capability of such a system is the ability to acquire knowledge about a new problem area and then to bring this knowledge to bear in following instructions while attaining goals specified by the user. It is our contention that only through such world knowledge of the domain can the system intelligently process the user's requests and move from essentially macro-based languages to context-dependent ones. This movement represents, we feel, the next major advance in programming systems.

## WORLD KNOWLEDGE ACQUISITION

In our report[1], we demonstrated the power of world knowledge acquisition through a hypothesized worst case situation in which the user, while not being evasive, only answered the system's requests for information. From an initial statement by the user of his goal, the system had to discover the relationships between the objects of that world, construct a model of that world from such relationships, and then utilize this model in achieving the user's goal.

We include below this hypothetical dialogue along with the hypothetical reasoning that we would like such a system to employ.

Lines preceded by U: are input from the user; lines preceded by S: are responses from the system; and everything within square brackets ([]) is an explanation of how the system is processing the input and the inferences it is making. Thus, analysis will always follow the input or response being analyzed.

- U: Let's build an Airline Reservation System.  
[Create a new model called "Airline Reservation System".]
- S: OK. How?
- U: We want to be able to tell how many seats are free on each flight.  
[There exist a set of entities called "flights". One of the attributes of flight is "seat" and there are an unknown number of seats per flight. One of the values of some attributes of seat is "free". Goal of "Airline Reservation System" is to keep track of free seats on each flight. Because free seats must be kept track of, there exists some operation or operations which changes either the number of seats per flight or the value of the unspecified attribute of seat to something other than "free".]
- S: Besides being free what else can seats be?  
[Since system must keep track of free seats, it attempts to find out what other "types" of seats there are.]
- U: Reserved.  
[Seats can be either "reserved" or "free".]
- S: How many seats are on a flight?  
[Now that "type" of seats are known, how many seats are there.]
- U: It depends on the type of airplane.  
[There exists a set of entities called airplanes which have a type and this type determines the number of seats on a flight. Hence there is an association between an airplane and a flight.]
- S: How are airplanes and flights related?  
[Ask user to state implied relationship.]
- U: A flight is the movement of an airplane from a departure point to a destination.  
[A flight consists of an airplane, a departure point, and a destination. The action of a flight is to move its airplane from its departure point to its destination. A flight does not have seats as an attribute. An airplane has seats as an attribute.]
- S: How does the type of airplane determine the number of seats?  
[Find out relationship between type of airplane and number of seats.]
- U: Let's worry about that later.  
[Mark this relationship for processing later.]
- S: OK, how do free seats become reserved?  
[Find out what operations exist to change "type" of seat.]
- U: A reservation for a seat on a flight changes a free seat to reserved, and a cancellation changes a reserved seat to free.  
[A reservation is an action which changes the "type" of a seat from free to reserved. A cancellation is an action which changes the "type" of a seat from reserved to free.]

Assume that cancellation is also for a seat on a flight and that therefore reservation and cancellation are inverse operations. Assume that the changed seat is part of the airplane associated with the specified flight.)

S: Is the altered seat part of the airplane associated with the flight?  
 [Test this assumption.]

U: Yes, it is on the flight.  
 [Seats are 'on' not 'part of' airplanes.]

S: How do reservations occur?  
 [Are reservations an externally- or internally-controlled action and what are its prerequisites?]

U: Both reservations and cancellations are specified from a terminal.  
 [One or more terminals will be connected to the resulting system. Reservations and cancellations are externally-controlled actions initiated by some input from a terminal.]

S: What input initiates a reservation?  
 [What is form of reservation command?]

U: "Reserve<flight> <date>"; similarly for cancel.  
 [(Note: angle brackets are used to indicate something which evolves to a specification of an object of the type named within the angle brackets.) A reserve or cancel command specifies the flight on which a seat is to be reserved or canceled and a date.]

S: What is the function of the specified date?  
 [What is the relationship between reservation, flight, and date?]

U: Flights occur periodically as specified in the airline schedule and date is used to specify a particular one.  
 [There exists an airline schedule which specifies when flights occur either with respect to some specified date or to some periodicity. To specify a particular flight, the flight specification must also be accompanied by a date.]

