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CHAPTER 6

Action as the Core of Work Psychology: A German Approach

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To establish a general theory of work behavior, one must begin with the concept of action. Action is goal-oriented behavior that is organized in specific ways by goals, information integration, plans, and feedback and can be regulated consciously or via routines. We will describe general theory along these lines. This is quite a different theory from the typical American theories in industrial and organizational psychology. This becomes quite clear when this general theory is applied to understanding certain phenomena:

- *Errors. Errors are the converse of efficient action. We will present an action theoretic taxonomy of errors and some empirical results. The concept of error management allows an active approach to dealing with errors.*
- *Interrelationship between work and personality. From an action theory point of view, a person develops his or her personality by acting. Thus, working has some impact on the development of personality. From this, it follows that work should enhance personality. Action styles provide a way to understand personality from an action theory perspective.*
- *Development of competence at the workplace and training. A particularly important concept is the issue of the superworker in action theory. The superworker uses better and long-term strategies, has a better understanding of the work tasks, and organizes things better than other workers, but does not work more than they do. Training enhances worker skills in the direction of the superworker and, therefore, the area of training has been of traditional importance to German action theory. We will discuss issues in training (e.g., active approach in learning, understanding, accidental learning, the use of heuristics, learning from feedback and errors, automatization of skills, and transfer).*
- *Task characteristics. We will present task characteristics from an action theory perspective, including task analysis instruments developed in Germany, and will discuss resources for action regulation, regulation requirements, and action regulation problems (stress).*
- *Work design. Finally, we will discuss the issue of work design from an action theory point of view.*

Introduction

THE BASIC ISSUE of a psychology of work has to be concerned with actions. Actions are goal-oriented behaviors. Without a conscious goal, there is hardly any possibility for a person to take action. A goal may be to develop a new motor, to achieve a certain career post, to write a letter, to finish one piece of work at the assembly line. Additional goals may be to earn money with one's work or to do one's job well.

Therefore, the basic starting point for industrial and organizational psychology has to be work action. This is what persuaded German industrial and organizational psychology to develop an action theory.

This is not the typical starting point in the United States. Here, the phenomena studied the most seem to be two types of prerequisites of action: abilities used in selection research and motivation. While they undeniably play an important role, one has to deal with the fact that people demonstrating the highest performance in a job are not always the most motivated workers, but rather those who have the best cognitive understanding of the job and the better work strategies (Hacker, 1992). In this chapter we will deal with a set of issues for which an action theory orientation proved useful. At the same time, we will see that the theory of action provides an integrative account of what happens with, to, and from the person working.

Three kinds of readers will profit from this chapter: (a) those who would like to become familiar with a rather well-developed cognitive theory of work behavior and who do not have access to the German literature in this area; (b) those who want to get to know an alternative theory to some of the dominant paradigms of American industrial and organizational psychology; and (c) those who are interested in the specific topics of this chapter: errors, work and personality (including action styles), superworkers and training, task characteristics (including job discretion, complexity, and stress at work), and work design. In general, action theory is a "grand theory" that provides quite a broad approach to understanding work actions in general. Unfortunately, this chapter may not be easy to read. Since it is necessary to first develop the theory in an abstract way, the reader will only become aware of its usefulness, and empirical underpinnings, after he or she has looked at the specific action theory topics.

Action theory is a cognitive theory. But unlike many cognitive theories, it is tied to behavior. It is an information processing theory. But unlike many information processing theories, it is tied to objective work environments and to the objective work outcome. It is a behavior-oriented theory. But unlike behavioristic theories, it is concerned with the processes that intervene between environmental input and behavior: the regulatory function of cognitions.

German psychology has by and large been more interested in grand theories than has the Anglo-American tradition. Action theory builds on the grand theory of Lewin and its newer system theory version of Miller, Galanter, and Pribram (1960). At the same time, it has been influenced by Soviet psychology, particularly Rubinstein (1962, 1968), Leontiev (1978, 1981), Vygotski (1962), and Luria (1959, 1970). Other influential figures were Oschanin (1976), Galperin (1967), and, in Polish praxeology, Tomaszewski (1964, 1978).

It should be added, however, that there are English versions of action theory that resemble the kind of theory we will discuss. For example, Carver and Scheier (1982) and Anderson (1983) have presented such theories. It should also be pointed out that the use of such theories in German work psychology is much older (the first books on this topic were Hacker, Skell, & Straub, 1968, and Volpert, 1971) and better developed.

Grand theories or frameworks are very often empirically and theoretically not as well developed as some readers may think they should be. One reason that it is fun to work with action theory is that it has been used—or promises to be used—to provide a unified framework to human factors, industrial psychology, and organizational psychology—namely, work psychology. Since all of these disciplines are facets of our knowledge of people's work, an analytical framework of work action is capable of integrating otherwise isolated issues of stress, errors, job performance, and skill development.

Action Theory: Toward a General Theory of Work Behavior

It is naive to think of general theories as ideas to be simply applied in work (Schönpflug, in press; Semmer, 1993). The degree of specification of a theory has to be adequate for its application. It is finer in general psychology and less fine in work psychology. Moreover, external validity questions are more important in work psychology than in general experimental psychology. Finally, work psychology problems often involve many variables that are not completely tested.

An action can be described from two points of view. First, an action proceeds from a goal to a plan, to its execution and to feedback being received. This is the action process. Second, an action is regulated by cognitions; the regulation processes can be conscious (called "controlled" by Schneider & Shiffrin, 1977) or automatic. This is the structure of action. Both points of view are combined in action theory. For purposes of exposition, we will present these two aspects of action consecutively.

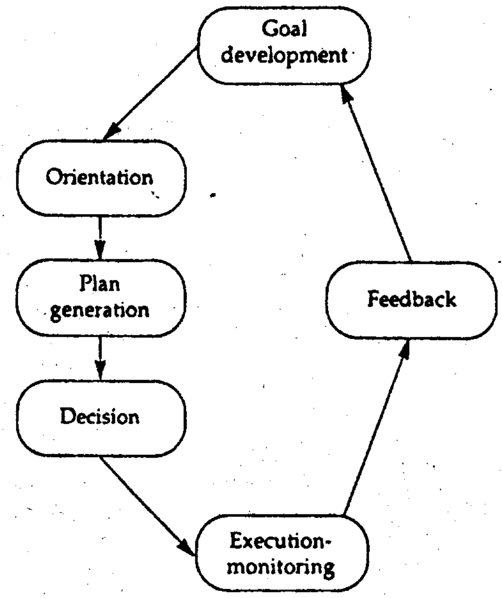
The Action Process

The action process consists of the following steps (Dörner, 1989; Frese & Stewart, 1984; Hacker, 1985, 1986a; Norman, 1986; Tomaszewski, 1964, 1978): (a) development of goals and decision between competing goals; (b) orientation, including prognosis of future events; (c) generation of plans; (d) decision to select a particular plan from available plans; (e) execution and monitoring of the plan; and (f) the processing of feedback.

Figure 1 presents these action steps. This model presents the action process as an orderly affair. Of course, actions are often quite chaotic; for example, goals may change in the middle of an execution. Moreover, later steps in the action process may change earlier ones; for example, a goal may be changed after one notices that the plan is not good. The figure presents a good first approximation. In the text that follows, we will discuss each of these action steps.

FIGURE 1

The Action Process



Goal Development and the Role of Tasks. The goal is certainly the most important concept in action theory, since action is defined as goal-oriented behavior. Hacker (1986a, p. 73) defines an *action* as the smallest unit of behavior that is related to a conscious goal. The concept of goal integrates motivational and cognitive concepts. The goal is a point of comparison for the action (the cognitive aspect), and the action is "pulled" by the goal (the motivational aspect).

Actually, it is a gross oversimplification to begin a description of the action process with a goal. As Heckhausen and Kuhl (1985) have pointed out, at first there is really a wish. This wish may be translated into a want. When there are potential opportunities, the time is right, and there is some urgency and importance, these wants may translate into an intention and then act as action-guiding goals.

While this is generally true of actions, the starting point for work actions is the task (Hacker, 1986a, p. 69). Usually a person is given a task at work and is expected to proceed with the task according to some rules. A *task* is the intersection between the individual and the organization (Volpert, 1987b). Via tasks, an individual or a subgroup takes over a part of the overall organizational goals.

It is useful to differentiate between an *external* and an *internal* task. People are developing goals either when they are creating their own tasks or when they are taking over external tasks. The external task is presented by the organization, though sometimes in a very general manner.

The result of an external task has to be anticipated as a goal, and conditions for its execution have to be taken into consideration. Making an internal task out of an external one is accomplished through the *redefinition process* (Hacker, 1982b, 1986a; Hackman, 1970). The task presented by an organization to an individual worker must be understood—it is interpreted on the basis of prior knowledge and general terms of the trade, and it is taken over in light of standards and certain implications. For example, if a supervisor asks a person to tend a machine, the worker can respond in two possible ways when the machine breaks down. The worker might simply wait until the supervisor comes by again to mention the problem, or the worker might fix the problem or actively report the problem to the supervisor. Many social conflicts can occur when different redefinitions collide, such as when a supervisor sees different implications in a particular action than a worker does.

Thus, the redefinition process depends on the degree of understanding of the external task and its clarity; the expectations, the values, the degree of acceptance, and the willingness to carry out the task; and the workers' prior experiences (Hackman, 1970).

The fact that goals are implied by tasks should not be mistaken to mean that people passively respond to environmental stimuli. Rather, according to action theory, people influence and shape their environment as well. Goals are changed according to one's accomplishments, usually in the direction of higher efficiency on the environment (White, 1959). Thus, most humans will proceed to develop new goals, even when a certain goal has been achieved.

Goals anticipate future results; therefore, goals should be considered anticipative cognitive structures (Hacker, 1986a, p. 115) that guide the action process. Goals are to a certain extent invariant—that is, they do not change very quickly (Hacker, 1985). A person still knows and pursues his or her goal even if the plan of action led astray. Only by being invariant to a certain extent can goals function as set points to interpret feedback.

While the actual behavior guiding goals is usually conscious, it does not have to be in the focus of attention all the time. Once a certain action pattern is put into effect, it is not necessary to keep the goal in consciousness unless the action pattern fails. This is particularly true for supergoals (like life goals; e.g., to be honest or successful in what one is doing). Often action patterns have the status of an implicit goal.

Actions are often directed toward multiple goals, and while acting on one goal, people scan the environment for opportunities to act on other goals. This leads to several problems. One practical problem is that the various goals may be contradictory (e.g., the goals of being honest and polite, increasing the profit rate, or trying to make people feel good at work). A theoretical problem is which goal will be operative at any particular time. The latter has been emphasized in the various theories of expectancy x valence theories (e.g., Heckhausen, 1991; Vroom, 1964). Since these theories, which also originated from Lewin, have been well developed in the Anglo-American literature (and are discussed by Kanfer, 1990, in the first volume of this *Handbook*), they do not need to be discussed here.

Reither and Städel (1985) have pointed out that goal development requires effort and is therefore usually reduced to a minimum. Goals are developed while the task is being carried out. Since often little thought is put into goal development, people have a tendency to overlook contradictions between different goals. Also, goals are often developed without reference to potential negative effects that occur after the goal has been achieved (e.g., what to do with the atomic waste that is created once a nuclear power plant has been built).

In general, important—and partly interrelated—parameters of goals are the following:

- *Difficulty*. Goal difficulty has to be distinguished from goal or task *complexity*. While complexity is related to the number of units in a system and their relationships to each other, difficulty has a more restricted meaning: A given degree of complexity may still pose various degrees of difficulty. For example, to shout louder than 90 decibels is more difficult than to shout louder than 60 decibels but not necessarily more complex.
- *Specifity of the goal*. Specific goals can be described in detail; a specific goal, therefore, usually has clearer implications for action than a more global goal. An example of a manager's global goal is that people should be satisfied in their jobs; an example of a specific goal is that the profit rate should be increased by 10 percent (Dörner, 1989; Locke & Latham, 1990).
- *Hierarchization of goals and subgoals*. This implies that subgoals are formed (goal decomposition; Dörner, 1989). This is not identical to goal specificity. For example, raising the profit rate by 10 percent is highly specific, but it may be very difficult to describe the subgoals necessary for reaching that goal.

- *Connectedness of goals and subgoals*. This implies that the different goals and subgoals are checked for potential contradictions.
- *Time range*. It is self-evident that goals can be oriented toward the future (long range) or toward the near future (short range).
- *Valence*. This is one of the better researched areas of psychology, referring to the positive or negative value that is attached to a goal state and its relationship (instrumentality) to other goal states (Heckhausen, 1991).
- *Process versus end-state goals*. Process goals are goals directly related to an action. Thus, the action itself is the goal. For example, a ballet dancer's goal is to move in a certain way. Often, process goals can be conceptualized as standards that should be maintained, such as behaving politely or conserving energy while working. In contrast, producing a commercial product is an end-state goal.
- *Efficiency divergence of goals*. This concept (Oesterreich, 1981, 1982) suggests that one should choose subgoals with the highest number of options (divergence) to reach potential other goals with a high likelihood (efficiency). For example, in a career path, a person may choose a low-salary position in a prestigious university because it opens many options for later jobs. Subgoals with high efficiency divergence should be approached when it is difficult to develop a whole plan in advance. Computer simulation experiments showed that high efficiency divergence subgoals were actually preferred by the subjects, even when other more favorable possibilities existed (Resch & Oesterreich, 1987). Moreover, subjects preferred action domains that included many points of high efficiency divergence, and they were more successful in reaching their goals within such action domains (Oesterreich, Resch, & Weyerich, 1988).

Orientation, Prognosis, and Signals. The orientation reflex is a basic response of human beings. Orienting oneself toward something novel is the lowest level of analysis of situational and object conditions. In dynamic systems, objects may change even without an intervention by the actors. Here, prognoses of future states must be calculated (e.g., the inflation rate when investing money).

Prognosis and orientation have been studied by Dörner and his group in problem-solving approaches using highly complex computer simulation programs (Dörner, 1987b, 1989; Dörner, Kreuzig, Reither, & Stäudel, 1983; Reither & Stäudel, 1985). To orient oneself within a system, one must search for and collect information, develop good analogies, and use abstract schemata. Of particular importance is a problem's *level of decomposition*. For example, repairing a machine requires a fine level of decomposition, as the various parts of the machine must be known. On the other hand, knowing everything about the particulars of the machine is of much less use to the production worker who must know how to operate the machine. (As a matter of fact, the repairperson may be less efficient using the machine, although he or she knows much more about it than the production worker.)

Orientation often means to attend to signals, because signals are action-relevant stimuli that are integrated into some knowledge system on the work task. This means that the worker has to know different forms of a certain signal prototype and process characteristics and how they are translated into observable signals. The worker also must have an action plan associated with the signal at his or her disposal (Hacker, 1986a, p. 118).

The following are important issues of signals (see also Hacker, 1986a, p. 232):

- The number of signals that need to be reacted to
- How easy it is to differentiate a signal from background noise and other signals (contrast and number of alternative signals; e.g., see Patterson, 1990)
- Compatibility and population stereotype (e.g., a red signal meaning stop and a green signal meaning go; e.g., see Hoyos, 1974)
- The predictability of when a signal appears and what kinds of signals one can expect
- Transparency of signals in terms of understanding the meaning of the signal within a system
- Consistency of the signal—that is, whether a particular signal has the same meaning all the time
- The active search for signals and the active construction of signals versus waiting for signals to come

In every case, the signals are related to the knowledge and the mental models that the worker has about the work process. (Later, the concept of mental model from an action theory point of view will be discussed.) Signal detection and the actions taken are therefore highly dependent on this knowledge.

Plan Generation and Decision. Some kind of plan is usually developed before the action occurs. This plan is, of course, not necessarily worked out in detail. Most often it is a simple list of subgoals. Sometimes the plan consists of an elaborate structure of a plan and backup plans in case something goes wrong. These plans can be more or less consciously represented or automatized (more on this later).

The action theory concept of *plan* is not to be confused with everyday uses of the term. The theoretical concept of plan means everything from a first idea of *how* to proceed to an elaborated blueprint (Miller et al., 1960). Also, a representation of well-automatized sensorimotor skills (like walking) is conceptualized to be a plan. Because of the different meanings of *plan* in action theory and everyday life, the term *action program* was introduced. *Action program* and *plan* are used interchangeably in this chapter.

Many aspects of the concepts of plans, strategies, and tactics will be discussed in the various application areas of action theory in this chapter. Therefore, only the important parameters of plans need to be mentioned at this point.

- *Detailedness*. As pointed out, a plan may or may not be developed in detail before action is taken. When the plan is not detailed beforehand, then it is worked out during the action itself.
- *Inclusive of potential problems—backup plans*. This is a variant of detailedness, but of a specific sort: One may develop backup plans in case something goes wrong, and even plan for events that are unlikely to happen.
- *A priori hierarchization of plans*. Plans can be broken up into subplans before the decision is made to take action. When acting, plans always have to be connected to lower-level plans; otherwise, no action would occur. Of course, the hierarchy of plans is related to the hierarchy of goals, but the two things are not the same. It is possible to have goals (or subgoals) without having a plan for how to achieve them. This will be discussed in more detail later.
- *Long range versus short range*. Similar to goals (and, of course, related to them), plans can have a long range into the future (e.g., a career plan) or a short range (what to do during the next few minutes).
- Miller et al. (1960) thought plans to be the bridges between thought and action. They are made up of TOTE (test, operate, test, exit) units. Thus, a plan is always a combination of thought and action. A TOTE unit consists of testing how far one has moved in one's action, performing an operation to get nearer to the goal, and testing again. If the goal (or subgoal) is achieved, one exits from this TOTE unit into the next one. Thus, there is no plan completely outside action and there is no action completely outside planning.
- The decision concerning which plan (or goal) to pursue has not been researched much within the tradition of action theory. There is, of course, a large body of research on decision theory that concerns itself with these questions (Baron, 1988).

Execution-Monitoring. Insofar as planning always implies some kind of operation, it is actually superfluous to include a separate phase of execution. However, from the perspective of higher-order plans, it is important to distinguish between the execution of a plan and the waiting period. For example, the overall plan to achieve a professorship at a prestigious university is not dealt with at each point in time. But it is important for the individual to note and take advantage of certain opportunities, such as when meeting a professor from that university. Thus, timely subplans should be used (see the concept of triggering in Norman's, 1981, activation-trigger-schema theory).

Various aspects are important for plan execution.

- *Flexibility*. How quickly is a plan abandoned if it does not work out immediately? Volpert (1974) suggests that efficient action implies steering a middle course between flexibility of the plan and keeping one's goals. Thus, one should be flexible enough to adjust plans to environmental demands but stable enough not to give up goals too easily.
- *Speed*. Speed of plan execution has been researched heavily within other theories (and one of the important concepts, of course, is the speed–accuracy tradeoff; e.g., Wickelgren, 1977). Within action theory, speed has been emphasized as important in dynamic situations (Dörner, 1989).
- *Sharing and coordination of plans*. In many cases, tasks have to be accomplished cooperatively. This requires communication about goals and plans in several respects. Tasks have to be redefined in the same manner, leading to compatible and supplemental goals and plans. Furthermore, the time frame of plan execution must be coordinated (Cranach, Ochsenbein, & Tschan, 1987; Cranach, Ochsenbein, & Valach, 1986).[1]
- *Overlapping plan execution*. One can either follow only one plan at one time or follow several. Hannover (1983) has shown that there are individual differences in how people do several tasks—consecutively or overlapping in time. This is related to the issue of multiple goals—whether they are pursued consecutively or not.

