Previous Page

Since this approach to human reliability has its roots in the traditional HF/E perspective, it does not include any systematic means for identifying errors due to failures in higher level human functions such as diagnosis. Nevertheless, such diagnostic errors can give rise to particularly serious failures, where they lead to an erroneous series of actions being initiated based on the mistaken diagnosis. The Three Mile Island accident was a typical result of these types of errors. In order to address cognitive errors of this type, a comprehensive model of human error is required, as is discussed in detail in Section 2.6.5 of this chapter. Techniques for systematically identifying human error in safety analyses are described in Chapter 5.

2.5.6. Summary and Evaluation of the HF/E Perspective on Human Error in the CPI

The traditional HF/E approach provides techniques and data relevant to optimizing human performance and minimizing certain categories of error in chemical process industry operations. The main application of human factors and ergonomics methods is in the design of new systems. However, audit checklists are available for evaluating HF/E deficiencies that could give rise to errors in existing systems. These are considered in Chapters 3 and 4. As part of this design process, many of the performance-influencing factors described in Chapter 3 are taken into account. Some of the techniques described in Chapter 4—for example, task analysis—are also employed during the design process.

The disadvantages of the classical HF/E perspective as a basis for human error prediction have been reviewed earlier. The approach focuses mainly on the external aspects of human performance and does not provide any systematic methods for error identification or for addressing underlying causes of errors. In addition, the HF/E approach does not provide a systematic framework for addressing and eliminating cognitive errors in areas such as diagnosis and problem solving.

2.6. THE COGNITIVE ENGINEERING PERSPECTIVE

The classical human factors engineering/ergonomics approach to human error was essentially based on a "black box" model of human behavior that focused primarily on information inputs and control action outputs. In this section a more modern perspective, based on approaches from cognitive psychology, is introduced. At one level, the cognitive perspective is still concerned with information processing, in that it addresses how people acquire information, represent it internally and use it to guide their behavior. The key difference from the HF/E approach is that the cognitive approach emphasizes the role of intentions, goals, and meaning as a central aspect of human behavior. The term "cognitive" is based on the Latin *cognoscere* meaning 'to know.'

Instead of the human being conceptualized as a passive system element, to be treated in the same way as a pump or valve, the cognitive approach emphasizes the fact that people impose meaning on the information they receive, and their actions are almost always directed to achieving some explicit or implicit goal.

In the context of a process plant, this could be long-term goals such as producing a given amount of product over several days, or more short-term objectives such as maintaining a particular temperature profile or flow rate. Thus, the cognitive approach opens up the black box that had represented the higher-level reasoning processes in the HF/E model of the worker.

The cognitive approach has had a major influence in recent years on how human error is treated in systems such as chemical process plants and nuclear power generation. In the next section we shall describe some of the key concepts that have emerged from this work, and how they apply to the analysis of error in the CPI. Discussion of the cognitive view of human performance are contained in Reason (1990), Hollnagel (1993), Kantowitz and Fujita (1990), Hollnagel and Woods (1983), and Woods and Roth (1990).

2.6.1. Explaining and Classifying Errors from the Cognitive Perspective

A major advantage of the cognitive perspective is that it provides a basis for the prediction and classification of errors in CPI operations. An effective classification system for errors is essential from several points of view. If we wish to aggregate data on human errors from industrial situations for the purpose of discerning trends, identifying recurrent types of errors, or for developing a quantitative data base of error frequencies, we need a basis for grouping together errors of a similar type. Although there was considerable interest in classification systems from the HF/E perspective, almost all of these systems attempted to classify errors in terms of their external characteristics, for example, action omitted, action too late or action in the wrong order. This was because a model or theory of errors had not been developed which connected the external form of the error or external error mode with the underlying mental processes that gave rise to it. Until such a connection had been made, it was not possible to classify errors in a systematic way, because the same external error mode could be due to a number of entirely different underlying causes.

For example, consider the error of a worker closing valve B instead of the nearby valve A, which is the required action as set out in the procedures. There are at least five possible explanations for this error.

