A Three-space Theory of Problem Solving

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Problem Solving as Search

Newell and Simon (1972) described problem solving in terms of search of problem spaces. This framework has proved to be useful for describing problem solving. However, to encompass a wider range of phenomena, it has been extended in two ways: 1) *dual-space* search; 2) an *understanding process*.

Dual-space search Simon and Lea (1974) proposed that induction can be related to problem solving through a dual-space search. The search for rules that describe a task is conducted in a *rule space*, the states of which are all possible rules, and operators that generate, modify and test rules. Testing requires movement within *instance space*, consisting of all possible states of the task. Klahr and Dunbar (1988) extended the concept of dual-space search and found that testing hypotheses led to better learning.

Understanding processes Before a problem solver can attempt a problem, the problem instructions must be understood. Hayes and Simon (1976) incorporated understanding into Newell and Simon's (1972) framework by proposing understanding as a subprocess that forms a representation of the problem space.

Understanding plus dual-space search

In a dual-space search theory, understanding processes must create the representation of not only the instance space, but of the rule space as well. Thus they define the instance states that can be searched, and the candidate rules that might govern instance states. Given that representations may change during problem solving, understanding processes could be regarded as conducting a form of search. Therefore they can be operators for searching a space consisting of different representational states, with operators that generate, modify, and test the adequacy of representations. We see representational states as encompassing the problem solver's current model of how a task works. Thus we term this space *model space*.

Model space In the three-space theory of problem solving the model space provides the representation of instances, and defines the rule space to be searched. Which rules appear plausible will depend on how a problem solver thinks the task works. For example, if each component of a system is thought to be independent, then rules proposing interactions will not be considered. If the model changes, then interactions may become part of states in rule space. There is no final goal state in model space, a better understanding of the task may always be possible.

The three-space theory of problem solving is presented in Figure 1. The possibility exists of each space affecting each other space, but in different ways. The links leading to model space are dotted because movement in model space may be rare. Note that Figure 1 is not a closed system. The raw data for the model space is provided by the description of the task; instances may require experiments to be evaluated; and memory provides data for movement in each of the spaces.

The three-space theory has both empirical and modeling implications.

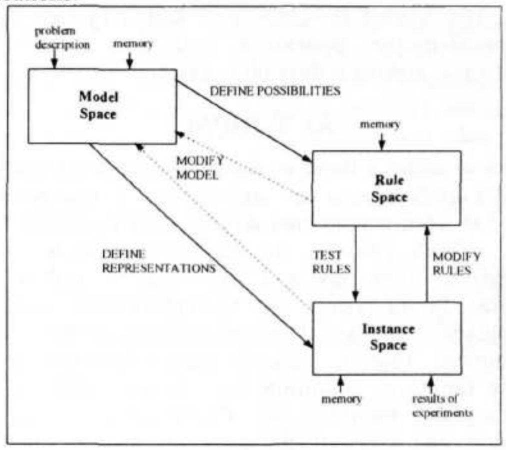

Figure 1: The three-space search theory.

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