The execution of the action is at the boundary of the subjective and objective world.

Therefore, action theory is not subjectivistic because actions change the objective world and the person receives feedback from the (changed) objective world. For this reason, practitioners of action theory feel comfortable with the behavioristic emphasis on the real stimulus situation; however, they are interested in the process of the interactions between the objective and subjective worlds.

Feedback Processes. Generally speaking, feedback is information about how far one has progressed toward the goal. Feedback is neither completely outside the person nor completely inside. It is partly outside because feedback puts the person in touch with the real world of objects. On the other hand, without a goal in mind, there is no chance to understand or conceptualize feedback—thus, feedback is a relational concept. Therefore, feedback can only be interpreted with reference to a goal. There is no doubt that without knowledge of results, there is no progress, such as in learning or performance improvement (Annett, 1969; Volpert, 1971). Thus, feedback is of particular importance for work performance.

There are some useful distinctions between various aspects of feedback, most of them developed in the area of sensorimotor skills (see Holding, 1965; Semmer & Pfäfflin, 1978a; Volpert, 1971):

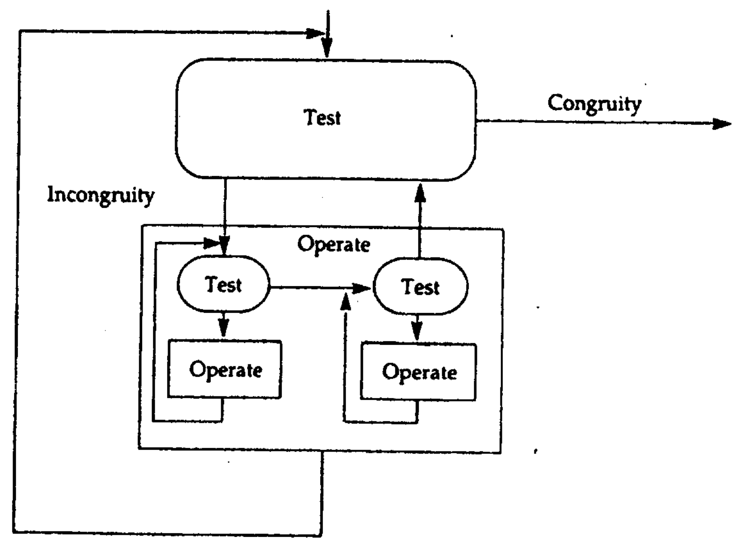
- *Concurrent versus terminal feedback.* There is feedback concurrent to one's actions (like proprioceptive feedback) and knowledge of results after a certain action plan has been completed.
- *Extrinsic versus intrinsic feedback.* Extrinsic feedback, also called artificial or augmented feedback (Annett, 1969; Holding, 1965), is introduced for the purpose of training (e.g., a ringing bell telling us that we have reached a target). Intrinsic feedback is given during the execution of the real-world task itself. Intrinsic feedback can be proprioceptive (information from the vestibular system; kinesthetic information) or exterioceptive (i.e., tactile, visual, auditive, or olfactory information).
- *Immediate versus delayed feedback.* Research shows how difficult it is for people to use delayed feedback to guide behavior (Brehmer & Allard, 1991; Cratty, 1973; Dörner, 1989; Lee, 1950).
- *Verbal versus nonverbal feedback.* Verbal feedback is usually more effective. One reason is that it comprises more information than nonverbal feedback (Holding, 1965).

Certain parameters can be differentiated in feedback processing.

- *Amount of "realism" versus self-serving interpretations.* Dörner (1989) found in his simulation experiments that people who processed feedback in a self-serving manner showed lower performance. Receiving negative feedback may affect the self-concept. When feedback is interpreted within a framework of keeping up the self-concept instead of dealing with the problem, actions are less effective.
- *Reaction to the social content of feedback versus reaction to the performance content.* Since feedback is often communicated via people, the social content of feedback may be important. Some people react primarily to the social rather than the performance content of feedback. This may lead to defensive strategies (e.g., when a superior only notices that a subordinate criticizes him or her).
- *Feedback search rate.* In highly uncertain dynamic situations, it is important to actively search for feedback and react quickly to it (Dörner, 1992). A high feedback search rate and planning activities may be opposed to each other, since a high feedback search rate may in and of itself lead to working memory overload.

FIGURE 2

The Hierarchic Structure of TOTE Units



From *Plans and the Structure of Behavior* (p. 36) by G. A. Miller, E. Galanter, and K. H. Pribram, 1960, London: Holt. Copyright 1960 by Holt. Adapted by permission.

The Hierarchical Structure of Action

The structure of action must be organized hierarchically. If actions were regulated by internal models in a nonhierarchical and sequential way, then models for every action would have to be stored in memory. Obviously, this behavioristic approach is not feasible. As Chomsky (1957) and Carver and Scheier (1982) have pointed out, the infinite number of potential concrete operations must be organized and generated by higher levels of regulation.

Tayloristic time and motion studies in work psychology are equivalent to behaviorist concepts in general psychology. Only the surface structure of the behavior of work is looked at. Action theory attempts to understand the "deep structure of action" as well (Hacker, 1982b, p. 91).

The hierarchy of action regulation is composed of so-called functional units (Volpert, 1982). The starting point of discussing functional units was the TOTE unit by Miller et al. (1960; see also Hacker, 1985, 1986a; Volpert, 1974, 1982); the TOTE units may be nested hierarchically (see Figure 2). Its basic technical analogy is the cybernetic feedback loop.

One can have several points of critique with the TOTE model (and action theorists in Germany have discussed these in depth). For example, the model does not clearly indicate that there are goals and feedbacks within this model (they are tucked away under the terms of *test* and *incongruity*). Moreover, the model looks too self-contained (or like a closed loop; Hacker, 1986a; Kuhl, 1983). There is, of course, an environment that may, for example, change the goals or plans. People will also sometimes construct the feedback themselves; thus, there is an active process of developing feedback. Moreover, goals can change, and therefore there is a dynamic development of action structures that is not well represented in Miller et al.'s theory. Every new goal leads to another set of actions because of new discrepancies between the world and the goals. There are also multiple goals that lead the concert of actions; for example, when working on a specific task, one may also want to do it efficiently and at the same time elegantly. In sensorimotor skills, parallel movements are organized by multiple goals as well (Broadbent, 1985; Fuhrer, 1984).

Finally, one critique is that action theory is concerned only with single actions pertaining to a single goal. Some of the conclusions in the discussion on multiple actions and the issue of heterarchy within action theory (Broadbent, 1985; Fuhrer, 1984; Gallistel, 1980; Kaminski, 1973; Turvey, 1977; Volpert, 1983) include:

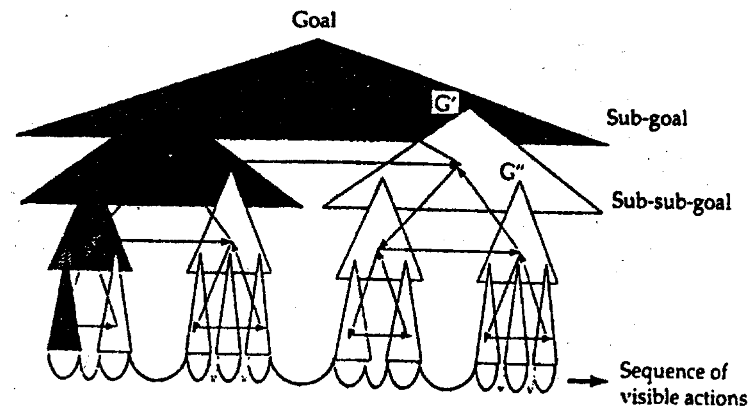
- It is in principle not difficult to include multiple actions within action theory. Since planning must be anticipative to a certain extent, action anticipation goes beyond the particulars of the action itself. This means that a certain amount of parallel processing has always been assumed in action theory.
- Two actions running their course can be intertwined with each other; often this is done by some time-sharing process on the intellectual level of regulation.
- A hierarchy does not imply that the lower levels of regulation have no regulatory functions except those delegated from above. Of course, lower levels react to feedback (even if, as in the case of proprioceptive feedback, conscious processes are not involved) and adjust the action to situational conditions without involvement of higher levels.
- Lower-level actions can lead to changes in the goals at higher levels when it turns out that one cannot pursue them adequately.
- Some errors show that lower levels can have "a life of their own." This implies that there is no "dictatorial power" of the higher over the lower level, but rather a sort of "negotiation" process (Turvey, 1977). The primary example is capture errors (Reason, 1979), in which a habitual routine takes precedent over a conscious plan, as in the case of a driver who takes a direct route home, although she had planned to divert to buy clothing. These actions that don't go as planned appear as intact sequences of action, perfectly coherent in all respects except that they were not what was intended at that time (Reason, 1988). This suggests that low-level habits can take over the action path vis-à-vis conscious higher-level plans.

For these reasons, the concept of hierarchy may be too strong. However, *heterarchy* is not really a good term, since *hetero* means "different" in Greek. We prefer the term *weak hierarchy* (Turvey, Shaw, & Mace, 1978). These points of critique should not divert attention from the fact that functional units are nested in some kind of upper- and lower-level processing.

Volpert (1982, p. 39) describes in Figure 3 how the functional units can be grouped into a hierarchic-sequential pattern. This model assumes a temporal organization: First an overall goal is set and then a series of functional units are produced and executed in a top-down manner. This means that once the lower-level units have been completed, the

FIGURE 3

The Hierarchic-Sequential Model of Action Regulation



From "The Model of the Hierarchical-Sequential Organization of Action" by W. Volpert. In *Cognitive and Motivational Aspects of Action* (p. 39) by W. Hacker, W. Volpert, and M. Cranach (Eds.), 1982, Berlin: Hüthig Verlagsgemeinschaft GmbH. Copyright 1982 by Hüthig Verlagsgemeinschaft GmbH. Reprinted by permission.

goal of the upper-level unit is accomplished. Some functional units (the gray areas) are resident but not in the foreground of attention, while the black unit is the one acted upon. The white units are not yet really thought out or fully activated—they will be elaborated and activated during the course of action. The regulations are elaborated before they actually are used in the action process—the term *breadth of anticipation* is used here (Hacker, 1973). The ascending arrows signify feedback (this is the bottom-up part of this figure). If the subgoal has been attained, the unit is completed.

A concrete example of such a hierarchic process is Hacker's (1986a, p. 137) description of how a tree along the street is replaced (see Figure 4).

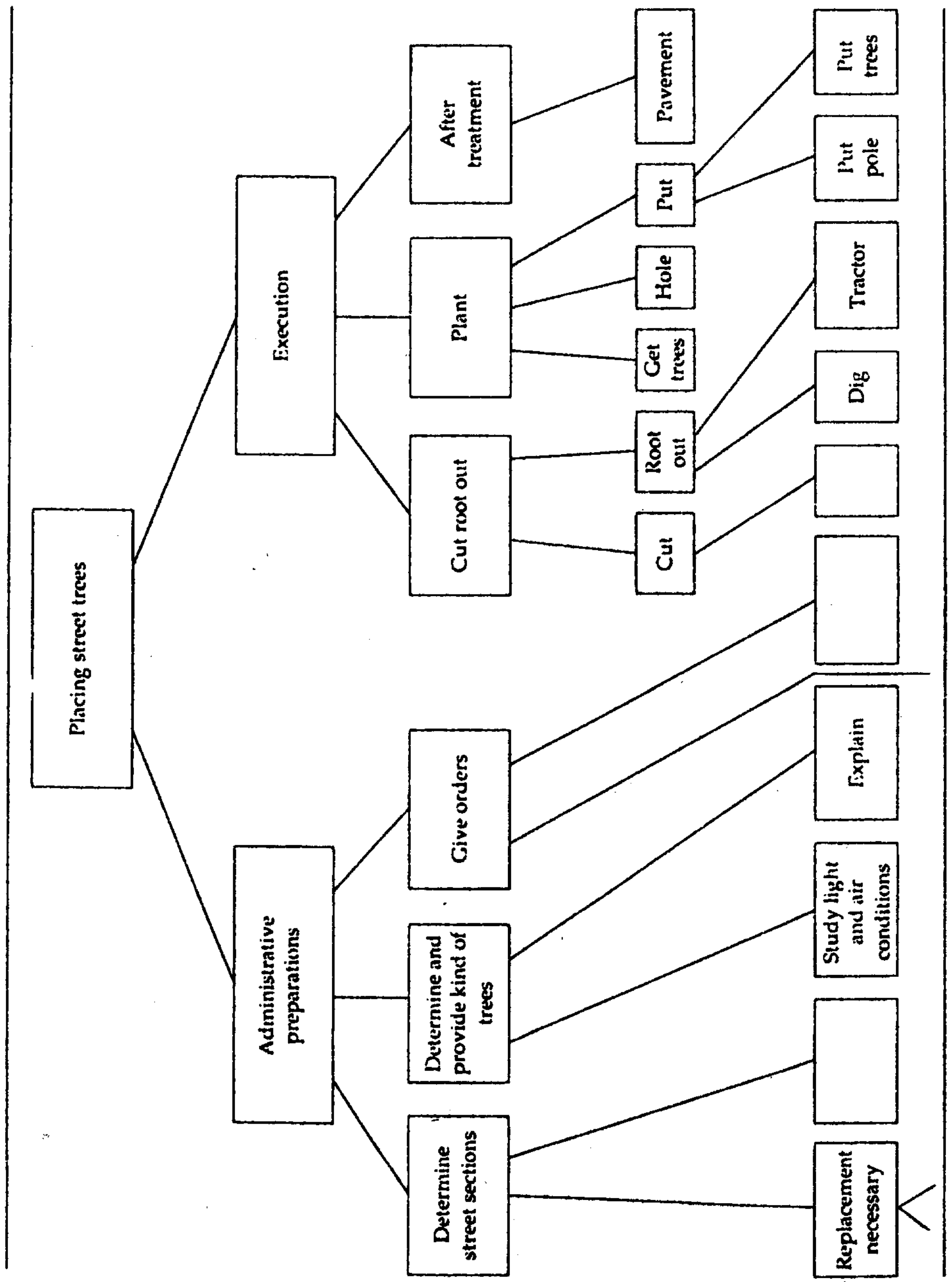
This hierarchy is usually described as going from higher levels (the intellectual level) that control and monitor the action process to lower levels directly linked to muscular activities (the sensorimotor level). Actually, we think there are two, albeit related, dimensions involved. One goes from conscious thought to automatized behavior, the other from thought to muscular action.

The first dimension goes from consciousness to automaticity. Consciousness does not necessarily imply that a thought is verbalizable; it can also be a vivid thought, picturing a certain action (e.g., Shephard & Metzler, 1971). Conscious strategies are necessary when a new problem is tackled or when a more routinized strategy fails to work.

With practice in redundant environments, actions become routinized and automatic. Then they tend to have the following characteristics (Semmer & Frese, 1985): (a) They become more situationally specific, (b) they require less effort, (c) they involve overlap between different operations, (d) they require less feedback from the environment, (e) they require fewer (or no) decisions to be made, and (f) movements take on a more parsimonious form.

The second dimension implies that thoughts can translate into muscular movements. Newer

The Hierarchic Structure of Action: An Example



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research, particularly by Gallistel (1980), whose theory was strongly influenced by the German biologist von Holst, shows the mediating mechanisms between a general goal and muscular movements, and does not need to be repeated here. A separate set of research on mental training (Vandell, Davis, & Clugston, 1943), taken as evidence for action theory, showed that just mentally imaging a certain movement led to an improvement in the skills of using these movements (Ulich, 1967, 1974). This phenomenon is documented well (Heuer, 1985). Moreover, mental training leads to physiological arousal in the muscle used in the imagined movement (Wehner, Vogt, & Stadler, 1984) and in pulse and breathing rate; however, the latter is somewhat reduced in comparison to actually doing a certain task, but is stronger than just watching the task (even the latter implies an increase in pulse and breathing rate; Rohmert, Rutenfranz, & Ulich, 1971).

It is interesting to note that the upper halves of both dimensions are related to conscious thoughts. Moreover, sensorimotor skills can combine both dimensions as well: They usually are highly routinized and related to muscular movements. For these reasons and for economy of exposition, these two dimensions are usually combined into one, and different levels are differentiated. The following four levels[2] seem to be most useful (Hacker, 1973; Semmer & Frese, 1985).

The Sensorimotor Level of Regulation. The sensorimotor level is the lowest level of regulation. Stereotyped and automatic movement sequences are organized without conscious attention. Regulation takes place with the help of proprioceptive and exterioceptive feedback. This type of regulation is largely unconscious and is done with little subjective effort (Kahneman, 1973). The concept of automatic processing (Shiffrin & Schneider, 1977) can be applied here. Information processing at this level is parallel, rapid, effortless, and without apparent limitations. Conscious regulation has some difficulty to modify action programs at the sensorimotor level. It can stop the action, but it is much more difficult to modify an automatized action.

At this regulation level, different levels of complexity of movements may occur. For example, performing a delicate ballet figure is more complex than driving a nail into a wall. Because of parallel information processing at this level, the execution and coordination of parallel movements is possible, but training for the movement must be done to a great extent at this level. For this reason, the ballet figure has to be practiced repeatedly for one to become accustomed to it. What makes the actions at this level difficult is the number of movements to be coordinated, their timing, and their accuracy.

The Level of Flexible Action Patterns. Action patterns can be conceptualized as schemata (see Norman, 1981, 1986; Schmidt, 1975). These are ready-made action programs that are available in memory and must be specified to situationally defined parameters. These action programs have been previously established and must be activated and integrated into an action chain for a specific situation. Moreover, the action patterns can be adjusted to the situation (Volpert, 1974). According to Hacker (1986a), these action programs are largely dependent on the perception of signals. Since in his view signals are well-trained concepts, they can trigger these well-trained action schemas.

The Intellectual Level of Action Regulation. On the intellectual level, complex analyses of situations and actions concerning problem solutions are regulated (Hacker, 1973). New action programs are designed comprising analysis of goals and environmental conditions, problem solving, and decision making. Execution on this level is necessarily conscious. It is slow, laborious, resource-limited, and works in a serial mode, interpreting feedback step by

TABLE 1

A Model of Levels of Regulation

Levels of Action Regulation	*Sensorimotor Level*	*Level of Flexible Action Pattern*	*Intellectual Level*	*Heuristic Level*
Consciousness of regulation	Unconscious; normally no access to consciousness	Access to consciousness possible, but not necessary	Conscious representation necessary	Both conscious and automatic use of heuristics
Elements of the operative image system	Movement-oriented schemata; not necessarily conscious	Flexible action schemata	Complex, intellectually mediated image systems	Generalized heuristics, possibly automatized
Goals	No independent goals available	Subgoals	Goals	Standard and metagoals
Action programs	Blueprints of elementary movement patterns and cognitive routines	Well-known action patterns with situational specifications	Conscious complex plans, strategies	Metaplans, heuristics
Feedback/ signals	Stereotype test programs, unconscious processing of kinesthetic and proprioceptive feedback signals	Processing of known signals/ feedback	Analysis and synthesis of new information	Abstract (nonobject-oriented) checks, logical inconsistencies

After Hacker, 1985, 1986a; Semmer & Frese, 1985; Volpert, 1975, 1987b.

step (see Shiffrin & Schneider's, 1977, controlled processing).

