Dynamic Constraint Relaxation Approach to Insight *

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In a past decade, more and more researchers have emphasized the emergent nature of cognition, as opposed to the traditional approach that assumes fixed representations and central control mechanism. Among many kinds of emergent cognition, insight has attacted many researchers' attention (Sternberg & Davisdon, 1995).

Insight has several mysterious properties. First of all, problems used in psychological experiments on insight is far from complex. Many subjects can understand the solution immediately after they are taught. However, it is awfully difficult to find it by themselves. Second, people stick to a wrong approach and repeated same errors. When solving a standard non-insight problem, people usually swith to a different strategy or search other paths after noticing failure. But, they do not do so in insight problem-solving. Third, they ignore useful information accidentally found or generated, and only later they realize its usefulness. Finally, insight appears to come to mind suddenly. These mysterious properties prevent the standard problem-solving framework from providing a coherent account.

In order to deal with these problems, we have developed the dynamic constraint relaxation theory of insight (Hiraki & Suzuki, 1998; Suzuki & Hiraki, 1997). This theory consists of three kinds of constraints (object-level, relational, and goal), and a relaxation mechanism. The main idea is that impasses are formed by these constraints and that qualitative changes are caused probabilistically by the failure-driven incremental relaxation of these constraints.

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The object-level constraint reflects people's natural preferences of how given objects are encoded. There are numerous ways of encoding objects. However, this constrains the selection of a specific encoding of a single object among possible alternatives. The relational constraint reflects people's natural preferences of how given objects are related. Like encoding an object, there are numerous ways to relate objects in a given situation. The relational constraint constrains specific types of relations among others. In our theory, each constraints is implemented as a set of strength values of operators which reflect the degrees of fixation. The goal constraint involves the desired state and evaluation function. This constraint evaluates a match between current and desired states, and gives feedback to the constraints responsible for generating the current states.

Initially the object-level and relational constraints jointly operate to lead problem solvers to an impasse. It is important to note that the operator selection by these constraints follows the sotmax algorithm (Bridle, 1989). This means that operators with lower strength values are selected even in the initial stage of their problem-solving, though those with higher ones are selected more often. If subjects' problem-solving attempts result in failure, feedback provided by the goal constraint dynamically changes the strength values of object-level and relational constraints. This increases the probabilities of constraint violations. At a certain point during problem-solving, problem-solvers accidentally violate each constraint appropriately, which provides them AHA experience.

As described above, the theory is based on quite natural assumptions used commonly in many problem-solving studies and very simple relaxation mechanism employed frequently in reinforcement learning. But this simple theory provides coherent explanations for various kinds of phenomena observed in insight problem-solving, such as sudden nature of insight, fixation (Suzuki & Hiraki, in press), effects of various types of hints (Miyazaki et al., 1999), time-course differences of constraint violations (Suzuki et al., 2001), and individual differences (Suzuki et al., in press), as well as the functions of the theory's components (Miyazaki et al., 1999; Suzuki et al., 1999).

Researchers in this fields have proposed various approaches to insight, including constraint relaxation ones. However, there are many important differences between theirs and ours.

Relaxation Our theory involves a clear relaxation mechanism. Knoblich et al. (1999) proposed constraint relaxation as a key mechanism to insight. However, their work only provided an explanation of which constraint is easier to be relaxed than others.

Nature of constraint Constraints proposed by Knoblich et al. are quite problem-specific which have no possibility to apply to other types of problems than the match stick arithmetic. In contrast, the dynamic constraint relaxation theory can apply to various kinds of problems, since the three types of the constraints in our theory are derived from the general nature of problem representation,

Time-course difference Learning occurs during problem solving. However, many theories of insight have not provided an explanation for it. Our theory provides a clear account for the time-course difference during insight problem-solving.

Readiness Several insight literatures reported a mysterious "cue-readiness" that problem-solvers accidentally generate important information, but they simply neglect it. No theory can provide a clear account for it. Our theory provides its explanation in terms of multilevel constraint relaxation.

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