

# Blueprints for thinking

## The role of planning in cognitive development

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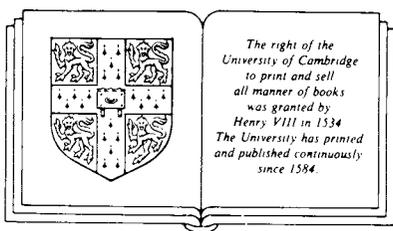
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# 1 The planning construct in the psychological literature

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*Ellin Kofsky Scholnick and Sarah L. Friedman*

## I. The problem of planning

The philosopher Wittgenstein (1953) noted that there are so many definitions of the word “game” that it is difficult to describe what they all have in common. He could just as well have chosen as his example, “planning.” Cognitive scientists have described problem solving as planful behavior and even labeled one problem-solving heuristic as “planning” (e.g., Newell & Simon, 1972). Comprehension of narratives is thought to be based on detection of characters’ plans (e.g., Schank & Abelson, 1977). Discussions of planning enter into analyses of behavioral control and intention. Plans are the subject of theories of behavioral attribution (Schmidt, 1976). Analyses of metacognitive activities, with their focus on executive monitoring and control strategies, also emphasize planning. Memory development (e.g., Brown, Bransford, Ferrara, & Campione, 1983) has been attributed to acquisition of planning skills, which enable the learner to treat each memory task as a problem overcome by shrewd tactics.

Planning has been used to account for so many diverse facets of functioning that the definition of the term has become vague. Two theorists who use the term may not share the same focus. Miller, Galanter, and Pribram (1960) define planning as execution of a behavior that matches a scheme, whereas Hayes-Roth and Hayes-Roth (1979) include anticipating a course of action as well.

No wonder there is such confusion. Planning is a set of complex conceptual activities that anticipate and regulate behavior. Planning relies on representation of the environment, anticipation of solutions to problems, and then monitoring of strategies to see whether they meet the problem and follow the plan. To plan is to act simultaneously on three levels: in the reality of a problem, in accordance with an imagined scheme, and in the role of mediator between the scheme and the behavior. The variety

of definitions of planning may result from emphasis on one of the three levels of planning activity; in turn, the vagueness may reflect a failure to specify which of the levels is being referred to or how the levels are integrated. An adequate theory of planning has to be very comprehensive and to encompass every level of cognition.

Second, planning has been treated from two frameworks, as a general cognitive skill or as a context-specific activity. Many theories of problem solving emphasize the general structure of planning activity, whereas in the study of memory and conversation the focus is on context-specific strategies, which are regarded as the same as plans. Because plans for conversation may have little to do with plans to reconstruct the Tower of Hanoi, it is hard for the reader to arrive at a definition of planning.

Yet a third source of confusion arises because in some theories, such as in the realm of problem solving, planning is a mandatory activity and little attention is devoted to the factors that prompt the person to plan in the first place. However, planning may be optional and the decision whether or not to plan may be determined by individual differences on dimensions such as cultural or personal norms about the desirability of plans, familiarity with the context in which planning is called for, and the cognitive and motivational status of the individual. Theories that regard planning as mandatory focus on the construction of the plan to the neglect of motivational aspects, whereas theories that recognize that planning does not always take place may concentrate on explaining why people plan and thus may deemphasize the mechanisms of planning. A fourth reason for the diversity is that some theories attempt to account for individual differences in planning efficiency in terms of the number of planning components present and the speed of their execution. Others stress stylistic variations in approaches to planning dependent on contextual cues. The stylistic variations may reflect qualitative differences in performance.

Yet a fifth reason why discussions of planning seem so diffuse is that planning not only takes place on many levels but also involves many different activities, each reflecting a facet of goal-directed action. Different analyses of planning emphasize different aspects of the course of goal-directed behavior, leading to the confusion. The aim of this chapter is to analyze which aspects of goal-directed action are captured by different theories of planning. We will even show that dictionary definitions of planning do the same, and focus on different aspects of motivated behavior. We hope that this framework will serve as a basis for understanding the chapters in this volume and the larger field as well.