1. The valves were close together and badly labeled. The worker was not familiar with the valves and therefore chose the wrong one. Possible cause: wrong identification compounded by lack of familiarity leading to wrong intention (once the wrong identification had occurred the worker *intended* to close the wrong valve).
2. The worker may have misheard instructions issued by the supervisor and thought that valve B was the required valve. Possible cause: communications failure giving rise to a mistaken intention.
3. Because of the close proximity of the valves, even though he intended to close valve A, he inadvertently operated valve B when he reached for the valves (correct intention but wrong execution of action).
4. The worker closed valve B very frequently as part of his everyday job. The operation of A was embedded within a long sequence of other operations that were similar to those normally associated with valve B. The worker knew that he had to close A in this case, but he was distracted by a colleague and reverted back to the strong habit of operating B. Possible cause: intrusion of a strong habit due to external distraction (correct intention but wrong execution).
5. The worker knew that valve A had to be closed. However, it was believed by the workforce that despite the operating instructions, closing B had a similar effect to closing A and in fact produced less disruption to downstream production. Possible cause: violation as a result of mistaken information and an informal company culture to concentrate on production rather than safety goals (wrong intention).

These explanations do not exhaust the possibilities with regard to underlying causes, but they do illustrate an important point: the analysis of human error purely in terms of its external form is not sufficient. If the underlying causes of errors are to be addressed and suitable remedial strategies developed, then a much more comprehensive approach is required. This is also necessary from the predictive perspective. It is only by classifying errors on the basis of underlying causes that specific types of error can be predicted as a function of the specific conditions under review.

2.6.2. The Skill-, Rule-, and Knowledge-Based Classification

An influential classification of the different types of information processing involved in industrial tasks was developed by J. Rasmussen of the Risø Laboratory in Denmark. This scheme provides a useful framework for identifying the types of error likely to occur in different operational situations, or within different aspects of the same task where different types of information processing demands on the individual may occur. The classification system, known as the skill-, rule-, knowledge-based (SRK) approach is described in a number of publications (e.g., Rasmussen, 1979, 1982; Reason, 1990). An extensive discussion of Rasmussen's influential work in this area is contained in Goodstein et al. (1988), which also contains a comprehensive bibliography. This book contains a paper by Sanderson and Harwood that charts the development of the SRK concept.

The terms "skill-, rule-, and knowledge-based" information processing refer to the degree of conscious control exercised by the individual over his or her activities. Figure 2.3 contrasts two extreme cases. In the *knowledge*-based mode, the human carries out a task in an almost completely conscious manner. This would occur in a situation where a beginner was performing the task (e.g., a trainee process worker) or where an experienced individual was faced with a completely novel situation. In either of these cases, the worker would have to exert considerable mental effort to assess the situation, and his or her responses are likely to be slow. Also, after each control action, the worker would need to review its effect before taking further action, which would probably further slow down the responses to the situation.

The *skill*-based mode refers to the smooth execution of highly practiced, largely physical actions in which there is virtually no conscious monitoring. Skill-based responses are generally initiated by some specific event, for example, the requirement to operate a valve, which may arise from an alarm, a procedure, or another individual. The highly practiced operation of opening the valve will then be executed largely without conscious thought.

In Figure 2.4, another category of information processing is identified that involves the use of rules (*rule*-based mode). These rules may have been learned as a result of interacting with the plant, through formal training, or by working with experienced process workers. The level of conscious control is intermediate between that of the knowledge- and skill-based modes.

2.6.3. The Generic Error Modeling System (GEMS)

GEMS is an extension of the SRK approach and is described in detail in Reason (1990). GEMS is intended to describe how switching occurs between the different types of information processing (skill, rule, knowledge) in tasks such as those encountered in the CPI. GEMS is shown in Figure 2.5. The way in which GEMS is applied is illustrated most effectively by means of a specific example.

Consider a process worker monitoring a control panel in a batch processing plant. The worker is executing a series of routine operations such as opening and closing valves and turning on agitators and heaters. Since the worker is highly practiced, he or she will probably be carrying out the valve operations in an automatic skill-based manner only occasionally monitoring the situation at the points indicated by the "OK?" boxes at the skill-based level in Figure 2.5.

If one of these checks indicates that a problem has occurred, perhaps indicated by an alarm, the worker will then enter the rule-based level to

KNOWLEDGE-BASED MODE CONSCIOUS	SKILL-BASED MODE AUTOMATIC
Unskilled or occasional user	Skilled, regular user
Novel environment	Familiar environment
Slow	Fast
Effortful	Effortless
Requires considerable feedback	Requires little feedback
Causes of error: • Overload • Manual variability • Lack of knowledge of modes of use • Lack of awareness of consequences	Causes of error: • Strong habit intrusions • Frequently invoked rule used inappropriately • Changes in the situation do not trigger the need to change habits

