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INTENTION, MEMORY, AND COMPUTER UNDERSTANDING

BY

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ABSTRACT

Procedures are described for discovering the intention of a speaker by relating the Conceptual Dependency representation of the speaker's utterance to the computer's world model such that simple implications can be made. These procedures function at levels higher than that of the sentence by allowing for predictions based on context and the structure of the memory. Computer understanding of natural language is shown to consist of the following parts: assigning a conceptual representation to an input; relating that representation to the memory such as to extract the intention of the speaker; and selecting the correct response type triggered by such an utterance according to the situation.

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I. Levels of Expectation

The primary emphasis that has been given to the study of the sentenee by linguists and computational linguists alike has brought about some peculiar ways of studying natural language. Clearly people do not understand nor generate sentences in isolation. It has been in fashion among linguists who like to attack other linguist's ideas of grammaticality, to shoot holes in a statement of ungrammaticality by finding a situation in which the supposed ungrammatical sentence makes sense. Lakoff [7] has recently noted the need for using presupposition - sentence pairs before one can discuss grammaticality. It has long been our assertion that, while it seems reasonable that linguists who are studying grammaticality rhould take context into account, the study of grammaticality itself seems a bit misguided (see Schank [12]). What would seem to be more reasonable is to realize that people talk in order to communicate something and it is the discovery of what this something is that is the proper domain of study for researchers interested in natural language. This point-of-view necessitates looking at language from an analytic point of view rather than the generative view of transformational grammar. It is this kind of viewpoint that eliminates notions that semantics consists of selectional restrictions which tell you what cannot be said. Clearly if something was said it must be dealt with regardless of its grammaticality.

But even if we recognize that the analytic study of language might yield some fruitful results, the possibility of falling into some of the traps left lying around by generative grammarians is extant. Of these traps, by far the most troublesome is the notion that the sentence is the core of the problem. Theories that are sentence-based simply miss the essence of the problem, namely that something is attempting to be communicated by the speaker and it can be ascertained by taking the entire situation in which it was uttered into account. Here we mean not only the linguistic context, but the physical, mental, emotional, and social contexts as well. (We will delve more deeply into this later.) Now this is not to say that we must disregard all work that has been done on sentence analysis up until now. On the contrary, many of the techniques used there have their analogues on other levels of analysis. But just as it was important to realize that it simply made no sense to analyze a sentence so as to detect all four or fifty possible syntactic arrangements for it (as the Kuno-Oettinger parser did for example [6]), likewise one does not wish to find more than one conceptual analysis of a sentence if the prevailing context clearly eliminates all but one of the choices.

What we should like to find is a theory which will account for the human ability to understand another human. Since understanding is impossible to measure on any scale other than that of the consequent reaction of the hearer, part of our theory of understanding must include the decision rules and heuristics that the hearer employs to operate on what he has understood in such a way as to transform the communicated information into the beginnings of a response.

We maintain that the Conceptual Dependency representations developed in Schank [10] and [11] are adequate for the representation of what has been said in an utterance. The techniques formulated for the analysis of a natural language sentence in Conceptual Dependency terms should shed light on the types of analysis to be done at levels higher than that of the sentence, given the basic conceptual structure.

For example, one element which we rely heavily on during a conceptual dependency analysis is that of expectaticm. We have spoken (Schank et al [11]) of the use of expectation criteria on two levels, the sentential and the conceptual. On the sentential, we can predict at any point in a parse what type of syntactic element is most likely to follow. Thus, if we have just seen a noun the likelihood that a verb will appear next is good assuming one has not already appeared. By the same token, an auxiliary or adverb is likely to appear but with a different probability. Some elements are much less likely to appear (an adjective for example) and some likely to appear depending on some of the semantic information contained within the noun. At any rate, guesses can be made based on what one might expect will occur. Guesses of this kind perform three major functions. First they point the way in searching a data base for an item. (This is not overly important on this level since the data base is linear). Second, they allow for disambiguation. On the sentential level, this means being able to choose between alternative senses of a word that are based on syntactic category. Third, they enable you to know that if a certain element has appeared and a different but related element was found, the related element is coming. This is important in establishing dependency information.

On the conceptual level, expectations work in roughly the same way. That is, we can guess the conceptual category that is needed to complete the conceptualization and the semantic content of that concept. Thus, we know what we are looking for when we search through a sentence attempting to find the conceptual structure underlying it. We can use this information for searching the data base, disambiguating, and creating dependencies.

But expectation information actually operates on more than just those two levels. Consider the following situation and conversation:

John meets his friend Fred on the street. Fred is holding a knife. John is angry because his wife Mary has yelled at him.

Fred: Hi.

John: What are you doing with that knife?

Fred: Thought I'd teach the kids to play mumblypeg.

John: I could use a knife right now. (agitated tone)

Fred: What's the matter?

John: Damn Mary, always on my back. She'll be sorry.

Fred: I don't think a knife will help you.

John: You're just on her side. I think I ought to . . . .*....

Now what can Fred expect that he will hear next? There are six distinct levels on which we can answer this question. Sententially, Fred expects a verb. Conceptually, there is a conceptual dependency diagram to represent what John has just said which has an arrow with a conceptualization necessary as its dependent, Thus conceptually a conceptualization is expected. Now, the next level which we can talk about expectations is the contextual. This is not a level in the sense that the others are but it is just as significant. That is, according to the context, there are only a certain set of concepts which will fit into the needed conceptualization such that the conceptualization makes sense in context. In other words, we most certainly would be surprised if the next piece of information would be 'I think I ought to have fish for dinner'. It is knowing what we do and do not expect at any point in any analysis which allows us to be surprised, shocked or whatever other emotional attribute by a piece of information. You are not able to be surprised if you don't anticipate and we do anticipate.

What we anticipate here are the following four types of statements in order of contextual likelihood:

1) hurt someone

2) end relationship with somebody

3) go to someplace

4) emote

These are classes of actions. We don't know which sentential form 'hurt' 'go' or 'emote' will take but we can estimate the likelihood of the class on the basis of the conceptual category and the prevailing semantic categories that have been used in context. All of these above actions are predicted on the strength of their likely consequences. That is, a desired consequence is known (John feel better) and the above actions would each lead to John's feeling better, but each in a different way. This will be explained at length later on.

The fourth level of expectation or prediction is conversational. That is, people talk for a reason, usually to communicate something or to gain some desired effect in the hearer. Here, it is either to arouse sympathy or to inform about something he is about to do. But the use of ought implies he might not do this, so that his probable reason in making this statement has to do with the effect which it will create on the hearer. Thus we can predict what kind of effect is intended to be made by the speaker and then expect certain types of utterances.

Another level of expectation has to do with a world view of the situation. This has the form of the hearer's understanding of the situation based on his own individual memory model. Thus, if he knows John to be a convicted murderer his expectation of John's completion of this sentence ought to be different from his expectation if John was an avowed pacifist.

The sixth level of prediction is based on a memory-structure that is common to the cultural norm rather than the particular language or particular individual. This memory structure will be explained in detail later on in this paper. The results of the expectations at that level have to do with the options that Fred can take as a result of the expected input from John. That is, the conversation is heading towards death (this idea will be explained in detail below) and Fred's expectation of this can avert the situation by appropriate action, either physical informative conversational or emotional conversational. It is hds expectation that decides the appropriate action and his expectation is based cm the life $\rightarrow$ death memory structure explained below.

Basically then, we must recognize that any complete processing system for a natural language utterance takes place within a context that is extremely complex simply by virtue of the fact that there are humans in the conversation and each has a complex memory to begin with and is now in a new complex situation. Part of this problem is being able to anticipate. The anticipation with respect to linguistic processing then is a function of a set of different types of expectations at any point in the analysis. These expectations are of various kinds and aid the basic analysis capability (see Schank [11]) tremendously. Our predictions are based at the following levels then:

1) sentential - what syntactic category is likely to occur
2) conceptual - what conceptual element is needed at this point in the parse to help complete the C-diagram
3) contextual - what information type fits in the structure created for information (kind of C-diagrams) at this point the overall parse (of the entire conversation)
4) conversational - similar to (3) but 'what answers, a question' or responds to the input in any of the ways mentioned on the previous page fits here
5) world view - what we expect of the substance of the information rather than its type, dependent on the presuppositions and basis of the hearer
6) memory structure - total correlation of this to life death continuum memory model. The process of 'living' is important here i.e. is this statement tending to describe information or events that will 'satiate' or 'hunger'. That is, 'Am I pleased by this?'

II. Conceptual Dependency

This section is intended to outline the conceptual dependency representation developed in Schank [10] and further explicated in Schank et al [11]. Those who have been following this work can skip to the next section.

The conceptual dependency framework is intended as an abstract system for representing the conceptual content of a natural language utterance. The representation is used to express the output of an automatic natural language analyzer that is intended to function as the front end of computer programs that require man-machine interaction in natural language.

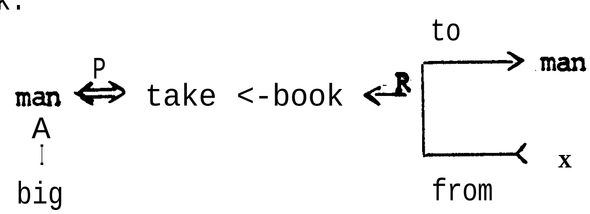
Conceptual Dependency theory operates as a stratified system, the highest level of which is intended to be an interlingua consisting of concepts and certain specified relations among these concepts. Linguistic behavior is considered to be a mapping into and out of this interlingual mental representation. In the analysis of a sentence, the mental representation can be considered to be a bundle of interconnected concepts (not words), where each concept is dependent on some other concept for explication of its meaning and where pieces of the conceptual network thus formed have their various sentential realizates.