## II. A plan for the discussion of plans

There is a difference between the action of Halley's comet and the behavior of the director of the Office of Management and Budget. Only the director is planful. Plans are the expression of goal-directed behavior, and more specifically, of behavior that is voluntary, self-conscious, and intended (e.g., Chapman, 1984; Kreitler & Kreitler, 1976). Goal-directed behavior has many components. Understanding a behavior requires knowledge of how individuals represent the environment and the problems that arise, decide on a goal that solves their problem, formulate a set of strategies to reach the goal, execute the strategies they have chosen, monitor and repair their strategic decisions and actions, and evaluate the outcome of actions and the schemes that guided them (e.g., Hayes, 1981). It is our contention that theories of planning tend to single out one or more of these components of goal-directed action and use them as the basis for their models of planning. Our discussion of plans will emphasize these structural components, but we shall also examine how these components are influenced by developmental and cultural differences. When presenting the structural components of planning, we will describe how these were treated in the existing psychological literature on planning as a general cognitive skill and in specific domains such as writing or story grammars. We will also deal with individual differences, and speculate where developmental changes are to be expected. Information about the development of planning receives additional consideration at the end of the chapter, where we draw together analyses of the origins of planning. Thus the plan for this chapter is to present a framework for viewing theories of planning and its developmental prerequisites.

## III. The components of goal-directed action

### A. Representation

In the *Oxford English Dictionary* (1971, p. 2195) one definition of "plan" was the inspiration for the title of this book, *Blueprints for thinking*. A "plan" is a "diagram, table or program indicating the relations of some set of objects or the times or places of some intended proceedings." This definition has two important implications. First, "plan" is not an action but an entity, such as a "map." Second, the definition emphasizes a crucial prerequisite for planning – the availability of a mental representation of the spatial and causal structure of particular events. Action always

takes place in an environment, but that environment is not always a direct copy of the stimulus world. Instead people mentally recreate the stimulus world to reflect their understanding of how, when, and where individuals and objects function. This representation of the environment constrains definitions of problems, goals, and means to solution. Consequently, plans and the actions they inspire reflect people's representations of the setting for a problem. Whereas few planning theorists only describe the model of the environment that people use in creating plans, several planning theorists claim that the content of plans is determined by a person's model of physical and psychological causation.

Discussions of representation in planning vary on two dimensions. First, some planning theorists argue that the planner's representation is a relatively faithful model of the problem space, although it may be incomplete. We will call these "veridical" models. Other theories note the existence of biases towards selecting aspects of the environment due to "idiosyncratic" personal experiences. Failures in problem solving reflect distortions in representation, not gaps. Those distortions are most apparent in problems that have open-ended solutions. Thus the first contrast is between veridical versus idiosyncratic representations. Second, some discussions of representation in planning attempt to account for particular problem-solving tasks, whereas others attempt to account for a general representation of the environment that would enable planning of any type to occur.

*1. Veridical-general plans.* Emphasis on the importance of initial representations is apparent in many discussions of text comprehension and problem solving. Because they postulate grammars or normative analyses of events, we discuss their content here. Story grammars, which relate the course of intentional behavior, begin with the setting that defines the framework for the plot (e.g., Rumelhart, 1977; Stein & Glenn, 1979). According to Newell and Simon (1972), problem solving starts with an analysis of the subject's representation of the initial parameters of the task because that initial state is a key determinant of performance. In Schank and Abelson's theory, a normative representation of goal-directed behavior is the basis for an entire theory of planning.

Schank and Abelson's description of plans arose from their attempts to write a computer simulation of text comprehension. Although they were concerned with the objective structure of narratives, their theory is meant to account for representation of any goal-directed behavior. They define plan as a

repository for general information that will connect events . . . made up of general information about how actors achieve goals. A plan explains how a given state or event was prerequisite for, or derivative of another state or event. (Schank & Abelson, 1977, p. 70)

The content of a plan as representation goes well beyond our earlier definition of representation of the initial problem state. Plans include representation of the goal and knowledge of the methods that would enable reaching it. The methods or plan boxes include knowledge of the properties and location of the goal object, ways to gain control over it, and preparations to use the object once it is obtained. Readers who possess such a comprehensive representation can determine whether each component is present in a text. If components are missing, they can note how story characters attempt to produce the necessary preconditions.