U: OK, let's test the system.  
 [Model is not complete. We can't simulate it yet.]

S: Wait a minute. First, how is the type of airplane on a flight determined?  
 [We need to know type of airplane for each flight, the airline schedule, and initial 'type' of seats on a flight.]

U: It is specified in the Airline Schedule which is in file Airline.Schedule.  
 [Airline Schedule specifies type of airplane on a flight. Airline Schedule is in file Airline.Schedule.]

S: Are seats initially free or reserved?  
 U: Free.  
 [Seats on a flight are initially free.]

S: OK, let's simulate the system.

In condensed form, the model consists of the following information:

1. Goal is to keep track of free seats on each flight.
2. A flight is the movement of an airplane from a source point to a destination.
3. The type of the airplane determines the number of seats on the flight.
4. Seats are either free or reserved, and initially they are all free.
5. Reservation and cancellation are actions, specified from a terminal, which change the status of one seat from free to reserved or reserved to free, respectively.
6. The flight and type of airplane used on the flights are specified in an Airline Schedule.

Several people who were shown this dialogue were unconvinced about its feasibility. They felt it only worked because the system always asked the right questions and because it made the right inferences from the replies given. Both these activities, they felt, depended upon a very large, and unstated, body of world knowledge. Thus, implementation of such a system would be infeasible.

#### EXPERIMENT 1: SIMPLE CONTENT SUPPRESSION

In an effort to dispel this criticism, we were forced to devise an experiment that would support our contention that only very limited use of world knowledge was necessary to support such a dialogue. Such an experiment requires the ability to cut off, or limit, the interactions between the new area being explained to the system and the body of world knowledge that might be brought to bear on understanding such a new environment. We felt this could be most effectively done, through Content Suppression, by translating each of the content words of the new domain into a nonsense word and presenting the information as a mixture of normal English with the translated nonsense words appearing wherever one of the content words of the domain would have been used.

We ran this experiment with four subjects, each of whom was a programmer. We asked them to solve the problem with the same ground rules as the previous hypothetical dialogue: namely, they had to ask questions to gain information from a user who understood the domain. Part of one protocol from this experiment is given in Appendix I; the full protocol and others are available upon request from the author.

Each subject was able to solve the problem in about one half hour, although none was able to relate the solved problem to any real-world situation. The scenario generally followed the hypothetical discourse, above, which was generated prior to the experiment. All of the subjects experienced difficulty with the use of the word 'flight' to represent a set of flights, which had to be disambiguated with a date to specify a particular one. Some of the subjects also experienced difficulty in realizing that: seats were indistinguishable; the domain had no way of getting to a particular one; and if they wanted to do so, they had to construct an internal data structure themselves.

We feel that this limited experiment demonstrates that people can acquire new knowledge in a formal way (i.e., symbolic and linguistic rather than experience-based knowledge) without a strong semantic understanding of the domain.

However, this experiment dealt only with a very well-thought-out problem and contained just fourteen content words that had to be translated. We also wanted to investigate whether the same techniques were applicable to real descriptions of how to do something or the way something worked. We therefore ran two other experiments, both of which dealt with descriptions that were randomly selected from books, with the same basic philosophy of substituting nonsense words for the content words of the domain.

EXPERIMENT 2: COMPLEX CONTENT SUPPRESSION

The second experiment involved a single subject (the author) and was noninteractive, consisting only of the translated description taken from a book. This problem was much more complex than the first one, involving eighty-six translated content words. It and the subject's solution are presented below as a set of triple lines. In each set, the top line represents the original untranslated text of the problem, the middle line represents the text as given to the subject, and the bottom line represents the subject's solution to the problem. These sets are followed by the subject's written protocol which he used to solve the problem.

