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COGNITIVE DEVELOPMENT
A Competence-Activation/Utilization Approach

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A dilemma that has obstructed the pursuit of satisfactory explanations of human behavior is that, on the one hand, there appears to be sufficient constancy of behavior across variable environmental conditions to warrant the inference that explanation requires the introduction of dispositional concepts (e.g., schemes, operations, structures, rules); on the other hand, behavior is also variable among individuals to the point that explanation requires the specification of environmental determinants. Frequently, investigators have sought to resolve the dilemma by denying or trivializing one or the other of its components. For example, contemporary structuralists sometimes appear to argue that universal structures, rules, or central-processing mechanisms are the sine qua non of explanation and treat individual differences and environmental effects as epiphenomena. Approaching from the opposite extreme, situationists propose that universal structures are at best temporary expedients and that ultimately these epiphenomena, as well as the variability of behavior, will be explainable by environmental determinants (Bowers, 1973).

Over the past several years, a relatively novel approach to the problem has been evolving in the field of cognitive development. This approach is characterized by the explicit assumption that both universal formal features and contingent features must be introduced as coequals for a complete understanding of behavior. From this perspective, the question is not which type of explanatory form ultimately explains behavior, but how are the two forms best interrelated to produce a more complete explanation. The approach itself has been generated by what has been termed the "competence–performance distinction" (Flavell & Wohlwill, 1969), but because this terminology has often led to some confusion, we will generally refer to the competence–activation/utilization model (Overton, 1976).

The aim of this chapter is to sketch several important features of this approach and to examine some of the empirical literature relevant to it. In pursuit of this aim we will first examine the competence–performance distinction. More specifically, we will examine the acquisition of competence, the research strategies generated by the distinction, and the criticisms raised against it. Next, issues and research entailing the activation of competence by various environmental contingencies will be explored, and finally, similar consideration will be given to factors that determine the utilization of competence.

THE COMPETENCE–PERFORMANCE DISTINCTION

This position maintains that a complete psychological theory would require two distinct components. The competence component or model entails idealized abstract systems of the form or structure of the individual's knowledge in various cognitive domains. The systems might alternatively be represented as rules, strategies, or logical systems. The performance, or activation/utilization, component or model involves the psychological processes along with task and situational factors that determine the application of competence in actual thought or behavior. Activation/utilization features might include memory, cognitive styles, task familiarity, stimulus features of the task, and so forth.

Because Piaget's theory of cognitive development has generated most of the research on this topic and because this theory presents the most clearly articulated competence model available, we will consider this theory throughout the remainder of this chapter both for illustrative purposes and for purposes of reviewing issues and research. However, competence–performance distinctions have been described in many areas of psychology. The current version was imported from psycholinguistics (Chomsky, 1965) by Flavell and Wohlwill (1969). In earlier years Werner (1937) made a similar distinction in cognitive development and termed it the process–achievement distinction. Hull (1943) employed the learning/habit–performance distinction, Lewin (1951) the genotype–phenotype distinction. More recently, in the area of verbal learning, Postman (1968) suggested relating "association" as a dispositional competence factor to performance factors such as drive and instructional effects. In the memory literature, Tulving and Pearlstone (1966) distinguished between the availability and accessibility of information, while Reese's (1962) concept of mediational deficiency and Flavell's (1970) concept of production deficiency focused on the absence of competence versus the failure of performance factors to elicit competence. Finally, in the area of social behavior, both Bandura (1977) and Mischel (1973) distinguish between an acquisition phase (competence) and a performance phase.

Piaget's theory is a theory of competence. As numerous investigators have noted, Piaget paid little systematic attention to the role of individual differences or contingent determinants of behavior. This should not be taken as a criticism, for Piaget chose an epistemologically distinct strategy from one that requires explanation of behavior in terms of contingent events. Piaget's strategy for understanding the cognitive domain, and Chomsky's for understanding language, requires that the theorist answer the following Kantian question: What must one *necessarily* assume about the nature of the organism in order for it to have the behaviors which it does exhibit? The method for answering this question is that of observing a sufficient subset of behaviors in the domain in question and constructing a competence model that best captures the universal features of the subset. If the model is valid and powerful, it will prove through further empirical demonstrations to be applicable to a much wider array of behaviors in the domain. The particular form of such a competence model is also guided by issues of parsimony, simplicity, internal coherence, and aesthetics (Miller, 1975; Stone & Day, 1980).

For Piaget, the construction of a model (and hence a *formal* explanation) of the universal features of cognitive skills was complicated by a developmental perspective which led to the view that there are progressive and qualitative changes in the nature of these features. This meant that several distinct but interrelated competence models were required. Piaget's solution was to construct four distinct models as the "best" representation of seemingly discontinuous cognitive skills that develop between infancy and adolescence. These are (1) the action schemes as integrated in structures d'ensemble at the sensory motor period; (2) the nascent operations of the preoperational period; (3) operatory structures as organized in logical groupings at the concrete operational period; and (4) operatory structures organized as a logical group at the period of formal operations. The first two of these competence models are presented in straightforward verbal format in the theory, while the competence models for the concrete operational and formal operational periods are presented in a logical format.

Two points are of general importance here. First, the format of the competence model is relatively independent of its validity (although it may be argued that logical–mathematical models are more powerful than other formats). Thus competence models may be presented as rules, logical–mathematical systems, strategies, structures, central-processing mechanisms, or in any number of other formats. The second point is that the failure of a particular competence model to demonstrate its adequacy through empirical tests is not a valid argument against the employment of competence models as necessary explanations of the domain under examination. This point may seem banal, but one hears arguments of the form "Since Piaget's INRC group is not a good model of adolescent thought, we should abandon a structural approach" with sufficient frequency to warrant this caveat.