As an example of the motivation behind the conceptual network, consider the sentence (1) "the big man took the book". Since a human can understand this sentence if studied one word at a time, we choose to deal with it the same way. "The" indicates to us that a noun will follow and that this noun has probably been referred to before. It has no conceptual realizate. "Big" cannot stand alone conceptually, but rather signals that there is a "something" that this refers to. Our knowledge of English syntax tells us that this **"something"** will probably immediately follow the end of the adjective string. **"Man"** **can** stand alone, and we are capable of understanding the concept of a **"man"**. We say that it is a PP (picture-producer) and we now can recognize that **"big"** can be understood as a descriptor of the PP. We thus say that **"big"** is a **PA(picture** aider) and is conceptually dependent on **"man".** We call this dependency, attributive dependency and denote it by " $\uparrow$ "**.**

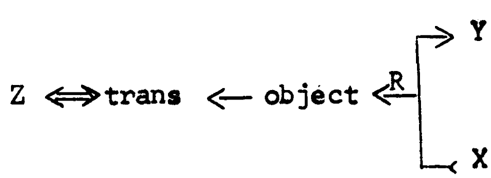
The next word, **"took",** is the past form of the action **"take".** An ACT (action) is dependent on the PP that is its actor, while the actor is dependent on it. We define a conceptualization as a network whose central part is the two-way dependency **($\Leftrightarrow$)** between an actor and an action. The $\Leftrightarrow$ link takes many tense forms, in this case we place a **"p"** over the link to denote that the conceptualization occurred in the past. The next **"the"** is treated as before. **"Book"** is the conceptual object of the ACT. We can understand **"book"** by itself, so it is a PP, but with respect to the conceptual network, it is dependent on the ACT for its explication. We call this objective dependency and denote by "$\xleftarrow{o}$" . Thus, the conceptual network consists of the unambiguous conceptual realizates of each work linked as follows:

$$\begin{array}{l} \text{man-take} \xleftarrow{o} \text{book} \\ \uparrow \\ \text{big} \end{array}$$

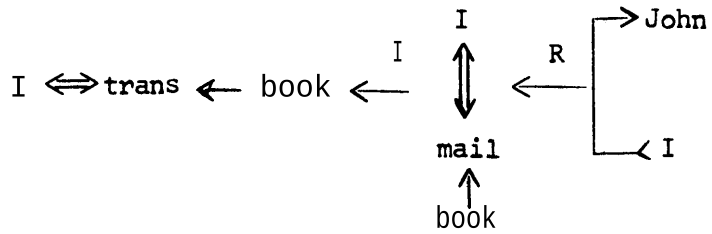
However, in attempting to uncover the actual conceptualization underlying a sentence, we must recognize that a sentence is often more than its component parts. In fact, a dialogue is usually based on the information that is left out of the various conceptualizations. For example, in this sentence, we know that there was a time and location of this conceptualization and furthermore that the book was taken from **someone** or **someplace** and is, as far as we know, now in the possession of the actor. We thus posit a two-pronged recipient case, dependent on the ACT through the object. The recipient case is used to denote the transition in possession of the object. Thus we have the following network:



In this instance the recipient and the actor are the same. We note that the underlying ACT here is really not "take" but an abstract ACT which denotes transition, which we call "trans ". We can thus define the English word "take" as the instance when Z = Y in the following network:



Thus, "give" is the realized verb when Z = X. "Receive" represents the same diagram as **give**. Similarly other "transition" verbs, for example "send" and "steal", have conceptual realizates where other aspects of the network are defined in some manner. Thus the following network, utilizing a conceptual Instrumental case, is realized with "send".



Realizates of this network include, "I sent John a book", "I mailed a book to John", and "John got a book from me in the mail". We cannot speak of any of these realizates as being "derived" from any other. Rather, they all represent the unique conceptual construct. The instrument of a conceptualization can be another conceptualization, or a PP. Some conceptualizations do not take an instrument (this is based on the category of the ACT involved and will be discussed below). We write a conceptualization on a **main-line" consisting of only PP's, ACT%, and ⇔ . Attributes of these governors are written perpendicular to that line. Thus, the instrumental conceptualization should actually be considered to go into the page on the z coordinate.

Conceptual Dependency utilizes four conceptual cases, objective, recipient, instrumental and directional. These cases, while not being too disparate from some notions of Fillmore [5], have their justification on conceptual grounds. We note that there is a difference between a conceptual instrument and the instrument as it functions syntactically. To better explain this it is necessary to digress for a moment to discuss a certain class of English verbs which we call "pseudo-state".

An example of a pseudo-state verb is "grow". When we say "John grew plants", we usually mean that it was the "plants" that "grew" and not "John". But "John" was an actor. However, the action that John did, which we call **growing**, was complex and probably consisted of weeding, hoeing, adding fertilizer, watering and so on. What we are really saying is that his action **doing** (not "he") caused the plants to "grow". We denote causality by "$\Uparrow$" between two two-way links. Thus, the above sentence is realized as:

$$
\begin{array}{ccc}
\text{John} & \overset{P}{\Longleftrightarrow} & \text{do} \\
 & \Uparrow & \\
\text{plants} & \underset{P}{-} & \text{grow}
\end{array}
$$

where the "do is a dummy ACT,

Now we can see that the sentential instrument of "fertilizer** in the following sentence

(2) "John grew the trees with fertilizer".

is conceptually the instrument of one of the "do's" associated with the verb "grow", and not the ACT **grow**. (In fact "grow" belongs to the class of intransitive ACTs (IACT) which take no conceptual case.) The most likely analysis of this sentence then, is:

$$
\begin{array}{ccccc}
\text{John} & \Longleftrightarrow & \text{do} & \xleftarrow{I} & \text{fertilizer} \\
 & \Uparrow & & & \\
\text{trees} & \Longleftrightarrow & \text{grow} & &
\end{array}
$$

Of importance here is the fact that the Instrument is dependent on "do" and not "grow" (nor on "cause"). However, the <u>verb</u> "grow" can take an instrument of **fertilizer**. This is an important distinction which is used by the parser through the verb-ACT dictionary discussed below.

The conceptual networks that we use are usually more complex than the examples given here so far. The complexities are caused by the fact that conceptualizations are often nested, the most common example of this being the state ACT's (SACT) which take entire conceptualizations as objects, e.g. (3) "I want to hit John", and (4) "I want a book".

```
I ⇔ want                          I ⇔ want
    ↑                                  ↑                        → I
  I ⇔ hit ← John ,             one ⇔ trans ← book ←|
                                                                 ← one
```

An interesting problem in the conceptual analysis of English is caused by abstract nouns. Often the conceptual realizate of an abstract noun is actually an ACT, This problem is tied up with the central one of paraphrase. Consider the two sentences (5) "I like running" and (6) "Running is enjoyable to me". Regardless of the syntactic position of "running" we consider that it is an action. Furthermore we claim that these two sentences are both graphed as follows:

```
I ⇔ run
  ⇑
I-pleased
```

In order to better explain this, it will be necessary to introduce some new notation. We use ⟺ to denote the link between a PP or ⇔ , and a PA in an attribute statement. An attribute statement functions similarly to a conceptualization. Certain attribute statements deal with mental states of the actor. These PA's are called ZPA's They are usually realized in English as verbs (e.g. comfort, please, hurt), We denote attributive cases such as location and possession by ⇑ and a marker to denote which case is meant.

Now consider the sentence (7) "John's love of Mary was beautiful**. Clearly this has the same surface structure as (8) "John's can of beans was edible" but each has a radically different underlying conceptual structure. We consider that "love" is an ACT no matter how it is realized and thus the NP in (7) is graphed:

$$\text{John} \Leftrightarrow \text{love} \leftarrow \text{Mary.}$$

The graph of the active sentence is then

$$\begin{array}{l} \text{John} \\ \Updownarrow \ \text{-beautiful} \\ \text{love} \\ \uparrow \\ \text{Mary} \end{array}$$

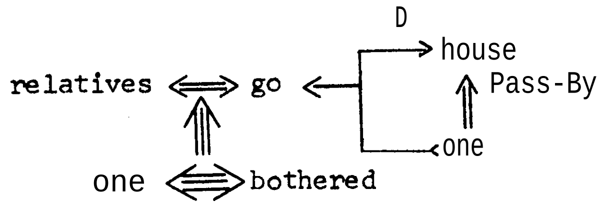
Here we have an abstract noun that is realized as an ACT, In (8) we have the abstract adjective "edible" and this too is an ACT conceptually. Thus the conceptual realization of thfs sentence is:

$$\begin{array}{lll} \text{one} \overset{c}{\Longleftrightarrow} \text{eat} & \text{f-beans} & \\ & \Uparrow \text{Poss} & \nwarrow \text{Loc} \\ & \text{John} & \quad \text{can} \end{array}$$

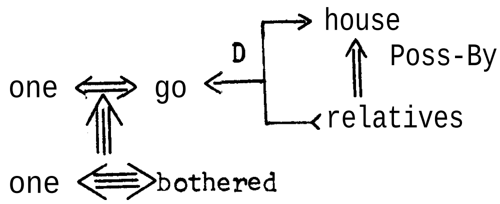
Here the "c" over the $\Leftrightarrow$ denotes possibility or conditionality. "One" is a dummy actor.

As a final example the classic sentence (9) "Visiting relatives can be a nuisance" has three interpretations expressed by the conceptual dependencies;

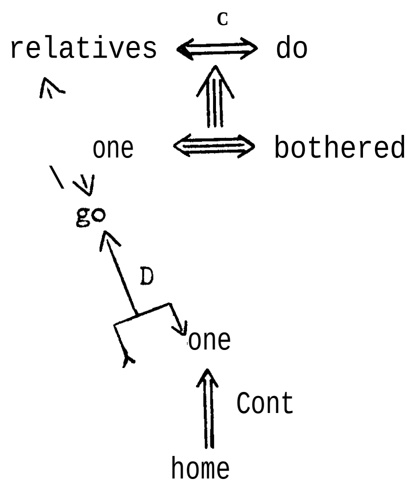
A)



B)



C)



The power of conceptual networks is shown in the difference between A and C where in C the actor is "relatives" and the action is an attribute of "relatives". In A, it is the entire conceptualization that causes the 'bother'. In other words, the event is a *'nuisance** rather than the **relatives**. We claim that this is an important distinction.