(1) Problem 1:

(2) When the chain attached to the lever of the flushing cistern is  
 pottle sprocked            framper            lorching    lank  
 --- connected            ---            ---            ---

(3) pulled, the hollow iron bell-shaped unit rises and  
 flumed            zif    lug    rampled            lorks  
 pulled            ---    ---    ---            ---

(4) opens the passage to the flush pipe. As soon as water flows down  
 rundles    trunk            lorched mit            krumper lud glimps  
 opens            ---            --- pipe            water flows down

(5) this pipe, a vacuum is formed in the cavity of the bell and causes  
 mit            luff    stifled            orindle            dorf  
 pipe            ---    formed            ---            ---

(6) more water to flow from the cistern through the bell and down the  
 krumper    lud            lank            dorf            glimps  
 water    flow            tank            ---            down

- (7) pipe. The cavity inside the bell thus acts as a siphon.  
 mit grindle grobble dor f yams zog  
 pipe --- within --- acts ---
- (8) When a vacuum is formed at C (by initially applied suction),  
 luff stifled brobed leepion  
 --- formed --- ---
- (9) water is drawn through the siphon tube. Once the flow has been  
 krump flitz zog plutz lud  
 water --- --- --- flow
- (10) started, it will continue. For the siphon to function, its outlet  
 foped nud zog orklon frob  
 started continue --- function ---
- (11) must always be below the level of the water in the tank. When the  
 gronk tove krumper mung  
 above or below level water container
- (12) chain of the water closet has been briefly pulled and released, the  
 pottle krumper frotz flumed regritchd  
 --- water --- pulled released
- (13) bell falls back into position over the inlet of the flush pipe,  
 dor f zorchs bart bletchlon blutz lorch mit  
 --- moves --- position mouth --- pipe
- (14) but the flow of water down the pipe continues - thanks to the siphon  
 lud krumper gllmp mit nuds zog  
 flow water down pipe continues ---
- (15) effect - until the cistern has been drained. As the water level  
 lerp lank zonked krumper tove  
 --- tank emptied water level
- (16) in the cistern goes down, the float descends and opens the water  
 lank gllmp blib yads rundles krumper  
 tank down float falls opens water
- (17) supply valve, so that the cistern fills up again. When the float  
 droortly cavem lank tuboats blib  
 --- valve tank fills float
- (18) has risen to a certain level, the inflowing water is cut off by the  
 rankle tove wipsening krumper rosehart  
 risen level rising water shut
- (19) valve. The capacity of the flushing cistern is usually 2 gallons.  
 cavem beglpt lorching lank panzers  
 valve capacity --- tank gallons
- (20) Fig. 3 (not shown) illustrates another type of cistern. When the rod is  
 omps arg lank leffer  
 shows type tank ---
- (21) briefly pulled up and then released, the water here, too, continues  
 flumed regritchd krumper nuds  
 pulled released water continues
- (22) to flow until the cistern is drained. The rod is provided with a  
 lud lank zonked leffer roppled  
 flow tank emptied --- ---

- (23) freely movable float which is prevented from floating to the surface  
 grotly metz blib whatsised blibing funk  
 --- --- float prevented floating surface
- (24) of the water by two stops on the pull rod. When the rod is raised  
 krumper zaps flum leffer leffer plated  
 water pins pull --- --- ---
- (25) and the inlet of the flush pipe is opened, the closing pressure which  
 blutz lorch mit runderl fluding cropper  
 mouth --- pipe opened --- ---
- (26) is developed by the water column in the full tank is reduced. The  
 nuffered krumper frag mung reganded  
 --- water left container ---
- (27) buoyancy of the float predominates and keeps the pipe inlet open.  
 drode blib goths lotsos mt blutz rundle  
 --- float --- keeps pipe mouth open
- (28) Then the rod descends and the rubber valve disc is thrust ag inst  
 leffer yads frerker cavem streuple ellis  
 --- falls --- valve --- held
- (29) its seat by the inflowing water.  
 gnagy wipening krumper  
 limit rising water
- (30) In some systems the flush pipe is connected to the water supply  
 rops lorch mit floppered krumper drost  
 models --- pipe --- water ---
- (31) through a lever-operated or a pushbutton operated  
 blitzened olpe vuffed  
 --- --- ---
- (32) valve. In the former the flushing operation is  
 cavem stiffer lorching vuffleion  
 valve former --- ---
- (33) initiated and terminated by hydraulic pressure equalization which  
 glbed roged marg cropper cropion  
 --- --- --- --- ---
- (34) is effected by the composite valve system. In the pushbutton  
 lerped zilla cavem rop olpe  
 --- --- valve model ---
- (35) type, actuation of the pushbuttc. initiates the flow, which is  
 arg bisbey olpe lud  
 type --- --- flow
- (36) subsequently likewise cut off by pressure equalization and spring  
 osehart cropper droplon donnering  
 shut --- --- ---
- (37) action.  
 yamion  
 action