The Acquisition of Competence

Before turning to an appraisal of competence models as psychological theory and consequently to the need for the introduction of activation/utilization processes, a few remarks are necessary concerning the developmental acquisition of the universal features represented by the competence model. These comments are made to note that contingent events do not enter as causal determinants with respect to competence, and hence their role must lie in other areas. Piaget's theory is again illustrative. As noted, the description of competence is provided by the structural and stage components of the theory. The answer to the question of how competence develops is provided by the functional component of the theory (see Overton, 1972). Here it is proposed that the infant begins with two defining characteristics: (1) a biological competence (actually a fifth model of competence but biological rather than psychological) and (2) an inherent activity. The latter is further specified by that primary phase of the activity which modifies the environment in conformity to the demands of the competence or structure (assimilation) and that phase which modifies the structures in conformity with the assimilated demands of the environment (accommodation). The theory assumes an inherent necessary movement from a state in which these twin activities are out of equilibrium to a state in which they are in equilibrium (i.e., match the ideal competence model of that period). The theory further assumes that following the development of competence at any given level, there is an inherent and necessary movement (reflective abstraction) to the next level (toward the next match) and the process repeats itself at each higher plane (the equilibration process). Two points should be made with respect to this developmental model. First, although the Genevans have recently tended to discuss the features of this model in process terms, it is basically a model that provides the necessary and universal features of development (Overton & Reese, 1981). That is, the developmental model is itself essentially a competence model which organizes the other competence models and thus provides an explanation (again formal) for their order and direction of development. The second and related point is that as a formal model, specific contingent events, such as environmental effects, do not enter as causal explanations of development. Contingent events are excluded by the logic of the position, and environmental effects enter only as they are themselves constituted by the formally defined processes. For this reason it has been maintained that contingent events can affect only the rate and terminal level of development and not the natural course of development (Overton & Reese, 1981).

The Competence–Activation/Utilization Approach

The ideal aim of any theory is to provide a complete explanation of the field under consideration. As described, Piaget's theory or any other competence model provides formal explanations; that is, explanation of the necessary and universal features of cognitive development. Thus competence theories explain the constancy of behavior–both momentary constancy and constancy of development–across variable environmental contingencies and across variable individuals. Such theories, although necessary for complete explanation, are not sufficient because they do not address the variability that also appears in behavior. In the past, such a deficiency in scope has often been interpreted as an inherent flaw in approach, and investigators who have been impressed with the variability of behavior have urged the abandonment of competence theories in favor of explanations based totally on contingent events. The unfortunate consequence of this latter approach is that as it is followed, it eventually becomes evident that explanations based on contingent events are not sufficient to account for the constancy of behavior (e.g., Cronbach, 1975; Gergen, in press). This in turn leads back to formal competence models, and the cycle repeats itself again and again.

The competence–activation/utilization approach is an attempt to break this vicious cycle. Conceptually, the approach involves the marriage of two distinct epistemologies. The marriage metaphor is here taken seriously because as in any good marriage the individual partners must maintain their individual identities and develop their own individual talents while cooperating and dividing their labors to achieve long-term aims and goals. The partners in the competence–activation/utilization marriage are those who have pursued a rationalist understanding of science and those who have pursued an understanding of science based on empiricism, and the primary long-term goal is the complete explanation of behavior.

Traditionally, the rationalists have followed Aristotle's distinction between the "necessary" and the "accidental." For the rationalist, scientific explanation consists of formulating formal laws of the regular, the normal, the necessary. Accidental or contingent events merely facilitate, inhibit, or deflect; they are not the essentials of science. Thus competence, as the formal explanation of cognition and its development, has often been the sine qua non for the rationalists, and the manner in which this competence is affected by various task and situational factors has been treated as unimportant (for an important contemporary exception, see Pascual-Leone & Sparkman, 1980).

For the philosophical empiricists, scientific explanation has consisted of attempting to derive laws from contingent observable events. From the manifold possible events that might affect behavior, specific variables are selected for experimental scrutiny under the assumption that discoverable cause–effect relations will ultimately yield generalized causal laws. Thus from this perspective, explanation begins and ends with a primary focus on antecedent variables. Investigations explore the presumed causal relation between factors such as memory, attention, individual differences, task features, situational features, and the behavior to be explained. Formal explanations (i.e., competence models) are viewed, at best, as temporary expedients to be granted only until observation and experimentation reveal the "real" (causal) explanations. At worst, formal explanations are viewed as a flight of fantasy (mentalism) that obscure the search for "real" explanations and beg the "real" questions.

Research Strategies

A marriage of these two historical rivals requires a continuing recognition of the independent but significant contribution of each partner, of the differential roles each plays in the overall explanatory effort, and of the ways in which cooperation rather than competition may be enhanced throughout this process. This recognition yields three relatively independent but interrelated research strategies. First is the strategy of formulating the idealized abstract models that constitute competence at each level of cognitive development. This is the problem of representing the organization–not the content–of knowledge at each level. Here the ambiguities and vagueness of specific psychological processes and specific task and situational anomalies are subsumed to the interest of providing general representations of the necessary fundamental features of thought.

The second research strategy involves the validation of the proposed competence. Here the research task is that of conducting studies which control individual psychological processes, task variables, and situational variables in an effort to demonstrate that the proposed competence has empirical as well as rational meaning. Thus, for example, it might be asked whether Piaget's logical grouping "primary addition of classes" is an adequate representation of the 8- to 10-year-old's understanding of problems involving hierarchical classes. This question may be answered empirically, providing that such processes as memory demand, attention, and emotional state and such task factors as stimulus saliency, response bias, and task instructions are carefully controlled. It should also be noted that well-controlled studies that fail to validate a particular representation of competence may provide clues for more adequate representations; they do not, however, as noted earlier, falsify the view that competence is a necessary component of a theory of cognitive development.

These first two research strategies focus on competence and bracket or control performance variables, and these will be discussed briefly when we turn to an examination of specific issues and research. The third strategy accepts competence as represented and focuses on performance variables themselves in an effort to discover how these are related to and determine the application of competence in actual thought or behavior. Here it is explicitly recognized that predictions concerning thought or behavior based on competence are distorted by various performance variables. Within this strategy, several research questions may be raised. One question asks how performance variables might enhance or retard the rate of the acquisition of competence. A second question asks how performance variables might activate the application of recently acquired competence. A third question asks how performance variables might facilitate or hinder the utilization of competence given that competence has been fully consolidated and stabilized. While the first of these questions is beyond the scope of this chapter, we will examine some issues and research related to the latter two questions.