FIGURE 2.3. **Modes of Interacting with the World (Reason, 1990).**

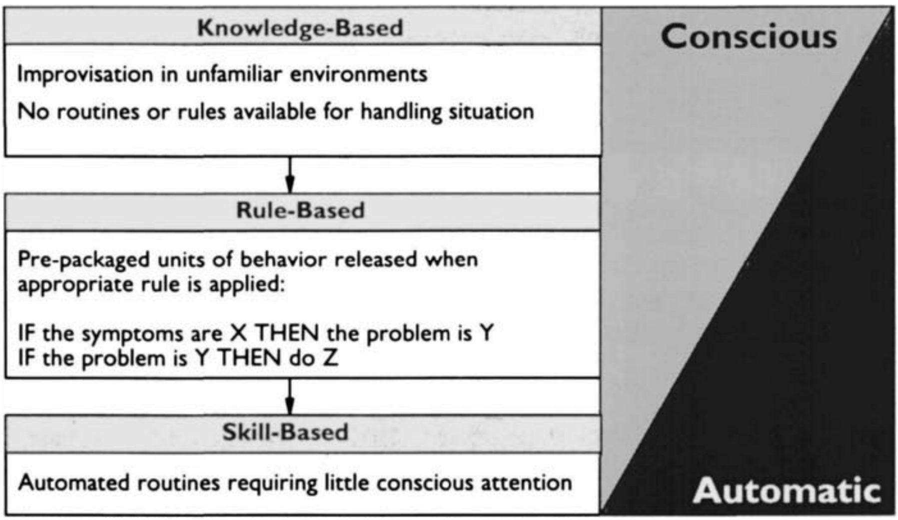

FIGURE 2.4. **The Continuum between Conscious and Automatic Behavior (based on Reason, 1990).**

determine the nature of the problem. This may involve gathering information from various sources such as dials, chart recorders and VDU screens, which is then used as input to a diagnostic rule of the following form:

<IF> symptoms are X <THEN> cause of the problem is Y

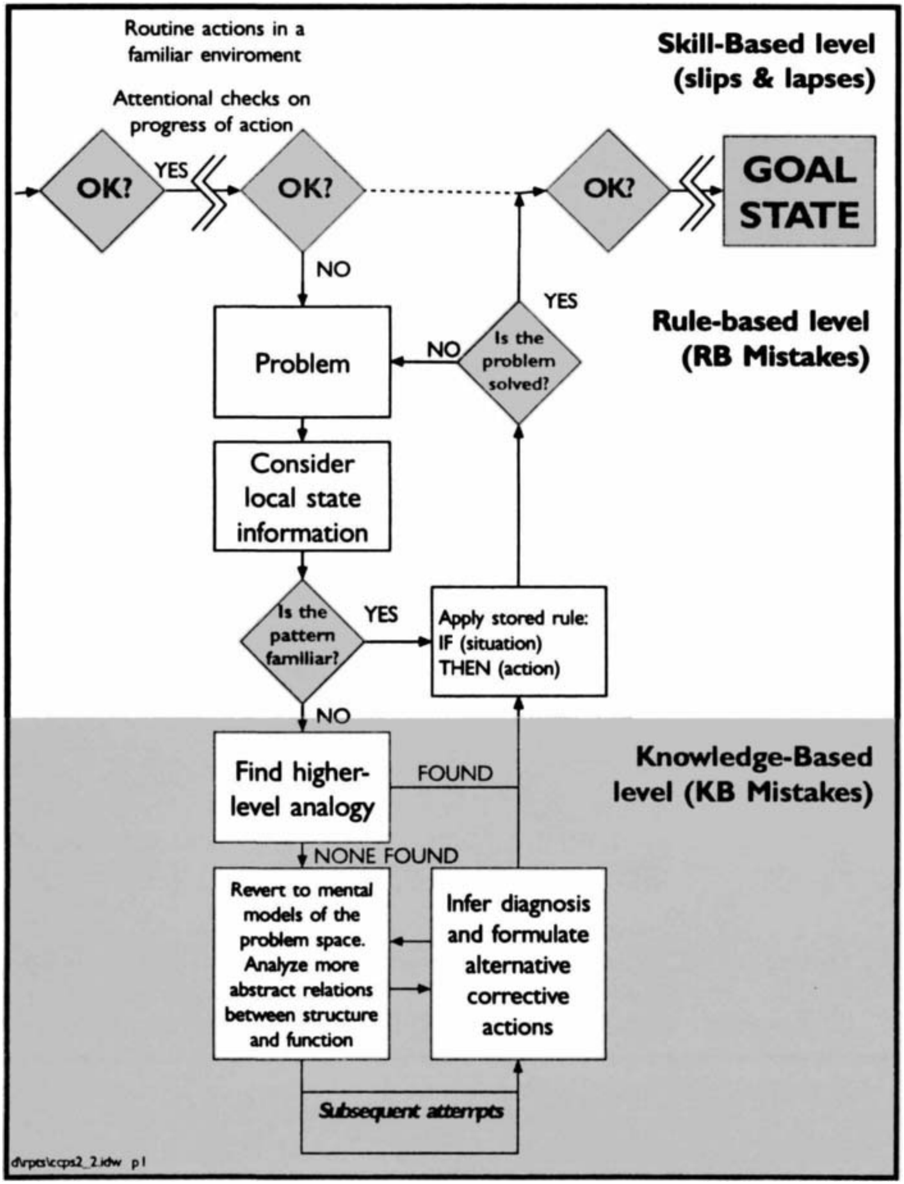

FIGURE 2.5. **Dynamics of Generic Error Modeling System (GEMS) (adapted from Reason, 1990).**

Having established a plausible cause of the problem on the basis of the pattern of indications, an action rule may then be invoked of the following form:

<IF> the cause of the problem is Y <THEN> do Z

If, as a result of applying the action rule, the problem is solved, the worker will then return to the original skill-based sequence. If the problem is not resolved, then further information may be gathered, in order to try to identify a pattern of symptoms corresponding to a known cause.

In the event that the cause of the problem cannot be established by applying any available rule, the worker may then have to revert to the knowledge-based level. The first strategy likely to be applied is to attempt to find an analogy between the unfamiliar situation and some of the patterns of events for which rules are available at the rule-based level. If such a diagnostic rule can be found that validly applies, the worker will revert back to the rule-based level and use the appropriate action rule. However, if a suitable analogy cannot be found, it may be necessary to utilize chemical or engineering knowledge to handle the situation. This process is illustrated in the following example:

Example 2.7: Moving among the Skill-, Rule-, and Knowledge-Based Levels in the GEMS Model

While scanning a control panel, a process worker notices that a pressure build-up is occurring during a routine transfer of reactant between the reactors (a skill-based check). He first checks if the appropriate valves have been opened. (Rule-based check: if pressure build-up, then transfer line may not have been opened.) Since the valve line-ups appear to be correct, he then moves to the knowledge-based level to draw upon other sources of information. The use of a data sheet of the chemical properties of the reactant and a piping diagram at the knowledge-based level identify the problem as solidification of the chemical in the line due to low ambient temperature. The formulation of corrective actions involves moving back up to the rule-based level to find an appropriate corrective action, for example turning on electric heat tracing at the point in the line where the blockage had occurred. If this action is successful, then the situation reverts to the skill-based level where the problem originally occurred.

This example illustrates the fact that several levels of processing may occur within the same task.

2.6.4. Classification of Errors from the Cognitive Perspective

2.6.4.1. Slips and Mistakes

The categorization set out in Figure 2.6 is a broad classification of the causes of human failures that can be related to the SRK concepts discussed in the last section. The issue of violations will be addressed later in Section 2.7.1.1. The distinction between slips and mistakes was first made by Norman (1981).

> Slips are defined as errors in which the intention is correct, but a failure occurring when carrying out the activities required. For example, a worker may know that a reactor needs to be filled but instead fills a similar reactor nearby. This may occur if the reactors are poorly labeled, or if the worker is confused with regard to the location of the correct reactor. Mistakes, by contrast, arise from an incorrect intention, which leads to an incorrect action sequence, although this may be quite consistent with the wrong intention. An example here would be if a worker wrongly assumed that a reaction was endothermic and applied heat to a reactor, thereby causing overheating. Incorrect intentions may arise from lack of knowledge or inappropriate diagnosis.

In Figure 2.6, the slips/mistakes distinction is further elaborated by relating it to the Rasmussen SRK classification of performance discussed earlier. Slips can be described as being due to misapplied competence because they are examples of the highly skilled, well practiced activities that are characteristic of the skill-based mode. Mistakes, on the other hand, are largely confined to the rule and knowledge-based domains.

In the skill-based mode, the individual is able to function very effectively by using "preprogrammed" sequences of behavior that do not require much conscious control. It is only occasionally necessary to check on progress at particular points when operating in this mode. The price to be paid for this economy of effort is that strong habits can take over when attention to checks is diverted by distractions, and when unfamiliar activities are embedded in a familiar context. This type of slip is called a "strong but wrong" error. The examples given in Section 2.6.1 can be classified as slips, mistakes, and violations using the categorization scheme in Figure 2.6.