A similar kind of trichotomization has been developed by Rasmussen (1982, 1987a, but without reference to Hacker, 1968, 1973, or German action theory). He differentiates between knowledge-, rule-, and skill-based strategies.

The Heuristic Level. The intellectual level is object oriented; metacognitive heuristics cannot be regulated on this level. Therefore, an additional heuristic level was introduced by Semmer and Frese (1985).[3] On this level, the heuristic functions of how to go about a certain problem or a class of problems in a certain area are regulated, logical inconsistencies are tested, and abstract heuristics are generated. The concept of metacognitions is related to regulation at this level (e.g., Brown, 1988; Gleitman, 1985).

The different levels of regulation are presented in Table 1 in a summary form. They are quite important concepts in action theory. They have only been sketched out briefly at this point, but the issues of levels of regulation will be taken up again when we discuss the applications of action theory.

The Operative Image System as the Knowledge Base for Regulation

In addition to the levels of regulation, there is the so-called operative image system. The operative image system can be considered as the sum of internal long-term representations of condition–action–result interrelations (Hacker, 1986a). It is the cognitive base for action regulation and comprises the knowledge that enables a person to act. Long-term representations comprise movement-oriented schemata to be regulated largely unconsciously at the sensorimotor level, flexible action schemata regulating routinized actions at the level of flexible action patterns, more complex schemata and strategies to be related to the intellectual level, and metaplans and heuristics referring to the heuristic level.

In other cognitive systems, procedural and declarative knowledge have been differentiated (e.g., see Anderson, 1976). This should not be confused with the difference between plans and goals and the operative image system. The operative image system is itself action oriented. Action theory does not deny that there is knowledge that is not linked to action at all. However, it is seen as the uninteresting part of mental events—at least of little relevance for applied psychology.

Operative image systems do not directly regulate actions. The correctness and sophistication of the operative image system determines the quality of the actions via goals, information processing, plans, and so on. Hacker (1986a) describes the operative image system of a process control operator. The operator knows which processes take place, how they are related to technological parameters, how this is part of the total structure of the plant; and the operator knows a lot of signals and how to act if they appear and the consequences of potential actions. The better the operator's operative image system, the more efficient the operator's actions will be.

There is some relation of the concept of the operative image system with the "mental model" (Gentner & Stevens, 1983; Norman, 1983). Mental models and operative image systems are similar insofar as the information they store is not a true copy of reality. Both share properties like selection of information and incompleteness. However, the term *operative* emphasizes the action-oriented character of operative image systems. They are developed by actions and comprise action-oriented images (e.g., how to print a text double-spaced). The concept of mental models is more an internal model of an external system—for example, a computer program (e.g., how formatting functions are organized in submenus). Action theory emphasizes the fact that operative image systems are learned and built by acting.

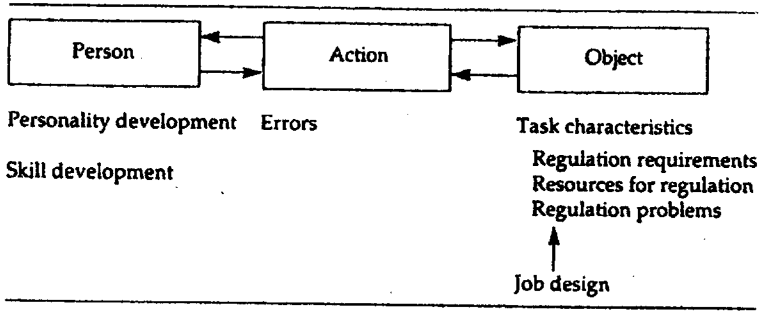
Properties of the Operative Image System. Operative image systems are prerequisites of the regulation processes. They include knowledge on goals, plans, and feedback. During action preparation (goal development, orientation, and plan development), operative image systems have guiding functions. They guide orientation and lead to parsimonious search strategies.

They are usually selective and even distorted because operative image systems do not have to represent a complete picture of the work situation. They need only represent those issues that are important for the tasks done. They can, for example, exaggerate differences of important signals and underrate irrelevant ones. Thus, operative image systems work with generalized schematic features (Bartlett, 1932; Piaget, 1969).

Not every action is represented. Thus, the problem of storage space is solved: The operative images imply rough outlines of actions that do not exceed storage space and can be complemented during the action process. Operative image systems are cost-optimizing systems.

FIGURE 5

Applications of Action Theory: An Overview



For example, they generate strategies that meet job requirements with the least amount of effort. The cost of storing information is optimized as well. Therefore, expenditures of decoding and encoding are minimized and stored in terms of rules and heuristics.

Operative image systems have to be differentiated from short-term processes of regulation (e.g., goal and plan development, monitoring, feedback processes). While operative image systems are elements of long-term memory, action programs must be kept at least partly in the working memory (Reason, 1990). The goals present information that certain parameters have to be retrieved from long-term memory to working memory.

Operative image systems comprise long-term knowledge on the input conditions of one's task, the throughput conditions, and the expected and prescribed results (Hacker, 1982a, 1985). The knowledge of the input conditions includes the intervention points, the laws of technological processes, and the conditions of the raw material. The throughput conditions imply knowledge of plans, tool use, signals, typical errors, and expected probability of success. The knowledge on expected and prescribed performance results should include in-between outcomes, standards, set points, and prediction of consequences, including unwanted ones.

Applications: An Action Theory Understanding of Phenomena in Industrial and Organizational Psychology

Action theory is useful in understanding certain phenomena that are typical of industrial and organizational psychology: errors, personality and work, competence and training, task characteristics, and work design. Figure 5 describes action as the mediator between the person and the work object. Without action, there is no change in the work object. The objective world of work, again, influences the actions. Personal prerequisites have an impact on action, but action also has an impact on the person.

The following presentation will be organized along the lines of Figure 5. At first we shall continue to concentrate on action as the centerpiece of the theory. Up to this point, action has been assumed to work out. Errors are the converse.

On the left side of Figure 5, aspects of the person are described; the two most important issues are personality development and competence. On the right side—the object side—the task characteristics are most important and will be presented next. Work design influences the task characteristics (and thereby also influences, for example, the development of competence, mediated by actions); work design is discussed last.

Errors in Actions

Action theorists have always been interested in the efficiency of action (Semmer & Frese, 1985; Volpert, 1974). Therefore, there has been great interest in the converse: inefficiency and errors. First we will discuss a definition of errors. Second, we will present a taxonomy of errors. Third, we will summarize some validity hypotheses that both support the error classification scheme as well as the basic theory. Finally, we will discuss some practical implication of error analyses.

Definition of Errors. There are three elements of a definition: (a) errors only appear in goal-oriented action, (b) they imply the nonattainment of goals, and (c) an error should have been potentially avoidable (Frese & Zapf, 1991b; Zapf, Brodbeck, Frese, Peters, & Prümper, 1992).

This definition is, for example, contrary to a phenomenological approach, which defines an error as an out-of-tolerance action, or a technical approach, which defines error as the violation of a rule or not meeting the normal system standard. Since one could purposely deviate from externally imposed actions or purposely violate a rule, this would not be considered erroneous from a psychological point of view (see Sellen, 1990). For example, risky behavior is often an intended deviation from a prescribed course of action (Hoyos, 1980; Hoyos & Zimolong, 1988). This definition of errors is in line with other cognitive and action-oriented approaches (see Arnold & Roe, 1987; Norman, 1984; Rasmussen, 1987b; Reason, 1987a, 1990).

Errors and inefficient behavior have a large conceptual overlap. A detour to reach a goal may be conceptualized as inefficiency but also as error, because usually one's goal is to proceed in the most straightforward manner (see Volpert, 1974). Pragmatically, behavior is inefficient even when it is successful in attaining a goal if the goal should have been more easily attained in a more direct manner (*direct* implies that each subaction leads closer to the goal and that no subaction has to be undone; Zapf, Brodbeck, & Prümper, 1989).

Since an action-oriented approach to human errors looks at errors in human action, this could easily lead to the assumption that it is always the human being that fails. However, scientifically it is quite difficult to give one clear cause of an error. Usually there is a chain of causes, and it is more or less arbitrary where one should stop seeking further causes (see Rasmussen, 1987c). Errors should therefore be considered the result of mismatched conditions within a sociotechnical system (Rasmussen, 1982, 1985).

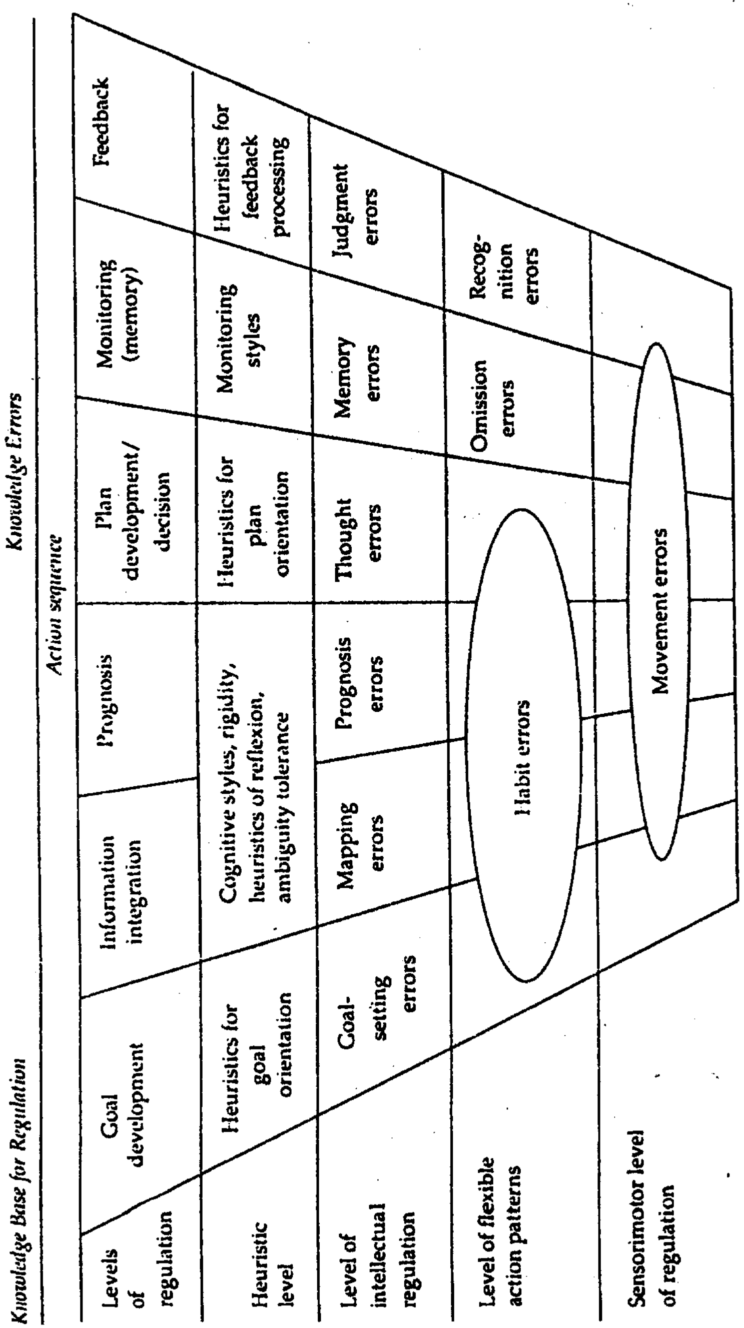
A Taxonomy of Errors. Errors can be differentiated according to steps in the action process and the different levels of action regulation. In addition to the levels of regulation, there are errors in the knowledge base for regulation.[4]

Figure 6 depicts a general taxonomy of errors (Frese & Zapf, 1991b, p. 21). Since there are hardly any theoretical criteria on what and how many types of errors should be differentiated, practical criteria are important: A taxonomy proves its relevance if different error types lead to different practical consequences, such as in training and system design.

The following categories exist (some examples stem from the domain of human–computer interaction for which the taxonomy was originally developed; for details, see Frese

FIGURE 6

A General Taxonomy of Errors



From "Fehlersystematik und Fehlerentstehung: Ein theoretischer Überblick" by M. Frese and D. Zapf. In *Fehler bei der Arbeit mit dem Computer: Ergebnisse von Beobachtungen und Befragungen im Bürobereich* (p. 21) by M. Frese and D. Zapf (Eds.), 1991b, Bern, Switzerland: Huber. Copyright 1991 by Huber. Reprinted by permission.

& Altmann, 1989; Frese & Zapf, 1991a; Zapf et al., 1992).

Knowledge errors occur when there is a lack of knowledge of facts about the tasks and the tools to carry out the tasks.

At the *heuristic level*, action styles, cognitive styles, and the impact of a lack of self-reflection can be discussed. *Cognitive styles* and *action styles* can be described as generalized and automatized heuristics. Cognitive styles are typically investigated with reference to errors (Messer, 1976); for example, reflexivity versus impulsivity using the matching familiar figures test (see Kagan, Rosman, Day, Albert, & Phillips, 1964) or field dependence using the embedded figures test (Witkin, Dyk, Faterson, Goodenough, & Karp, 1962). Dörner (1981, 1987b) described lack of self-reflection as an important prerequisite for errors in problem solving. Good problem solvers showed more self-reflections than bad problem solvers. Furthermore, the number of self-reflections decreased under conditions of failure.

On the *intellectual level* of action regulation, errors occur because the information processing capacity is limited (see Reason, 1990). *Errors in goal setting* occur when goals are inadequately developed. Examples for typical errors described by Dörner (1989, 1991) are the deficient decomposition of global goals into subgoals. Goals are sometimes unclear: There is only a vague criterion that helps in deciding whether the goal is achieved or not (e.g., the library should become more user-friendly).

Mapping errors occur in gathering, integrating, and elaborating information (Dörner, 1991). Here, the goals are correct, but information needed to reach the goals is ignored or processed incorrectly. In complex situations it is often necessary to search actively for information. A series of simulation studies showed the difficulties people have in predicting the behavior of dynamic systems (Dörner, 1987a; Dörner et al., 1983). For example, *prognosis errors* occur in predicting nonlinear system states (e.g., prognosis of AIDS incidents; Badke-Schaub, 1990; Dörner, 1989). *Thought errors* occur when plans are inadequately developed or when wrong decisions are made in the assignment of plans and subplans. Typical planning errors occur when long-term and side effects are not considered, or in methodism, which is the unreflected replication of a course of action that has been successful before (Dörner, 1991; also Luchins & Luchins, 1959). *Memory errors* occur when a certain part of the plan is forgotten and not executed, although the goals and plans were initially correctly specified. *Judgment errors* appear when one cannot understand or interpret the feedback.

Errors on the *level of flexible action patterns* occur when well-known actions are performed. *Habit errors* imply that a correct action is performed in a wrong situation. Some examples from human–computer interaction are presented by Zapf et al. (1989, 1992): A person switches from the use of one word processing system to the next one. Doing this, she still uses the function keys that were correct in the former system but which are now incorrect. There is a tendency to use more routinized behaviors even if they are not adequate (Semmer & Frese, 1985; see also Reason's [1990] frequency gambling and Rasmussen's [1982] model). *Omission errors* occur when a person does not execute a well-known subplan. An example may be that a person forgets to save a file after he is interrupted by a telephone call, although he usually does this routinely at the end of a session. *Recognition errors* occur when a well-known message is not noticed or is confused with another one.

Movement errors are placed at the *sensorimotor skill level*. There is only one category here because at this level it is empirically difficult to differentiate between planning, monitoring, and feedback. For example, typing errors or stumbling could be classified at this level (for more on this, see Gentner, 1987; Grudin, 1982).

Though there are other error taxonomies (e.g., Arnold & Roe, 1987; Heckhausen &

Beckmann, 1990; Norman, 1981; Rasmussen, 1982; Reason, 1987b, 1990), they are usually not validated in field studies. A field validation study was carried out by Frese and Zapf (1991a; Zapf et al., 1992). In this study on computerized office work, a reduced version of the taxonomy described above was used (see Figure 6).

As hypothesized, errors at the intellectual level of regulation and knowledge errors required more error-handling time. This is the case because the in-tellectual level implies conscious thoughts that are processed in a slow, sequential mode. Additionally, the errors are more complicated at this level. Knowledge errors imply a need for additional time because one must either look information up (e.g., in a handbook) or explore to find the correct procedure. Errors at the intellectual level and knowledge errors can often be corrected only with some external support (such as from co-workers; Brodbeck, Zapf, Prümper, & Frese, 1990).

Errors at the lower levels are related to well-known actions; moreover, handling of a wrong action step is usually not complicated at lower levels (Zapf, Lang, & Wittmann, 1991). Therefore, errors at lower levels can usually be corrected without any external help.

Knowledge errors appear more frequently in novices. Novices do not have enough knowledge about, for example, functions or commands. They also make more thought errors because they have more difficulty applying their computer knowledge to their tasks. In contrast, expert users make more habit errors. This is expected because expert users regulate more actions at the lower levels (Prümper, Zapf, Brodbeck, & Frese, in press). Thought and memory errors appear more often in highly complex jobs (Zapf et al., 1992) because complex jobs require more regulation at the intellectual level.

Sensorimotor errors fall into a separate class. First, there is no need for support. Second, differences from habit errors are apparent in the distribution of novices and experts. These empirical results are encouraging and support a taxonomy of the type suggested here.

The Error-handling Process. Error handling can be defined as the process from error detection to recovery from an error (or quit to recover). The error-handling process comprises the following stages (see Bagnara & Rizzo, 1989; Reason, 1990; Zapf et al., 1991): error occurrence, error diagnosis (including error detection and explanation), and error recovery.

Error detection is defined as the user's realization that an error has occurred independently from knowing what the error is like and how it came about (Zapf, Maier, Rappensperger, & Irmer, in press). To know whether an error has occurred or not implies some knowledge about the user's goal. Thus, error detection is essentially related to the feedback that there is a deviation from the goal. In many cases, the people involved in the action themselves are the only ones who know about their goals. In all these cases, only they can detect the error. For example, say a user wants to adjust the page layout margins but instead presses the print key. In this case, only the user knows that an error has occurred, since the result looks reasonably correct. In such a case, error detection cannot be done by a computer. The results of both a field study and some experiments showed that error detection by computer systems has clear limitations (Zapf, Frese, et al., 1991; Zapf, Lang, E. Whittmann, 1991; Zapf et al., in press).

The Concept of Error Management. There are essentially two ways to deal with errors: error prevention and error management. The more typical strategy used by software designers, trainers, and industrial engineers is the attempt to reduce the number of errors. In contrast, an error management strategy does not reduce the number of errors per se but attempts to make error handling easier rather than trying to avoid errors under all circumstances (Frese, 1991; Frese & Altmann, 1989). To understand the concept

of error management, one must differentiate between the error occurrence and the negative error consequences. For example, one negative error consequence is time loss due to an error. An error management strategy exists when a system supports quick and effective recovery procedures.

There are several reasons for using error management (Frese, 1991):

- It is often assumed that errors occur more often in complex work environments. The most important strategy to reduce complexity is to increase the division of labor. A reduction of complexity should lead to a reduction of errors as well. Our data show a relationship between complexity and errors for thought and memory errors but not for all other kinds of errors (Zapf et al., 1992).