The following protocol was used by the subject of the above experiment to solve the problem. The numbers following each component of that protocol represent the line of the text (see above) from which the information was found that helped generate that component. The table of Attributes and Relations was used to structure this protocol.

#### ATTRIBUTES AND RELATIONS

x is an operation on y	(IO x y)
x is a relation between y and z	(x y z)
x is a part of y	(IPO x y)
x is an attribute value of y	(AVO x y)
x is nondiscrete	(nondiscrete x)
x is associated with y	(IA x y)
x is an attribute of y	(Atr x y)
x modifies y	(Mod x y)

(IO flum <pottle>)2 (sprock pottle framp)2  
 (of framp lank)2 (AVO lorch land)2  
 (AVO lorch wuffle)34 (AVO lorch mit)32  
 (AVO zif unit) (AVO lug unit)3  
 (AVO rample unit)3 (IO ork unit)3  
 (rundle unit trunk mit)4 (AVO glimp lank)16  
 (nondiscrete krumper)6 (eq lud flow)6  
 (eq yam act)7 (encloses dorf krumper)6  
 (contained in krumper lank)6 (eq tuboats (one of rises fills))17  
 (rundle bilb krumper ?)16 (rundle ? blutz ?)26  
 (eq rosehart shut)18 (of tove krumper)11  
 (IO lud krumper)4 (AVO glimp krumper)4  
 (set mit)5 (IO stiffle luff)5  
 (of arindie dorf)5 (IO fop lud)9  
 (IO nud lud)10 (IA glimp mit)6  
 (eq grabble within)7 (yam grindie zog)7  
 (IO flutz krumper)9 (of plutz zog)9  
 (through plutz krumper)9 (when (fop lud)(nud lud))10  
 (IO ork zog)10 (of frob zog)10  
 (type gronk position)11 (container mung krumper)11  
 (of frotz krumper)12 (of pottle frotz)12  
 (IO pottle gritch)12 (of blutz mit)13  
 (eq bletch position)13 (eq zorch move)13  
 (eq ork function)10 (eq tove (one of level temperature))18  
 (eq gronk (one of above below)11 (eq omp show)21  
 (eq arg type)21 (eq nud continue)10,14  
 (eq blutz mouth)13 (eq zork fill)15  
 (eq glimp down)16 (eq rosehart (one of closed shut))18  
 (eq rankle risen)18 (eq wipsen(one of rising entering))18  
 (eq bilb float)18 (eq cavem valve)18  
 (eq yad(one of falls descends))16 (eq rundle opens)16  
 (like leffer pottle)22,12 (eq whatsis(one of stop prevent))24  
 (of yaps leffer)25 (eq funk(one of top surface))24  
 (eq ellis held)9 (eq frag left)27  
 (eq rop model)32 (eq stiffle form)34  
 (type beqipt measure)19 (unit panzer beqipt)19  
 (eq lotso keep)29 (eq spruck (one of attach connect))2  
 (type flum move)3 (opposite flum gritch)12  
 (eq fop start)10 (type zog valve)5-7

This experiment was only partially successful. Rather than solving this problem by creating a formal model of the interactions between the components of the domain, the subject performed a type of cryptanalysis and attempted to decode the problem into terms that he understood. He thus brought to bear very large amounts of world knowledge in decoding particular passages of this text. As an example, consider the passage from lines 5 through 6 which was the key to decoding this problem: "and causes more krumper to lud from the lank through the dorf...". The subject noticed in this passage that krumper was not pluralized; hence, he drew the conclusion that krumper was a mass noun, that is, something considered as a group of things without consideration for the individual elements. Examples of such mass nouns are sugar or flour. The next part of the passage says to lud from someplace through something. Thus, lud is some type of a movement verb. From our knowledge of English syntax, English vocabulary, and how mass nouns move, we know that lud is probably either pour or flow. The subject was thus utilizing all the world knowledge at hand to find out some properties about the objects being discussed and then fitting those into the set of known possibilities for such properties.