Criticisms

Before turning directly to an examination of various issues and investigations generated by these research strategies, several criticisms of the legitimacy of a competence–performance distinction should be addressed. A common criticism maintains that sufficient constancy has not been demonstrated to warrant the inference of competence. The problem here is the question of what constitutes "sufficient" constancy, and unfortunately the answer often lies in the eye of the beholder. That is, in a good deal of psychological work significant correlations between performances on various tasks in the order of .40 or above are accepted as meaningful in suggesting a reasonable degree of constancy across variable conditions. On the other hand, for the critic who starts from the assumption that variability is the rule, the counterargument can always be made that such correlations do not account for a sufficient amount of the variance to move away from a situationist perspective. Even as the correlations increase, the same counterargument can be made. For example, in reviewing the work of Inhelder, Sinclair, and Bovet (1974), Brown and Desforges (1979) note that reported correlations between various tests of operational thought were significant but "none accounts for more than 50 per cent of the variance and we believe that Piaget's descriptions of stages leads us to expect much more coherent structures than these results suggest" (p. 107). The point is that, except at the extremes, the issue is not resolvable by data. For the critic who comes to the enterprise with epistemological biases against the acceptance of competence, there will always be enough variance left over to mount an attack which proposes we ignore constancy and focus on variability. As we mentioned earlier, the competence–performance distinction is an attempt to break this vicious cycle of either-or explanation through the recognition that both constancy and variability are legitimate facts of psychological life.

A second criticism of the legitimacy of the competence–performance distinction also focuses on competence and is also generated from epistemological biases. This criticism maintains that since competence is necessarily inferred from behavior, all we have in reality is behavior or performance. As a consequence, the criticism continues, the competence–performance distinction diverts us from our primary focus which should be a careful analysis of what the child actually does in performing various tasks and how this is affected by cultural and stimulus determinants. It is beyond the scope of this chapter to elaborate the epistemological reasons for postulating some form of competence (Overton, 1975, 1976; Overton & Reese, 1973, 1981), but it should be clear that such a criticism is deeply rooted in the empiricist precept that all knowledge and hence all theoretical concepts (i.e., competence) must be reducible to observations. The competence–performance distinction, on the other hand, requires some reasonable degree of acceptance of the rationalists' precept that theory, although based on observations, can never be reduced to mere observation.

As a third criticism of the competence–performance distinction, it is noted that the distinction is frequently employed as a speculative post hoc explanation in situations where research failed to generate predicted results. Thus to take a simple example, an investigation may examine two age groups under the expectation that the older group will demonstrate formal operational competence on a variety of tasks. Both groups perform significantly more poorly than would be expected on any reasonable criteria of formal thought, and the researcher explains the lack of demonstrated competence of the older group by asserting that it was probably masked by some unknown performance variables. The use of the competence–performance distinction in this post hoc fashion is indeed open to legitimate criticism, but the criticism is appropriate only to this particular usage and not to others.

This third criticism is legitimate in cases where competence is not well articulated and perhaps not appropriate. For example, competence models have not been elaborated for psychometric intelligence, yet it is not uncommon to hear intelligence testers complain that the competence of various individuals or groups of individuals has not been adequately tapped because of interfering performance factors. What this means, in effect, is that the IQ scores did not attain the level the tester had expected based on some covert, implicit rationale. The competence–performance distinction is viable only to the extent that we have in hand a relatively well articulated and reasonably validated explicit model of competence. If competence is proposed in a fashion that is vague to the point of having no specifiable empirical implications, then it does not constitute formal explanation and plays no meaningful role in scientific explanation.

A fourth and final criticism is related to the third, but its resolution is different. Here research is explicitly designed to examine empirically a potentially meaningful competence–performance relationship. However, the performance variables tested do not demonstrate a relation to competence. The researcher again introduces a post hoc explanation proposing other possible effective performance variables. Stone and Day (1980) criticize this approach by suggesting, "It would always be possible to specify additional performance factors as potential explanations of a child's failure to reveal a particular competence" (p. 333), and as a consequence, the claim that the child possesses a particular competence is unfalsifiable. There are two problems with this criticism. First, it should be noted that the validity of competence is assessed by different research approaches than is the exploration of the relationship between competence and performance factors. Second, the exclusion of some potential performance variable can reasonably be viewed as a positive feature of the competence–activation/utilization approach. An example may best illustrate the point: Liben and Golbeck (1980), noting sex differences favoring males in the child's behavior on Piagetian spatial tasks, raised the question of whether these were the result of competence differences (e.g., a developmental lag in the emergence of competence for females) or were due to some activation/utilization variables. The researchers selected alternative forms of the task as a potentially effective activation/utilization variable. However, this variable failed to reduce the sex differences, and the authors proposed that "other performance factors may be operating differentially for males and females" (1980, p. 596). If a number of investigations fail to find activation/utilization factors that ameliorate the difference, the weight of evidence will move to the view that the difference is competence-based. However, it is a perfectly reasonable research program to search for alternative activation/utilization explanatory variables.

To summarize, competence models present abstract systems of formal features of behavior potentialities in the field of cognition. Competence models do not include the actual psychological processes or environmental factors that generate behavior in any specific situation. Activation/utilization (performance) models are designed to specify the psychological processes and environmental events that result in the application of competence or the distortion of behavioral predictions that would be made on the basis of competence models. Keeping the nature of the two models distinct facilitates the employment of several research strategies designed to ultimately integrate the roles played by each component and provide more complete explanations of cognitive development.

THE FORMULATION, VALIDATION, AND DIAGNOSIS OF COMPETENCE

Formulation

The task of formulating each qualitative level (i.e., stage) of competence is theoretical in nature and requires both a rational and empirical approach. In essence, the theorist in formulating a particular competence proposes (rational analysis) that certain principles, rules, or logicomathematical structures are adequate general representations or models of the actual organization of the mature cognitive behaviors (empirical observation) of the period under consideration (Feldman & Toulmin, 1976; Overton, 1975).