From this perspective, plans reflect theories or abstractions about the structure of the social and physical environment (e.g., Brown, Collins, & Harris, 1978; Bruce, 1980; Kagan, 1984). Therefore, examination of plans provides a window into the nature of representation. The content of plans may also vary with age and cultural setting. Two- and 3-year olds can already recognize when an object, an event, or a behavior deviates from a standard (i.e., representation) they have abstracted (Kagan, 1984). Yet because they are ignorant of the meaning of an action, its preconditions, and usual consequences, they may have difficulty generating adequate plans. Because plans tap expectations of normative behaviors and motives associated with particular situations, there are bound to be differences among cultures in the content, if not the structure of plans.

Two chapters in this volume describe the development of planning in terms of general representational skills. De Lisi suggests that advances in planning result from advances in representational skill. Cocking and Copple search for the origins of representational skills by examining several representational media such as play and art.

2. *Veridical-specific plans.* Schank and Abelson discussed the general structure of plans, but plans are often tailored to specific circumstances. The Hayes-Roths' (Hayes-Roth & Hayes-Roth, 1979) description of errand planning includes among the components of planning a knowledge base that contains situation-specific data. When the plan is to eat at a restaurant, the knowledge base provides data on specific routes and other information useful for testing the viability of the plan. Even if people had general spatial and causal knowledge, a plan would be inadequate without knowledge of the local environment. The Hayes-Roths' model

stresses the importance of translating abstract plans into tactics consistent with local conditions.

These vertical models of planning suggest that an essential component of planning is a representation of the environment that contains both the general causal and spatial networks that underlie interactions and the local conditions for generating and executing particular plans. From the cognitive science viewpoint, planners need a richly structured knowledge base. Developmental differences in planning often reflect differences in knowledge. As in any domain of problem solving, the child will appear more expert when the plans to be generated deal with familiar circumstances. When we look at the origin of plans, the question is not merely the quantity of knowledge entering a representation, but the emergence of symbolic skills toward the end of the first year of life.

*3. Idiosyncratic-specific plans.* John Bowlby (1969) and Hans and Shulamith Kreitler (1976) suggest that the specific information and global world view that people incorporate into their representation of reality and therefore into their plans may be biased by idiosyncratic personal experiences. In trying to account for individual differences in attachment behavior, Bowlby attributes one source of variation to the person's model of the interpersonal and physical environment in which attachments are created.

During his second and third [year] when he acquires the powerful and extraordinary gift of language, a child is busy constructing working models of how the physical world may be expected to behave, how he himself may be expected to behave, and how each interacts with all the others. Within the framework of these working models he evaluates the situation and makes his plans. How these models are built up and thenceforth bias perception and evaluation, how adequate and effective for planning they become, how distorted as representations they are and what conditions help or hinder their development, all of these are matters of great consequence for understanding. (Bowlby, 1969, p. 304)

For Bowlby, the origin of planning is toddlers' growing awareness of their own intentions and the intentions of their attachment figures. The discovery of differences between the two sets of intentions leads to plans to make them agree. These interpersonal plans are shaped by the child's concepts of the self and others as loving and lovable as well as the complexity and adequacy of the child's working model of the world.

*4. Idiosyncratic-general plans.* The Kreitlers (e.g., Kreitler & Kreitler, 1976) who are contributors to this volume, also stress the role of personal meanings in constructing a representational model in which planning can

take place. However, their model extends to all domains of planning, and they are more specific about the constituents of planning. They suggest that one of the first steps in formulating a plan is stimulus interpretation. People impose meaning dimensions on events, and individual differences in behavior are predictable from knowledge of the availability and frequency of use of those dimensions. The Kreitlers describe four kinds of meaning variables: (a) contents (such as temporal, sensory, or emotional); (b) logical form of the relation between meaning and object (such as negation); (c) type of relation (such as similarity or comparison); and (d) relation to other objects in the representational or semantic field. Of greatest interest are the content dimensions that are conducive to and may even be prerequisites for planning. Because planning takes place in space and time, attention to these dimensions fosters planning. People who are interested in how things work are probably going to devise effective plans. Plans involve both contingent and causal relations so that the tendency to analyze sequences and notice antecedents and consequences sets the stage for planning. Sensitivity to the range of situations in which particular relations hold may also facilitate plan construction. Because novel plans often develop through noticing analogies to similar circumstances, the tendency to engage in comparisons may also foster planning.