Analysis of the protocol by the subject himself has, however, begun to yield a set of rules which we hope will begin to define the way such formal models are built up and knowledge is extracted from such passages.

### EXPERIMENT 3: GROUP CONTENT SUPPRESSION

In an attempt to overcome the decoding process which occurred in the second experiment, and to make more accessible the reasoning processes which were being used by the subject, we devised a third experiment. This again was a noninteractive experiment in which the subject was presented with a description of how to do something or of the way something worked, taken from a book, after the content words had been translated. We made two significant changes in this experiment. First, the sentences were presented to the subject one at a time. A protocol was taken on each sentence so that the subject was forced to focus on that particular sentence and extract all the information he could from it. Second, instead of a single subject, we had a group of subjects sitting around

a table and conversing with one another to make explicit both the conclusions they were reaching and the evidence being extracted from the problem. The subjects were explicitly told not to attempt to decode the problem, but rather to build a model that represented the interactions between the objects being described.

The original and translated versions of the problem are given below and a protocol of the first few sentences appear in Appendix II.

- (0) Sooner or later everyone runs across the problem of fastening  
potting
- (1) something to a wall inside the house. Though the first impulse may  
sprock lorch
- (2) be simply to drive a nail into the wall, this seldom proves a  
lank flum sprock
- (3) satisfactory solution. Since interior walls are usually hollow, the  
zif sprocks lug
- (4) nail merely breaks through into empty space - leaving you with  
flum ramples lork rundle
- (5) little more than some cracked plaster and a useless hole for your  
tranked mlter krump
- (6) trouble.
- (7) To provide a more satisfactory solution to this problem, there
- (8) are many special wall fasteners that can be used. Regardless of  
sprock pottiers
- (9) the size or weight of the fixture being hung, chances are there  
luff stifle grindle foped
- (10) is a fastener available which will do the job. The load  
pottier grobble
- (11) that can be supported is limited only by the strength  
yamed zoged brob
- (12) of the wall material itself.  
sprock leep
- (13) For light-duty jobs, such as hanging small pictures and  
flitz plutz fopine nuds
- (14) decorative plates, there are hangers available which can be  
ork frobs fopers
- (15) cemented in place against the wall. Some of these come with  
cronked sprock
- (16) a separate liquid adhesive, while others are adhesive-  
mung frotz frotz



demonstrated how incredibly quickly people are able to lock on to and utilize stage-setting information to establish context.

### CONCLUSION

In conclusion, then, these experiments seem to indicate that

1. subjects are able to acquire knowledge about a domain described in unfamiliar terms;

2. the use of function words in such descriptions is very important to the understanding process;

3. some portion of such knowledge acquisition seems to be mechanizable through a set of rules;

4. subjects utilize world knowledge extensively to test local plausibility of interpretations;

5. style is an important aspect of a description, for it enables subjects to determine the important sections and how a description flows from one sentence to the next.

### REFERENCES

- 1 Baizer, Robert M., Automatic Programming, USC/Information Sciences Institute, RR-73-1, (draft).

## APPENDIX I: EXPERIMENT I EXAMPLE PROTOCOL

Below is the first part of the protocol of one subject in our experiment to test the feasibility of domain-independent problem acquisition and solution. The protocol is followed by the dictionary of domain-dependent words and the corresponding nonsense words.