An issue of primary importance to the construction of competence is the level of generality at which competence is formulated. A theory such as Piaget's postulates competencies that model the general form of logical thought across a range of specific concepts. The advantage of this approach is that it provides breadth of (formal) explanatory scope and hence theoretical power. The disadvantage is that the very generality may lead to the empirical results that the actual understanding both within and between specific concepts is sensitive to a number of task, stimulus, and individual difference factors. Thus, for example, Piaget's grouping "primary addition of classes" models the general logical similarity in children's reasoning required for the solution to a number of tasks entailing class inclusion or the hierarchical ordering of classes. However, a number of studies have found that a variety of task variables affect the actual understanding of hierarchical classes (Trabasso, Isen, Dolecki, McLanahan, Riley, & Tucker, 1978; Winer, 1980). From the perspective of the competence–performance distinction, however, this apparent disadvantage becomes salutary as the task, situational, and individual difference factors become part of the activation/utilization model.

If competence is formulated at a less general level, then the relationship between competence and actual behavior forms a tighter unity. This approach has been termed "task analysis," and it entails the generation of principles or strategies that are presumed to underlie specific tasks or concepts (Siegler, 1980). Thus, for example, Gelman and Gallistel (1978) formulated five principles to account for numerical counting, and Siegler (in press) formulated separate rule sets for several tasks (balance scale, projection of shadows, and probability tasks) that derive from the Piagetian formal operational literature (see Wilkening & Anderson, 1980, for an alternative rule assessment methodology). Siegler and Richards (1979) have also produced a rule set for the concept of time. Two cautionary notes should be made regarding this type of approach. First, care should be taken to avoid focusing merely on superficial levels of performance (Keating, 1979; Siegler, 1980). Second, it should be recognized that as the number of task specific competence models increase, theoretical power decreases. To take the extreme case, imagine that for every specific concept, a distinct competence was formulated. All theoretical generality would be lost. Rules would function primarily as simple descriptive summaries of the specific behaviors, and again, the field would have moved away from a position which valued both formal and contingent explanation to a position claiming complete contingent determination. Thus do the distinct epistemologies subtly move back to a stance of either-or rivalry.

Validation and Diagnosis

Following formulation of the idealized competence at each qualitative level or stage, research is conducted to establish various facets of the validity of the competence models. This is a complex methodological enterprise since it entails the assessment of the sequential nature of the competence models (see Tomlinson-Keasey, in press; Wohlwill, 1973, Ch. 9) both within and across cognitive levels or stages as well as the construct validity of each competence model as an integrated system. With respect to Piagetian theory, investigations of stage sequences include a large portion of the total research that has been conducted. Recently, many such studies recognized and/or addressed the methodological problems involved in identifying invariant concurrences and sequences (Hooper, Toniolo, & Sipple, 1978; Hooper, Wanska, Peterson, & DeFrain, 1979; Niebuhr & Molfese, 1978; Tomlinson-Keasey, Eisert, Kahle, Hardy-Brown, & Keasey, 1979). With respect to the construct validity of the Piagetian competence models, studies by Tomlinson-Keasey et al. (1979), concerning the concrete operational model, and Neimark (1975a,b) and Shayer (1979), concerning the formal operational model, suggest that regardless of final decisions concerning specific logical features of the models, each represents a good approximation or a mapping of the coherence of thought that occurs during these periods. (For an opposing perspective, see Brown & Desforges, 1979.)

For purposes of the present discussion, the issue of interest is neither the specific methods appropriate to establishing the validity of the various competence models nor the ultimate outcome of such research (see Tomlinson-Keasey, in press, for a review). Rather, at issue is the question of how the competence–performance distinction facilitates the process of validation. The answer is that for purposes of validation, variables that form features of the activation/utilization model are controlled in such a way that we may cut through performance in an attempt to establish the psychological reality of the underlying competence. Flavell (1977) treats this as the issue of diagnosing the child's cognitive abilities in the context of controlling factors (performance variables) that might otherwise lead to an underestimation (i.e., a false negative error when the child has the ability but testing procedures lead to the inappropriate conclusion that he or she does not) or an overestimation (i.e., a false positive error when the child does not have the ability but testing procedures lead to the conclusion that he or she does) of the child's actual ability. Here, however, in order to differentiate the competence models from specific skills or abilities (i.e., avoid confusing competence and performance models) as suggested by Stone and Day (1980), and similarly to avoid the view that it is possible to assess pure knowledge (Miller, 1978), the issue is conceptualized as validating competence models through control of performance variables.

Potentially relevant differences in psychological processes, states, and styles that can lead to false negative evaluations of the validity of competence models include selective attention (Miller, 1978), attentional or mental capacity (Miller, 1978; Pascual-Leone, 1976a), memory (Stone & Day, 1980; Flavell, 1977), ability to comprehend verbal instructions and produce verbal explanations (Braine, 1968; Brainerd, 1973), motivation and emotional states (Flavell, 1977), and variation in information-processing approaches associated with cultural factors and cognitive style (Neimark, 1979, 1981; Overton & Meehan, 1981; Pascual-Leone, 1976b). These organismic variables in turn interact with situational and task factors such as complexity of task instructions (Danner & Day, 1977), figurative task features, stimulus salience, and complexity (Miller, 1978; Scardamalia, 1977; Winer, 1980), and task familiarity (Neimark, 1979).