Thus, our framework provides the medium for the expression of certain conceptual relations. In addition, what is particularly important, especially for a dialogue program, is the conceptual information that is implicit in any **sentence. Our** framework makes much of this explicit both in terms of underlying associated concepts derived from realizations on the **conceptual** level, and empty slots for information that has not been received but that we know must exist based upon certain case requirements.

In order to understand this paper it is basically necessary to know only this:

1) Underlying sentences there **are** abstract conceptualizations.

2) A conceptualization is a relation between concepts of action and their actors and objects. It is represented by a $\Longleftrightarrow$ **where** the actor is to the left the action to the right.

3) **Actions** have labeled dependents denoting conceptual cases of which there are four: Instrumental, Objective, Recipient and Directive.

4) Conceptualizations can relate to other conceptualizations by: temporal causality denoted by $\Uparrow$ between the first $\Longleftrightarrow$ and the second occurring $\Longleftrightarrow$; or nested states that cause entire conceptualizations to be the object of a certain type of ACT **(SACT).**

5) Conceptualizations are modified as to tense by letters over the $\Longleftrightarrow$. These are: **p(past); c(conditional); f(future); t(transition); k(continuant); t_s/t_f(transition** starting or finishing); Δ (timeless); ϕ **(present).**

III. Associations

1. PP-ACT

We can begin by considering a simple type of association - prediction discussed in Schank et al [11]. The question was raised in that paper of how one might find that the underlying conceptualization for 'I like books' was really reflective of the faot that 'I like reading books' is true. Conceptual Dependency analysis solves an important part of this problem because of the conceptual rules that do not allow certain combinations. Thus the analysis

$$I \Leftrightarrow \text{like} \overset{o}{\longleftarrow} \text{books}$$

is not an allowable construction conceptually beaause the ACT (action) 'like' is of two possible conceptual types, each with its own semantic restriction. As what we call EACT (emotion ACT), 'like' allows conceptual objects (as shown above by '$\overset{o}{\leftarrow}$ books') but requires that these objects be of the class 'animal'. The other sense of 'like' is conceptually an SACT (state ACT) which requires an entire conceptualization as object. A conceptualization must have an ACTOR and an ACTION at the least and we are thus faced with the problem of uncovering these in the analysis of the above sentence. We have then:

$$\begin{array}{ccc} I & \Leftrightarrow & \text{like} \\ & & \uparrow \\ & & \Leftrightarrow \end{array}$$

We know that 'books' is part of this conceptualization and by the heuristics of the conceptual dependency system we know that 'I' is as well. The problem is what arrangement and what ACTION is correct.

Now we know that the most reasonable answer to this problem is:

$$\begin{array}{lll} I \Longleftrightarrow \textbf{like} & & \\ \quad\quad\quad \uparrow & & \\ \quad\quad I \Longleftrightarrow \textbf{read} & \xleftarrow{o} & \text{books} \end{array}$$

The question is how we arrive at such a conceptualization.

Consider the dictionary entry in a conceptual verb-ACT dictionary for **'read'.** The **ACT'read'is** listed in our system as requiring a *human* subject and an object that is chosen from the set of objects that have been made by men for exactly the purpose of *reading* them. That is, while we could list all possible such objects (books, newspapers, etc.) or categorize them in some artificial hierarchical structure, conceptually the object of *reading* is *that which is **read'.** Specifically this class could include anything with printing on it or whatever. The point here is that we can call the potential object a member of the class **'read-PP'** (where PP is the abbreviation for conceptual **nominals).** Then, in any listing of the elements of the world, their semantic category would be the place that fit in our ACT-based model. **'Book'** would be:

book: N; read-PP;

where **'read-PP'** denotes that it is the conceptual object of the ACT **'read'.** Then our diagram must **become:**

$$\begin{array}{lll} I \Longleftrightarrow \textbf{like} & & \\ \quad\quad\quad \uparrow & & \\ \quad\quad \Longleftrightarrow \textbf{read} & \xleftarrow{o} & \text{book} \end{array}$$

The only thing missing is the actor, which is **'I'** due to a heuristic which governs these situations.

There are conceptual representations for most man-made-objects which can be made in the same way as was done for *book*.' For example, consider *knife*, 'Knife' is an instrument of cutting. A funny way to say 'I sliced the meat with a knife' is to say 'I cut the cuttee with a cutter'. Now of course, the specificity of the particular concepts is lost with this paraphrase, but a *knife* is a potential *cutter* and that is what is important here. That is, when *knife* or any other cutting instrument is mentioned the association with cut or some specific cut term must be made. A context aids this process considerably, but regardless of context some association will be made by the human and must therefore fit in with any theory of a system of expectation for conceptual predictive analysis,

Thus, we can say that 'knife' is an instance of 'cut-PP_I'. This means that it serves as the conceptual instrument in conceptualizations involving 'cut'. More accurately, we can say that a 'knife' can be expected to be used in this way and also that conceptualizations involving 'cut' will have as instrument a member of the class 'cut-PP_I'.

The primary point is that there are associations between man-made-objects and the action for which they are made which are fairly straight forward which are an important part of the process of expectation and more importantly-one part of what has been understood from an utterance,

2 ACT-ZPA

Now consider another point discussed in Schank et al [11], namely the associations between certain ACT's and other ACT's. We mentioned there that the sentence 'I fear bears' was directly rebated to the harm that a bear might do. That is, a correct analysis might be:

```
        I ⟺ fear
              ↑
bears   ⟺    do  <°- I
              ⇑
        I   ⟺ hurt
```

Here again, this action ('fear' is related to a conceptualization rather than one particular concept. (In other words, you 'fear' consequences not properties.) What would seem reasonable here is that 'fear' and 'hurt' are directly relatable. Now it is possible to think of this relationship (fear-hurt) as some relatable grouping of ACTIONS. But this is not the case. We are dealing here with ZPA's. (ZPA's are mental state attributes which are nearly always expressed in English as transitive verbs. They look very much like pseudo-state verbs (see [11]) in that the object sententially is always the subject of the attribute statement. (e.g. 'x hurt y' means 'y is hurt'.) This means that certain ACT's like fear should have consequent ZPA's that they are related to. We can carry this one step further. The reason that 'hurt' is *feared* is because of another consequence, namely 'death'. Now this may seem a little melodramatic, but it does in fact seem to be the case, In other words, a lot of 'hurt' leads to 'death'. Now 'death' is conceptually the IACT - *die*. So we have here a relationship from SACT (fear) to ZPA (hurt) to IACT (die). In fact, there is one element missing here, namely the 'do' associated with 'bear'. This 'do' may be 'claw', 'eat' or some other PACT. So what we have is the set of relations SACT - PACT - ZPA - IACT (see Weber [14] for detailed explanations of these terms, The main point here is analogous to that made in the previous section: Whenever certain concepts are encountered other concepts are actually present in the underlying conceptualization and must be ascertained before a reasonable claim of understanding can be made.

Now it happens that this relationship between PACT - ZPA - IACT is not only not the case only in this instance but is the case generally. This is a rather obtuse way of saying that people do and say things for reasons or desired effects. Thus, actions have their consequences in new mental states for a doer or receiver of this action and these lead to new actual states. Now to talk of actual states is rather impossible without explaining the notion of variant levels within a conceptual base. Celce and Schwarcz[1] and Tesler [13] discuss the notion that certain concepts have both mental and physical realities, For example, you read a 'mental book* but lift a'physical book'. This dichotomy can be broadened to include levels of a social, emotional and spiritual nature as well according to Tesler. Actions, for example, can be seen to have different but related meanings on each level. Consider 'go'. Physically 'go' means to go from one place to another. This has its analogue socially in two ways. On the one hand, you can go to a 'social place' e.g. a convention. On the other you can go to a place within society i.e. social climbing (He went upwards socially after his election'.). One can 'go' emotionally ('After his death, I went to a state of depression*.) Mentally we have, 'My thoughts went to the days in Tangiers.* And spiritually we have the common' 'You will go to heaven'.

The reason for this apparent digression is that certain ACT's relate to certain ZPA's and IACT's according to the variant level of the ACT. Thus, the statement 'I was afraid that the bear would claw me' is a statement of physical dimension where the relation

$$[\text{claw-obj}]_{\text{PHYS}} \rightarrow \text{obj - hurt}_{\text{PHYS}} \rightarrow \text{obj - die}_{\text{PHYS}}$$

holds. Now the fear of death that is implied here does not indicate that the object is aware of his fear of death. For example, if you lift a pussycat high in the air he will squirm for a while and then get still as you lift him higher. We can safely say that the cat is afraid. To say that he is afraid of dying would be a little out of hand because he is probably incapable of comprehending the notion of death (whether humans can comprehend the notion of death is unclear). But he is afraid of something and even if he has never been hurt he can be said to 'know' in some way the implication of fright - danger - harm - death. He may not 'know' that he is afraid of 'harm' or 'death' but that is what he is afraid of.

This same kind of ACT-ZPA-IACT statement can be said to exist on each variant level. Consider the statement 'We are going to take away all your political power in this state'. The 'take' that is being used here is hardly the physical 'take' ($\text{take}_{\text{PHYS}}$) used in 'He took my toy'. Rather it is a social 'take' (take_{SOC}). Now this social 'take' leads to *impoverishment*$_{\text{SOC}}$ just as a physical 'take' leads to impoverishment$_{\text{PHYS}}$. That is, when something is taken from one, the consequence is that the 'taker' is richer in some way and the *taken* is poorer in some way. This is the ZPA of attribute in this case. The last consequence of 'death' holds as well in this case, but here it is 'death$_{SOC}$'. That is to say, the end result of such an action as stated above is that after his political power is taken away, he can be said to have 'died' politically. The end result is 'die$_{SOC}$'.