The goal of this experiment is for you to design an implementation of a model that I am going to describe to you. I am going to describe a goal and it is going to be a simple statement of what it is you are supposed to accomplish. Now, after that, it is expected that you are going to be the active element in the discourse, so that you will ask me for any information that you need to carry out the goal and I will give you that information. I am not going to spontaneously give you information. You have to ask for whatever you need. OK? What we have done is purposely express this model in terms of some nonsense words so that you cannot relate it to anything you know about. We are recording this so it would help if you do your thinking out loud. OK - the goal is to build a frobnication system and what we're supposed to do is to keep track of the number of gronked frobs on each tove.

- Q. On each tove?  
A. Tove - t o v e.  
Q. OK - that's it. How do frobs get gronked?  
A. There's an operation called frynation which changes the status of a frob which is not gronked to gronked.  
Q. How are frobs created?  
A. Frobs are neither created or destroyed - they are part of a frotz.  
Q. OK - are many frotz part of a tove?  
A. No. Associated with each tove there is a type of frotz.  
Q. So each tove represents a frotz and a frotz is made up of many frobs. Why are frobs frynated? Does a frynation of a frob make it a gronked frob?  
A. Right. That's part of the operation of this system.  
Q. Is the number of toves static?  
A. Yes, it's specified in the bletch.  
Q. A bletch is...  
A. A bletch is a table that is part of the input to the system. You can look up in the bletch how many toves there are.  
Q. OK - so the bletch is the initialization, basically.  
A. Yes.  
Q. OK - I've bletched and now have a given number of toves which are all made up of frotz and those frotz contain frobs.  
A. Each tove may have a different frotz.  
Q. Right, certainly - and how are the frotz specified?  
A. That's also part of the bletch.  
Q. Are frotz all specified initially during the bletch to be ungronked frobs?  
A. Each frob on a frotz is initially gronked.  
Q. Is initially gronked...how do you ungronk a frob?  
A. There's an operation called munnation and a munnation of a frob changes the status from gronked to munned.  
Q. Is a munned frob the same as an ungronked frob?  
A. Yes.  
Q. Under what circumstances will munnation occur in the frob?  
A. Both munnation and frynation are specified from one of a set of terminals.

- Q. OK - do you want a constantly running number of the number of drunken frobs?
- A. At any point I wish to be able to query and find out how many drunken frobs there are on a tove.
- Q. On a particular tove?
- A. Yes.
- Q. How does one specify a tove?
- A. A tove is specified by both a tove name and a bart.
- Q. A bart is...
- A. A bart is an atomic thing.
- Q. A bart is a frob.
- A. A bart is something that is used. A tove by itself specifies a set of toves, actually - a tove name by itself specifies a set of toves - to pick out a particular one you have to specify also a bart so a combination of a tove and a bart gives you a particular tove.
- Q. OK. Is the tove in a bart in a bart a reasonable access path?
- A. A tove and a bart and a bart?
- Q. Namely, how many levels of tove are there - by what you just said there appear to be two levels of toves. There's a tove - you access by saying a tove in a bart.
- A. I'm a computer user - I don't understand computer terms. I don't know what access means.
- Q. OK - to get to a frob what maximum amount of information are you willing to give me to get to this frob?
- A. I don't understand the word "information" either.
- Q. A tove and a bart is a tove.
- A. A tove name with a bart specifies a particular tove.
- Q. ...and do you want to specify a frob which is part of that tove?
- A. The blotch specifies the type of frobz associated with the tove.
- Q. Frozb...
- A. And the blotch also contains the number of frobs for each type of frozb.
- Q. Can we go over what's a frozb again? A frozb is a collection of frobs?
- A. Yes - a frozb is associated with the tove and each tove has associated with it a type of frozb, and that's the same for all toves without specifying a bart. In other words, if you just give a tove name that specifies a set of toves which are identified by their barts but all of those toves have the same frozb. To completely specify a tove you need both the tove name and a bart, but all the things with the same tove name independent of the bart have the same frozb.
- Q. All the things with the same tove name have the same type of frozb.
- A. Yes.
- Q. Independent of what?
- A. Bart.
- Q. A tove name followed by a bart leads to a tove.
- A. Right.
- Q. And that tove - let's talk about that specific tove - tove name followed by the bart - that tove is made up of a frozb.
- A. Right.
- Q. And that frozb is made up by several different frobs.
- A. A number of frobs.
- Q. Number - specified during the blotch?
- A. Right.
- Q. Now is a tove name followed by a bart followed by something specification of a particular frob?
- A. No - all we know about frobs is the number of them on