Increasing the division of labor was, of course, the strategy suggested by Taylor and his followers (Taylor, 1913). Taylor's strategy stands in contrast to work design concepts developed by action theory (see the section on work design later in this chapter).

- One strategy for solving the problem of human errors is automatization. The less people actually do, the fewer errors there should be. In one sense, this strategy works. However, the long-term consequences might be rather negative. This has to do with the "ironies of automatization" (Bainbridge, 1983). The automated production or data flow must be supervised by human beings. This means that error-prone human beings should interrupt production if something goes wrong with a machine. However, such actions are rarely practiced anymore and skills not practiced will not run smoothly and without problems.
- Some argue that errors can be avoided by qualification. However, qualification does not reduce the number of errors per se; as a matter of fact, in some cases experts commit even more errors than novices (fewer knowledge but more habit errors; Prümper et al., 1992).
- The data on error detection show that it is not possible to automatize error recovery because only a small percentage of errors can be detected by the system (Zapf et al., in press). Undetected errors cannot be handled by the system.
- Last, but not least, empirical studies both in psychology and engineering show that it is impossible to avoid errors completely.

The concept of error management tries to overcome the potential negative side effects of error prevention. Error management is a special case of giving control to the worker.

With these empirical findings in mind, the advantages of an action theory approach to human errors can be summarized.

- Unlike phenomenological approaches, an action theory approach to errors is based on underlying psychological mechanisms (see Rasmussen, 1987a). Based on phenomenological error descriptions, it would be difficult to develop measures to overcome error situations.
- The model integrates different approaches to human errors—for example, errors in complex problem solving (Dörner, 1987a, 1987b, 1989, 1991); the analysis of action slips (Heckhausen & Beckmann, 1990; Norman, 1981; Reason & Mycielska, 1982); taxonomies based on Rasmussen's skills, rules, and knowledge classification (Rasmussen, 1982, 1987a, 1987b; Reason, 1987b, 1990); and taxonomies oriented to the action process (e.g., Rouse & Rouse, 1983). Errors in

complex problem solving are located at the higher levels of regulation; action slips at the lower levels.

- The model clarifies the differentiation between mistakes (wrong intention) and slips (correct intention but wrong execution; Norman, 1984; Reason & Mycielska, 1982). The concept of slip indicates first that there is an error in a routine action and second, that it is an execution error but not an error in the intention. However, errors of execution are not necessarily at the lower levels of action regulation; they can also occur at the intellectual level. If someone wants to do a multivariate analysis of an empirical problem and chooses, for example, the multivariate variance analysis procedure correctly (correct goal), then the decision for a wrong parameter is still the result of intellectual regulation but at the same time part of the wrong execution of the correct goal (i.e., slip). According to our model, this would be an error at the intellectual level of regulation.
- Action theory distinguishes between errors at the intellectual level of action regulation and knowledge errors, which is not done by Rasmussen (1982, 1987a) and Reason (1987b, 1990). Errors at the intellectual level are more dependent on the complexity of a task; knowledge errors are mainly dependent on users' qualifications (Zapf et al., 1992).
- Action theory is able to explain the somewhat surprising finding (Prümper et al., in press) that additional expertise does not necessarily lead to fewer errors. The person with a higher level of expertise delegates regulation to lower levels (routine levels). This implies that the chances of committing errors at these levels increase with expertise.
- Finally, the concept of feedback-driven actions implies that errors and correct actions are two sides of one coin. Feedback drives behavior by comparing the current state with the goal. Errors are essential feedback components of human actions. Errors often tell us that our picture of reality is not congruent to reality. Therefore, errors also have a positive function (Frese, Brodbeck, Heinbokel, Mooser, Schleiffenbaum, & Thiemann, 1991). They support the construction of realistic models of the world and are necessary steps toward achieving a goal.

Work and Personality

In the Anglo-American literature, personality is usually taken as the independent variable in industrial and organizational psychology. Action theory presupposes that this may not necessarily be the case. Since work is the prototype of action and since in work action personality is changed, personality may be the dependent variable (Hacker, 1986a; Rubinstein, 1968).[5]

This is the area of occupational socialization (Frese, 1982). Needless to say, action theory quite enthusiastically embraced the concept of lifelong development (Baltes, Reese, & Lipsitt, 1980), with work being a major factor in the adolescent and adult years.

Moreover, German-speaking work psychology has turned the issue around in the sense that it is believed that work should allow further chances for the enhancement of the personality[6] ("Persönlichkeitsförderlichkeit der Arbeit"; Hacker, 1986a; Ulich, 1978b; Volpert, 1989). Quite a bit of the discussion in German-speaking work psychology surrounds the question of what constitutes prerequisites of good work design. Since work

psychology is supposed to provide a methodology for work design, criterion issues on the adequacy of a work situation are important. Much of this is ontological—for example, the criterion that work should not damage a person's mental and physical health in the long run or that work should allow social interactions to take place.

One of these criteria is the chance for personality development. This criterion emphasizes particular aspects of personality—namely, a set of cognitive and procedural skills developed in work, like problem-solving, social, and general metacognitive skills (Hacker, 1986a). One should be able to use one's abilities, develop one's own goals and plans for work, and use creative ideas in work. Two important issues are the chance for the individual to be active in work and the acceptance of the job in the society (Hacker, 1986a; Ulich & Baitsch, 1987).

Personality enhancement should lead to a transfer from work to active and enjoyable leisure activities (Hoff, 1986; Hoff, Lempert, & Lappe, 1991). It should also be related to productivity because of the higher level of qualification of the workers and because of better work strategies (see the issue of superworkers discussed later).

Empirically, there are some well-established effects of work complexity on intellectual functioning and flexibility that are about as strong as the impact of education (Häfeli, Kraft, & Schallberger, 1988; Kohn & Schooler, 1978, 1983; Schleicher, 1973). Research has been done with different methodologies and different dependent variables. While Kohn and Schooler (1978) have used a measure of intellectual flexibility that has not been validated independently (Greif, 1978), Schleicher (1973) has used a traditional IQ measure (the Intelligence-Structure-Test of Amthauer, 1955) and essentially found a similar relationship. These empirical results suggest that certain skills developed in complex work situations generalize to some kind of general use of flexible intellectual functioning.

Moreover, the relations between work and leisure activities (Hoff, 1986; Karasek, 1976, 1978; Meissner, 1971; see also Ulich & Baitsch, 1987) show some spillover from work into leisure time; however, these relations are certainly complex and difficult to interpret, and causal relations have not yet been well analyzed.

One concept helpful in understanding how work can translate into personality development is action styles (Frese, 1983; Frese, Kreuscher, Prümper, Schulte-Göcking, & Papstein, in press; Frese, Stewart, & Hannover, 1987; Sonnentag, Frese, Stolte, Heinbokel, & Brodbeck, 1992). For example, if the work environment encourages the development of long-range goals, this may transfer to actions outside work. Two concrete action styles researched were goal orientation and planfulness (Frese et al., 1987). Goal orientation means that a long-range goal is developed in detail and that it is particularly persistently pursued. Similarly, planfulness implies that the plan is long-range-oriented, that the plan is not given up quickly, and that it is developed in detail before action is taken (e.g., there are backup plans available in case something goes wrong).

The functioning of these action styles is assumed to be related to the following process (Frese, 1983; Frese, Stewart, & Hanover, 1987): To have long-range goals is a metacognitive heuristic that is developed on the heuristic level (see the earlier discussion of the levels of regulation). The use of this heuristic can be automatized as well. Thus, if a person is often in a situation that requires long-range goal setting, this heuristic to set goals with a long-term orientation will be automatically used. Automaticity implies that the first thought for a person with high goal orientation in unconstrained (or weak) situations (Weiss & Adler, 1984) may be questions like, "What does this imply in the long run?" Automaticity does not imply, of course, that this person always uses a long-range goal because she may consciously decide to use a different strategy in this particular situation or the situation may suggest the use of a certain strategy in the first place.

Since automaticity develops with practice, the job can either strengthen the use of a heuristic used before entering the job (since it is now practiced repeatedly, it will become automatized) or a new heuristic can be developed at work and automatized there. Finally, a prior heuristic can be reduced in its applicability. This may mean that the generality of the action style is reduced.

A questionnaire on goal orientation and planfulness was shown to have adequate reliability and validity (Frese et al., 1987). Goal orientation has been related:

- Negatively with depression in several studies (Frese et al., 1987, Frese et al., in press)
- Positively to the Type A behavior pattern (Frese et al., 1987)
- To growth need strength (Frese et al., 1987)
- To students' grade point average (Frese et al., 1987)
- To leaders' goal orientation with performance in software development groups (Sonnentag et al., 1992)
- To good performance in insurance agents (Frese et al., in press)
- To programmers with high goal orientation who can recognize important material in programs more quickly (Albrecht, 1988)

Planfulness was less clearly related to work variables, although one study shows that there is a weak positive correlation with work complexity and with certain forms of inefficiency (Stumpf, 1991).

We would assume that the action-style goal orientation might be a moderator in goal-setting studies, although we do not have empirical support for this supposition yet.

Another action style is action versus state orientation (Kuhl, 1983, 1992). Kuhl (1982) argues that people are in different metacognitive states when they have formed an intention; they may either be occupied with goal-irrelevant cognitions about the situation and about their emotional state or they may be oriented toward planning and acting. The former is called *state orientation*, the latter *action orientation*. A scale measuring the construct was shown to mediate between the intention and the action (Kuhl, 1982). State orientation also leads to a perseverance effect in which people stick to an unattractive task that they have begun (switching is more action oriented; Kuhl, 1983, 1992). Moreover, this action style moderates the influence of noncontrol situations on helplessness, with only state-oriented people showing the helplessness effects (Kuhl, 1981). On the other hand, managers with high state orientation are probably better decision makers in complex and risky situations, while action-oriented managers are better decision implementers (Kuhl, 1992).

Another issue relating work and personality is control. Control at work implies a certain amount of autonomy with regard to the sequence, time frame, and content of the work goals; work plans; the use of feedback; and the conditions of work (Frese, 1989). Not having control implies that the goals and plans of work are outside the person working (this is related to Hackman & Oldham's, 1975, concept of autonomy). An example would be that a person is told in detail how to perform a certain procedure at work. Control at work may have an influence on control cognitions. While this has been shown to be true in cross-sectional studies, there is no longitudinal evidence for this assertion (Frese & Zapf, 1988). One would assume that this leads to less self-confidence in one's goal and plan development—a notion similar to self-efficacy (Bandura, 1986). For this reason, people with low control at work should also be more passive and less productive (Karasek & Theorell, 1990). In situations that require independent actions, such as using and applying a new software program to one's work, control at work is an effective moderator (Papstein & Frese, 1988). Thus, knowing that

one is in control of one's goals and plans may have its own impact on productivity (Hacker, 1986a).

In a study on East German blue collar and white collar workers (Frese, Zempel, Kring, & Soose, in press), the relationship between control at work and developing initiative vis-à-vis work issues has been shown to be true as well. Moreover, people with less control at work rely on more authoritarian principles in education (Kohn, 1969).

For this reason (and for the effect of control in health issues; see Frese, 1989; Karasek & Theorell, 1990), control cognitions have been of interest to action theorists.

Thus, personality is seen as the dependent variable within action theory research. Obviously, action theory does not deny the importance of personality variables as predictors of work performance and adjustment. As a matter of fact, there are suggestions to adapt the work situation to personal prerequisites, including personality variables of a person. This is one issue of work design that is taken up in the last section of this chapter.

Competence and Its Development

One of the crucial variables for action theory is competence. Therefore, there has been quite a lot of research in this area and on the question of training. It is in the area of performance that action theory has the most promise. Anglo-American work psychology has usually focused on motivation when looking at performance. The most important interest of action theory has been in knowledge of the background of the production process and in the work strategies used.

Performance, Knowledge, and the Superworker. There is, of course, more than one way to increase performance. Hacker (1986a) distinguishes the following methods.

General Increase of Activation. This is a pure motivational approach. It does not change the direction of task performance but just the intensity. While this is certainly useful over short periods of time, in the long run activation has more negative effects by increasing fatigue and the number of errors, including a decrease in error detection. For this reason, Hacker (1986a) suggests use of the following strategies, which are all based on some kind of learning.

Sensibilization. This implies that signal differences can be perceived adequately. For example, steel workers can perceive very small differences in color of the melt in a blast furnace. This gives them a signal concerning whether the iron is ready or not. Similarly, radiologists can discover the smallest abnormalities in an X-ray picture with phenomenal speed (Dahm et al., 1991). Of course, sensibilization is a result of practice and the development of a good operative image system.

Psychological Automatization. With practice in redundant environments, skills become routinized. This has the advantage that the use of automatized skills does not require a high level of cognitive effort; additionally, the movements are smoother and more parsimonious because different movements, thoughts, and actions overlap to a greater degree (Hacker, 1986a). Moreover, cognitive operations can be performed while acting because automatized operations do not require a lot of attention.

However, there are also disadvantages: Automatization carries with it a certain degree of rigidity. This rigidity is partly due to the fact that there is no conscious attention to the action and to the feedback. It is also difficult to unlearn automatized skills. Reintellectualization of an automatized skill is not only effortful, it is also very slow. Particularly under stressful conditions, there is a tendency to revert back to prior automatized skills (Semmer & Pfäfflin, 1978b).

Verbalization. Verbalization may mean two things. First, it may mean conscious verbalizable knowledge of some facts or some work procedure. If something is explicitly verbalized, it helps to orient one's attention toward the right signals. It also facilitates flexible knowledge. Second, and more importantly, the learning process is facilitated by verbalization. Galperin (1967) has suggested that learning is facilitated by interiorization of speech. Thus, it would help to verbalize a certain work procedure. This verbalization is then interiorized, which means the verbalization is shortened until an abbreviation of a command is used to regulate behavior. Thus, more and more, external speech becomes inner speech. Elssner (1972) has shown the viability of such a procedure in training (more on this later in the section on training).[8]

Intellectual Penetration. By this, Hacker (1986a) means a deep intellectual understanding of the task and of the activities necessary to accomplish the task. Intellectual penetration is what differentiates superworkers from average workers. Superworkers have a better operative image system. For example, excellent blue collar workers are more realistic about how long it will take to carry out a task (Hacker, 1986a); excellent white collar workers are more realistic concerning the time it will take to perform a computer task, and they can anticipate better what another person would want to do with a certain procedure (Lang, 1987a). Because of their higher anticipation, superworkers perform fewer work activities and produce more, as in the case of weavers with semiautomatic looms (Herrmann, 1967). A North American study on managers yielded similar results: The best managers anticipated more problems, knew more about the implications of an event, predicted events more accurately, and avoided negative ones (Klemp & McClelland, 1986). Similarly, Jeffries, Turner, Polson, and Atwood (1981) found that expert programmers used more time to understand the problems at hand than nonexpert programmers.

In another set of studies, Rühle (1979) and Schneider (1977) have shown the differences between excellent and average blue collar workers in a textile factory. Table 2 shows Hacker's (1992) summary of their results. This table is another indication that it is not the greater motivation to work hard that distinguishes superworkers from nonsuperworkers, but rather a better operative image system and better work strategies.

While Hacker and his co-workers usually looked at blue collar work, in another set of experiments Dörner and his colleagues (Dörner et al., 1983) have used very complex computer simulations. For example, subjects had to work as a dictatorial mayor of a city. These computer simulations included 4,000 variables that were interdependent and dynamic (e.g., inflation increased even when nothing was done, the number of unemployed in the city changed when investments were low). Each experiment lasted for several days.

Successful subjects had more precise goals and asked more questions, particularly more "why" and more abstract questions. The questions were also on the right level of decomposition; in other words, they made sure to develop an adequate operative image system that was useful in understanding the problems at hand. This allowed them to set clearer and better priorities (e.g., economic priorities of inflation reduction instead of providing every citizen with a public telephone). They also developed more hypotheses and tested their hypotheses. They planned more, directed their actions more toward their goals once they were established, and did not act impulsively. They made more decisions and had more goals. They were more self-reflective and thought more actively about changing things rather than just describing them (Dörner et al., 1983; Reither & Städel, 1985).

They were also less neurotic, but there were no differences in IQ compared to the bad performers (Dörner et al., 1983; Dörner & Kreuzig, 1983; Dörner & Pfeifer, 1991). This result is, of course, akin to Sternberg's

TABLE 2

Empirical Results on the Superiority of Superworkers in Two Studies

Area	*Criteria*	*Direction of Results*	*Significance*
Intensity of work	Use of work time; speed	—	n.s.
Sensorimotor skills	Skills in two areas	—	n.s.
Operative image system	Search time for causes of errors	Shorter	Sig.
	Error prevention	More frequent	Weak sign
	Disruption of normal work for planning	More frequent and longer	Sign
	Organizing periods of machine use without tending them	More frequent and longer	Sign
	Interviews		
	Knowledge of frequency of errors	More comprehensive	Sig.
	Knowledge of signals of error causes	More comprehensive	Sig.
	Knowledge of duration of repair and other operations	More exact	Sig.
	Knowledge of efficiency of strategies	More comprehensive	Sig.

Adapted from "Expertenkonnen Erkennen und Vermitteln" by W. Hacker. In *Arbeit und Technik* (Vol. 2; p. 15) by M. Frese and H. Oberquelle (Eds.), 1992, Stuggart, Germany: Verlag für Angewandte Psychologie. Copyright 1992 by Verlag für Angewandte Psychologie. Reprinted by permission.

discussion of practical intelligence (e.g., Sternberg, 1986).

More Active Approach. A more general description of the work strategies of superworkers is Hacker's (1986a) differentiation of momentary versus planning strategies.[9] Momentary strategy implies that one reacts to the situation that exists at the moment. In contrast, a person using a planning strategy plans ahead and actively structures the situation, including potential feedback. Thus, planning strategy implies a more comprehensive and more penetrating intellectual representation of the work process, a longer time frame to plan ahead, a larger inventory of signals, a better knowledge and anticipation of error situations, and a more active orientation toward work.

This comparison also sheds some light on the riddle that superworkers sometimes seem to work less yet produce more. Because of their planning strategy, they are more efficient in the sense of getting a higher yield with less effort than people using a momentary strategy. Hacker and Vaic (1973) found that superworkers were not significantly different from other workers in their actual work time (time spent in production), but there were significant differences in preparatory activities (e.g., getting supplies), in having exact goals in work, and in presenting work rationalization ideas to the company.

The concept of superworkers is somewhat different from the concepts of novice versus expert. There is certainly some conceptual overlap between them. The novice versus expert concepts are quite fuzzy but are often based on the dimension of experience. In contrast, the superworker concept refers to the notion of efficient strategies of action, which may very well be different from experience.

Thus, there is ample evidence that superworkers in real-life work situations show a better understanding of work processes and potential strategies, and also use more active strategies to control the work situation rather than have it govern them. This is not only true of blue collar workers, but also of managers and subjects in a very complex simulation. Superworkers do not necessarily work harder (they usually do not, and sometimes show even less work behavior) than other workers, but work more efficiently.