What we are saying then is that it is possible to get a great deal more information out of one ACTION then is readily obvious. On the most apparent level, the notion of expected objects and subjects and other conceptual case dependents can be predicted. But more significantly, we can also make simple implications as a result of the position of the ACT in question with respect to its relation to other conceptual consequences, That is, we can know the way in which an ACT relates to *living* or *dying* on a certain level and the range of human mental reactions on these levels to such an ACT.

Consider the following PACT's:

a) eat, drink, love, fight, hit.

b) hit, cut, attack, divorce

The ACT's in list (a) are positive with respect to the subject. Those in list (b) are negative with respect to the object. (Before we explain this notion, it should be realized that statements of this kind are with ordinary circumstances prevailing. That is, it is easy to envision circumstances under which the ordinary implication of an ACT are wrong and the reverse is true, but this is like the prediction question. We assume that predictions are made in order to provide both information as to what is the case and information as to what is not the case. Here therefore, we would expect that when our assumptions are wrong, information to that effect will be provided.)

When we say that an ACT is positive with respect to the object, we mean that the subject performs this ACT with the intention of having a good (or **$\rightarrow$live**) result occur on the particular level with which we are dealing.

By the same token, if an ACT is negative with respect to the **object,** we can assume that this **ACT's** consequent effect on the object is bad for the object and tends to hurt him on some level **($\rightarrow$die$_{LEVEL}$).**

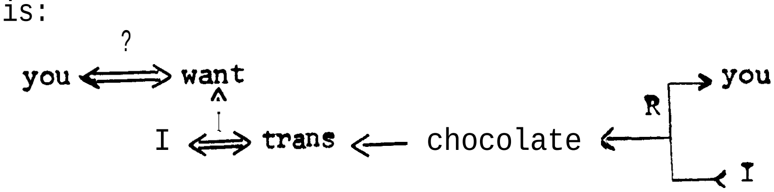
Consider a sequence such as this:

Q: Do you want a piece of chocolate?

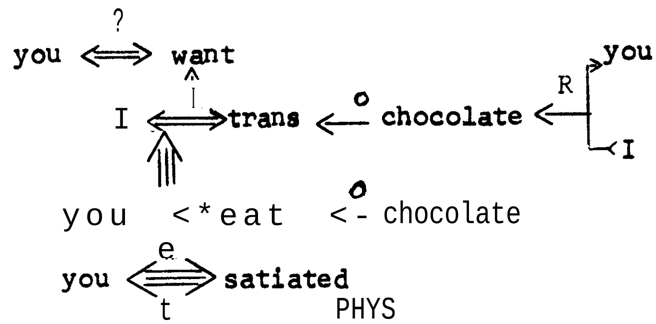
A: I just had an ice cream cone.

In a model of natural language understanding, it is unreasonable to **claim** that the system has understood the utterance unless it is capable of producing for (A) not only a conceptual diagram of the information just stated, but also something like the answer **'no I don't** want a piece of chocolate*. That is what a human could understand in the above situation and it is **incumbant** upon any so-called understanding model to understand the same.

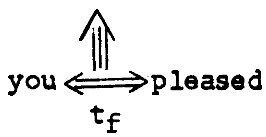
We can actually do this as follows. The conceptual dependency analysis of **(Q)** is:



However, the model that we have been discussing would be charged with taking the conceptual representation of the input and **drawing the necessary** implications that can be said to be understood implicitly. In this case, chocolate is discovered in the dictionary to be an **'eat :PP'.** The association between **'want'** and **'eat'** fits into the SACT-ACT-ZPA-IACT paradigm cm the physical level because of the definition of **'eat'** and yields the implications that the ZPA *satiate* is caused by the connection with respect to the subject of 'want'. This gives us:

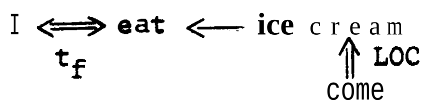


Now it is also true that people eat for reasons other than satiation, particularly for pleasure. So the causal connection

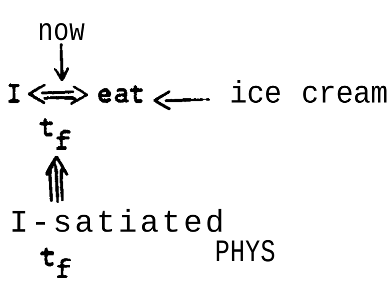


is also a consequence of the 'eat' conceptualizaticm. But this is not necessary here.

Now we are ready to analyze the answer (A). The conceptual diagram associated with the input is:



This diagram is obtained by utilizing the dummy quality of 'have' and finding the ACT associated with 'ice cream*, again 'eat'. Here again, 'eat' implies the causal for satiation and we have:



Now we can compare the question and the answer. The question can be matched with the answer by looking at:

$$
\begin{array}{l}
\text{you} \overset{?}{\Longleftrightarrow} \text{want} \\
\qquad\qquad\quad \Uparrow \\
\qquad\quad \text{you} \underset{t_f}{\Longleftrightarrow} \text{satiated} \\
\qquad\qquad\qquad\qquad\qquad \text{PHYS}
\end{array}
$$

from the question, and:

$$
\begin{array}{l}
\text{I} \underset{t_f}{\Longleftrightarrow} \text{satiated} \\
\qquad\qquad\qquad \text{PHYS}
\end{array}
$$

from the answer. Since 'you' and 'I' represent the same token in memory, the answer to a question about desired transition (t) has been answered with a statement of completed transition (t_f). In other words, we can assume that we have, 'do you want to be satiated?*, - 'I have just been satiated*. Thus we have the simple implied negative.

The point here is that the implications that are to be found in this memory model are part and parcel of the understanding process and in fact make little sense without-them. We can expect that a natural language analysis system must be continually making these associative implications in order to be able to use them when they are needed.

Essentially we are setting up a peculiar kind of world model here. We are saying that people do things for reasons and that people say things for reasons and understanding these reasons is an important part of understanding natural language utterances. It is the analysis of the intention of an utterance or ACT that is the primary element necessary to correctly responding to that utterance or ACT.

IV. Analysis of Intention

Consider the task of a computer program analyzing an utterance which was made as a response in a psychiatric interviewing program. In the following sequence:

Computer: How are you feeling?

Patient: Rotten.

Computer: Why?

Patient: I took a beating at the track yesterday,

The last response is a bit difficult to correctly analyze using traditional procedures. On the surface, the conceptualization that best represents its meaning would appear to be:

$$
\begin{array}{l}
\text{one} \Longleftrightarrow \text{beat} \longleftarrow \text{me} \\
\quad\ \Uparrow \text{LOC} \\
\quad\ \text{A track} \\
\quad\ \ | \\
\text{yesterday}
\end{array}
$$

However, while an analyzer that can find this underlying representation has completed an arduous task, it is only a part of what really needs to be done to 'understand' this sentence. Here 'beat' is really a metaphor, or in terms of our leveled analysis, we really mean *beat$_{SOC}$'. Now., when we talk of social death, unlike 'die' on other levels, this 'die' has two aspects; one is the 'die' of death within the society, that is lack of importance in society, 'death' meaning 'ostracization'. But in particular societies 'die' has particular realizations. In our society the primary realization of social 'live $\longrightarrow$ die' has to do with money. Essentially, bankruptcy is a kind of die$_{SOC}$.

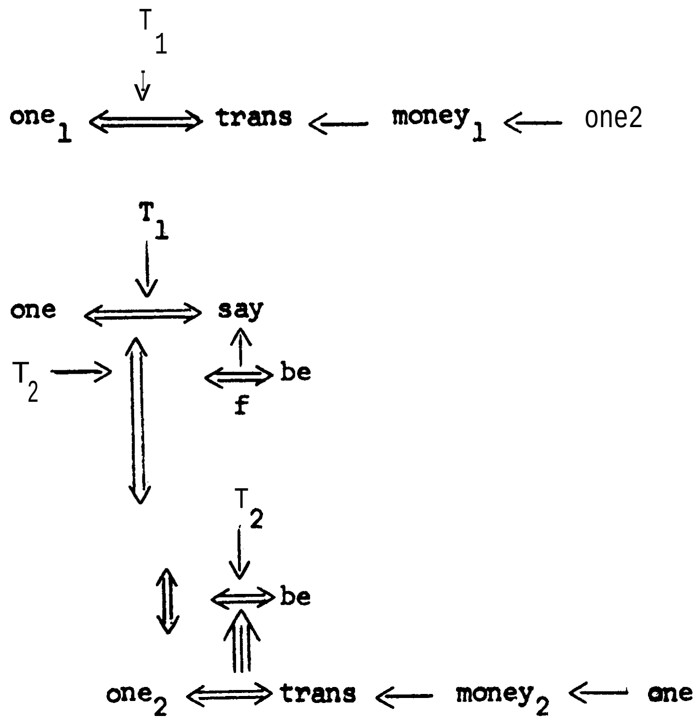
Now **'beat'** is negative with respect to the object, which means that the object of 'beat$_X$' is tending towards 'die$_X$'. Here, his 'social beating' implies a 'social death' or in this case, a reduction in amount of accrued money. The question is, how do we know that we are on the **'social'** level here and what should the final analysis of this sentence look like?

The solution to the problem here is to focus on the intention of the speaker. That is, the speaker is trying to communicate some item of information. What is it and how do we get to it?