- each frotz.
- Q. OK - if I wanted to frynate a frob the way I name that frob is by a tove name followed by a bart.
- A. Right.
- Q. ...followed by what?
- A. Followed by nothing. A frynation just says do it to one of the frobs on that particular tove-bart combination.
- Q. And I assume mungnation is the same phenomena in the opposite direction.
- A. Right.
- Q. Why are you making a distinction about different types of frotz? For what?
- A. Each different type of frotz has a different number of frobs.
- Q. So one type of frotz has always a specified number of frobs.
- A. Right. And that number is given in the bletch.
- Q. Is the bart also a tove name?
- A. No - the bart is used to disambiguate a tove name.
- Q. In what sense?
- A. A tove name by itself gives a set of things which have that tove name. Each of those has a different bart and so by specifying both the tove name and bart you get a particular one.
- Q. So the tove name is really a name of a type of the frotz.
- A. No. Things with different tove names may have the same frotz - they may have different ones - but everything with the same tove name has the same frotz.
- Q. Everything with the same tove name has the same type of frotz.
- A. Right.
- Q. ...so any tove name followed by a specific tove name followed by any bart will lead me to a frotz with the same number of frobs on it.
- A. Yes.

#### DOMAIN-DEPENDENT DICTIONARY

Fronication System	Airline Reservation System
Frobs	Seats
Cronked	Free
Tove	Flight
Munged	Reserved
Frotz	Airplane
Gritch	Departure point
Zorch	Destination point
Mungnation	Reservation
Frynation	Cancellation
Mung	Reserve
Fry	Cancel
Bart	Date
Bletch	Airline schedule

## APPENDIX II: EXPERIMENT 3 PROTOCOL

Sooner or later everyone runs across the problem of pottling something to a sprock inside the lorch.

- : There is a great deal of context in that...
- : Well, let's see. Suppose we know that lorches are different from sprocks because...
- : ...because sprock is inside the lorch.
- : Well, it could stick out..it could be an appendage to something that is tightly locked or pottled and like sticks out. I'm getting visions of things. It sure is wild.
- : Well, I don't know if this is a valid thing to say but since everybody runs across the problem it can't be too highly mechanical a problem.
- : A lorch could be some kind of a container or it also could be some kind of mechanism of which a sprock is a part.

Even if the thing was a mechanism isn't that a kind of container?

- : Well, I was thinking of something inside like an automobile engine. I don't consider an automobile engine a container but you could do something to a something inside the engine.

The engine is a container.  
That's not its primary use...

- : All right...

But it seems to me that the word 'inside' only means container.

- : OK. The word 'the' really strikes me as funny...

How's that?

- : As inside 'the' lorch. The first sentence says this is really the context. This is a sentence out of the middle of a logical paragraph -- it wasn't the first thing that was ever said in the book.
- : Although a smart robot mechanism might take this sentence to mean 'the lorch' which means that every person or every family or every organization of some type has a lorch.
- : Within the law. Inside the law.
- : Well, customarily, like you might say...do you talk about doing something to the car and the context there is that customarily every family has 'the' car or several 'the' cars.
- : Or every once in a while you get stuck with the job of vacuuming around the house.
- : You have to strain to think that 'the' is really part of the introductory sentence.
- : Well, pottling seems to be fitting. If you pottle something to a something. There is a contact. It means making contact with a community.
- : But pottling is also probably not a specific. A very task-specific kind of word (verb).
- : ...because apparently there are many things that can be pottled to sprocks.
- : That's right...the problem is when it's inside the lorch.
- : I'd like to know whether a sprock is a part of a lorch or a sprock is a thing that's inside a lorch.
- : ...whether a lorch is a container in which you do this pottling or whether you are actually pottling the sprock.

: ...every lorch is sprocked or has some sprocks.