The salience of these meaning variables may predict general planning skills. Moreover, people may be more prone to construct or use plans that incorporate particular content if that content is more prominent in their meaning network. A popular planning task, the Tower of Hanoi (Anzai & Simon, 1979; Klahr, 1978), sets the problem of transferring rings stacked on a pole in increasing size order to another pole without violating the size order. Someone who is conscious of size differences may be more successful on the Tower task than someone else who is highly attuned to feelings and who in turn may excel in planning resolutions to interpersonal dilemmas (Spivack & Shure, 1974).

The Kreitlers have devoted most of their attention to analyzing the sources of individual differences in "cognitive orientation" and to the implications of such differences for the content and adequacy of plans. They have extended their analyses of individual variations beyond the content of plans to the goals plans are intended to fulfill. Yet the Kreitlers' list of meaning variables is also a rich source for a developmental analysis of the cognitive prerequisites for planning. Planning frequently requires awareness of the spatial, temporal, causal, and enablement relations in an environment (see also Brown, Collins & Harris, 1978; Pea, 1982; Wilensky, 1981a, 1981b). If the child does not have these meaning dimensions available or if they are available in an incomplete form, those gaps will

handicap planning. Attempts to teach interpersonal planning to children (e.g., Spivack & Shure, 1974) incorporate lessons on these same conceptual prerequisites. Similarly, Piaget (e.g., 1978) noted that thorough understanding of the mechanisms of causation is a prerequisite for anticipatory planning.

### *B. Choosing a goal*

Knowledge of the environment is insufficient for forming a plan because the planner must also know how to define and evaluate goals. So we turn to the next step in planning. This facet of intentional behavior is the basis for one dictionary definition of a plan as "a project or definite purpose" (Stein, 1975 p. 1015). The amount of attention the process of goal definition receives in a theory of planning seems to depend upon the kinds of tasks to be accounted for and the model of the planner. Some problems have well-defined goals or "final states" (Newell & Simon, 1972) which people are presumed to know in advance and to maintain intact during problem solving as a guide to behavior. Alternatively, some problems like essay writing are ill defined (Flower & Hayes, 1981). Often, even when the goals are clear, people prefer to work opportunistically, refining and redefining goals as they learn more about the task and the outcomes of initial actions (e.g., Hayes-Roth & Hayes-Roth, 1979). Fluid goals may also characterize planners who are inexperienced or who have multiple, conflicting aims (e.g., Bruce & Newman, 1978; Wilensky, 1981a, 1981b). Theories that account for problem solving in ill-defined domains and for planners who are opportunistic, inexpert, or conflicted often include elaborate descriptions of the mechanics of goal selection. In contrast, discussion of the process of goal definition is skeletal in analyses of performance on tasks with well-defined end states (e.g., Newell & Simon, 1972). When a problem is defined by the experimenter and understood by the planner, the leap from problem representation to specification of the nature of an appropriate solution may be so rapid that the appeal to elaborate goal detection mechanisms may be unnecessary.

*1. Detection.* Cognitive science models of planning or plan comprehension discuss three aspects of defining a goal: detection, monitoring, and evaluation. In accounting for story comprehension and demanding problem solving, Anderson (1983) and Greeno, Riley, and Gelman (1984) invoke a pattern recognition device. The device scans situations to detect the conditions that invoke certain learned problem-solving procedures with their associated goals. Algebraic equations may immediately elicit the goal of placing the unknowns on one side of the equation (e.g.,

Brown, Collins, & Harris, 1978). Goal detection is inherent in the situation and is managed automatically by production statements. In the problem-solving strategy of means-end analyses, where the goal is well defined, individuals analyze the preconditions for solution and then choose subgoals to realize those preconditions.