The answer is that the intended-communicated conceptualization is the implied conclusion of the initial sentence. To go back to our initial paradigm we have the implication of **'beat$_{SOC}$'** is **'hurt$_{SOC}$'**. 'Hurt$_{SOC}$', according to our model, means either social ostracization or loss of money or both. So we are left with the one missing item, namely the definition of what a track is. This leads us to the question of world knowledge and how to characterize it. What should be clear is that certain elements from the definition are needed here. At the very least the societal nature of 'track' must be made evident as well as the **'money'** and 'betting' parts. That is, while in our definitions of banana (**eat:**PP$_o$) and book (**read:**PP$_o$) we were able to relate them to the actions for which they were created, that is, they serve as objects of a **conceptualization** which entailed their derivative action, here, you **don't** 'bet track', you **'bet** at a track'. **That** is, track is a location (LOC) where something takes **place.** So **'track'** can have the defining conceptualization of:

$$\begin{array}{l} \textbf{one} \Longleftrightarrow \text{bet} \longleftarrow \text{money} \\ \quad \Uparrow \textbf{LOC} \\ \text{track} \end{array}$$

Nw, the concept **'bet'** is actually very complex and **represents** something like:



Here the blank conceptualization ($\Updownarrow$) represents the subject of the bet. The bet is on the future existence. **'$Money_1$'** and **'$Money_2$'** may or may not be the **same** amounts depending on the bet. The first two conceptualizations occur at the same **time T_1** and ths third occurs at some later **time T_2.**

Although this conceptual **construct** is called **'bet'** in **English,** it is not necessary to translate into it in order to get out of it what we need.

Now admittedly we are dealing with special cases here. For one thing, the sentence may well refer to a physical **'beating'.** For anothor, **'track'** might refer to auto racing and the **'beating'** might be as a racing driver who lost a race. But the question here is one of context and thus in solving this problem it is necessary to be setting the context up in some rigorous manner such as to use it in the fashion that humans would use it in a similar situation.

Let us assume a memory structure of a very smple kind.' Consider a language-processor that had three parts. One is the conceptual dependency analyzer described in Schank et al [11]. The other two are a specific type of short-term memory and long-term memory. The short-term memory structure is of use in language analysis as a kind of context-holder. That is, the structure of what is going on in the conversation, the whys and wherefores of the conversation existence, is inherent in the short-term memory. This memory structure is in constant interaction with the conceptual analyses produced by the language analyzer so as to alter them-and operate upon them in order to create a sort of super conceptualization or one that is revealing of the intention of the speaker.

The short-term memory can be thought of as having one portion devoted to the predications that have been made within the *current* discourse. Also present here would be the structure of the current discourse, including the topic currently under discussion, both within the minor headings (the sentence) and the more major headings (the paragraph and a higher discourse structure).

An additional part of the short-term memory is held waiting for the restoration of past context as part of the present context. Assume, for example, that'in the above conversation, the patient is an inveterate gambler. The probability that the statement about his beating refers to loss of money is extremely high. If he is known to gamble on horses then the probability that the track referred to is a horse racing establishment is again very high. These contexts must be called into play in any analysis. That is, one uses one's model of a speaker 'in order to interpret his statements the way they were intended.

Now we can imagine an intentional disambiguation apparatus that would work as follows:

1) 'I took a beating' is handled by the conceptual dependency analyzer in the usual manner to yield:

$$\text{someone} \Longleftrightarrow \text{beat} \leftarrow \text{I}$$

2) 'beat' is then discovered to have conceptual realizations at various levels, and the search for the correct level is begun.

3) The first implication is made from 'beat' yielding 'obj hurt' but the level of hurt is still unknown.

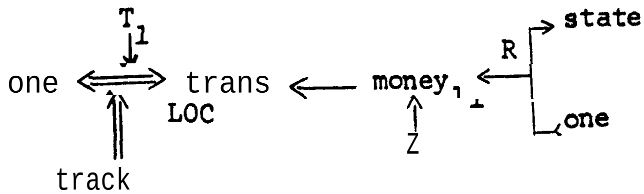
$$\begin{array}{ccl} \text{someone} & \Longleftrightarrow & \text{beat} \leftarrow \text{I} \\ & \Uparrow & \\ \text{I} & \Longleftrightarrow & \text{hurt} \end{array}$$

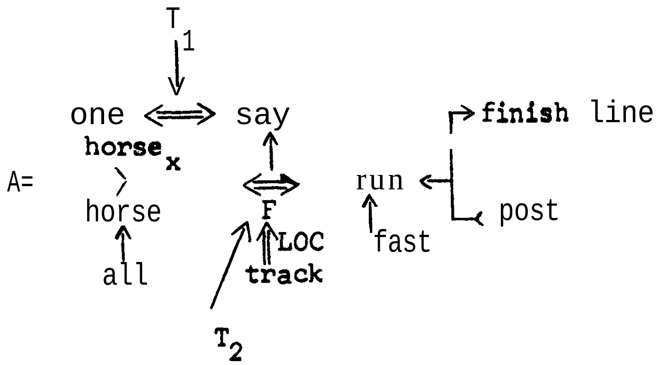
4) The conceptual analysis is continued until 'track' is placed in its locative position :

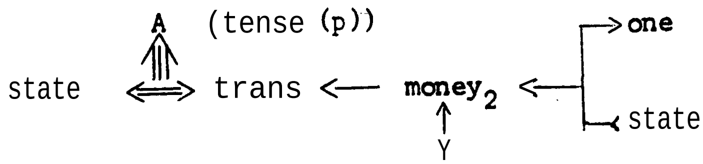
$$\begin{array}{ccl} & \text{track} & \\ & \Downarrow \text{LOC} & \\ \text{someone} & \Longleftrightarrow & \text{beat} \leftarrow \text{I} \\ & \Uparrow & \\ \text{I} & \Longleftrightarrow & \text{hurt} \end{array}$$

5) A search is made for clues into the level at which these conceptualizations are existent. 'Beat' is discovered to have realizations at the physical, emotional, mental, and social levels. 'Track' is examined since it is nonhuman. (The reason for this is that by definition all human concepts can potentially exist at all five levels and then would be of no help in disambiguation.)

6) **'Track'** is discovered to be represented in long-term memory as







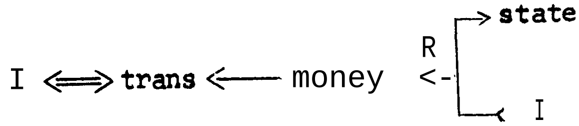
(where Z and Y are unknown quantities)

7) A search through the representation for closely related items that clearly represent a level is made (this corresponds roughly to the dictionary disambiguation search of **Quillian [9]).** The items present are **'trans', 'money', 'state',** and **'horse', 'run'.** That is, **'tracks'** have **'social' ('trans'** is a social ACT) and 'physical' **('run'** is a physical ACT) aspects as primarily relevant.

Now if the sentence had been **'My** horse took a beating at the track' the search would uncover the comparative (horse,) horse) and be able to determine that horse had lost a race. al3

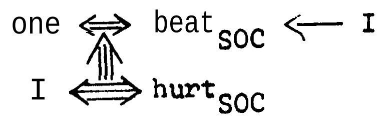
But the blank subject (one) in the **'trans'** conceptualization keys this as the conceptualization that is of use in the statement **'I** took a beating at the **track'** since **'I'** is an instance of **'one'.**

Thus we have the hypothesis that the conceptualization

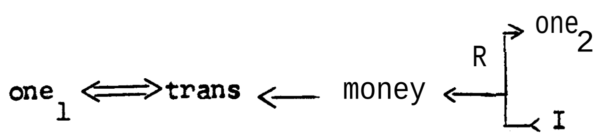


is true. Since this is a statement on the social level we can guess that originally we had 'beat_{SOC}'.

8) The original conceptualization is, at this point, as follows:

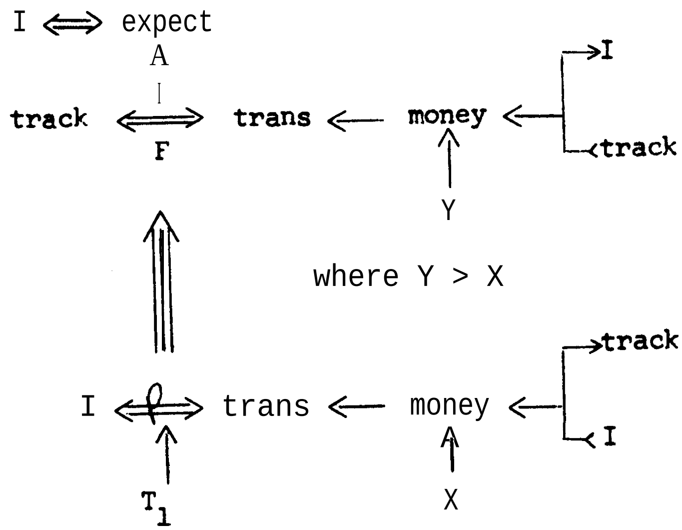


But, we know that the cause of 'hurt_{SOC}' is loss of money or social position. Since ' money' is present in the context of the STM (from the **'trans'** conceptualization) we can hypothesize that the conceptualization

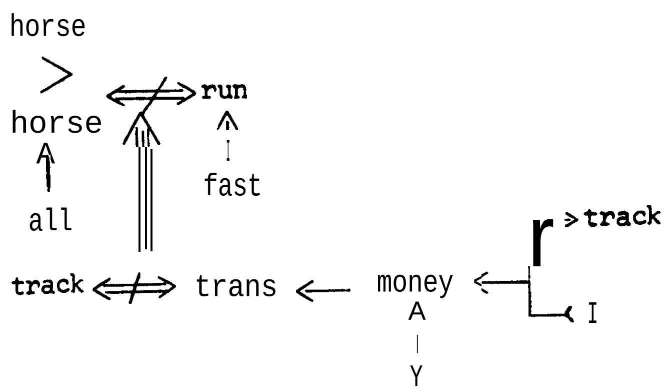


is true. (That is, that a money loss was incurred.) This conceptualization is rather difficult to interpret since it is derived from the notion of 'betting'. One doesn't **'lose'** money. Either you leave it sow where or you bet it and don't win, but conceptually **'loss'** is anomalous. So here, the **'bet'** conceptualizations are only partially realized, that is, the consequent **'win'** conceptualization doesn't materialize. If this happens frequently, we can say that he lost a lot of money i.e. he took a beating_{SOC}.