Skills and Skill Acquisition. Much of the literature on training in action theory was done in the area of sensorimotor skills (e.g., Ulich, 1964, 1967, 1974; Volpert, 1971, 1976) and learning computer skills (Frese et al., 1988; Greif, 1989). However, there is also an active literature on training in social skills (Hartwich & Okonek, 1979; Kühbauer & Schmidt-Hieber, 1978; Rieger & Rummel, 1979; Semmer & Pfäfflin, 1978a), although there is less research in this area.

From action theory comes the following propositions on skill acquisition and training:

- People are active learners.
- The action is regulated by an operative image system. The better a training program improves this system, the better is the action.
- Every person begins a learning situation with a rudimentary operative image system. Accidental learning results will be incorporated into this system.
- Cognitive strategies and heuristics structure the training process and lead to a better operative image system for the training process.
- People learn from feedback and errors.
- In the beginning of the learning process, the rules and plans are conscious. With practice, they are transferred to lower levels of regulation.
- Transfer of training to everyday work depends on task orientation and practice support at work.
- Mental training should have an effect on physical performance.

People Are Active Learners. One assumption of action theory is that people are active toward their environment (Rubinstein, 1968). As a matter of fact, learning is facilitated by action. Only through action is it possible to develop routines. In principle, one can have thoughts that are not related to actions. In such a case, these thoughts will not really regulate action (Semmer & Frese, 1985). Only thoughts that are actually connected to actions will result in better performance. It is easier to solve a problem that is action oriented than one that is not (Johnson-Laird, 1983). Even perception may be much more action oriented than classical perception theory held to be true (Gibson, 1979; Hofsten, 1985; Neisser, 1985). Again, it is easier to learn something about the environment when we are acting on it than when we are sitting still.

In the training literature, an active approach has been discussed under the rubric of exploratory learning (Bruner, 1966; Greif, 1992; Greif & Keller, 1990). There is ample evidence that this approach is superior to learning that does not allow an active approach (Carroll, Mack, Lewis, Grischkowsky, & Robertson, 1985; Frese et al., 1988; Greif & Janikowski, 1987, Greif & Keller, 1990; see however, contrasting discussion by Ausubel, Novak, & Hanesian, 1968). In one study (Hiltscher, 1992; Hiltscher & Frese, 1992), two training

procedures were compared—one attempted not to allow any exploration (sequential training); the other necessitated exploration. One result was that the exploration group learned more than the sequential group. However, there was a second, more important finding: Our hypothesis was that some people in the sequential training would deviate from the instruction and would explore anyway. We found that those subjects learned more than the people who actually followed the instruction.

The Importance of an Operative Image System. Ausubel et al. (1968) were critical about exploration because it always involves a certain amount of "blind trial and error." They suggest giving trainees a clear cognitive orientation—an advanced organizer—to enhance training. This is also in line with trainees' preferences to be able to first observe the skill that they are to learn and then use more active approaches of learning (Volpert, 1969). Thus, these concepts speak for the importance of the operative image system.

A good operative image system leads to better performance. It is developed by providing good background knowledge on the work process involved and a set of principles by which the work process and the task execution is done effectively (Freier & Huybrechts, 1980; Josif & Ene, 1980; Rühle, Matern, & Skell, 1980).

The operative image system must have two characteristics. First, it should be in some way holistic; thus, it should include the important parameters of the task. In tasks that are too complex to learn in one practice session, an overall global concept of the task should be given to the trainee (Volpert, 1971). This stands in sharp contrast to the sequential orientation that Seymour (1954) suggested. The sequentional orientation leads to one-sided and low-level training procedures and thus produces little intellectual insight into the task.

Second, the operative image system has to be action oriented. In an observational study on computer users, only those parts of the mental model that had direct relevance to actions were useful (Lang, 1987b).

There is a certain contradiction between the issue of exploration just discussed and the issue of providing a good operative image system. In fact, exploration implies a certain amount of trial and error, though this may be hypothesis-driven. In contrast, presenting a good operative image system in the beginning of training helps to avoid trial-and-error periods, although discovery learning is minimized. In actuality, most training programs do not pit discovery learning against giving a good mental model before the training—rather, they use both. For example, Greif and Janikowski (1987) have first presented an orientation poster that provides a hierarchy of the program commands to be learned. Next, they gave the subjects a chance to explore.

In one experiment, these two procedures were tested against each other (Frese et al., 1988). One group of computer-naive subjects received an orientation poster (Greif & Janikowski, 1987) and a good introductory handbook. The other group—the exploratory group—was asked to develop some hypotheses on how the computer program might function and tried out to work with these hypotheses (at some point, the trainer would provide a correct answer). Both groups did about equally well with an insignificant superiority of the exploratory group. In another experiment simulating a chemical process control, performance was better for a group that received a set of optimal rules than it was for a group that developed its own set (Freier & Huybrechts, 1980). One explanation for the superiority of the rule presentation may have been that feedback—which is crucial for exploratory learning—was not optimal.

Thus, there may be two different processes by which a high degree of learning takes place—the learning made by active exploration and the learning made by using good rules. Both may also lead to high performance. Note that both involve practice. However, exploratory training emphasizes learning through action to a higher degree than learning through the use of good rules (which may prove positive), but it may invariably lead to certain errors and pitfalls. They may in turn lead to incorrect conceptualizations that need to be eradicated over the long run (which may work against efficient learning). In contrast, initially giving a good operative image system reduces the amount of active learning (which may actually reduce good learning). This is true even though it will give a good mental model initially, thus minimizing wrong turns and dead-end roads (which may prove positive). Of course, a combination of the two approaches would be best from an action theory point of view.

The action theory perspective in training implies that pure drill has its limits (Frese et al., 19[illegible], Semmer & Pfäfflin, 1978a). Drill may provide certain experiences in performing a task. However, drill reduces the chances to develop a good mental model. Drill may work with very rudimentary types of tasks, but if the task has a certain amount of complexity, important task characteristics will be missed because they are not self-evident (not even when a model is presented). Drill just produces skill acquisition on a lower level of regulation. Therefore, an intellectual understanding will be minimized. Additionally, drill does not guarantee flexible reactions when environmental changes occur because action patterns have been learned as invariants.

Rudimentary Operative Image System and Accidental Learning. People start out with a rudimentary operative image system. This is usually some kind of metaphor or analogy. For example, a typewriting metaphor is often used by computer novices when they are learning a word processing system. This leads to characteristic errors, such as in the interpretations of blank spaces and the possibility to overwrite a blank. A blank has no particular meaning when one is working with a typewriter, while it has its own representation in a word processing program. In contrast, using the metaphor of building block letters leads the subjects to avoid creating blanks, since a block letter "blank" is conceptualized to exist (Waern & Rabenius, 1987).

Humans beings are uniquely adjusted to changing environments by drawing inferences very quickly. This has the disadvantage that a mental model is formed even when there is actually not enough information available. In one training, we observed a computer novice perform the following process with a word processing system: When inserting a letter, he would first "make room" for it by inserting a blank space, then, he would insert the letter and delete the blank space that was now unneeded. He had been using this procedure quite consistently for a long period of time. People develop operative image systems quite quickly and without having an adequate knowledge base (Norman, 1983). This means that trainees should be cautioned against developing a fixed operative image system too early. Exploration may help to reduce a premature fixation because people are encouraged and sometimes forced to test new hypotheses. Additionally, trainees should learn to look for disconfirming experiences (this may be an advantage of error training, as will be discussed later).

Cognitive Strategies and Heuristics. One way to sharpen the operative image system and avoid premature fixtures on one type of explanation is to give heuristics to trainees. Training with heuristics has been shown to be superior to training without heuristics. Skell (1972, p. 48) has, for example, given the following heuristics to tool and dye maker apprentices (nonliteral translation by the authors):

- Compare the drawing with the raw material. What do you have to do to achieve the changes demanded by the drawing?

- Are there any prerequisites not immediately observable in the drawing?
- Is there anything else to do after you have performed all the steps?
- Try to eliminate movements that are not necessary; you can do this by thinking about the following questions:

  Can different types of actions be performed with the material clamped the same way into the vise?

  Can the clamped item be used again?

  If you have a choice between the same clamp setting or the same tool, ask yourself which one is more time-consuming!

  If a different clamp setting is used for the material, can it be used to do different things at the same time?

Skell (1972) and others (e.g., Höpfner, 1983; Sonntag, 1989; Sonntag & Schaper, 1988; Volpert, Frommann, & Munzert, 1984) showed that heuristics such as these produce work performance superior to that which results when these suggestions are not given.

Rühle, Matern, and Skell (1980) reported two experiments on giving heuristics to switchpersons in railway stations and to multiple machine operators. The use of heuristics and their interiorization increased optimal decisions in the switchpersons and increased the work performance of the multiple machine operators. Additionally, the operators with the new training procedure experienced less monotony and satiation in their work than those trained with the traditional procedure.

Heuristics were not only used in skills for blue collar workers. Computer training (Frese et al., 1991; Greif, 1989, 1992; Irmer, Pfeffer, & Frese, 1991) and social competence training (e.g., discussion and negotiation skills) were also advanced by using heuristics (Hartwich & Okonek, 1979; Kühbauer & Schmidt-Hieber, 1978).

The theoretical importance of heuristics is, first, that they further a clear and action-oriented operative image system, and, second, that they provide a set of easy-to-remember rules of thumb that help prevent pitfalls. Third, it is important that they do not attempt to present a complete orientation that would be too difficult for the novice to remember and that would only produce a partial information extraction leading to a lopsided mental image; heuristics leave room for exploration. Fourth, at the same time, a set of heuristics can be complete enough to present a mental image that is in some ways holistic. Fifth, heuristics can be used in the sense of progressive interiorization of commands. That is, in the beginning they have to be spoken out loud; after a while, a shortened version is used, this version is then only mumbled, and finally, only an abbreviated version of inner speech is used (Skell, 1980).

Learning From Feedback and Errors. There is no doubt that feedback is necessary for learning to occur (Annett, 1969). This is, of course, one issue that has led to the development of action theory in the first place, with its heavy orientation toward a feedback loop. However, feedback is only useful when it is similar to real-life feedback. For example, augmented feedback (i.e., feedback used only in training) leads to worse real-life performance because one has become accustomed to the feedback in training (Volpert, 1971). Moreover, feedback is of no use if there is no external task or internal goal to compare the feedback with. Without a set point, feedback has no guiding function for action.

Feedback has a number of functions in the learning process. First, one knows from feedback whether a certain movement is still oriented toward the goal or is leading away from it. Second, negative feedback tells the trainee what he or she has not learned yet, and positive feedback reveals what is known. Third, negative feedback describes the boundaries of the operative image system as it exists now—what cannot be solved with the particular mental model one has developed so far. Fourth, feedback connects the trainee to the objectivity of the world. Fifth, feedback has a motivating function; positive feedback encourages one to persist on the path, and negative feedback encourages one to correct the path and orient oneself toward the environment to scan it for unnoticed clues.

In comparison with behavioristic and humanistic views, action theory has a higher opinion on negative feedback. An error is one type of negative feedback, and a particularly useful one. Errors have been shown to improve training in a number of studies from different groups in Germany (Frese & Altmann, 1989; Frese et al., 1991; Greif, 1992; Greif & Janikowski, 1987).

Errors have several advantages. First, errors help people understand that a certain part of the operative image system is *not correct* (possibly a boundary condition). For example, some trainees had difficulties with the use of rulers in a computer system because it was not used to underline text (as subjects thought) but to set margins (Frese & Altmann, 1989). This error led the subjects to know that they should expect exceptions to underlying metaphors. Moreover, the trainee may realize that he or she does not know something well enough, which may lead to self-reflective thoughts.

Second, errors can sometimes lead to new phases of exploration and to creative solutions. Many scientists have reported that errors led to new discoveries.

Third, errors can bring about a reintellectualization of the action. Potential premature routinization of behavior will be broken up. This gives the person a chance to think consciously of the adequacy of the operative image system. Moreover, premature routinization is a problem in training and needs to be broken up before automatization is developed too far because alternative learning is then very difficult.

Fourth, errors produce a more complete operative image system because they sharpen the knowledge on potential pitfalls, potential problems, and difficult areas in the task structure. Therefore, more caution and enhanced attention is used in these areas, and therefore quicker detection and correction.

Fifth, error making helps to develop skills in error handling. Since errors appear quite frequently in real work life (Zapf et al., 1992), skills in error handling help to use errors productively and efficiently.

Sixth, errors always have the negative effect of being frustrating. But since they occur regularly, it is useful for people to learn to deal with this frustration. Thus, using errors in training in some ways provides stress management training (Greif, 1986).

Errors have been experimentally researched by comparing one group that received ample opportunities for making errors (essentially by being given tasks that were too difficult to do) with another group that was given instruction in how to go through the difficult tasks. The instruction did not allow someone following it to make an error. The error training group consistently fared better than the group that received no training (Frese et al., 1991; Greif & Janikowski, 1987; Hiltscher, 1992; Thiemann, 1990). Most of these trainings also presented general heuristics to the subjects on how to deal with errors, such as "I have made an error. Great!" or "There is a always a way to leave the error situation" (Frese et al., 1991, p. 83). Since these were all laboratory experiments with volunteers as subjects, error training was also used in a normal school for teaching computer skills (Irmer, Pfeffer, & Frese, 1991). Again, various error training groups were superior to groups receiving standard

training in a performance test given after the training.

Automatization of Action Regulation. With practice, there is a change from conscious regulation to lower levels of regulation: Action theory presupposes that with practice, skills become automatized. For example, the novice driver cannot talk while driving—all of the person's attention is oriented toward driving. In contrast, the expert driver shifts gears without thinking about it and talks while driving without problems ocurring (except when he or she gets into a difficult situation and when something does not work properly). Routinization develops rather quickly. As a matter of fact, after doing something for a few times in a redundant environment, routines develop. As discussed before, it is hard to break up routines; particularly when people are under stress, there is a tendency to stick to old routines.

This implies for training that it is necessary to prevent premature routinization. This can be done by keeping the environment nonredundant. It may be one of the advantages of an exploratory form of training that the environment is kept nonredundant. In contrast, sequential training (Seymour, 1954) deliberately introduces redundancy to increase the routinization of skills in partial tasks. While this leads to a quick routinization of these partial tasks, it is more difficult to connect different parts of the complete action because organizing the parts into a whole requires new strategies. The different parts may form some kind of gestalt. This gestaltlike character is more difficult to achieve in sequential training. If the partial tasks have been prematurely routinized in separate practices, it may be very difficult to combine the parts.

A general problem of automatic behavior is the difficulty in changing it. This implies that verbal forms of retraining are useless. The alternative actions must be practiced until one has achieved a certain routine in this new behavior. This is the case, for example, in leadership behavior. Alternative leadership behavior will not be used in the real work situation as long as one has not practiced the alternative behaviors. Thus, practice is an important part of training. It is not so much a problem of changing cognitions, but one of making the new cognitions regulatory significant; much of the work is in getting the person to really act according to the new rules (Semmer & Frese, 1985).

Transfer of Training to Everyday Work. Transfer of training should be enhanced by a clear orientation toward the task at work and a chance to practice in safe environments and with task-oriented support.

We have discussed the importance of the task for an action theoretic conceptualization. Since the reason for action is to accomplish tasks, it is little wonder that action theorists have looked at the role of task orientation in transfer. Papstein and Frese (1988) have suggested that there is a difference between training tasks and work tasks. Usually in training, the development of system knowledge stands in the foreground. For example, most trainers will explain in great detail how to use the computer as a system but not how to apply it in the specific tasks at hand. To transfer this to the work task requires a separate set of principles and new knowledge: task application knowledge. Task application knowledge implies knowledge on how the system can be used in practical work situations (e.g., knowing concrete examples). In a study involving training people on a computer program, task application knowledge was an effective mediator between performance after the training and the use of the software six months later (Papstein & Frese, 1988).

Moreover, goal orientation and planfulness (both related to long-term orientation and precise goal setting and planning) proved to be an effective moderator (Papstein & Frese, 1988). Thus, people who think about the long-term use of the training material show a higher degree of transfer.

The more decision latitude the work situation allows, the easier it is for employees to develop such safe environments for themselves. This may be one reason why work situations with a high degree of job discretion show more transfer than work situations with little autonomy in work (Papstein & Frese, 1988).

Of course, task orientation can be incorporated into the training itself, either by using normal work tasks as examples or by asking the trainees to apply the training content to their normal work tasks. This was suggested in cognitive therapy (Kanfer, 1975; Watson & Tharp, 1972) and social competence training; application contracts that specify how and when to use what one has learned can help to further this goal (Greif, 1976; Semmer & Pfäfflin, 1978a).

One way to understand theoretically the difficulties in transferring knowledge learned in training is to look at the action structure. In the beginning of the learning process, the actions are conceptualized as a global structure without specific relations with the actual performance of these actions (Volpert, 1971). Slowly, the regulatory processes are strengthened and the global structure is replaced by an operative image system that has regulatory power to control the particular acts. At this point, actions are regulated at the intellectual level. It is an important issue to connect this intellectual level with lower levels.

Since the tasks have usually been done before and are therefore well routinized, there is a necessity to unlearn old routines and to establish new ones. This may be of greater importance than all other issues in training because lack of support for this transmission from training to work and from intellectual understanding to actual routine use of new action patterns is largely responsible for the inefficiency of training as an instigator of on-the-job-behavior.[10]

The Effects of Mental Training. Evidence that purely imagining a movement leads to an improvement has strengthened the concept of cognitive regulation of action. Therefore, mental training—or, as it was also often called, mental practice—was one of the first issues taken up by action theorists (e.g., Däumling et al., 1973; Rohmert, Rutenfranz, & Ulich, 1971; Ulich, 1964, 1967; Volpert, 1969, 1971; Wunderli, 1978). In mental training, the movements must be imagined very concretely (e.g., in skiing, how one uses the legs in turning left).

Obviously, so-called behavioristic concepts like systematic desensitization are easily reinterpretable within this framework (Semmer & Frese, 1985). Similarly, in training assertiveness skills, it is useful to imagine how one talks about a sensitive issue.

Mental training probably works through two different mechanisms. One is related to the training of cognitive aspects of the movement. Movements that are more cognitively regulated, such as learning to go through a maze, will be better after cognitive training. However, mental training additionally shows a practice effect even with more motoric movements (e.g., dart throwing). The function may be to integrate thoughts and muscular actions, or more specifically to integrate motoric and kinesthetic schemata (Heuer, 1985).

