The Structure and Process of Talking About Doing

James A. Levin and Edwin L. Hutchins

Center for Human Information Processing
University of California, San Diego

People talk about what they do, often at the same time as they are doing. This reporting has an important function in coordinating action between people working together on real everyday problems. It is also an important source of data for social scientists studying people's behavior. In this paper, we report on some studies we are doing on report dialogues. We describe two kinds of phenomena we have identified, outline a preliminary process model that integrates the report generation with the processes that are generating the actions being reported upon, and specify a systematic methodology for extracting relevant evidence bearing on these phenomena from text transcripts of talk about doing to use in evaluating the model.

POINT OF VIEW

Reports of problem solving actions are often used as evidence about the underlying cognitive processes involved in generating a problem solution, as "problem solving protocols" (Newell & Simon, 1972). However, these reports are obviously a kind of language interaction in their own right, in which the subject is reporting on his/her own actions to the experimenter. We have analyzed problem solving protocols of people solving a puzzle called "Missionaries and Cannibals" and have found that in their reports, people adopt a "point of view" with respect to the problem, through a consistent use of spatial deixis. For example, when a subject says:

> "... I can't send another cannibal across with another missionary or he will be outnumbered when he gets to the other side ... "

the deixis in her report places her as speaker on the "from" side of the considered action. This is indicated both by the choice of the verb "send" and by the description of "the other side". The same subject indicated the "to" side as her point of view in another part of her protocol:

> "...'cause you've gotta have one person to bring back the boat..."

Here, both the verb "bring" and the adverb "back" indicate "point of view".

Although people almost always unambiguously specify a "point of view" within the problem they are solving in their reports, they also deny awareness of taking such a point of view. However, this point of view is important to the underlying problem solving processes. The strongest evidence for this comes from the high correlation between point of view and errors in problem solving actions. Subjects in the Missionaries and Cannibals task can make errors by taking actions that violate the constraints of the task. Most of these errors occur on the side away from their current "point of view", even though their point of view changes from one physical side to the other during the course of solving the puzzle. More interesting is that most of the "undetected" errors occur on the side away from their point of view. Some errors are spontaneously detected by the subject immediately after taking the action that leads to a violation; others are "undetected". After the experimenter interrupts to point out these undetected errors, the subjects often switch point of view so that the violation condition is now on the same side as the subjects' point of view.

We see the point of view indicated by spatial deixis in the report of problem solving as reflecting an underlying allocation of effort (or attention). Few errors occur with problem elements that are given processing effort, while constraints that are given little attention are more often violated.

In this way, these reports are reflecting changes in the organization of the problem elements that occur over the course of reaching a solution. We have also identified other ways in which reports embody the use of different conceptual organizations of the problem, including organizations that vary from abstract to concrete and from perception oriented to action oriented.

JUSTIFICATION ARGUMENT STRUCTURES

There are multi-utterance structures that occur regularly in problem solving talk that we call "justification argument structures." These structures have the form of:

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(did  ) (do    )          (since    )
(could)+(not do)+(action)+(because)->(justification
(will )                              argument)
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(Alternatively, these two segments can be reversed in order, by using connectives like "therefore" or "so".) For example, these kinds of dialogue units occur in many of the protocols studied by Newell & Simon (1972):

> "Each letter has one and only one numerical value ....
> (E: One numerical value.) There are ten different letters and each of them has one numerical value. Therefore, I can, looking at the two D's each D is 5; therefore, T is zero." (Newell & Simon, 1972:230-231)

In studying our problem solving protocols from the Missionaries and Cannibals puzzle, we have identified several kinds of argument structures, depending on what kinds of problem solving approach each subject took to the problem at each point in time. For example, one common justification argument structure is the "elimination of alternatives" structure: All available actions A_n from this state except A_i can be ruled out. Therefore do action A_i. Here is an example of this kind of argument structure:

> "... If I put a cannibal on, then he goes back and the guys on the other side of the river, the missionary, is outnumbered and he will be eaten. If I put on.... this is all my combinations and permutations.... If I put two missionaries on, I mean two cannibals on the boat and send them back, then it is just ridiculous at the other end. ... so what I'll have to do is one of each."

Another argument form is one we call "pragmatic argument". (We have borrowed many of our names for

argument structures from a rhetoric book (Perelman & Olbrechts-Tyteca, 1969).) Although this book is a "normative" account of argumentation, we find it valuable as a guide to our attempt to give a descriptive account of naturally occurring informal "argumentation" occurring in our subjects' reports of their problem solving.) The pragmatic arguments is: Doing action A would lead to result R (among other things). Result R is undesirable. Therefore don't do action A.
An example from our protocols is:

> "... Both missionaries are going to have to come back because. 'cause if they don't come back, well, one would get left and eaten. So both missionaries come back. ... "

One interesting point about this particular example is that it is embedded within an "elimination of alternatives" argument structure. That is, this "pragmatic argument" is used to eliminate one of the alternatives, leaving only one to take.