I think it's best at this point to just recognize that it's something we want more information about and see if the information comes in the following text.

- : ...it says "a sprock"...there are probably several sprocks...
- : ...there are probably inside and outside sprocks...
- : ...that could be...it's a possibility...
- : Well, what's the problem. Is the problem pottling or is the problem because it's inside?
- : I think the inside is ambiguous.
- : In what way?
- : In the fact that we brought out -- that the sprock could be attached to the inside of the lorch and that you have to pottle something onto it, or that the lorch is a container in which you do the pottling...
- : Are there any other alternatives?
- : Let me see...
- : A sprock seems to be an object. It could be a human, but I doubt it.
- : We ought to number these sentences...
- : Let's call this one 1.
- : Yeah, I think we should number the sentences so we can refer back. Let me summarize my knowledge to this point: lorches are either contained or have as constituents some sprocks.
- : That's much better than mine -- sprocks -- less than or equal to lorch; lorch -- container/mechanism; pottle -- contact or communication. I have inside and outside sprocks.
- : Also, probably many things can be pottled.
- : If we've already guessed it we have to keep quiet.
- : If you already guessed it?
- : I'm ready for another sentence.

Though the first impulse may be simply to lank a flum into the sprock, this seldom proves a satisfactory solution.

- : I think we have somewhat of a definition of pottling. To pottle -- to lank a flum -- seems to be one of the ways to pottle.
- : No -- to lank a flum into is a way to pottle to.
- : That's right. I guess if you lank the flum into the sprock that would be the same as pottling. That would define pottling something to the sprock.
- : It's an instance. That's right. But evidently there are more.
- : Is the flum something in the previous sentence.
- : I think so...
- : It may not be. I mean it may...
- : Maybe this is something you have to do before you can pottle something on it you have to clear the sprock.
- : Right. So a flum is just an attachment that will enable something to be pottled.
- : ...pottles onto it.
- : On the other hand a flum might be for you to pottle it.
- : Or it might be that. And the lank would be actually an instance of pottling.
- : On the other hand, if the flum were a thing you were pottling to the sprock then they would have probably said that you pottle a flum to a sprock, not pottle something.
- : Maybe pottling a flum is incorrect usage of flum. Maybe you would never say pottling from the end of the Penn Central.
- : Lanking sounds not too good -- lanking sounds like it just talks of it. I would say lanking is like tossing. Lanking

- is not a thorough job. Or else a flum sounded very good when you do it.
- : Well, maybe lanking a flum is a good way of doing some things but it's not as good as pottling to a sprock. It might even be a good way of pottling to something else.
  - : It could be that it lengthened a flum that isn't very good.
  - : Or maybe lengthening is fine if it's the flum...
  - : There are lots of instances where one method of attachment is good for one thing but isn't good enough for another thing. Does it involve some kind of linking of something.
  - : Either linking or...
  - : ...including...
  - : Well whatever it is lanking a flum... or a flum doesn't do it. I'm not sure whether it's the flum or the lanking -- the flum or the lank.
  - : You can do something else to a flum.
  - : Or just lanking it once you are inside the sprock or into the sprock...somewhere in that combination is... I would bet that it's because it's inside that there's a problem.
  - : Are you doing all this inside the lorch.
  - : ...maybe you can lank a flum...
  - : Well, there's still, I guess, one...almost four ambiguous possibilities whether you can...

I haven't counted, but it sounds to me like you're talking about many more than that.

- : Well, the main situation is that either to lank could be -- well, not counting all the possibilities -- the simple possibility that lanking is what causes the problem or that flum is the problem -- or that you can't lank a flum...
- : Or that the problem is that you are undecided...
- : ...I'm sure you can lank a flum because you would try that but if you can't do it into the sprock or that the whole thing is done in the context of inside the lorch.
- : This seems to imply that you can actually lank the flum into the sprock under these conditions.
- : Yes, that's right...
- : ...but if you do it won't work -- it won't pottle very well.
- : It might accomplish the problem but later it could fall apart...
- : ...something will happen at night...
- : Well, I'm ready for the next sentence...