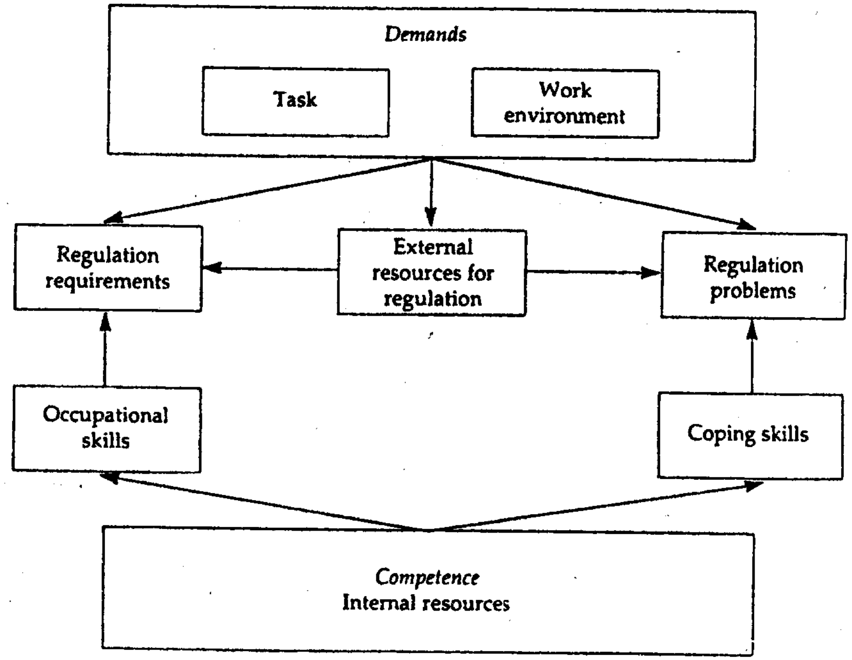
Task Characteristics

Hackman (1970) differentiated four approaches in job analysis: behavior description, behavior requirement, ability requirement, and task description. From an action theory perspective, task characteristics are described with reference to regulation processes—the regulation requirement approach. This actually constitutes a fifth approach, although there are certain similarities to the behavior requirement approach.

Three aspects are distinguished: the regulation requirements of a task, the resources for regulation, and the regulation problems (see Figure 7).

FIGURE 7

Classification of Task Characteristics



Resources for Regulation: Control at Work. A central variable for work design is control. Many different terms are used in this area: control (Frese, 1977, 1989; Oesterreich, 1981), *Handlungsspielraum* (room for action; Semmer, 1984; Ulich, 1972), degrees of freedom (Hacker, 1986a), decision latitude (Karasek, 1979), and autonomy (Hackman & Oldham, 1975, 1980). There is high conceptual overlap between these terms, and all of them can be subsumed under the term *control*.

Control means to have an impact on the conditions and on one's activities in correspondence with some goal (Frese, 1977). Decision possibilities exist with regard to the sequence of the action steps, the time frame, and the content of goals and plans (see Figure 8). Decision points with regard to sequence include which tasks are carried out first, in which sequence plans are performed, and in which sequence feedback information is processed. *Time frame* refers to both when and for how long a certain task is performed. *Content* refers to the substance of the decisions, such as what particular task is done and what plan is performed.

A high amount of control might allow one to define the general goal of the work itself. A lower level of control might only allow one to choose between goals and plans at lower levels of action regulation.

FIGURE 8

Aspects of Control

	Decision Possibilities		
Action sequence	Sequence	Time frame	Content
Tasks (Goals)			
Plans			
Feedback (Signals)			
Conditions			

From "A Theory of Control and Complexity: Implications for Software Design and Integration of the Computer System into the Work Place" by M. Frese. In *Psychological Issues of Human Computer Interaction in the Work Place* (p. 316) by M. Frese, E. Ulich, and W. Dzida (Eds.), 1987b, Amsterdam. North-Holland. Copyright 1987 by North-Holland. Reprinted by permission.

In the context of action theory, the goal-oriented nature of control is emphasized. Without a goal, there is no issue of control (see Frese, 1987b). This differs, for example, from Seligman's (1975) concept of control as noncontingency of events (i.e., an event appears or disappears regardless of a person's action). According to Seligman's (1975) definition, a person would have control if he or she accidentally and contrary to his or her intention produced a mistaken outcome. A goal-oriented definition would suggest that this person had no control.

Several issues have to be emphasized in this context (Frese, 1987b, 1989). First, the goal-oriented nature of control: Decisions are made with some goal in mind. As long as something is irrelevant to a goal, noncontrol is not an issue. Second, control and risks: Real freedom exists only when decisions do not involve high risks. High-risk decisions are aversive. Third, the personal meaning of control: There is only control if the decision possibilities make sense and they are relevant to the person. There must be real alternatives of goal attainment (e.g., sorting out eggs in a hen farm for breeding does not offer real decision possibilities; Hacker, 1986a).

Subjective and objective control can be distinguished (Frese, 1978; Hacker, 1986a; Oesterreich, 1981; Ulich, 1972). Objective control consists of potential decision points with regard to a goal. Objective control is determined by the logic of work products; means and machinery and their physical, chemical, or biological structures and regularities; and organizational variables that, for example, determine the division of work or prescribe work procedures. Subjective control is the control a person perceives in a situation. Skills are particularly important as prerequisites of control. They determine whether objective decision possibilities are actually perceived and whether the perceived decision parameters can be realized. Perceived control might sometimes be higher than objective control. However, since feedback conditions are usually more obvious in work life, illusion of control should be lower in the work domain than in other settings (Frese, 1992).

Functionality, Transparency, and Predictability: Prerequisites for Control. Functionality, transparency, and predictability have become important issues in human–machine systems (Ulich, 1991). An action theoretic concept of control allows one to integrate these concepts into a theoretical framework (Frese, 1987b; Hacker, 1986a).

Functionality refers to whether a tool, such as a computer program, permits or enhances the completion of a task. Without the functionalities of tools, there is no control because goals cannot be achieved at all or must be changed (see Zapf, 1991c). However, a high

degree of functionality does not necessarily imply control. For example, a typist with a powerful word processor whose task is writing standard letters has little control.

Transparency implies that one can easily develop an operative image system of the tool (see Maass, 1983). Under conditions of nontransparency, one cannot make adequate goal, planning, and feedback decisions. However, transparency is not identical to control because it is possible to develop a system that is completely transparent but does not offer any control (Frese, 1987b)—for example, a computer system that explains every step it takes in a process and provides clear prompts but does not allow the user to make any decisions.

Predictability has some overlap with transparency. Transparency refers to the present and the predictability to the future. If a system's behavior cannot be foreseen, it is not predictable. As with transparency, a system can be predictable but noncontrollable. Take the typist example: When writing standard letters, it is easy for the typist to predict what will happen next, but the person has little control over the task.

Regulation Requirements. From an action-oriented perspective, regulation requirements are related to properties of the hierarchic-sequential organization of action. In this section we will differentiate between the complexity, variety, and completeness of actions.

Complexity. In contrast to control as a set of decision possibilities, complexity implies *decision necessities*. Thus, high complexity leads to a high degree of regulation requirements necessary to perform a particular task. *Complexity* is an interactive term. It refers to a person's skills and the requirements of the situation. For example, if a person has done a certain task frequently, the person will have routinized the decisions necessary for performing the task; thus, the complexity of the task is rather low. In contrast, the task will have a high degree of complexity for the novice, even if it may turn out to be a noncomplex task after practice. This is in contrast to, for example, Kieras and Polson's (1985) concept of complexity as completely independent of a person's experience.

Thus, a high level of regulation always implies more complexity than a low level of regulation. An example for low-complexity work is certainly assembly line work, which can be almost completely regulated at the lower levels of regulation after a short period of practice. Thus, the altitude of the hierarchy illustrated in Figure 3 is a good approximation of complexity.

The situational parameters of complexity can be described in analogy to Figure 8. Decision *necessities* are based on the following parameters (Dörner, 1976; Frese 1987b; Fuhrer, 1984):

- The number of different goals, plans, and signals (feedbacks) that have to be regulated and put into a time frame
- The dissimilarity of the goals, plans, and signals
- The number of relationships within and between goals, plans, and feedback
- The number of conditional relationships

It makes sense to differentiate complicatedness from complexity. A system becomes complicated when it is complex *and* when one of the following additional conditions apply (after Frese, 1987b, p. 322): little control, little functionality, little transparency, little predictability, fewer decision possibilities than necessary, and when the complexity is neither socially nor technically necessary or adequate. Complicatedness is related to the regulation problems to be discussed presently.

This view has implications for work design. Work may allow too little complexity. However, it does not help to induce complicatedness into the process because this would just increase negative stress effects. Rather, true complexity and control have to be increased at the same time.

Complexity and Control. There are some approaches that confound complexity and control (Karasek, 1979; Karasek, Baker, Marxer, Ahlbom, & Theorell, 1981; Volpert, Oesterreich, Gablenz-Kolakovic, Krogoll, & Resch, 1983). This is understandable from an empirical perspective, since complexity and control are usually highly correlated (Semmer & Zapf, 1989). Theoretically, however, control and complexity can be differentiated. While control can be considered as the amount of *decision possibilities*, complexity represents the amount of *decision necessities*. In other words, a complex task requires complex decisions whether the person wishes this or not. In a sense, complexity is a prerequisite of control: If there is no complexity (e.g., only decisions at the sensorimotor level are required), then little control is possible (decision possibilities at the level of movements). But even if a task is very complex, there might be little room for deciding how to perform the task. Since control is seen as a positive factor within action theory (Frese, 1989; Hacker, 1986a; Semmer, 1984; Ulich, Grosskurth, & Bruggemann, 1973) while complexity can have negative influences in some cases, it is important to distinguish control from complexity. Semmer (1984) pointed out that workplaces with high complexity and low control are particularly stressful.

The major reasons complexity can be negative are that it leads to overload and responsibility. Responsibility is related to complexity and control in a curious way. First, responsibility usually implies that a certain number of decisions must be made. Second, these decisions often imply high risks or high negative consequences. This may be aversive, although it often enlarges the freedom of action on the job. Since we have defined control as decision possibilities and complexity as decision necessities, responsibility should only be aversive if it implies too much complexity and/or too little control.

Variety. Variety as an indicator of job content was used by Hackman and his colleagues (Hackman & Lawler, 1971; Hackman & Oldham, 1975; Jenkins, Nadler, Lawler, & Cammann, 1975). According to action theory, variety can be interpreted as the amount of different actions required by the tasks, independent of the complexity. Since having many different tasks in a given job implies variety, the amount of hierarchies needed to do the job constitutes variety. Thus, variety refers to the latitude of the pyramid of the hierarchic-sequential model. The pyramid of hierarchic-sequential action regulation would either be very narrow or very wide.

Completeness of Action. From the perspective of action theory, the completeness of action can be added as a further concept of work content (Hacker, 1985). Completeness refers to both completeness of the action process and completeness of the hierarchy-of-action regulation. The action process is complete when all steps in the action process (goal setting, plan development, plan decision making, monitoring, and feedback processes) are carried out. Actions are, for example, incomplete when there are no possibilities to define goals (because they are defined by supervisors) or when there is no feedback to the worker (e.g., quality control).

The hierarchy is complete when all levels of regulation are used. When a person can regulate all of his or her actions on a low level of regulation (as, e.g., at the assembly line), the action is not complete.

The completeness of an action has been discussed as a sort of ontological given within action theory. Volpert (1978) argued that the nature of humans was to act and perform complete actions. He introduced the concept of "partialization of actions" to describe the phenomenon that higher levels of regulations are cut off (Volpert, 1975). In his view, modern

industrialization has led to a reduction of complete actions. Certain problems arise from partialized actions, such as a reduced level of competence and a reduced ability to deal with problems from more than one perspective.

Research has shown that work regulated on the lower levels only is related to a lower degree of competence and job satisfaction and higher stress (evidence in Hacker, 1982a, 1982b, 1985, 1986a; however, there is also contradictory evidence, e.g., in Zapf, 1991b). While it is clearly possible to develop other hypotheses to explain these results, they have been taken as a starting point to demand that work design be oriented toward allowing complete actions.

Stress and the Concept of Regulation Problems. Action and stress can be related in two ways: (a) The action process can be influenced and changed under stressful conditions, and (b) actions can produce stress.

The Action Process Under Stress Conditions. We will discuss two aspects here how the action process is changed under stress conditions in general, and a taxonomy of stressors developed from the perspective of how it influences the regulatory processes in actions.

Planning and feedback under stress conditions. Stress conditions can influence the various elements of action regulation, such as goal setting, planning, and the levels of regulation.

For example, under stress (time pressure and noise), subjects show a higher number of operations, a lower efficiency (Schulz & Schönpflug, 1982), and more sensorimotor errors (Zapf, 1991a) than subjects working under nonstress conditions.

Under stress, people compensate for past inefficiencies. Schulz (1980) simulated clerical work by giving subjects a series of decisions to make regarding such things as checking bills, replying to customer complaints, and responding to credit applications. The subjects were able to look for additional information in computerized directories. A highly effective strategy was to memorize the directories, because otherwise the subjects had to interrupt their work frequently. The results indicated that people under stress tended to give up long-term planning and fall back on more short-term strategies; for example, they did not memorize the directories and had to request information frequently.

Simple performance studies do not always lead to the effects just described. People compensate for stressors and misregulations. For example, Dörner and Pfeifer (1991) reported that subjects working with a fire-fighting simulation under stress used less adequate strategies but compensated for this by working harder (i.e., giving more commands to the fire-fighting units).

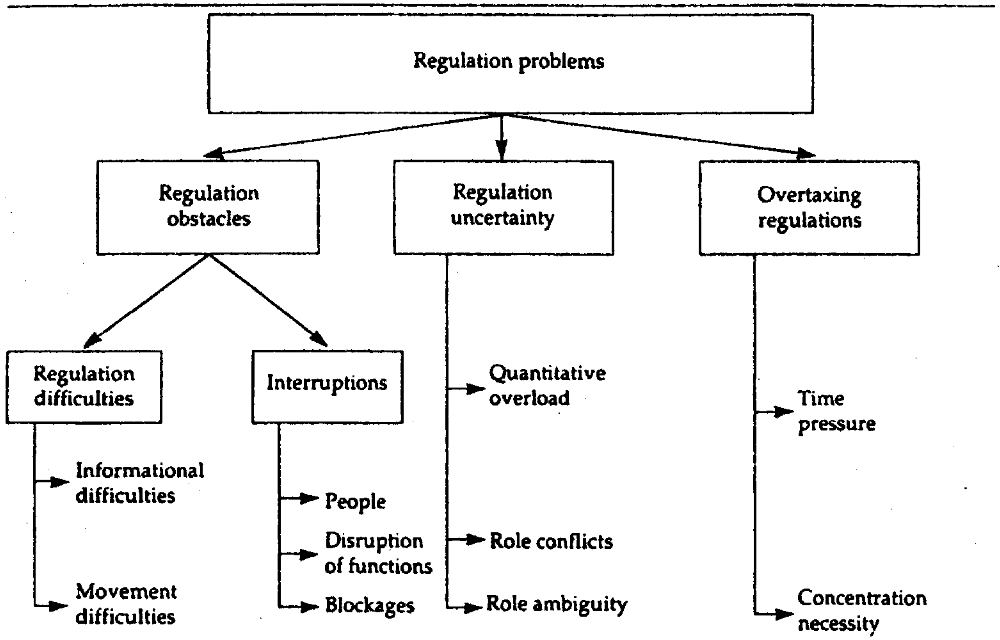
Other experiments on mental load have shown its impact on the action dynamics (Hacker & Richter, 1980; Hockey & Hamilton, 1983; Schönpflug & Wieland, 1982). The interesting point here is that action theory might present a way to integrate these findings. For the sake of brevity, we will not be able to elaborate in this chapter.

A taxonomy of stressors. Many reviewers of stress research have criticized the fact that there is no theoretically derived taxonomy of stressors (e.g., Kasl, 1978; one exception being role conflict and ambiguity, Katz & Kahn, 1978). For example, many studies treat nearly every work characteristic as a stressor (e.g., Frone & McFarlin, 1989; Spector, Dwyer, & Jex, 1988). Action theory suggests a taxonomy of stressors on the basis of how the stressors affect the action regulation.

From an action theory perspective, stressors can be considered to disturb the regulation of actions (Semmer, 1984). These regulation problems can be differentiated into the following groups: regulation obstacles, regulation uncertainty, and overtaxing regulations (see Figure 9).[11] The content of Figure 9 (after Leitner, Volpert, Greiner, Weber, & Hennes, 1987; and Semmer, 1984) will be discussed in the following section.

FIGURE 9

A Classification of Regulation Problems



Note: The content of this figure is taken from Leitner et al. (1987) and Semmer (1984). We have changed the English terminology used by Greiner and Leitner (1989) because we think ours better conveys the theoretical meaning.

After K. Leitner, W. Volpert, B. Greiner, W. C. Weber, & K. Hennes, 1987, and N. Semmer, 1984.

Regulation obstacles. According to Leitner et al. (1987), "regulation obstacles are events or conditions that are directly related to the task at hand" and make it harder or even impossible to pursue a goal and to regulate an action. "The actor has to expand additional effort or has to use more risky actions" (p. 21; translation by the chapter authors). An example is a crane operator who has to make sure that there are no people underneath the crane before being able to swing the crane across some space. An obstacle exists if the operator is not able to oversee this space without any difficulty. Obstacles have a negative influence on an otherwise intact action. They can be conceptualized to be "daily hassles" (Kanner, Coyne, Schaefer, & Lazarus, 1981) in the workplace.

Additional effort may imply that one has to give up on a particular task or start anew, that some steps have to be repeated again, or that detours are necessary. It may also mean more physical strength is necessary in some cases.

One subcategory of regulation obstacles is regulation difficulties: It is in principle possible to do a task, but it is made more difficult than is necessary. Examples are lack of information or bad tools. Regulation difficulties do not directly pertain to the external task. If a

person's task is to look for information, a lack of information is not a regulation difficulty (e.g., a telephone operator looking for a number that is difficult to find). However, other difficulties that make it hard to find the information fall under this concept (e.g., no computer being available).

Another subcategory refers to interruptions that are produced by unpredictable outside events. Interruptions can appear because of other people (colleagues, supervisors), technical problems (machine breakdown), and organizational problems (lack of supplies). Semmer (1984) has shown organizational problems to be one of the best predictors of psychosomatic complaints among the various stressors ascertained.

Regulation uncertainty. Regulation uncertainty means that one does not know how to achieve a certain goal, which kinds of plans are useful, and what feedback can be trusted (Semmer, 1984). Qualitative overload is a related category (Frankenhaeuser & Gardell, 1976).

Another issue is uncertainty caused by insufficient or delayed feedback. For example, a process control operator who never knows if his or her decisions really produce a chemical correctly until much later must live with this stressor even when he or she is optimally performing all the time.

The traditional concepts of role ambiguity and conflicts fall under this category (Kahn, 1973). From an action theory point of view, uncertainty is the underlying concept of role ambiguity and role conflict, such as when a supervisor has to push production but is supposed to keep safety first and does not know how to achieve these two goals simultaneously.

Overtaxing regulations. Overtaxing regulation does not mean that it is impossible to develop adequate goals, plans, and feedback, as in the case of uncertainty. Rather, the problem is the speed and intensity of regulation. For example, time pressure taxes the person's capabilities because of the high speed required. One response is for the person to expend a higher degree of energy. The resulting arousal is not a problem over a short time span, but becomes one over a long time span (Rissler, 1979). The problem is to find out what the normal maximum speed is. We know that people can compensate for higher demands for some time—that is, they can work with a higher speed (with a higher physiological arousal level) and thus work beyond their capacity (see Frankenhaeuser & Gardell, 1976).

Speed of processing (time pressure) produces problems because action regulation cannot be done as planned within a given time frame. A second problem is information overload of the short-term working memory during action execution (concentration). Too much information has to be kept in the working memory at the same time (Zapf, 1991b).