Both Schank and Abelson (1977) and Schmidt (1976) have posited a motivation analyzer or detector that scans people's actions and infers from them the goals that motivated them. Those inferences are based on a model of universal motivations or standard goals such as fulfillment of biological needs and self-preservation and a set of role stereotypes about the kinds of motives particular people like stockbrokers might possess. Failure to detect the goal results in inappropriate plans and problem-solving strategies. One prevalent explanation of young children's poor performance on Piagetian tasks is that they do not share the same view of the task and do not have the same goals as the experimenter (e.g., Donaldson, 1979) and hence do not create adequate problem-solving plans.

2. *Monitoring.* Schank and Abelson suggest a second role for the system which deals with goals: monitoring their fate during the execution of a planned action. Goals may be changed in midstream; one goal may be substituted for another or abandoned. Sometimes completion of one goal is interrupted until another more pressing goal is satisfied. The monitor keeps track of every goal so that the problem solver can return to it when disrupted or can explain why goals have been cast aside.

3. *Evaluation.* Wilensky (1981a, 1981b) adds evaluation to the other functions of the goal system because he tries to account for situations in which multiple goals arise. He proposes a "goal detector" that will eventually generate goals to be handed on to the rest of the system, which will then create and execute plans. The goal detector often works simultaneously on many overlapping or conflicting goals. On the basis of evaluative criteria, the "generator" selects the goals to be used in forming plans. The generator is aided by a "noticer," which monitors the person's internal states (such as hunger) and external conditions (e.g., the presence of an ice-cream vendor) for changes of interest to the system. This input helps the evaluation of the importance and feasibility of realizing particular past and present goals. Thus the noticer detects needs, opportunities, and potential dangers, which form the basis for evaluation.

4. *Selection.* Intertwined with the formation, monitoring, and evaluation of goals is the process of goal selection. In explanations of planning in well-defined problems, goal selection is a mechanical property of the

system. In Anderson's (1983) analysis, goals are stacked by recency, situational fit, and past success. Schank and Abelson (1977) propose that goals are stacked in terms of their availability, feasibility, cost, and effort in attaining them. But who does the computation, and how does the system learn to adopt those criteria? Greeno and his colleagues (1984) contend that problem solvers themselves evaluate the goals they detect to see if the prerequisite and corequisite conditions for goal attainment exist. For example, when the goal is to attend a wedding in a distant city, the potential guest checks the availability of money, a local airport, and a convenient flight schedule. In both Wilensky's and the Hayes-Roths' theory, decision making is assigned to a particular specialist. The noticer in Wilensky's system prioritizes according to a fixed set of instructions. Some instructions eliminate goals that are unfeasible, difficult, or impossible to achieve. Similarly, like Schank and Abelson, Wilensky claims that some instructions incorporate a cost-benefit analysis. The noticer is instructed to choose the goal that is the most valuable and least costly in terms of time and effort. Other instructions describe ways to combine goals for multiple plans so as to conserve resources. The metaplan in the Hayes-Roths' model actually constructs task-specific decision criteria.

Wilensky's model assumes that all planners use the same criteria with the same weightings to set goals and that planners have the knowledge germane to those decisions as well as the competence to calculate those weightings. Both developmental and cross-cultural researchers are wary of these assumptions. Children may not know what is realizable because of inadequate evaluation of their own ability. They may value efficiency less and consider any solution adequate. Hayes-Roth (1980) contends that young children may be less prone to evaluate consciously their goal choices, and even adults may not set appropriate priorities during planning because they misconstrue the task constraints and their own resources. As we shall see in the next section, people may also decide that it is too costly to analyze goals. They would prefer to devote their effort to action rather than to goal choice and planning. Finally, people possess different values. Dreher and Oerter in this volume (also Oerter, 1978) note that Western societies value highly economy of effort and delegation of responsibility. Each value dictates the necessity of planning as well as the contents of plans. The Kreitlers (1976) argue that a theory of goal choice also assumes a theory about what the person wants to attain, thinks others attain, and thinks are general standards for goal attainment. People actually work with *several* theories of goal evaluation which may be difficult to reconcile.