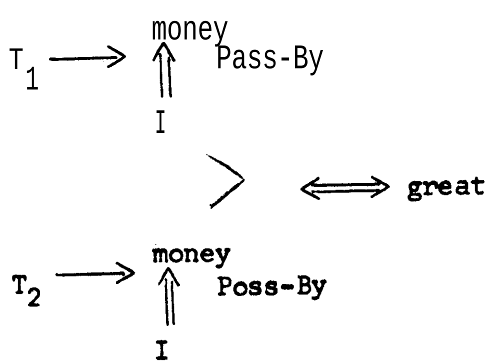
9) A final analysis then, should have the following information:



but /



but/



10) The main problem in an analysis of this kind then, is; to extract the level at which the statement is made; make the appropriate association according to context (in this case 'track'); make impli-

cations on the basis of level (i.e. $hurt_{SOC}$); find causal element for implication (i.e. money-bet); place information within context to determine intended conceptualization.

V. Searching Into Memory

A. Communication based on Common Memory

If we begin to talk about the meaning of a sentence with reference to the intention of the utterance, we open a box of problems that have as a general solution the setting up of an entrance into the memory structure and the defined operations within that structure as a rightful notion of 'meaning'. Previously in conceptual dependency theory, we have said that the conceptual diagrams are 'intended to convey the content of what was said. But it has been seen that what was said is often not quite what was meant. In order to have an effective program that can converse with a human, it is necessary for the program to know what the speaker 'means' at any given point. This notion could be carried to the logical absurdity of trying to figure out what the speaker 'really' want. Was he lying for example, This in fact is what a sophisticated psychiatric interviewing program must do. But a program which is intended to simulate the language understanding ability of a typical human should not be as sophisticated as a psychiatrist. That is, it must carry out the logical implication and inferences that a normal speaker performs. What are these then?

The answer to that question is manifold. The first part of the problem is what structure or type the solutions conform to. That is, are conceptual dependencies the representation of the entire situation? Here we must make the differentiation between the meaning of the sentence and the meaning of the speaker. That is, a conceptual dependency representation is a characterization of the meaning or conceptual content of a sentence (i.e. 'what was actually **said'**). The meaning of the speaker is what we have been dealing with in this paper. **This** corresponds to the question **'I don't** understand what you **mean?'**. We often say this, when the conceptualizations that we have derived from what a speaker has said do not fit in with our previous experience or do not have enough information to let us know how to interpret the utterance, We thus make the distinction between interpretation and understanding (as have others e.g. Deese [4]). Understanding is capable of being characterized by conceptual dependency networks. The interpretation process utilizes these networks in conjunction with the overall **memory** structure so as to produce the impetus for the generation routine. That is, the end result of the interpretation process is used in conjunction with the 'reasons for talking', and the structure of the conversation in order to begin the generation of a response either verbal or physical. For example, the meaning of **'Fire.'** is

$$\begin{array}{ccc} \text{something} & \overset{tk}{\Longleftrightarrow} & \text{burn} \\ & \Uparrow & \\ & \text{here} & \end{array}$$

but the interpretation process utilizes this network in addition to its knowledge of what happens when **'something$\Longleftrightarrow$burn'** to produce a result. Here we have:

something ⇔ burn
⇑
something ⇔ die

and

x
⇕ LOC
something ⇔ burn
⇑
something ⇔ burn
↗ ↑ ⇑ LOC
x
other combustible

and human ⇔ combustible

For the hearer this **means:**

tk
something ⇔ burn
⇑
hearer ⇔ die
ct

This coupled with hearer ⇔ want
^
|
hearer ⇔ live
k

yields

ts D → any
hearer ⇔ go ←
→ x

That is, **'Fire'** initiates the response in the hearer of getting out of the vicinity of the fire.

Sometimes then, there is a clear distinction between the waning of the sentence and the waning of the speaker. This **dis**tinction becomes slightly fuzzy in a sentence such as **'He** acts like Harry'.

We can say that a sentence such as this is meaningless in the case that the hearer has no idea who [redacted] is or how 'Harry acts'.

This conforms to the oft heard hearer statement 'I hear what you're saying but I don't get what you mean'. That is, the hearer doesn't understand.

In terms of conceptual structures, the network representation is twofold. First, we have the notion that 'he' acts in some manner (x):

he ⟺ do
↑
x

For 'Harry' we have the same conceptualization:

Harry<=> do
↑
x

Now, this is virtually meaningless, as is this sentence unless we know something about Harry. If we do, then the second conceptualization acts as a pointer into memory to retrieve the set of ACTs known to be associated with Harry. For instance, if we have in memory:

Harry $\overset{b}{\Longleftrightarrow}$ cat

Harry ⟺ pounce on ⟵ birds
⇑
birds ⟺ die

Harry ⟺ eat ⟵ cat food

one ⟺ pet ⟵ Harry
⇑
Harry ⟺ purr

Here we see that the statement 'He acts like Harry' 'is still meaningless unless the range of remembered ACTs of Harry is delimited. In actual conversation the delimitation is often made by the context.

That is, if I note that 'he is acting like Harry' when I see him watching birds, I might be saying that:

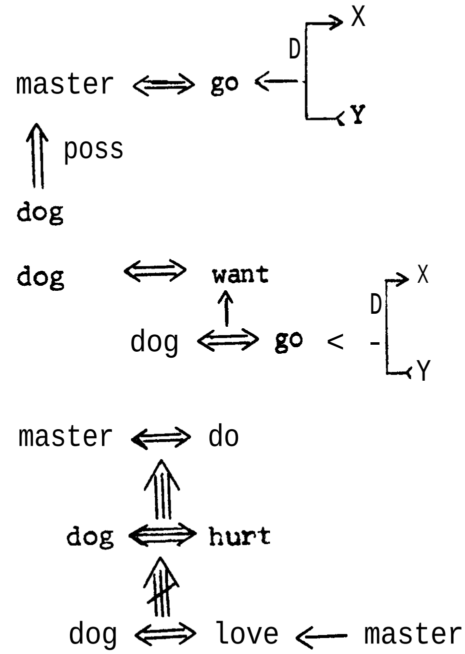
$$
\begin{array}{l}
\text{He} \Longleftrightarrow \text{look - at} \xleftarrow{o} \text{birds} \\
\quad \Uparrow \\
\text{he-pounce - on} \xleftarrow{o} \text{birds} \\
\quad \Uparrow \\
\text{birds} \Longleftrightarrow \text{die}
\end{array}
$$

and furthermore that

$$
\begin{array}{c} \text{he} \\ = \\ \text{Harry} \end{array} \Longleftrightarrow \text{look - at} \xleftarrow{o} \text{birds}
$$

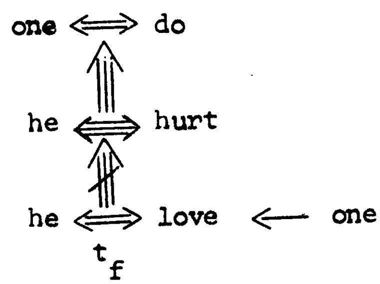
That is, the first set of conceptualizations are obtained from a directed memory-search, where information about 'Harry' is retrieved with respect to the particular context. This is the partial intention of the speaker. We can assume that the rest of the statement is intended to draw the parallel between 'he' and 'Harry'. The second conceptualization equates 'Harry' and 'he' with respect to a particular action. (This uses the representation of comparatives described in Schank [10].)

Often the kind of memory retrieval to which we are referring can be assumed to be directly derivable as the meaning of the sentence when the contextual delimitation needed for such a retrieval is provided by the sentence itself. Consider 'He is doglike in his devotion'. This sentence is effectively a command to memory to seek out any knowledge of the devotion of dogs. Clearly, this statement is meaningless if such Rnowledge is lacking. But, assume an item in memory about the behavior of dogs, e.g.



Now, 'devotion' is an English-word which keys into this memory structure for 'dog'. That is, in some sense it can be said to be an English idiom with a conceptual heuristic for a realizate.

So the meaning of the above sentence is that 'he' should be substituted in the memory structure keyed by 'devotion-dog'. A plausible inference then is



Thus, certain words, and word-pairs can cause procedures in the memory to be called into operation. Usually, the operation is based on the immediately previous established context, but often this context is established by the common particular structure in the long-term-memory of each conversant. That is, cultural definitions of how dogs behave with respect to devotion facilitate communication for this sentence. If the conversation were conducted in English by members of two radically different cultures, it might be possible that communication would be stymied. Consider, for example, a hypothetical culture where dogs are a constant threat to children and food supply and are thus hated and feared. Clearly, to such a person the above statement, when heard, would be misunderstood with respect to the intention of the speaker. Thus, a definition of 'devotion' would not match in structure any item in the memory of the hearer having to do with 'dogs'.

We thus distinguish three different types of information within a memory structure.

Cultural Conceptual Structures - These are associations having to do with people and their environment. Mostly these are associations and judgments about things. Particularly the behavior of humans is the concern of this part of the memory. That is, each culture would interpret 'His behavior will cause him trouble' in a different manner.

Idiosyncratic Conceptual Structures - Here a person's own experience with the outside world creates his own individual world. That is, while the cultural norm might be that 'devotion-dogs' brings the above structure, his own personal experience might be very different from the cultural norm. That is, he might think dogs to be vicious and not the least bit devoted. Thus, his interpretation of such a sentence would be quite different, This idiosyncratic memory operates largely cm relative adjectives (trouble, devotion). That is, 'trouble' for a policeman is perhaps different than it is for a minister.