The introduction of false positive evaluations arise primarily from experimental situations that permit such factors as guessing and response biases to be introduced or which employ tasks that permit solution strategies inappropriate to the competence being validated (Flavell, 1977). This latter factor deserves special mention because although it introduces a false positive into the specific study under examination, it also has the rather ironic effect of suggesting the nonvalidity of the sequential nature of the competence model being assessed. Thus, for example, although the several competence models proposed by Piaget are not tied to specific ages, given their assumed sequential nature, it would obviously prove embarrassing to the theory if behavioral implications of concrete operational competence were found in children at ages 3 to 4 years or if formal operational competence were discovered at age 6 or 7. The possibility of obtaining such effects spuriously occurs through the use of "simplified" tasks (Larsen, 1977) or tasks which permit solution strategies appropriate to lower levels of competence than that being assessed (e.g., figurative solutions in the assessment of logical competence). It is known, for example, that lower animals can discriminate and match to sample various numerical arrays. This task and the skill it demonstrates, however, are functionally distinct from the logical competence which represents the child's understanding of number concepts during the concrete operational period (see Piaget, 1968b, for criticism of number tasks on which very young children have been found to "conserve"). Similarly, demonstrations that some forms of transitivity (Flavell, 1977) or class inclusion (Winer, 1980) tasks can yield figurative solutions do not speak to the issue of the logical competence proposed by Piaget. The general point at issue here is that although competence models cannot be reduced to specific behavioral assessment procedures (Feldman & Toulmin, 1976), reasonably articulated models do present structural demand characteristics. If appropriate assessment of the competence models are to be made, then task selection must proceed by careful a priori analysis of these characteristics, and not on the basis of simple surface appearances.

It should be clear from the foregoing that the validation of competence models through the control of performance factors is not a simple matter that can be dealt with in a single study or series of studies. One methodological approach that can facilitate the process entails the use of training. Recently, a number of investigators have begun to present the view that under certain conditions training procedures are best interpreted as a method for uncovering or diagnosing competence rather than inducing the acquisition of new behaviors (Flavell, 1977; Gelman, 1978; Gelman & Gallistel, 1978; Holland & Palermo, 1975; Hornblum & Overton, 1976; Overton & Newman-Hornblum, 1980). This interpretation is conditional upon two factors. The first of these is that the training should not include specific instructions on the criterion task. The second factor involves the extent of training and extent of responsiveness to the training. That is, to the degree that the subject improves significantly on the competence criterion task following minimum exposure to training, it is reasonable to infer that training, in essence, acted as a vehicle for cutting through performance factors to uncover competence. Inversely, to the degree that extensive training leads to minimum improvement, it is fair to assume the absence of competence. Finally, in those cases when extensive training or specific instructions lead to improved performance, traditional but cautionary (see Wohlwill, 1973, pp. 317–321) interpretations concerning training would be appropriate. Specific examples of the use of training as a diagnostic tool will be presented in the following sections.

In this section, the emphasis has been on controlling performance factors in an effort to reach decisions concerning the validity of competence models. In the following sections, the competence models are accepted as represented, and the focus is on analysis of how various performance factors are related to and determine the application of competence in actual thought and behavior. As stated earlier, we will not consider the issue of how performance variables influence the rate of the behavioral acquisition represented by the competence models. This is a topic which covers a great deal of the developmental literature (see Beilin, 1971, 1976, 1978; Wohlwill, 1973, Ch. 11) and is far beyond the scope of this chapter. The following sections will examine how performance factors may function to activate recently acquired competence and how performance factors facilitate or hinder the utilization of consolidated competence.

THE ACTIVATION OF COMPETENCE

Perhaps one of the most interesting and general findings to emerge from the cognitive developmental literature over the past decade is that specific environmental agents or conditions tend to influence behavior only to the extent that the competence relevant to these behaviors is already present (see Beilin, 1971, 1976, 1978; Gelman, 1978; Gelman & Gallistel, 1978; Inhelder & Sinclair, 1969; Strauss, 1972). This is demonstrated, for example, in the Genevan findings that training effects depend upon the child's developmental level, that is, on the competence that the child has at its disposal (Inhelder, Sinclair, & Bovet, 1974). One interpretation of this general finding is that many of the specific experimental effects demonstrated with respect to cognitive skills may not be functionally related to the acquisition of competence at all but, rather, they may serve to activate recently acquired competence (Overton, 1976; Overton, Wagner, & Dolinsky, 1971). This interpretation suggests, as has been detailed elsewhere (Overton, 1978; Overton & Reese, 1973, 1981), that the acquisition of competence is subject to laws that are quite distinct from those which explain the actual demonstration of competence in overt behavior. An analogy to the development and actual functioning of anatomical structures is illustrative. The eye, for example, has a necessary developmental course that is determined by a series of interactional effects within the differentiating embryo, and this results in a fully formed structure. The eye does not function at this time; however, it is ready and awaits specific environmental events, which occur following birth, to be activated and make adaptive responses. Thus anatomical structures are subject to what Carmichael has termed the "law of anticipatory function" (1970, p. 448); that is, structures are complete and ready to function prior to their first adaptive responses, and these responses are determined by external agents distinct from those factors that explain the development itself.

It is assumed that cognitive structures follow this same general course. A basic competence is developed in accordance with necessary principles (Overton & Reese, 1973, 1981). Following this development, there ensues a phase during which specifiable environmental agents, that is, performance or activation variables, result in the activation of the structures and thus result in significantly improved task behavior (Overton, 1976). This proposal is compatible with, but distinct from, the early competence–performance distinction formulated by Flavell and Wohlwill (1969). In the present case, the focus is on how specific activation variables interact with a given competence. Flavell and Wohlwill, on the other hand, focused primarily on sequence issues relative to the acquisition of competence itself. To integrate the two approaches, we may say that our interest is on activation variables as they are related to Flavell and Wohlwill's phases 2 and 3 of any competence model (i.e., situations when the competence is present but is not always reflected in performance).

The strongest support for a competence–activation model comes from investigations that include an age-by-conditions design. The optimal design includes three age groups: one group that on theoretical or a priori grounds should not have the target competence, a second group that possesses nonactivated competence, and a third group that demonstrates competence in a variety of situations. The experimental prediction is that the presumed activation variable (condition) will significantly affect only the second group's competence-related behavior. It has also been suggested that pretested cognitive level be substituted for age groups in order to attain a more direct measure of competence status (i.e., precompetent, transitionally competent, and fully competent) and thus avoid issues involving an age by cognitive level confounding. Although this proposal often has merit, it can also generate theoretical and methodological problems. As an illustration, the issue emerges as to which specific feature of competence should be pretested. If the target competence is, for example, cross or multiple classification, then pretesting for conservation raises the question of the exact competence relations between cross classification and conservation. On the other hand, a direct pretesting of the target competence may minimize the impact of subsequent activation experience.