In summary, planning involves goal choice. Few theories of planning discuss solely goal selection, but it is central to Wilensky's analysis. As in

our analysis of representation, this component in planning is very complicated, requiring an elaborate model of decision making. Developmental psychologists are particularly interested in the origin of priorities and growth in skills in weighing and computing such priorities.

### *C. Deciding to plan*

The elaborate analysis of goals assumes a reflective problem solver using a set of criteria to evaluate goals and then proceeding to be equally reflective in devising a plan for goal satisfaction. In reality, vast individual differences exist in the extent to which people deliberate when choosing means to satisfy goals. We capture this aspect of planning in the adjective “planful.”

Although many cognitive science models of planning assume that once a goal is chosen, the individual automatically stops to plan an attack, many developmental and personality theorists have speculated about the origins of planfulness, the kinds of situations that evoke planning, and the kinds of persons who plan. Often young children, and impulsive, hyperactive, and distractible individuals do not plan, so there have been several theories that emphasize planfulness and many programs that attempt to remediate deficiencies in planfulness. Those analyses stress one or more of the following components underlying planfulness: (a) a set of beliefs about the self and the task; (b) sensitivity to the situations that warrant planning; (c) the status of the strategy to be activated by a plan; and, most importantly (d) the level of the person’s self-control.

*1. Planning beliefs.* European Action Theory, which inspired the research of Oppenheimer and Dreher and Oerter in this volume, addresses the beliefs that underlie planfulness. Skinner and Chapman (1984) suggest that how and whether the individual plans depends on a constellation of three beliefs. The raw material for planning, as we have stated in the section on representation, comes from the individual’s beliefs about the causal structure of the physical environment in which planning occurs. A second set of environmental beliefs about control also affects planning. Assumptions that factors such as fate, chance, the forces of nature, or an unresponsive government completely determine the outcome of events hamper willingness to plan. Often the elderly and impoverished fail to plan because they feel themselves at the mercy of uncontrollable forces. Thus European Action Theory includes the same factors found in American theories of locus of control and social attribution and specifically applies them to the decision to plan. As in those theories, an additional set of beliefs about the self also influences decisions to plan.

Skinner and Chapman call those beliefs "agency," whereas Bandura (1981) has labeled them "self-efficacy." Planners must believe they can reach a goal by their own efforts. People who deem themselves incompetent may fail to plan because they think they are incapable of carrying an action through to its conclusion.

Skinner and Chapman suggest that this triad of beliefs has a social origin because cultures transmit opinions about people's ability to control events in general and beliefs about the ages at which mastery is likely to arise and to diminish. They differentiate occupations and educational levels on the basis of the extent to which they require planning. Dreher and Oerter's data on planning in this volume support this view. Moreover, social interactions provide information about personal competencies. The chapter by McGillicuddy-De Lisi and her colleagues describes how a handicapped child affects parental expectations of planning.

2. *Knowing when to plan.* General beliefs about one's ability to affect a malleable environment are often supplemented by knowledge of situations where plans would be helpful. The most extensive discussions of situations that lend themselves to planning appears in the metacognitive literature. In examining research on use of mnemonic strategies and communication skills (e.g., Flavell, 1977; Patterson & Roberts, 1982), it became apparent that children may understand the goal of a task but that they are ineffective problem solvers because they do not know they *need* to step back from the problem to plot a solution that capitalizes on what they know about themselves and the problem-solving environment. De Lisi in this volume suggests that awareness of the need to plan characterizes one of the most mature forms of planning.

As in other aspects of planning, there is controversy over the nature of the need to be planful. The debate lies between those who use a general problem-solving approach versus those who analyze situation-specific cues prompting planfulness. The general approach stems from work with impulsive children, which demonstrated that teaching specific plans had little impact on behavior. Numerous researchers tried to hand children ready-made strategies and plans, but once prompts to use plans ceased, the children ceased using them (e.g., Borkowski, 1985). Knowing when and why a strategy is useful facilitates deliberation in children. Similarly, training programs for children whose impulsivity and distractibility makes them poor planners have often handed children plans of action that specify when the child is to act and what is to be done, but the child used the plan only in the setting in which it was taught unless he or she