Actions and Their Influence on Stress. A somewhat novel issue is action theory's emphasis on the influence of action on stress. Stress theory is by and large very optimistic postulating that, once a person acts, there is little stress because one can deal and cope with stress (Gal & Lazarus, 1975). Proponents of this kind of theory include Lazarus and co-workers (Lazarus & Folkman, 1984). Although Lazarus and Folkman certainly see a potential negative impact of coping on the stress process, they do not really emphasize this point. From an action theory point of view, Schönpflug and his co-workers (Battmann, 1984; Schönpflug, 1979, 1983, 1985, 1986a, 1987; Schulz, 1979, 1980, 1982) have taken a different perspective: that actions consume energy and require effort in setting goals, planning, and processing feedback. Thus, actions can aggravate stress or even produce new stress. This can lead to a vicious cycle. While stress itself can produce certain problems in the action process, the actions taken up under stressful conditions may themselves increase the stress problems. Resulting misregulations must be compensated for by additional actions, and these compensating actions can lead to even more stress

The various aspects of the action process can be discussed from this perspective (Schönpflug, 1985). For example, planning takes extra effort, particularly if there are little resources available. Realistic and detailed feedback can be used for effective action execution. However, looking for feedback can be very laborious if it is not at hand. This may contribute to stress (Battmann, 1988).

From an action theory perspective, disengagement can be considered a strategy to cope with stress. Schönpflug (1985) suggests two different patterns: disengagement as giving up and disengagement as an instrumental act. Disengagement as giving up is an avoidance strategy that comes about when negative outcomes of actions outweigh the positive ones. For example, not being able to solve a work task may result in complete inactivity (Schulz & Schönpflug, 1982). In social systems, disengagement may also be a strategy to engage other people's help, thus transferring a task to someone else.

Applications of Action Theory in Job Analysis Instruments. In order to be able to design and change workplaces, German work psychologists were always interested in how objective work conditions affect people.

Since action theory emphasizes its relatedness to the outside world, it is not surprising that job analysis instruments based on this theory claim to measure objective rather than subjective representations of work characteristics (Oesterreich & Volpert, 1987). This is by no means common sense, since it is often argued that the perception of work characteristics should be measured because they are the best predictors of such aspects as performance and health outcomes. This is particularly true in the stress field.

However, both practical and methodological reasons for an objective conceptualization and measurement of work characteristics (Frese & Zapf, 1988; Oesterreich & Volpert, 1987; Zapf, 1989) include the following:

- Practically, one needs objective parameters to redesign work independently of a particular worker (institutional approach). This institutional approach can only be used if objective work characteristics are shown to have an impact on people's behavior, ill health, or personality development. If objective work characteristics do not have any impact on the individual but all variance is explained by individual cognitive appraisals, it would not make sense to redesign working conditions. In this case, the only sensible approach would be to change the individual.

- Methodologically, objective measures can overcome the problems of trivial correlations between subjective measures of work characteristics and psychological well-being and ill health (Frese & Zapf, 1988; Kasl, 1978).

Based on action theory, several job analysis instruments were developed: an instrument to identify regulation requirements in industrial work (VERA: Verfahren zur Ermittlung von Regulationserfordernissen in der Arbeitstätigkeit; Oesterreich & Volpert, 1991; Volpert, Oesterreich, Gablenz-Kolakovic, Krogoll, & Resch, 1983), the activity evaluation system (TBS: Tätigkeitsbewertungssystem; Hacker, Iwanowa, & Richter, 1983), an instrument to identify regulation obstacles in industrial work (RHIA: Leitner, Volpert, Greiner, Weber, & Hennes, 1987), and an instrument for stress-oriented job analysis (ISTA: Semmer, 1984; Semmer & Dunckel, 1991). These instruments have several characteristics in common. First, they are related to the objective environment. Second, they are based on the concept of the ideal typical worker (an average worker with sufficient skills to perform the necessary tasks;

TABLE 3

The VERA Model of Regulation Requirements*

Level 5	*Development of new action spheres* The result of the work task cannot not be predetermined in detail. The result can only be achieved by developing new ways of production. Thereby, it is open [as to] exactly what needs to be produced. Thus, new production areas are opened up or inferred (e.g., research).
Level 5	Plans for new tasks and technological processes have to be developed and coordinated.
Level 5R**	Plans for changes of existing tasks and technological processes have to be developed and coordinated, but the existing conditions should be changed as little as possible.
Level 4	*Coordination of action spheres* The result of the work task cannot not be predetermined in detail. Several action spheres have to be coordinated and sometimes initiated in the work process. This means tha developing subgoals in one area has implications for dealing with the subgoals in a second area. The functions of the action spheres are interrelated and influence each other. Therefore, they have to be coordinated (e.g., repair of a complex system).
Level 4	Several interrelated subgoals of the work domain have to be planned and coordinated.
Level 4R	Only one subgoal has to be planned. However, other interrelated subgoals have to be taken into consideration.
Level 3	*Subgoal planning* The result of the work task cannot not be predetermined in detail. Reaching the production goal cannot be done by using a preprogrammed plan. The result can only be achieved by developing a set of subgoals that are worked through step by step. Achieving the subgoals cannot be one by planning everything in detail beforehand (e.g., the work of a tool-and-dye maker).
Level 3	Only a rough series of subactivities can be planned. After achieving a subgoal, the plan to attain the next subgoal has to be thought through. Each subgoal is reached by regulation on level 2.
Level 3R	As in level 3, but the sequence of subgoals and respective sequences of subactions are preplanned by external order or in the way the production system is organized. Therefore, there is no own planning of subgoals, but the sequence of subgoals has to be recapitulated. Each subgoal is reached by regulation on level 2.
Level 2	*Action planning* The result of the work task cannot be produced by a movement program alone. Different movement programs have to be combined in a new way (e.g., cutting and installation according to a plan).
Level 2	The sequence of work steps has to be planned. By combining different movement programs, it is possible to plan the whole task in advance, since the task is familiar to the worker.
Level 2R	There is a given sequence of work steps by external order or by the way the production system is organized, but with some variations. Therefore, there is no own planning of the worker, but the plan of the work steps has to be recapitulated.
Level 1	*Sensorimotor regulation* The result of the work task is produced by a sequence of movements that have been used frequently (e.g., assembly line work).
Level 1	An initiated action program can be carried out without conscious regulation; however, small variations in work material, work results, and tool use occur.
Level 1R	Same as level 1, but there is no occasional use of a different tool and variations of material seldom occurs.

From "Task Analysis for Work Design on the Basis of Action Regulation Theory" by R. Oesterreich and W. Volpert, 1986, *Economic and Industrial Democracy, 7,* pp. 42–45. (Translation of original work by W. Volpert, R. Oesterreich, S. Gablenz-Kolakovic, T. Krogall, & M. Resch, 1983). Copyright 1966 by Sage. Reprinted by permission.

* This is not a literal translation of Volpert et al. (1983, pp. 42–45). However, we have tried to be true to the text as much as possible. However, we have at times changed the terminology used by Oesterreich and Volpert (1986) in an English-language publication. We think (and hope) that our translation better conveys the theoretical meaning.

**R = restricted level

Oesterreich & Volpert, 1987). From a practical point of view, any worker who knows how to do a certain work task can be considered as an ideal typical worker (e.g., employees who have worked at least one year after their education for the job). Third, the instruments make use of "observational interviews" in which the observer who is familiar with the underlying theory both observes the work actions and asks questions to understand his or her observations. Fourth, the instruments are not concerned with the individual qualities of the workers but with general regulation requirements; that is, they take no account of interindividual differences in mental regulations. *Objective* implies here that the measures are independent of an individual's cognitive processing (Frese & Zapf, 1988; Oesterreich & Volpert, 1987).

VERA: Instrument to Identify Regulation Requirements in Work. The instrument VERA (Verfahren zur Ermittlung von Regulationserfordernissen in der Arbeitswelt), which identifies regulation requirements in work, was developed to assess the requirement of planning and thought processes in certain jobs (Oesterreich, 1984; Oesterreich & Volpert, 1986, 1991; Volpert et al., 1983).

A VERA analysis breaks down the job into tasks. Two criteria are used to distinguish tasks: (a) If units refer to a common identifiable goal, they are grouped together as a task; (b) if two units cannot be performed independently by two people without them giving information to each other, they belong to the same task.

Each task is then analyzed to determine at which levels the task accomplishment should be regulated. The levels are based on Oesterreich's (1981) five-level model of action regulation (Table 3). This model differs to a certain degree from the levels of regulation described earlier. The lowest level corresponds to Hacker's (1986a) sensorimotor level. The level of action planning roughly represents the level of flexible action patterns. The higher levels of regulation in the VERA instrument all refer to intellectual levels.

The so-called "restricted level" R was introduced to further differentiate the VERA model. This applies if regulations arising at this level only need to be performed in an incomplete and restricted form (examples in Oesterreich & Volpert, 1986).

VERA can be used to analyze blue collar work, but not white collar, engineering, or management work. Separate versions of VERA were developed to evaluate flexible manufacturing systems (Volpert, Kötter, Gohde, & Weber, 1989; Weber & Oesterreich, 1989) and office work. This was done within the framework of another instrument—the *Contrastive Job Analysis* (Dunckel, 1989; Dunckel & Volpert, 1990; Dunckel, Volpert, Zölch, Kreutner, Pleiss, & Hennes, 1993; Volpert, 1987a, 1992). The *Contrastive Job Analysis* asks which parts of a job should be computerized and which parts should remain with the worker. Work tasks that are regulated at the sensorimotor level are candidates for computerization.

VERA is constrained, however, to one important aspect of work. It does not measure work stressors or communication. Therefore, it should be applied together with other instruments, such as the RHIA instrument. A weak point of VERA is that it does not differentiate between work complexity and decision latitude, as was described earlier.

RHIA—Instrument to Identify Regulation Obstacles in Industrial Work. The instrument RHIA (Regulationshindernisse in der Arbeitstätigkeit; an instrument to identify regulation problems in industrial work) was developed to identify, describe, and quantify task-related mental stress in industry (Greiner & Leitner, 1989; Leitner et al., 1987). Our section on regulation problems was largely based on the background theories of the RHIA instrument (see Figure 9).

RHIA was developed to measure stressors at work through observational interviews, independent of whether the particular

conditions are evaluated by the worker as disturbing. In this sense, work characteristics are considered to be stressors when they require additional efforts for people to carry out a particular task.

The instrument is based on the theory described in Figure 9; the emphasis is on regulation obstacles and overtaxing regulations. Regulation obstacles influence the action regulation directly and require immediate reaction from the workers. They are measured on a common dimension—the length of additional time required to respond to the obstacles. Capacity overtaxing appears when continuous conditions reduce the mental and physical achievement capacity of the worker over the course of the workday.

Most prominent for this instrument is the measurement of regulation obstacles. These have to be identified by the job analyst with the help of observations, interviews with the job incumbents and supervisors, or document analysis.

The value of this instrument is certainly its strong theoretical basis and its clear theoretical distinction between several types of regulation obstacles. The method leads to concrete descriptions of stress events that can be easily communicated to practitioners. The observed stressors show moderate size correlations with psychosomatic problems and irritation/strain (Greiner & Leitner, 1989). A disadvantage is that it only tackles a part of potential stressors at work (Semmer & Dunckel, 1991).

Like the VERA instrument, RHIA was developed to analyze blue collar work. An integrated VERA/RHIA instrument for the analysis of office work is available (Leitner, Lüders, Greiner, Ducki, Niedermeier, & Volpert, in press).

TBS—Tätigkeitsbewertungssystem (Activity Evaluation System). The TBS is an instrument for evaluating the chances for personality enhancement in a job (Hacker & Iwanowa, 1984; Hacker, Iwanowa, & Richter, 1983; Iwanowa & Hacker, 1984). This instrument evaluates the completeness of actions in several respects. A complete action according to this instrument includes sequential completeness (including goal and plan development and preparatory phases of the action process) and hierarchical completeness (including regulation at all levels). As additional features, cooperation and communication made during work are measured. Based on this concept, five groups of scales were developed, as shown in Table 4.

There are several variants of the TBS for different jobs and a special version for mental activities such as software development (Rudolph, Schönfelder, & Hacker, 1987).

The instrument provides cutoff values for each scale, resulting in a typical job profile. Given minimum values, personality enhancement at work should be possible. Scale values that are below the cutoff points indicate job areas that need to be redesigned.

The TBS covers the full range of job content variables. The most important part of the TBS is certainly the measure of complete activities at the workplace (which are assumed to enhance personality). In this way, the TBS is a typical theory-driven form of job analysis and evaluation instrument that can be used to support the need for the redesigning of jobs. Since there is no concept of personality enhancement at the workplace in the Anglo-American literature, there is also no comparable instrument available. There are, however, certain areas of overlap with the *Job Diagnostic Survey* (Hackman & Oldham, 1974, 1975).

Action Theory and Work Design

In Germany, work psychology is seen not just as a descriptive science of work behavior but as a prescriptive science that should contribute to work design. Unlike the situation in the United States, this is regarded to be of utmost importance, and issues related to work design take up a large proportion of the professional discussion in German industrial and

TABLE 4

The Scales of the Job Evaluation System (TBS)

The TBS Scales

A. Organizational and technological conditions that determine the completeness of action.
- A.1. Completeness of the action process. The amount of so-called preparatory activities are of particular importance. Furthermore, items for error checks and organizational activities are included here.
- A.2. Variety of work tasks and cycle time
- A.3. Possibilities for psychological automatization
- A.4. Transparency of the production process
- A.5. Predictability of job requirements and time constraints
- A.6. Controllability (degrees of freedom)
- A.7. Physical (bodily) variety, including variety in posture and bodily movements

B. Cooperation and communication
- B.1. The range of necessary cooperative work
- B.2. Types of cooperative work
- B.3. Variety of cooperative work
- B.4. Communication

C. Responsibility resulting from the external task
- C.1. Content of individual responsibility
- C.2. Amount of responsibility for results
- C.3. Collective responsibility for performance

D. Required cognitive performance
- D.1. The level of action regulation required
- D.2. Information required by the job (ranging from simple signals to complex states and processes)
- D.3. Intellectual information processing required (problem-solving activities, ranging from algorithmic cognitive operations to creative problem solving)

E. Skill requirements
- E.1. Required formal education for the job
- E.2. Actual use of occupational education
- E.3. Job requires constant learning

Adapted from A. Iwanowa and W. Hacker, 1984, and W. Hacker, A. Iwanowa, and P. Richter, 1983; translated and extended by the chapter authors.

organizational psychology. Certain prerequisites must be met if design is to be taken seriously:

- There should be strong relationships to the engineering sciences, like machine construction and computer sciences.
- One should know the psychological parameters that are affected by work design.

- Design always implies certain value decisions; they must be made transparent and tied to scientific knowledge. For example, it is a value decision to answer the question, "Is it more important that work contributes to health, or is productivity more important even if it damages health?"
- Design decisions can never be completely based on empirical work because future use of a technology or a machine to be designed for the first time cannot be studied empirically (Ulich, 1991). Thus, they have to be derived from a design theory that is anchored in other empirical work.

Many of the action theory concepts discussed earlier were developed to justify design work. The central variables from an action theory perspective are the completeness of action, the increase of regulation requirements and control, the reduction of regulation problems, and the concept of personality enhancement. Ontological givens, such as being active or the necessity to develop one's own goals and plans, were hypothesized. Moreover, action theory may also provide a theory that can help determine how new machines should be designed. A discussion of the most important criteria for work design appears below.

There is no one best way, in the sense of Taylor (1913). Since regulation necessities and regulation possibilities usually go hand in hand, action theory takes a nondeterministic view (Frese, 1987b). A situation may require complex regulations, but may not prescribe a particular way of accomplishing them. Since people have different priorities, styles, and mental models, different work strategies result. This is partly in contrast to the concepts of Newell and Simon (1972) or the GOMS-model of Card, Moran, and Newell (1983; see the critique of the GOMS model by Greif & Gediga, 1987). The more complex a situation is, the greater are the chances of there being individual strategies (see Ulich's [1990, 1991] principle of individualization of work). Empirically, different strategies may lead to a similar productivity (Ackermann & Ulich, 1987; Triebe, 1981; Ulich, 1990). For this reason, it is useful to allow a person to choose his or her own work strategy.

Volpert (1975, 1978) and Hacker (1986a) maintain that an action is an ontological given and that phylogenetic development of the person involved the possibility to use action with control over goal setting, planning, and the use of feedback and involves all levels of regulation. This contrasts with the notion of partialized action (Frese, 1978; Volpert, 1975), in which certain levels of regulation are not under the control of the individual. For example, in assembly line work, the worker only works on the lowest level of regulation but has little conscious problem-solving activities; thus, higher levels of regulation are not at his or her disposal but are concentrated in the engineers who set up the assembly line. Another example is a job that does not give feedback or a job that does not allow one to develop one's own plans and goals. Complete activity is related to better health effects and higher productivity (Hacker, 1987b).

An action should be allowed to run its course. It is aversive when it is interrupted by outside events that do not belong to the task (Frese, 1987b; Semmer, 1982). Any obstacles to doing one's work should be reduced. Very often these obstacles result from bad organization (see our earlier discussion on stress).

People should be allowed to be active in their work (Hacker, 1986a; Volpert, 1987b). Again, this is related to the ontological given that people are better when they are acting than when they are just observing. Phylogenetically, people are not cognitive or mental beings, but rather actors who use cognitions to regulate their actions. Therefore, work should allow people to be active. Any task that takes away action will lead to problems, as the difficulties of vigilance tasks amply show

(Mackworth, 1970). From this follows the concept of the active operator (cited in Hacker, 1986). In contrast to complete automatization of, for example, piloting, the active operator concept allows the person to stay in active control of the process. He or she still must act. Lomov and co-workers (cited in Hacker, 1986) show that active pilots perform better than pilots working with highly automatized machines (see also Wiener, 1985).

The issue of control has come up repeatedly and is one of the central issues in work design. In contrast to Emery and Trist (1960) and Emery and Thorsrud (1976), who similarly prefer work to be designed to allow more control, action theory's arguments are not based on the grounds that control is a prerequisite of democracy at work. Nor is the basis a humanistic type of psychology. It is also not a motivational theory, as is the one by Hackman and Oldham (1980). Rather, action theory's idea is that people who have control can do better because they can choose adequate strategies to deal with the situation. For example, they can plan ahead better and are more flexible in the event that something goes wrong (see our earlier discussion of the superworker concept). Skills can only be acquired in a lifelong process when there is control at work.

This view is supported by recent studies of Wall and collaborators (Jackson & Wall, 1991; Wall, Corbett, Martin, Clegg, & Jackson, 1990; Wall, Jackson, & Davis (1992). In a job redesign study in advanced manufacturing technology, computer numerical control (CNC) operators' jobs were restricted to merely loading, monitoring, and unloading machines. In the case of a machine fault, they had to alert specialists. In a field experiment (Wall et al., 1990), the operators were trained in fault diagnosis and fault management (e.g., recalibrating mechanisms that worked out of tolerance, resetting machines, editing programs to cope with variations of raw material). Fault diagnosis and fault management then became a part of the operators' jobs, and specialists were only called upon in situations with more fundamental difficulties. The results showed a decrease of machine downtime and a corresponding increase in output. These results were not only due to a quicker response to machine breakdowns that could be caused by higher motivation and the time saved because no experts had to be called; a reanalysis by Jackson and Wall (1991) revealed that there was a long-term learning effect that produced a reduction of faults. This result appeared gradually over several weeks. The explanation is that the increase of complexity and control by job redesign provided the possibility to develop a more differentiated operative image system and better strategies to prevent machine faults.