Evidence for activation may also be obtained from a conditions design in which the subject population consists of a single age group that is presumed to possess latent competence. For example, within Piaget's theory, concrete operational competence develops between approximately 5 to 8 years of age, and thus this represents the appropriate group where activation measures should be effective. It is obvious, however, that findings from such a single age group can be taken as no more than suggestive, since any obtained effects might also be applicable to younger or older groups and hence not imply activation of competence. In the following discussion, we will examine several factors that support or suggest the value of the competence–activation model.

A strong candidate as a class of activation variables is the figurative features or stimulus saliency of the task. If the young child's (5 years of age) competence is characterized primarily by a figurative approach to problems and the older child's competence is operational in nature, then a decrease in figurative task features or an increase in logical task features should facilitate the activation of operational competence (see Inhelder & Piaget, 1964). Reasoning from this position, Overton and Brodzinsky (1972) examined the effect of reduced figurative task features on the solution of cross-classification or multiple-classification problems. Three groups of children (4 to 5, 6 to 7, and 8 to 9 years of age) were presented with either of two forms of a matrix completion task. One form was the standard task which has strong figurative demands, and the second form reduced the figurative features of the task while maintaining the logical task requirements. In support of the activation hypothesis, only the transitional group (6- to 7-year-olds) showed any effect of task differences. This group's performance was significantly improved under the logical task structure.

In a recent paper, Odom (1978) has argued that since with an increase in stimulus saliency, 4-year-olds can solve matrix completion problems, figurative processes may provide an alternative conception to Piaget's position concerning cognitive change. However, it should be noted that an increase in stimulus saliency with respect to this task actually lowers the probability that the test is measuring Piaget's operational or logical competence model (see also, Overton & Jordan, 1971).

Reducing figurative task features as a means of activating operational competence has also been examined with respect to spatial skills. Brodzinsky, Jackson, and Overton (1972) tested children at 6, 8, and 10 years of age on modified versions of Piaget's three mountains task (single-object array and multiple-object arrays). Half the children at each age received the standard form of presentation, while half had the scene perceptually shielded from their view as they chose pictorial representations of several alternative spatial perspectives of the scene. Results supported the activation hypothesis in that performance was enhanced under the shielded condition for the older ages. This effect was primarily limited to the multiple arrays. Brodzinsky and Jackson (1973) later replicated the general finding and went on to examine the interaction between shielding and the internal complexity of the object arrays. Walker and Gollin (1977) conducted a similar study but found that shielding led to a reduction of egocentric-type errors in a 4-year-old group. Although this finding does not support the activation hypothesis, it should be noted that this study employed only a single-object array and therefore may implicate an earlier level of competence than operational competence (see Flavell, Everett, Croft, & Flavell, 1981; Masangkay, McCluskey, McIntyre, Sims-Knight, Vaughn, & Flavell, 1974).

Reducing figurative task features by the procedure of perceptual shielding has also been employed in studies of conservation. Here, however, the issue is complicated by the fact that degree of shielding of perceptual conflict features can in fact transform the problem to one that does not require operational competence (i.e., pseudoconservation, Piaget, 1968a). That is, if conservation entails a conceptual quantitative invariance in the face of perceptual conflict, then the absence of perceptual conflict effectively destroys the structural task demands. Beilin (1978) and Miller (1978) have reviewed investigations of conservation shielding, and each suggests interpretations compatible with the activation hypothesis. Of greatest relevance is a study by Strauss and Langer (1970) which demonstrated screening effects were most pronounced for transitional children.

In an early study of class inclusion, Wohlwill (1968) found that reducing distracting perceptual cues by presenting inclusion questions in verbal form significantly enhanced performance of transitional children. Although Winer (1980) has suggested that this activation effect may be primarily due to the additional verbal cues, the perceptual reduction effect has not been ruled out by appropriate designs focusing on this feature. In general, a number of class inclusion studies have found various figurative or stimulus saliency effects; however, these have not been adequate to test the activation hypothesis, because of either the absence of appropriate designs and controls or because the type of tasks employed tap figurative processes rather than the logical competence of class inclusion (see Winer, 1980, for a review).

With respect to conservation, Miller (1978) has reviewed a number of variables beyond figurative and stimulus saliency features which might serve an activation function. These include the interest value and familiarity of task material, the number of task components, and the type and degree of transformation needed for solution. Miller, in turn, relates these and other variables mentioned earlier to processes of selective attention and attentional capacity (i.e., activation/utilization model processes). Although the evidence reviewed is compatible with the activation hypothesis (i.e., the effect of the variables are generally related to cognitive level), it is only suggestive due to the lack of designs appropriate to generate specific experimental tests of activation.

With respect to the importance of familiar task content in the activation of competence, it should be noted that some researchers (e.g., Uzgiris, 1964; Zimmerman & Lanaro, 1974) explain the phenomenon of horizontal decalage (i.e., the fact that the various conservation notions are acquired at different times and in a certain order) as due to the differing degrees of familiarity the child has with the materials involved. For example, the child may deal with number-related activities more frequently than weight-related activities. Thus, according to Zimmerman and Lanaro (1974), it is not surprising that the acquisition of number conservation precedes the acquisition of weight conservation.

Another variable that may produce activation effects is task instructions. White and Glick (1978) tested kindergarten, first-, second-, and third-grade minority children on liquid conservation following instructions that varied according to whether they alerted the children to possible deception and whether the deception was embedded in the context of a story. Results indicated enhanced performance for the story-deception group, and this effect was limited to the transitional first and second graders.

As described earlier, training effects have increasingly been interpreted as affecting behavior only to the extent that the target competence is already present. Thus although training does not indicate specifically which activation variables are relevant, training may function to activate latent competence or to disclose that competence is not available. Beilin (1971, 1976, 1978) and Strauss (1972, pp. 337–340) review evidence relevant to this interpretation. Here we will examine some research not included in earlier reviews.