Universal Conceptual Structure - We have discussed this. structure at length elsewhere (Schank [10]). Basically the universal structure is an encoding of world knowledge. This section of memory deals with physical rather than emotional or social aspects of trees, dogs, people and so on. We can assume that while all people's perception of particular physical items in the world are not the same, they are potentially the same. That is, with a minimum of learning of discriminations they can be made to be the same.

It is interesting that these three aspects of the memory structure correspond to the levels at which a conceptualization can exist discussed earlier. That is, cultural corresponds to social, idiosyncratic to emotional, and universal to physical.

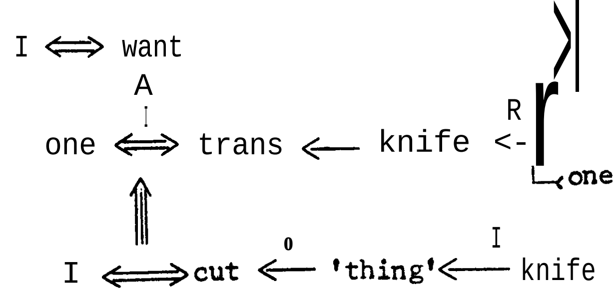
Now, we can explain the ability of two individuals to 'communicate' based on their cultural norms with respect to the topic being the same; their idiosyncratic judgments of a particular item as being similar; their universal understandings having included similar discriminations (this is not all that important since it can be learned); and their mutual understanding as to what level a particular conceptualization is supposed to exist at.

B. Context

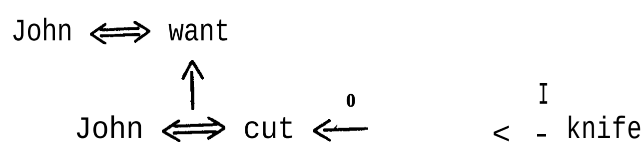
It is now reasonable to go back to the levels of expectation with which we were concerned earlier. In the conversation between 'John' and 'Fred' we noted that the context predicts what kinds of conceptualizations are likely to be asserted. That is, what do we expect him to say that would fit in with the contextual situation?

We answered by claiming that what was likely was that John would say 'I think I ought to $\left\{\begin{matrix} \\ \text{kill}\end{matrix} \left\{\begin{matrix}\text{Mary}\\ \text{you (Fred)}\end{matrix}\right\}\right\}$' or 'I think I ought to {end my relationship with {Mary / you (Fred)}}'. It should be clear that the particular words that would be used here are not at issue, but only their conceptual content. Now, the question is, how do we get a machine to make these predictions?

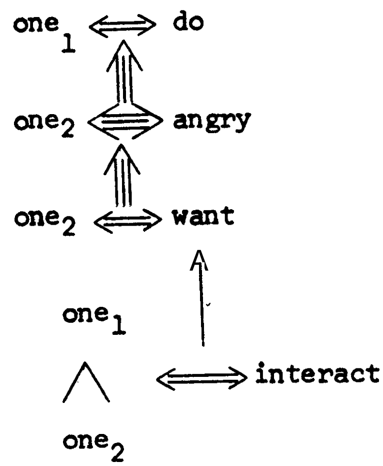
The problem is one of derivation. That is, where would this information come from? The memory model will help. Consider the statement made by John previous to the one under discussion ('I could use a knife right now'). This is represented as:



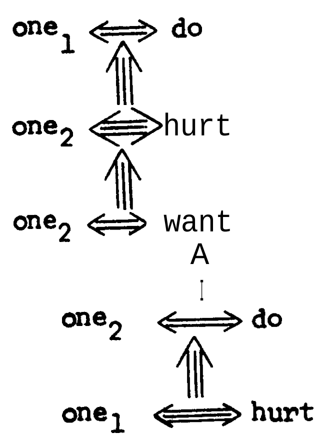
Here the first causal implication comes from the SACT - ACT - ZPA - IACT paradigm, or, in this case - 'want - ACT - ZPA -live'. Now, we can say that we have a conceptualization in the short-term memory that will affect the context. That is,



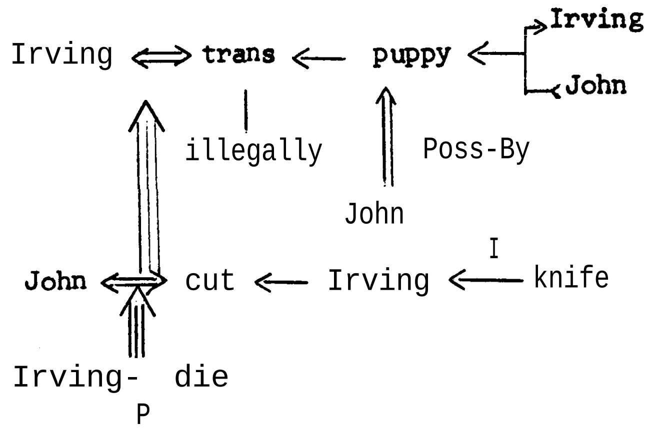
In order to make accurate use of this information, it is necessary to have at the system's disposal a belief that could be characterized as part of the world view expectation. This belief is of the general order:



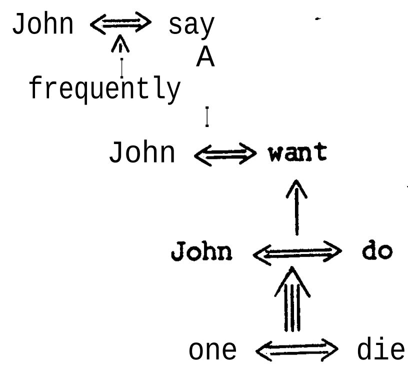
That is, this rule explains that if one is angry at someone that means that one **doesn't** want to interact with that person right now. Now there could also be a rule that says:

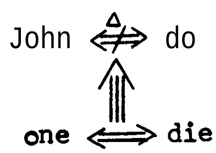


In other words, if one is hurt one wants to retaliate. Now of course, this rule is not always true for every individual. We would like to note the conditionality of this rule by placing a **'c'** over **'$one_2 \Longleftrightarrow$ want'** and then using the rule if it is the case that in our memory of the individual to whom we are talking we have for example :



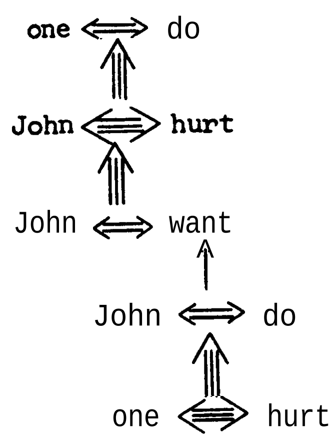
That is, if we know that John already killed for some reason like this, we might guess that John will retaliate again. On the other hand we might have the rule from memory:



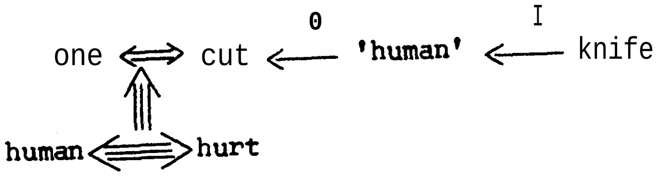


That is, John talks about killing people but never has done it.

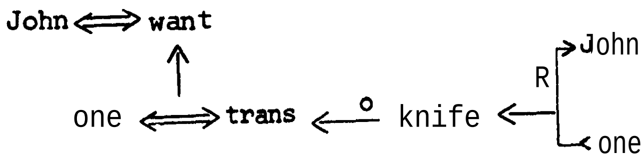
The point is that if we can decide that it is the case that John will at least say that-he believes that:



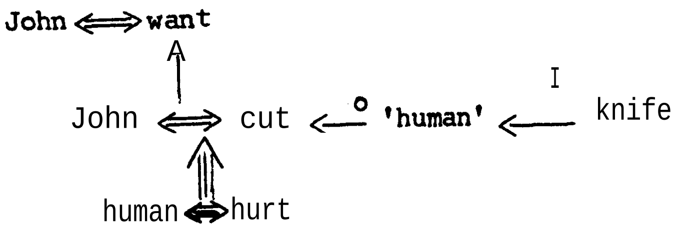
and, we know that:



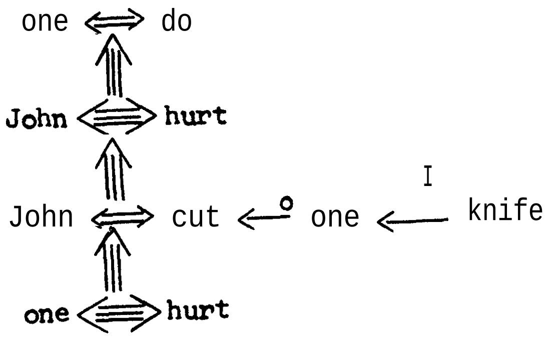
and, we know that:



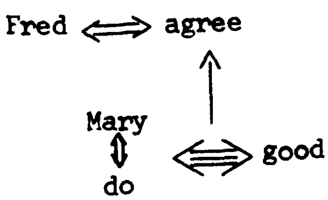
then we can conclude that



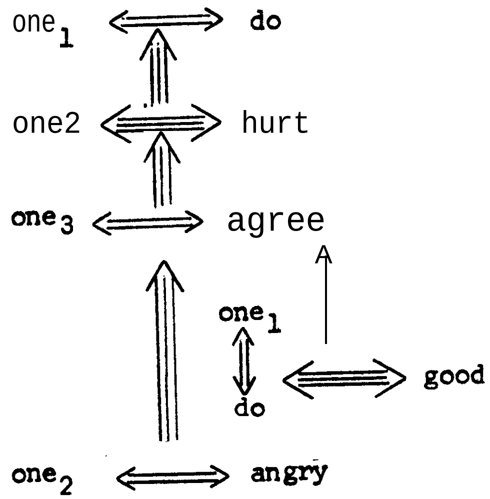
Now the question is, who fits the paradigm?



