Point of View in Problem Solving

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Problem solvers adopt "points of view" when solving problems, expressed through the deixis of their verbalizations, that are strongly related both to the commission of illegal moves and to the occurrence of blocked conditions. This paper describes an analysis of point of view in the Missionaries & Cannibals task, and presents a model for problem solving that incorporates point of view as a resource allocation mechanism useful for dealing with the the finite capacity of human problem solving processing. This analysis relates the subjects' actions in this task to their talk about these actions.

When solving a problem, where do people put themselves? After solving a simple puzzle (the Missionaries & Cannibals task), all of our subjects reported having taken a "bird's eye view", looking down on the puzzle elements from above. Yet their verbal reports of puzzle actions were in terms of motion relative to their own positions, thus placing the problem solvers within the local space of the problem elements rather than removed from it. The English language permits a speaker to describe motion in space relative to his/her own position (or relative to other spatial landmarks). This problem solving "point of view" shifts over the course of solving the problem. More importantly, a person's point of view is related to progress in solving the problem.

The analysis of what people say while solving problems has played an important role in problem solving research. There has been controversy over the status of what people say about what they are doing. At one end of a spectrum, the manifest content of problem solving "protocols" is taken as an accurate reflection of a subset of problem solving processes (Newell & Simon, 1972). At the other end of the spectrum, this kind of talk about action has been rejected as valid data (Nisbitt & Wilson, 1977).

In this paper we take a position that neither assumes a simple link nor dismisses talk but instead closely looks at what the relation is. A detailed examination of the talk about actions in solving a simple puzzle reveals a systematic relation of which the subjects themselves (and previous researchers studying this puzzle) are not consciously aware. This relation can serve as an important building block of a model of problem solving that encompasses both talk and task actions.

In our experiments, the subjects sat facing the experimenter with the puzzle pieces on a table between them. The puzzle pieces consisted of a piece of paper with a river drawn on it, three tokens labeled with Ms to stand for missionaries, three tokens labeled with Cs to stand for the cannibals, and a paper boat that would hold a maximum of two tokens. The object of the Missionaries & Cannibals puzzle is to get all the people across the river using the boat, without ever having more cannibals on a side than missionaries. In all cases, the verbal interaction between the experimenter and the subject was tape recorded.

Point of View

The subjects represent the spatial aspect of the problem in their accounts primarily through the use of deictic verbs (come, go, take, send, bring, etc) and place adverbs (here, there, across, etc). The use of these lexical items positions the speaker relative to a spatial field.

For example, one subject began the task with the following statement:

"I want one cannibal and one missionary, and they go to the other side, and the guy drops off the cannibal and the missionary comes back again."

The condition which has to be met in order for "go" to be appropriate is that the speaker is not at the goal of the action at the time of the utterance (Fillmore, 1974; Clark & Garnica, 1974). For the verb "come" on the other hand, the condition which must be met is that the speaker is at the goal of the action. In this case we therefore assume that the subject has an implicit point of view on the problem which places him on the start shore throughout the two moves described.

Another subject started the task with the next statement:

"First thing I want to do is get a cannibal over to the other side. Let's take him over there with a missionary. Missionary takes the boat back."

In this case the problem solver has expressed a shifting point of view. At the outset, the subjective point of view of the problem solver is at the start shore. This is shown both by the fact that the verb "take" indicates that the subject is not at the goal of the action at the time of the utterance and by the reference to the goal side of the river as 'the other side.' In the course of the move the point of view changes to the goal shore as the problem solver travels with the creatures in taking them to the other side. The point of view of the problem solver remains at the goal shore through the execution of the next move. This is indicated by the deixis of the phrase 'Missionary takes' which again places the subject on the shore of the origin of the action rather than at the goal of the action.

In previous approaches, (Thomas, 1974; Greeno, 1974; Jeffries, Polson, Razran, & Atwood, 1977) the subject was notified immediately upon the production of an illegal state. In the procedure employed here, illegal states were noted by the experimenter, but the subject was not told that an illegal state had been produced until a following move was attempted. This provided the subject with an opportunity to self detect illegal states. If the subject failed to notice an illegal state, it was pointed out by the experimenter when the next move was attempted. This procedure permits us to distinguish illegal states that are self-detected by the subject from those that go unnoticed by the subject.

Any move can be classified in terms of its actual legality and its judged legality. This classification is shown in the two by two table below.

		JUDGED: legal	JUDGED: illegal
ACTUAL	legal	LEGAL MOVE	BLOCKED CONDITION
	illegal	ILLEGAL MOVE	CORRECT REJECTION

Errors of commission

Of these types of moves, the analysis of moves that produce actual illegal states is the most straightforward, so we will begin with it. Since an illegal state is produced when the cannibals outnumber the missionaries on either side of the river, and since they cannot simultaneously outnumber them on both sides, illegal states have a sidedness relative to the river. Where it is possible to determine the subject's point of view at the time of the illegal move, the illegal state can be labeled a near side illegal state or a far side illegal state. Near side illegal states are those in which the rule violation occurs on the same side of the river as the subject's current point of view. Far side illegal states are those in which the rule violation occurs on the side of the river away from the subject's current point of view.