The basis for any good work design is the good qualification of the worker. Therefore, qualifications are necessary prerequisites for good work design but are also important consequences. If work does not allow the use of qualifications, they will be lost due to disuse. Any work reorganization program must also involve a qualification program (Ulich et al., 1973).

Qualifications can only be upheld if work has a certain complexity. For this reason, action theory is much more concerned than other approaches in psychology with keeping complexity in the job and even increasing complexity. For example, cognitive psychology applied to tool use seems to have quite an opposite approach (e.g., Card, Moran, & Newell, 1983; Kieras & Polson, 1985). It may be useful to differentiate between complexity, which increases the amount of intellectual work in the job, and complicatedness, which increases mental load. "With an increase of memory load, the quantity and quality of performance deteriorates and fatigue increases. In contrast, increasing the complexity of intellectual tasks does not yield such a deterioration, at least as long as memory load remains constant" (Hacker, 1987a, p. 123; see Hacker, 1986b).

Obviously, it follows from action theory that work should provide feedback. This

feedback should be natural; that is, it should result from doing the work itself and not from some system superimposed (e.g., feedback only given by the supervisor).

Work should minimize the amount of information that must be kept in memory at any one time. One way to reduce this amount is by chunking (Miller, 1956), and being able to chunk is a function of good qualifications and experience. This suggestion is not necessarily opposed to having a certain amount of complexity in the job, as Hacker's earlier quote shows.

Thus, there are certain design criteria developed from an action theory perspective. Work design concepts can be put into a different perspective within an action theory orientation, such as in job rotation and job enlargement. These concepts have been interpreted to be restricted design concepts because tasks of a very similar nature are combined (Herzberg, 1966). From an action theory perspective, regulation requirements and control are certainly the same across the tasks. However, there may be different regulation problems in the tasks combined (stressors, errors). One result may be that job rotation and enlargement decrease one-sided physical and mental loads. In contrast, job enrichment and semiautonomous work groups imply an increase of regulation requirements and control. More complex goals and plans can be developed and may allow for the use of complete actions in work. The effects on regulation problems may be the same as for job rotation and enlargement. However, insofar as increased control functions as a moderator, job enrichment may lead to fewer stress problems, given a certain amount of stressors.

Design can mean several things. Ulich (1991) has suggested differentiating the following design strategies:

- *Corrective work design.* This is the typical situation for the work psychologist—to be called in to suggest a redesign because certain problems have arisen (e.g., a high accident rate, high staff turnover, or high absenteeism).
- *Preventive work design.* That is, design of machines and workplaces that do not yet exist. This is preferred because cooperation with the design engineer allows for workplaces to be developed from scratch from a work psychologist's perspective.
- *Prospective work design.* While preventive work design aims at the potential negative impacts of the job, prospective work design attempts to anticipate the positive impacts for personality development.
- *Differential work design.* This implies that the job is adapted to an individual's personality (Ulich, 1978a, 1983). Therefore, such a work design leads to productivity gains (Ulich, 1990). One disadvantage is, of course, that many different designs must be realized. Moreover, the design may cast a person into a certain mold that may not fit after a while. Therefore, Ulich (1983) suggests complementing this with the principle of dynamic work design.
- *Dynamic work design.* This means that the work design is adjusted to the growing aspirations of the job holder.

Since work design is influenced by new technology, it follows that action theorists have a keen interest in issues related to new technologies. The use of new technologies has been studied intensively. The above design strategies imply that one would prefer blue collar workers to become programmers and supervisors of their machines (e.g., tool-and-dye machines), rather than just the monitors of them. Thus, results like the one by Wall and Clegg (1981) fall well in line with this thinking.

Another aspect of work design involves looking at the tools used in work. For this reason, software ergonomics became an important field for German work psychology (see Frese, 1987c, and Frese, Ulich, & Dzida, 1987, for English-language overviews). The following aspects are important in tool design (see Ulich, 1986, 1991).

- Tools change the action process at work. Thus, tool design is always work design to a certain extent (Hacker, 1987a, 1987b; Ulich, 1989, 1991) because, depending on the tools, important parameters of the jobs change (e.g., help provided, which strategy is supported, complexity and control at work). For this reason, tools have to be evaluated according to how they interact with general work dimensions and what effects they have on the general work situation.
- Tools should truly support the task accomplishment. Since the task is the primary goal of the worker, tools must be well adapted to the task, their use must be learned within a reasonable time, and they should not interrupt task completion or the usual routines of task completion. Whenever a tool has its own logic—aside from the support of the task actions—it hinders task completion.
- Tools should be consistent. This means two things: (a) consistency with the specialist knowledge in the field of application and (b)internal consistency. The former implies that users can rely on their specialist nomenclature and on their prior concepts of how the work is to be done when using the tool; the latter means that all the parts of the tool should react in the same way. Examples are that error messages should always appear in the same line or that function keys should operate consistently throughout a software program. Inconsistencies produce problems because people develop complete operative image systems and automatize their behavior very quickly.
- Tools must be transparent, meaning that users can develop a good operative image system from using the tool. This means that the original intentions of the designer are clear (Keil-Slawik & Holl, 1987; Maass, 1983).
- Controllability of a tool means that users can adapt the system to the task and to their own strategies and preferences. Moreover, it should support flexible use, since strategies change and should be allowed to change over time (e.g., with fatigue; Sperandio, 1971). One implication of this is that the tool should not adjust itself (adaptiveness), but its change should be under the user's control (Haaks, 1992). In contrast, some cognitive human factors scientists suggest that a computer system should adapt to the user automatically (Kass & Finin, 1988).
- One variant of controllability is individualization (Ackermann & Ulich, 1987; Greif & Gediga, 1987; Ulich, 1990). This means that a user can adjust a system to his or her work strategies. This may be done through macroprograms. It may also be done through systems that grow with the knowledge a person has of a system (the so-called genetically growing system; Greif, 1988).
- Finally, the tool should support error management. We already discussed error management in the section on training. From an action theory point of view, errors are ubiquitous because they can be seen as aberrations on the way toward the goal. Overcoming the error is more important than error making per se. Moreover, the cognitive apparatus of human beings is error prone, precisely because it is so well adapted to an environment in which one must react quickly.

Error management is also useful because it reduces costs. What makes errors costly, both in terms of stress effects and economic costs, are the error consequences, such as error handling time, but not the error per se (Frese, 1991). Thus, error handling time should be reduced by supporting error management strategies. Computer systems often offer features, such as the UNDO key on a computer's keyboard, that support error management. Many additional features can be developed (for an overview, see Zapf, Frese, Irmer, & Brodbeck, 1991).

Postscript

This chapter provides an introduction to action theory. First, a general concept of action theory was developed by describing action as goal-oriented behavior. The core of action is the feedback cycle. This implies that there is a goal, which constitutes the set point to which action outcomes are compared. The theory describes an action process, consisting of goals, information integration, plans, monitoring, and feedback. In addition, action regulation is hierarchically structured. There are four levels of regulation—the sensorimotor level, the flexible action patterns level, the intellectual level, and the heuristic level. The most important differentiation is between actions that are consciously regulated and those that are routinized. Long-term knowledge of these processes is stored in the operative image system.

In the second part of this chapter, the general theory was applied to understanding certain phenomena such as errors, the interrelationship between work and personality, the development of competence, tasks characteristics, and work design.

It is tempting to contrast American with German industrial and organizational psychology, but such a contrast is very often misleading. Clearly, both American and German industrial and organizational psychology are rather heterogeneous. Even when there are differences, it is really hard to say whether one has used sufficiently representative materials from each country. Moreover, the differences that one finds are often more a matter of degree of emphasis rather than a clear-cut distinction between the approaches used in the two countries. Nevertheless, we feel that there are some differences, and that action theory has something to contribute to American psychology. Here we offer a few speculative remarks.

We think that the major advantage of action theory is not its cognitive orientation, but rather the ease with which it can relate cognitive issues to applied field settings. Cognitive psychology tends to be rather elementaristic, as with mechanistic concepts. This makes it hard to use such concepts in a field of application. In contrast, action theory is much less fine-grained but allows an easy application to such issues as task analysis, task design, and training. Moreover, action theory encompasses within one theoretical orientation a far broader range of issues. This provides the advantage that one can integrate findings of middle- and small-range theories and various practically important phenomena of industrial and organizational psychology.

The other side of the coin, however, is that action theory has not been clearly defined or as well tested as some cognitive theories. At times, action theorists seem to have been content with being able to use a concept in the field rather than to verify it independently.

Still, we think that action theory has a lot to offer. For example, American industrial and organizational psychology tends to look largely for motivational concepts when explaining differences in job performance. In contrast, the concept of the superworker allows a different approach. Similarly, issues of participation in decision making are typically related to motivation. Again, in action theory, participation in decision making implies that knowledge is shared. This has practical implications: With a pure motivation concept in mind, one might suggest setting up group discussion sessions designed to make persons feel important to the overall work effort. Our concept of participators implies simply that maximal transfer of knowledge must be organized and implemented.

We do not want to say that motivation is unimportant.[11] In the concept of goals, cognitive and motivational aspects of action are closely related. Also, there is certainly a motivational side to having complete actions (e.g., as discussed by Hackman & Oldham, 1980). But motivation does not constitute the whole picture. As a matter of fact, a simple increase in motivation does not produce higher productivity, while a better understanding of a job does.

Moreover, action theory is objectivistic. A purely cognitive point of view often negates the function of cognition for human beings—namely, to be able to act properly. Experiments often show that illusions exist. This view has been quite prominent in American industrial and organizational psychology as well (Salancik & Pfeffer, 1977). An action theory concept implies that this is only true if the person cannot act (Neisser, 1985; Sabini, Frese, & Kossman, 1985) because generally the perceptual cycle (Neisser, 1976) is supplemented by feedback received from the objects acted upon. Obviously, there are limits to this objectivity. These different views have practical implications. From an action theory point of view, one would, for example, be much more cautious in expecting a reduction of stress from a change of subjective perceptions without also changing the objective stressors and resources. This may lead to illusions that cannot be upheld against reality over the long run—an issue that becomes particularly clear when optimism is confronted with grim realities (e.g., in the case of unemployment; see Frese, 1987a).

Moreover, the job analysis instruments attempt to be objective as well. Of course, the practical reason is most important: An objective instrument allows the design of jobs to be done independently of a particular individual. Without the concept of an objective environment that affects the individual, the only sensible approach would be to change the individual. The concept of object-oriented action—that is, changing the objective world—will correspond well to the practical requirements of work analysis.

As we see it, personality is usually conceptualized as an independent variable in the United States. We do not quarrel with this point of view, but feel the full picture should also include the view that personality develops through action. This produces a different orientation, the most important result being the concept of personality enhancement in the workplace. From this perspective, it is obvious that selection may be seen differently. At times, selection procedures assume that there is a stable personality that is not affected by the job at all. Again, this has practical consequences: In a typical concurrent validation program, a correlation between person characteristics and performance is used as a good approximation of the prediction of performance from the person characteristics. From an action theory perspective, working effectively in a job produces certain person effects that may partly explain the correlations in a concurrent validation procedure. Thus, interpreting them as

predictors of performance only may oversimplify the case.

Since action theory is an integrative theory, it allows for a higher degree of integration of areas that are rather differentiated in the United States. For example, there seems to be little integration between human factors and industrial and organizational psychology. Action theory allows such an integration to a larger extent because it specifically integrates upper and lower levels of regulation. This implies, for example, that motor movements are not seen as completely distinct from thinking.

From a historical perspective, the following three points made action theory a powerful paradigm in German industrial and organizational psychology:

- It superseded the stale controversy between cognitive theory and behaviorism.
- Work action is taken as the legitimate starting point of work psychology.
- People are seen as active rather than passive beings who change the world through work actions and thereby change themselves.

Superseding the Controversy Between Cognitive Theory and Behaviorism

The nearest thing to an action concept is, of course, behaviorism. However, behaviorism does not allow a closer look at the goals and tasks of working people and the thought processes that take place while they are working. While behaviorism was at one time a useful theory for looking at work from a time and motion study perspective, modern technology made simple time and motion studies obsolete. When supervising a machine, simple physical action was not the important contributor to the work outcome. Rather complex, thoughtful, and goal-oriented actions like setting, servicing, and controlling the machine and checking the output were most important. Those activities were not usefully described within the tradition of time and motion studies. Thus, an action theory that was connected to cognitive processes was needed. (After it was developed, one result of the theory and its studies was that even simple work could not be well described with time and motion studies that were disconnected from cognitive processes, either; see Hacker, 1986a.)

Behaviorism developed a high methodological sophistication to study behavior, its antecedents, and its consequences. Additionally, it allowed the study of psychology with a clear objective reference point—the behavior of people. On the other hand, it was not consistent with the knowledge that such aspects as expectancies, thoughts, and mental models guide actions above and beyond antecedents and consequences. The apparatus of a behavioristic animal would simply be too unwieldy and nonorganized to survive in reality (e.g., Chomsky, 1959, suggested that a few transformation rules allow the generation of language, while learning language in the sense of behaviorism would take too long and be too complicated).

One of the most important arguments of behaviorism against early cognitive theorists was that a goal referred to something in the future that could not have an impact on the behavior that was occurring right now. Moreover, it was a metaphysical concept and therefore not worthy of study for the new natural science of psychology (Hull, 1943). The cybernetic feedback cycle (Miller et al., 1960) has allowed the understanding at a purely mechanical level that goals and feedback can have the function of regulating behavior toward a goal. The computer analogy helped to overcome this largely philosophical behavioristic argument.

Cognitive theory, on the other hand, keeps the human animal lost in thought (Guthrie, 1935). The phylogenetic function of thought was not just to understand but to be better able to act because of the good understanding of a situation (Hofsten, 1985; Neisser, 1985).

Miller et al. (1960) set out to bridge the gap between cognition and action. The major link was the concept of plan. Since a plan is hierarchically organized, action theory is a molar as well as a molecular kind of theory. It is possible to discuss the trajectory from a specific thought to a specific muscle movement (Gallistel, 1980), as well as the trajectory from a wish to action (Heckhausen & Kuhl, 1985) within the same kind of theory.

Work Action as the Starting Point of Work Psychology

Work in the sense of developed and systematic tool use is unique to human beings (Dolgin, 1985; Schurig, 1985). Thus, the starting point for an industrial psychologist should be the human being at work. The ultimate purpose of work is to produce a product (which can, for example, be a physical object, an intellectual concept, or a certain emotion). Production means acting on the world in a systematic way. Work action is therefore the theoretical and empirical starting point of industrial and organizational psychology. From this perspective, it is surprising that the earlier edition of this *Handbook* did not even mention the concept of action in its subject index (Dunnette, 1976; this is also true of its equivalent in Germany; see Mayer & Herwig, 1970).

Work means accomplishing a task via action. A task is a conglomerate of redefinitions and objective demand characteristics (Hackman, 1970). But a task cannot usually be accomplished without some reference point in the world of objects. The tasks of work may be to hunt an animal, produce a new automobile, sell a computer, design a software program, or make a customer happy. In each case, there is an object that needs to be changed (or at least it has to change hands) in an objective sense. With the development of culture, the object of action may not be directly tied to a physical object, such as in the case of working out a theory. But even such a theory will be of little use if there is not some tie to real-world objects. Thus, in the final analysis, work psychology must be rooted in the objective world. Work psychology cannot be just the study of cognition at work or just the symbolism involved in work. (This does not mean, of course, that symbols are not important— they are, and they must be incorporated into an action theory of work.)

Moreover, work uses tools in changing objects. Such tools are either physical or mental (e.g., a pair of scissors or a brainstorming session). A tool is more than just some material shaped in a certain way. It is always an objectification of a certain procedure to work—the tool as a plan of action. The same is true of social tools, like the organization of work. An organization is an objectification of how one deals socially with a certain object (Berger & Luckmann, 1966).

The Human as an Active Rather Than a Passive Being

In contrast to the perspective of behaviorism, here human beings are not seen as only responding to their environment; instead, they are seen as influencing and shaping their environment as well. Moreover, living is acting. Thus, we usually have a goal and some kind of idea of how to proceed with it (at least as long as the action is not routinized). Goals change in accordance with one's accomplishments, usually in the direction of higher effect on the environment (White, 1959). Thus, an active person will continue to be active, even when he or she has achieved a goal.

The conceptualization of humans as active does not imply, however, that the environment is unimportant. When working, physical objects are changed directly or indirectly. By changing physical objects, workers are changed as well. The example of tool use demonstrates this. When producing a tool, a procedure for doing something is developed materially. When using this tool afterward, the person is to a certain extent bound to the procedure. Thus, the person changes because of work. After the invention of the spoon, eating soup changed; at the same time, a spoon can only be used in a certain way and a spoon actually produces an affordance (in the sense of Gibson, 1979) to use it for bringing watery substances to the mouth.

Changes in objects and social organizations produce cultures and also produce changes in the people working. Thus, work action is something that shapes people collectively and individually. Thus, by working, people change the world and thereby change themselves. For this reason, work socialization has been an interesting issue for action theorists (Frese, 1982; Hacker, 1986a; Volpert, 1975).

Action theory has been a useful theory, both in terms of integrating various areas pertaining to work and in providing a structured approach to studying and researching work psychology. Certainly it is not yet a fully developed theory, but it consists of fragments that have been studied in detail and areas that have heuristic value. It is a tool to be used in gaining a better understanding of one area—work—that differentiates the human animal so clearly from other animals.

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Notes

1 Actually, there is a whole tradition of a social action theory that is not covered in this chapter (see Cranach & Harré, 1982).

2 For a different approach, see Oesterreich (1981, 1984).

3 They used the term *level of abstract thought* then.

4 There are several concepts for internal representations: the operative image system, with its emphasis on plans and actions; and mental models, with their emphases on structural parameters of the environment. To use a term that embraces both of them, knowledge base for regulation was introduced.

5 Of course, there is no doubt that personality may also be a prerequisite for doing some kinds of work well.

6 It is interesting to note that enhancement of personality or growth in personality is the major psychological variable discussed in the German constitution—quite a contrast to the more hedonistic pursuit of happiness in the United States.

7 It is interesting to note that learning theorists have used this as a paradigm of regression—the rat reverts back to the more routinized route if under stress (Mowrer, 1950).

8 Of course, Meichenbaum (1977) has popularized this concept in the United States in the area of stress immunization training.

9 Hacker published in East Germany under socialist rule. One can assume that the concept of planning strategy was used to accommodate the leading ideology of socialist planning. This may very well be so. As it turns out, however, it might be a myth that socialist countries were planning well or were planning at all. While there was quite a lot of metaplanning on the societal level, there was very little planning of production. This lack of planning of the particulars of work and the little use of feedback (and the little attempt to look actively for realistic feedback) may have been two factors leading to the low work efficiency in the Eastern European countries.

10 In this connection it is interesting to note that in the recent *Frontiers* book of the Society for Industrial and Organizational Psychology on training, there is no mention of the problem of transfer and *transfer* is not even in the index (Goldstein, 1989).

11 We have left out an action theory approach to the area of motivation that is quite unique and potentially very interesting for applied psychology (e.g., Gollwitzer, 1990; Heckhausen, 1991). This area was left out because these motivational constructs have not been used in industry up to this point.

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