In an examination of cross or multiple classification, Overton and Kirschner (1972) trained children 4, 6, 8, and 10 years of age on 16 matrix completion problems. Training consisted of corrective feedback, and the experimental effects were limited to the 6-year-old group. Here, corrective feedback provided by the experimenter resulted in significant error reduction. Another study of cross classification (Parker, Sperr, & Rieff, 1972) is particularly interesting because it supports the activation model being described, despite the fact that neither earlier research nor competence considerations played any apparent role in the conceptualization of the investigation. In this study, children 5½, 6½, and 7½ years of age were presented with either a 12-step sequenced feedback training program, a single-step feedback training program, or a control condition. Performance on a transfer task demonstrated significant training effects only at the 6½- and 7½-year level. Halford (1980) has recently extended this work and suggests direct training effects occur at approximately the 5½-year level when mental age, rather than chronological age, is employed.

Several investigations which examined training effects with respect to class inclusion competence are also relevant to the activation hypothesis. In one study, Youniss (1971) extended an earlier class inclusion investigation conducted by Ahr and Youniss (1970). In the later study, children were pretested on a series of tasks considered to be precursors to class inclusion and then received a correction training procedure. The results supported a conclusion that the training was effective for those children who already had acquired the prerequisite structural competence. Langer (in press) attempted to induce recognition of a contradiction prior to class inclusion testing. He found that only children who were transitional benefited from the training. Similarly, Inhelder, Sinclair, and Bovet (1974) found that the effect of multiple training procedures on class inclusion was limited by the child's initial level of competence.

To this point the activation hypothesis has been discussed exclusively with respect to concrete operational competence. This has been dictated by the fact that virtually all the research conducted on this issue has been directed to this particular competence. This focus has been limited less by theoretical considerations than by the fact that traditionally it has been more difficult to determine a reasonable time interval during which formal operational competence is latently available to the child (e.g., see Sims-Knight, 1979). There are however several studies that are related to the issue of the activation of formal operational competence. In one study, Moshman (1977) tested tenth- and eleventh-grade children for their understanding of logical implication and disjunction. Arguing from Flavell and Wohlwill's (1969) four-phase model, Moshman predicted that the negation of these logical forms—considered as a performance variable—would be unrelated to early and late phases of competence but would suppress the normal activation of competence during phase three. The results supported this prediction. This study is unique both in its use of the phase model and in suggesting a performance variable that may hinder activation.

Two studies have been conducted which focus on the activation of logical conditional reasoning through the manipulation of task instructions. O'Brien and Overton (1980) presented third-grade, seventh-grade, and college students with a series of conditional inference problems. Following a procedure introduced by Wason (1964), half the subjects at each age level received evidence that contradicted possible faulty inferences. Significant improvement was found for the college group following the introduction of the contradictory evidence, and this effect generalized to new conditional-reasoning tasks. In an attempt to establish a more precise point at which this manipulation first becomes effective, and hence more clearly relevant to activation, O'Brien and Overton (in press) replicated the study with eighth and twelfth graders. In this study, significant improvement and generalization to new tasks was found for the twelfth-grade group. Research is currently in progress testing the intervening grades.

In conclusion, the research described in this section illustrates the heuristic value of an approach which considers contingent effects as determinants of competence activation rather than as determinants of competence itself. Obviously, further systematic empirical research employing appropriate designs and controls is needed to support and elaborate this perspective. Of particular value would be research focusing on the generality of activation effects across tasks and across time. In this section we have focused on how several task, instructional, and general training features affect recently acquired latent competence. In the following section we will examine how these features, as well as various individual difference factors, affect the expression of maturely functioning competence.

THE UTILIZATION OF COMPETENCE

Although there are divergent views on this issue (see Flavell & Wohlwill, 1969; Flavell, 1977, p. 115), the only necessary implication of any competence model of behavior is that the behaviors represented can be performed across a variety of content areas. That is, a competence model represents capacity, and issues of spontaneity of application or level of proficiency (Flavell, 1977) are features of the activation/utilization model. Thus given that competence has been activated, the question remains as to whether there are systematic factors which affect the conditions under which the competence is applied. This brings us to a discussion of utilization variables.

Conceptually, the distinction between activation and utilization, although at times somewhat arbitrary, is roughly analogous to the distinction drawn by the experimental ethologists and behavioral embryologists (Bateson, 1978; Gottlieb,

1976) between environmental factors that facilitate development and environmental factors that maintain mature behavioral systems. Obviously, a single variable or set of variables might serve neither, one, or both of these functions. At the level of research, if a particular factor affects only phases 2 and 3 of Flavell and Wohlwill's four-phase model, then it serves only an activation function. If, on the other hand, the factor serves primarily to enhance relatively adequate performance or is effective well after the time mature competence has been demonstrated for most individuals, then its function is that of utilization. Finally, to the extent that a factor is effective both at the time of latent competence and continuously effective across an extended time, it has both activation and utilization characteristics. As an example, in the O'Brien and Overton (1980, in press) studies described earlier, a purpose of the research was to explore the question of the activation of competence. However, if future research demonstrates that the contradictory instructional effects are also present at, for example, the tenth- and eleventh-grade level in addition to their impact at the twelfth-grade and college level, this factor would reasonably be considered an activation/utilization variable.

A theoretically systematic approach to the examination of the relation between competence and utilization has been proposed by Pascual-Leone (see Chapman, 1981, for a summary). Pascual-Leone's formulation is essentially a general theory of cognitive development. He begins from a basic assumption of Piaget's competence models, but the actual behavior of a subject is determined by the interaction of competence schemes and specific organismic factors termed "silent operators." These include the subject's previous learning experiences, perceptual field effects (i.e., stimulus effects), affective and personality factors, and mental effort (M operator). The silent operators, or what we would term utilization factors, are weighted with respect to the probability of producing a competence-related behavior. The relation between competence and utilization factors is then applied to specific issues such as (1) the effects of a task's information load on the performance of that task; (2) the role of perceptual field effects in inhibiting or facilitating performance of that task; (3) the problem of horizontal decalages (Pascual-Leone & Sparkman, 1980); and (4) the problem of style and other individual difference effects (Pascual-Leone, 1976b).