A third kind of argument structure we have identified is called "ends-means": If state S occurs, then there is an action A to get to goal G. Therefore establish state S as a subgoal.
For example:

> "... So if ever I could get these over there, I would be O.K. ..."

Obviously, this argument form is similar to the classic "means-ends analysis" proposed as part of many current theories of problem solving. The argument forms we have identified occur when certain kinds of underlying cognitive processing is going on, and this kind of protocol text has been used as evidence for this underlying processing. Some people have assumed that this kind of language interaction corresponds to a subset of the underlying processes (Newell & Simon, 1972). Other people have questioned whether there is any correspondence between what people do and what they say (Nisbett & Wilson, 1977). Our position is that there is a fairly rich interaction between action and report of action, which we will describe in our report of our preliminary process model of doing and reporting. (This position is similar to one outlined recently by Ericsson & Simon (1979).)

A PROCESS MODEL OF DOING AND REPORTING

We have been constructing a process model of problem solving within an activation process framework (Levin, 1976; 1978). Within this framework, multiple processes are simultaneously active, and the the interactions between the active processes is specified by their representations in a network structured long term memory. Each process is active a certain amount, with a certain amount of "salience", and the more salient a process is, the larger its impact on other processes (and therefore on the overall processing).

There are processes that are closely related to the performance of the problem task, and others that are closely related to the report of the task actions. In the particular problem domain of the Missionaries and Cannibals puzzle, the task related actions and objects are defined as concepts in the long term memory that become active during the problem solving. The constraints of the problem are represented in the same way, and get activated to varying degrees during the problem solving. Errors occur when the constraints are insufficiently salient to prevent an action which leads to a violation of that constraint.

Report related processes impact the task behavior by modifying the distribution of salience to the task related processes. "Point of view" of the problem solver has its impact on the processing by adding salience to those active concepts associated with location where the problem solver has conceptually located him/herself. Justification argument structures similarly impact the distribution of salience by increasing the salience of of those inference processes defined to be associated with the argument structures. In this way, language can aid the problem solving, by adding to the resources of the talked about processes. It can also hinder if it locks the problem solver into a particular organization of the problem that isn't fruitful. For example, to the extent that language use focusses salience away from constraints that are being violated causing errors, and especially if this occurs to such an extent that these errors are undetected, then the focussing effect of language can be a barrier to solving the problem.

EVALUATION

So far, we have described some phenomena we have observed in our collection of problem solving reports, and also a preliminary process model of problem solving action and report. How can we use our data to evaluate our model?

There are many levels of evaluative testing that we could use. At one extreme, theories can be strongly evaluated by deriving predictions from them of specific data, which is then collected. Especially when the predicted data are unexpected, this provides a rigorous test of a theory.
At another extreme is a "sufficiency test" (Newell & Simon, 1972). A model of an organism performing some task passes the sufficiency test if it also can perform the same task. This is the evaluation test commonly used today for artificial intelligence models.
A more rigorous test is to try to fit a model to a mass of data. This is the evaluation technique most often used today in evaluating cognitive psychology theories.
A fourth technique is to identify a set of "critical" phenomena in the data against which to evaluate a model of that data. As illustrated in the list below, this is a more powerful evaluation technique that simple sufficiency, but less powerful than the other two techniques. We feel that at this point in the state of the art, this is the appropriate evaluation technique to use to evaluate our process model in light of our data.

1. Sufficiency: Does the model globally perform like the behavior being modelled?
2. Critical phenomena: Does the model exhibit behavior that corresponds to observed selected "critical phenomena" in the data of interest?
3. Close fit of data: Can the model exhibit behavior that corresponds closely to the mass of data of interest?
4. Prediction of unexpected data: Can the model exhibit unexpected behavior that then can be observed?

In order to extract the phenomena we have identified in our data for use in evaluating our model, we have been developing coding techniques that are used by trained human coders. These coders detect and annotate the occurrence of these phenomena in transcripts of problem solving talk. For example, we have been able to train coders to reliably determine a

"point of view" for a problem solver at each point in the problem solving from a record of the problem solving report and a record of moves made. Then, we use this extracted trace to evaluate our model of the role of point of view in problem solving.

SUMMARY

We have reported here a three pronged approach to the study of problem solving action and report: 1) the collected of data on problem solving and talk about problem solving, 2) development of a process model of these behaviors, and 3) use of coding techniques to extract traces of "critical phenomena" from the transcripts for evaluating the model. So far, we have focussed our efforts on two types of problem solving phenomena: the changes in the problem solver's organization of the problem ("point of view"), and systematic multi-utterance structures used to express the forms of inference used to solve the problem ("justification argument structures").

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