The results of this analysis is shown in Table 2. Of the 15 illegal moves for which it was possible to assign an unambiguous point of view, 10 occured on the river bank away from the point of view of the subject, while only 5 occured on the river bank of the subject's point of view. Further, four of five near side illegal moves were detected by the subject before making another move, while eight of ten far side illegal moves went undetected by the subject.

	Violation side: Near	Far
Detected by subjects	4	2
Undetected by subjects	1	8
Total	5	10

Errors of Omission

The analysis of errors in problem solving has largely focused on errors of commission, the illegal moves that subjects make. However, a "problem" is not just a situation where a person makes illegal moves. It may also be a situation where a person is unable to progress toward some goal, even after repreated attempts. This situation can be caused by "errors of omission", where the person fails to make a progressive move, as well as by the commission of illegal moves.

Legal moves do not have sidedness in the same way that illegal moves do. As noted above, an illegal state results from a rule violation that is located on one side of the river or the other. When there is no rule violation, there is no sidedness. However, these moves are still amenable to point of view analysis.

Novice problem solvers are sometimes blocked several times at the same state before sucessfully getting through it. These several passes through the same state may show changes in point of view. A particular point of view on the problem may lead the subject to discard a legal move, while a different point of view on the same state may make the legality of the next move obvious.

Early research on problem solving, especially that by the Gestalt psychologists, focussed on obstacles to achieving goals. For example, some of the early work by Kohler (1925) looked at how various organisms dealt with a physical block, a wire mesh fence between the organism and some food. How can we characterize the condition of being blocked? Kohler's animals were blocked when they made repeated attempts to get to the goal, none of which made progress toward the goal. These non-progressive moves included backing away from the fence and running into the fence.

By analogy, we can extend this criterion for being blocked into a more abstract task such as the Missionaries and Cannibals puzzle. A subject is blocked in a state when s/he makes at least two non-progressive moves out of that state with no intervening progressive move from that state.

With this definition of a "blocked condition, we identified fourteen instances in our data across the three experiments. In four instances, the subject expressed a definite "point of view" for both the first move taken when blocked and then the first progressive move that broke through the block. In all four cases, the point of view expressed when blocked was different than when not blocked.

Toward An Activation Model of Problem Solving

We have been developing a dynamic interactive model of problem solving, based on an activation framework for cognitive processing (Levin, 1976, 1981). Within this framework, the current state of the problem solving is modelled by the current set of activations of concepts in the problem solver's long term memory. Each activation influences other activations, increasing or decreasing the salience of its neighbors. Processing resource in this framework is directly captured by the salience metric, as highly salient activations have a large influence on the global result of processing, and activations that lose salience disappear from the scene. More salient activations of concepts are more likely to have effect than less salient contradictory activations.

In this model, possible moves in a problem are activated by their pre- and post-condition states. The current state of the problem will be strongly activated by perception, and actions for which the current state is a pre-condition will thus be salient. Post-conditions that are

similar to the goal state are also more salient. Post-conditions that are "illegal" are inhibited by the constraint concepts. The interaction between current state, goals, and constraints creates a dynamic set of activated moves with differing relative saliences.

Point of view, in this framework, is a salience allocation mechanism, contributing salience to the activations associated with the location of the problem solver's diectic position. The likelihood of an illegal move resulting from a violation of a constraint is inversely related to the salience of the constraint activation on the side where the error occurs.

Illegal Moves. Illegal moves are, in this framework, more likely to occur on the "far" side (away from the point of view position of the solver), since those constraints are less salient than "near side" constraints. In addition, detection of an illegal move once made is more likely when the constraint concepts are more salient.

Blocked conditions. A blocked condition results when the progressive move in a situation is less salient than alternative moves. In the simplest case, the progressive move never acquires enough salience to be activated at all. In this case, the problem solver is totally "unaware" of the progressive move. In a more complicated case, the progressive move is considered, but not taken because it is less salient than alternative moves. A change in point of view may shift the relative saliences of the various simultaneously active alternative moves, and thus can lead to the solver selecting the previously rejected move, surmounting the roadblock to progress.

The appearance of point of view in problem solving protocols and its apparent relation to problem solving processing casts new light on the relation of verbal protocols to the processing they describe. Much of the processing that goes into our problem solving is transparent to the solver. That is, we do it and are not aware that we have done it. In the case of point of view, we not only do it, we speak about it as well, and still we are not aware that we have done so. In fact one could (and many have) read the protocols many times and never notice the use of deixis. These transparent processes are important in our problems solving, but they are mercifully invisible to us. Were they continually in consciousness, we would surely become confused. In analysis, we have the luxury of being able to examine both what is being done and how it is being done. In the phenomenon of point of view in problem solving, we see an aspect of the problem solving processing finding expression in the verbal protocol, without the problem solver being aware of it.

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