Several investigations of formal operational competence have suggested that reduction of task ambiguity through modified instructions, repeated presentation, or task modifications enhances utilization (Danner & Day, 1977; Kuhn, Ho, & Adams, 1979; Martorano, 1977; Stone & Day, 1978, 1980). Further, Martorano (1980) has shown that figurative factors (arrangement of stimuli and visual noise) suppress successful utilization, and Martorano and Zentall (1980) suggest that prior experience designed to focus attention on critical task dimensions may serve an activation/utilization function.

Of particular interest with respect to activation/utilization are the Stone and Day (1978, 1980) studies. These investigators assessed the formal operational competence of 9-, 11-, 12-, 13-, and 14-year-olds using Inhelder and Piaget's (1958) bending rods task. Initially, modified instructions and repeated task presentations were employed as activation variables to assess whether subjects (1) lacked competence, (2) possessed available but latent competence, or (3) spontaneously applied competence. Task modifications were also presented and this variable affected performance of both the latent and spontaneous groups; that is functioned for activation/utilization. Several additional measures, including tests of memory capacity, selective attention, and cognitive style (field independence), were employed. Although memory and attention did not differentiate the latent and spontaneous group, the spontaneous group performed significantly better on a test of field independence. This variable did not differentiate the latent and noncompetent groups. This finding strongly supports the view that cognitive style functions primarily as a utilization variable.

Studies which have further examined the relationship between cognitive style and formal operational competence are reviewed by Neimark (1979). These have assessed reflection–impulsivity (Riebman & Overton, 1977), field dependence/independence (Lawson, 1976; Linn, 1978; Saarni, 1973), or both (Neimark, 1975b). Neimark (1979) points out that the results from this work are consistent with the view of formal operational thinkers as being reflective, analytic, and field independent. Unfortunately, although they are suggestive, these studies were not specifically designed to yield direct support for the activation/utilization functions of cognitive style.

An investigation by Brodzinsky (1980) on reflection–impulsivity and concrete operational competence (spatial perspective-taking) is more specifically relevant to the issue of cognitive style and activation/utilization. On tests of 4-, 6-, and 10-year-olds, reflectivity was associated with performance on spatial perspective-taking only at the 6- and 8-year levels. This suggests that cognitive style may have served an activation function. However, for the 6-year-old group, cognitive style was related to specific error patterns (egocentric and adjacent errors), while for the 8-year-old group, style was related to overall accuracy. Although the effect for the younger group might reflect an earlier entrance into and faster development through the transition period for the reflective children, the effect reported for the 8-year-olds appears more consistent with a utilization function. For the 10-year-old group, a ceiling effect precluded style-related task differences. Liben's (1978) finding that field dependence is negatively related to performance on Piagetian spatial tasks at a time well past normal consolidation of concrete operational competence, that is, twelfth grade, provides additional support for interpreting cognitive style as a utilization variable.

In concluding this section, we examine two topic areas in which group performance differences are relevant to the issue of competence and its application. One topic of interest concerns the fate of competence in the elderly. Hornblum and Overton (1976), following Bearison (1974), argued that poor performance on concrete operational tasks (conservation) among the elderly was due to a failure of utilization rather than a lack of competence. This view was supported when, following brief exposure to corrective feedback, the performance of these elderly subjects was significantly enhanced on near and far transfer tasks as compared to subjects in a control group. Levin and Overton (1977) extended the general argument by demonstrating that following training for cognitive flexibility (set-breaking), the performance of elderly subjects on a spatial perspective-taking task improved significantly.

A second topic involves findings of individual differences for competence-related behaviors. Sex differences are illustrative of the general issue. Several investigations have found sex differences with respect to both concrete and formal operational competence (Chapman, 1975; Dale, 1970; Douglas & Wong, 1977; Elkind, 1961, 1962; Keating & Schaeffer, 1975; Liben, 1978; Liben & Golbeck, 1980; Martorano & Zentall, 1980; Riebman & Overton, 1977). When this finding occurs, females generally perform more poorly than males. This result is open to two interpretations: females may lag behind males developmentally in the acquisition of competence or the differences may be the product of activation/utilization variables which depress the expression of competence.

Liben (1978) and Liben and Golbeck (1980) examined the problem of sex differences on Piagetian spatial tasks from the perspective of the competence–performance distinction. As mentioned earlier, Liben and Goldbeck (1980) presented children in grades 3, 5, 7, 9, and 11 with modified forms (activation/utilization variables) of the spatial tasks. However, as in the original Liben (1978) study, sex differences again emerged. Although this finding is consistent with the developmental-lag hypothesis, it also provides the basis for moving in new directions with respect to other potential activation/utilization variables. Thus following Elkind's (1961, 1962) suggestion that sex difference in operational competence may reflect different social-role expectations for males and females, Overton and Meehan (1981) examined the formal operational competence of 13-year-olds in relation to sex roles and learned helplessness. This study found both variables to be significantly related to the expression of competence. Similar results for sex role are reported by Signorella and Jamison (1978) and Jamison and Signorella (1980) for spatial tasks. Along similar lines, Newman-Hornblum, Attig, and Kramer (1980) recently found that when the content of Piagetian concrete and formal operational tasks is modified to match the sex-role orientation of elderly subjects, task performance is affected.

CONCLUSION

The competence–activation/utilization approach described in this chapter offers two advantages over traditional approaches to the understanding of development. First, it provides a framework within which traditionally rival forms of explanation can be integrated. Competence and changes in competence are explained through formal explanation, activation and utilization are explained through contingent causal explanation. Second, the approach suggests several research strategies that can be applied in an effort to differentiate and evaluate the role of various necessary component processes in the functioning of the developing individual. The research reviewed suggests that this provides a more integrated and realistic perspective than one that focuses on a single component and treats other features as noise or error.

As a final note we would like to emphasize that although Piaget's competence theory has been focal in this chapter, the general approach described is applicable whenever a competence model is generated. In the field of cognitive development, as Siegler (1980) has noted, the use of task analyses to generate rule systems that describe the competence of the child is becoming increasingly popular. Given the assumption that such rule systems will prove to have reasonable scope, the issue of the conditions under which they are activated and utilized will be open to the approach and strategies discussed in this chapter.

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