Since, John has said that Mary angered him, she fits the paradigm by definition of 'angered'. Since, Fred has just convinced John that:



we can say that 'Fred' and 'Mary' are in the same situation in the paradigm. This is done by yet another belief that says:



That is, if one sides with one's enemy then cme is angry at the enemy's compatriot also, Thus we can say that John is likely to say that he will kill either Fred or Mary. Also, we can say that the context of the knife aside, he is likely to say that he doesn't want to interact with either Fred or Mary.

The important point here is that it is possible to make contextual predictions as to the content of expected conceptualizations, but that this process of prediction is based on a belief system that includes generalized rules for operating in the world, and idiosyncratic beliefs about the behavior of an individual in the world based upon ones view of people and the particular person under discussion.

Although it may seem so, the number of the primitive beliefs necessary to handle tasks such as this is not large. Colby [3] and Morris [8] have estimated the core beliefs of a human as under 50.

VI. Conclusion

A. Conversations

I have talked here about certain kinds of predictions that can be made about what a speaker is likely to say at any given point. I have avoided discussing conversational predictions because the work that we have begun to do on them is still even more sketchy than that presented here, and more importantly is of a very different character,

To a large extent the conversational expectations are dependent on generative mechanisms, that is, a sort of 'why are we talking' apparatus must be used. As an example of the kind of mechanism that we are talking about,an illustration from some recent research that we have been doing will help.

We spent some time with a child of age 2.2 years, talking to her and endeavoring to understand her understanding mechanism, During discussions with her we obtained some interesting examples of unusual answers to questions that suggest a model for generation of responses in the child,

Mother: Did you go to the toilet?

Child: I go home,

Mother: Did Peter go to the bathroom?

Child: Peter cry,

Interviewer: Did you ever go in a plane?

Child: I go in a bus.

Responses of this kind indicate an answering mechanism in this child that has as its primary purpose the making of true statements.

A procedure that would generate this behavior would simply check the proposed conceptualization with memory, and if it is not found check to see if a new case dependent will fit in the conceptualization and make it true. Two factors are important in choosing this new object: first the immediate context or short-term memory is checked for similar conceptualizations; if that fails, a true conceptualization with the same semantic category is checked for. If no possible case dependent is found, the case is eliminated altogether and a new ACT is looked for, again by the same standards,

Another interesting insight into the understanding mechanisms of this child was provided by the following two exchanges:

Interviewer: What's that? (pointing to a picture of butter)

Child: Butters.

Interviewer: And what do you do with butter?

Child: Eat it.

Interviewer: How do you eat it?

Child: On a spoon.

Interviewer: On bread?

Child: Yes.

The association between 'bread' and 'butter' was then used by the child in the following sequence that occurred half an hour later.

Mother: (to another child) What did you eat for lunch?

Other Child: Sandwich.

Interviewer: What do you want to eat?

Child: Sandwich too.

Mother: What kind of sandwich?

Child: Butter on it.

Mother: She has never asked for butter before.

Here we see the child making statements that may in fact not even be true for her. She might very well object to receiving a butter sandwich if one was made for her. She seems here to be testing the new association (butter-bread) that she heard, and is in fact expanding it (butter-bread-sandwich).

The point here is that this child has a set of rules for talking that are quite different from the typical adult rules for talking. (The work discussed here will be fully discussed in a future Artificial Intelligence Memo. A computer program is currently being written that will attempt to simulate the linguistic behavior of this child.)

We also have examples of reasons for talking in abnormal adults which can possibly shed light on normal conversational behavior.

At the Stanford Artificial Intelligence Project there is currently in operation a computer program that attempts to simulate a paranoid patient (Colby [2]). The human at the console can act as a psychiatrist and interview this patient and the patient (Parry) will rerpond in a manner that a paranoid patient might be expected to. This program is not intended as a simulation of language under- standing. Rather it matches patterns that it is looking for as best it can depending on where the conversation has proceeded. The program -assumes it is talking to a peychiatrirt whose intention is to help him. Yet Parry is always on his guard looking for things which will indicate whether the 'psychiatrist' is really out to help him or if he is actually out to get him like most others in Parry's delusional world. That is, Parry performs what might well be an intentional analysis of all input questions. He attempts to find intentions that confirm his paranoid hypotheses. That is, he makes some assumptions and then operates on these assumptions in order to make some conclusion. He then uses these conclusions to direct his own part of the conversation so as to say things that will achieve his own ends. That is, he also has intentions when he talks.

Now it would be wrong to say that the procedures we have been discussing are actually used in the paranoid model designed by Colby. The model does, however, use procedures like these even though it does not work in the way we have been describing. His model does what it can to simulate paranoid linguistic behavior.

But, assume that we were to describe a simulation of a paranoid person that did understand language and made the same kinds of decisions that Parry does when in operation. We would then have to deal with the problems of intentional analysis as well as generating statements which have some intention. This is true of 'normal' adults as well. The difference is in the driving mechanisms or underlying assumptions. We can assume that these assumptions differ from person to person and from psychological state to psychological state. The question is, what do the processes that are going on here look like in general and in a normal understanding situation in particular?

These kinds of problems are part of the conversational prediction problem.

B. Understanding

It is reasonable to inquire why we really need to make all these predictions anyway. Is this really part of the language understanding process? Furthermore, won't all the beliefs and necessary knowledge needed in order to do these kinds of analysis be unbelievably enormous?

The answer to these questions and others like them is really one of the nature of the assumptions underlying this work and in fact all work in either language or memory.

My reasons for doing this work are clear. I should like to enable computers to use natural language in any manner that one might want them to, and I would like to understand how it is that people do these things that we would like our machines to do. In order to achieve this goal, I claim that it is not possible to separate language from the rest of the intelligence mechanisms of the human mind. Language simply does not work in isolation. It is a nice idea that one should in prinoiple be able to fully describe and characterize language by itself as most linguists are trying to do, but in fact it is as absurd an idea as trying to understand the workings of the human mind by cutting off a man's head and taking a look inside. No doubt it is possible to find out some things that way, but the separation is artificial, it destroys the very process that we would be trying to investigate. So it is with language. The ability of linguists to ignore this while trying to separate language into neat formal rules has caused an unbelievable number of unrealistic studies to take place under the banner of linguistics. People neither randomly generate sentences nor do they attempt to assign syntactic markers to input discourse. It is certainly true that humans may perform some of the subtasks that are needed in order to have a formal model do these things, but the overriding question is one of purpose. What are we trying to do, and might not there be a better way?

The answer to these and other like questions is that language exists as a medium for expressing thoughts. We use language so that we can give our thoughts or ideas on a particular subject or in a particular circumstance to someone else. That is, language is used to communicate. The logical question to ask is, what is it we are trying to communicate? Clearly, we are trying to communicate ideas. In order to deal with ideas on a machine it is necessary to characterize them in some way. That is we must extract the inherent ideas from the linguistic input and characterize these ideas in some fashion so to be able to use them. It is the use of these ideas that has been sorely neglected by linguists, yet it is precisely the use of ideas that is the communication process. In order to claim that we have understood what somebody has been telling us we must process the received input in a certain way. Now this does not mean that we must react to the input in the correct way in order to claim to understand it. If I say 'go get me a pickle', the hearer's lack of motion does not indicate that he doesn't understand me. It may simply indicate his recalcitrance at being ordered around. But, if the above statement is the punchline to a joke, and the hearer does not laugh, it might well mean that he has not made the correct inferences necessary to 'understand' my joke. In some sense, even a different sense of humor is an inability to understand my speech. This is in fact what communication is all about. Certain pairs of people find it harder to communicate than other paris. This is indicative of a lack of certain common memory structures and inference relations. We cannot understand somebody whose initial assumptions and cultural background are radically different from our own, even if we share a common language. That is, understanding <u>language</u> is a misnomer or at least is only a small part of the problem. Understanding what one has heard is a complex process that necessitates connecting words with certain conceptual constructions that exist in one's memory. The entire linguistic process uses the output of such understanding and interpreting mechanisms in order to produce reasonable replies (verbal or not). What constitute8 a reasonable reply is an intrinsic part of the linguistic process, but yet is still a conceptual process and is therefore I suppose out of the domain of traditional linguists. Yet it is unreasonable for it to remain in that scientific no-man's-land. A computer model must respond as well as understand. Of course, its response must be connected to a powerful responding mechanism that is in fact the point of the entire computer program, that is, why the program was written in the first place. These then are the problems of computer understanding of natural language.

Now it might be reasonable to ask if the topics dealt with in this paper contribute to our understanding of this understanding process. Clearly I think they do. But why? Or, what might be a more pertinent question, why should it be necessary to make all these different predictions that have been outlined here? The answer is that in a complete automatic linguistic system the responses that are generated will be dependent on the corraboration of the predicted input as compared to the actual input and the memory structure. That is, we respond differently to different people saying the same things, and differently to the same people saying the same things in different contexts. These contexts include, physical, conversational and time contexts. In other words, no person is really the same at any given point in time as he was at some other time with respect to the viewer's own memory model of that person. So, in some sense, the context is always different and the responses should always be potentially different according to the time of the conversation. It is precisely the predictive ability that permits this difference in response. And, the difference in response is caused by the difference in analysis. That is, in order to effectively analyze a given linguistic input, it is necessary to make predictions as to what that input might look like, compare the actual input to the expected input and coordinate both with the memory model. Understanding is, therefore a complicated process which cannot be-reasonably isolated into linguistic and memory components but must be a combined effort of both.

The remaining question is, will the suggestions made here for understanding natural language actually work? The answer is that we can't really know that until we are through. The structures that must be built are large and the number of primitive beliefs and implication rules are also large. But the basic elements of the process should be not much larger than has been described here.

It should in principle, be possible to use the suggestions made here for a beginning to attempt to truly understand input utterances. Our intention is to create a Spinoza III program which will begin to expand these ideas in their intended context.

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