2.6.4.2. Rule-Based Mistakes

With regard to mistakes, two separate mechanisms operate. In the rule-based mode, an error of intention can arise if an incorrect diagnostic rule is used. For example, a worker who has considerable experience in operating a batch reactor may have learned diagnostic rules that are inappropriate for continuous process operations. If he or she attempts to apply these rules to evaluate the cause of a continuous process disturbance, a misdiagnosis could result, which could then lead to an inappropriate action. In other situations, there is a tendency to overuse diagnostic rules that have been successful in the past.

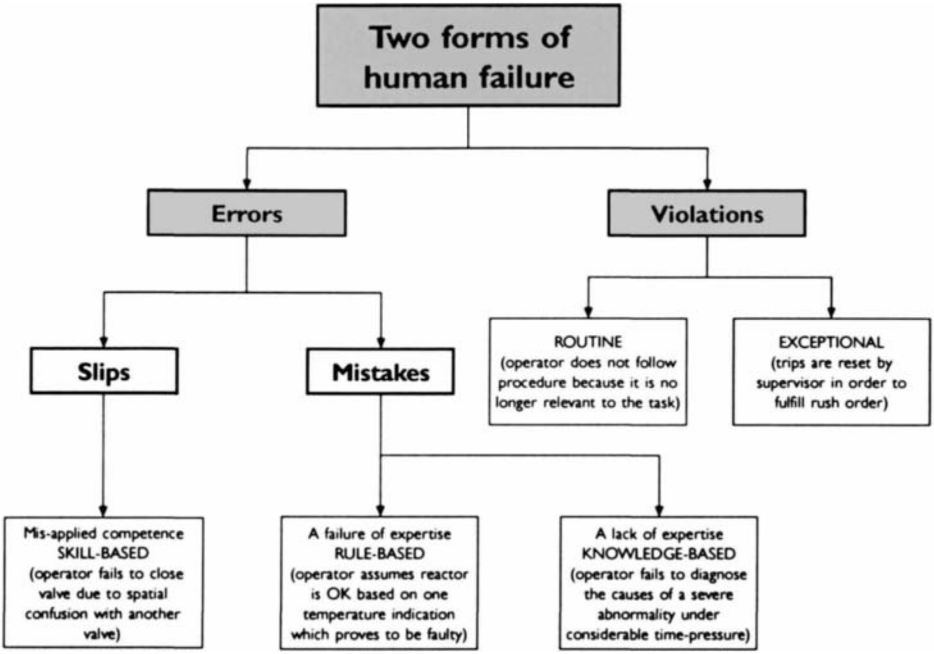

FIGURE 2.6. **Classification of Human Errors (adapted from Reason, 1990).**

Such "strong" rules are usually applied first, even if they are not necessarily appropriate.

There is a tendency to force the situation into the mold of previous events. Case study 1.15 was an example of this type of mistake. Following some modifications to a pump, it was used to transfer liquid. When movement was complete, the worker pressed the stop button on the control panel and saw that the "pump running" light went out. He also closed a remotely operated valve in the pump delivery line. Several hours later the high-temperature alarm on the pump sounded. Because the worker had stopped the pump and seen the running light go out, he assumed the alarm was faulty and ignored it. Soon afterward there was an explosion in the pump. When the pump was modified, an error was introduced into the circuit. As a result, pressing the stop button did not stop the pump but merely switched off the running light. The pump continued running, overheated, and the material in it decomposed explosively.

In this example, a major contributor to the accident was the worker's assumption that the pump running light being extinguished meant that the pump had stopped even though a high-temperature alarm occurred, which would usually be associated with an operating pump. The rule "If pump light is extinguished then pump is stopped" was so strong that it overcame the evidence from the temperature alarm that the pump was still running. By analogy with the "strong but wrong" action sequences that can precipitate skill-based slips, the inappropriate use of usually successful rules can be described as "strong but wrong" rule failures. Other types of failure can occur at the rule-based level and these are described extensively by Reason (1990).

2.6.4.3. *Knowledge-Based Mistakes*

In the case of knowledge-based mistakes, other factors are important. Most of these factors arise from the considerable demands on the information processing capabilities of the individual that are necessary when a situation has to be evaluated from first principles. Given these demands it is not surprising that humans do not perform very well in high stress, unfamiliar situations where they are required to "think on their feet" in the absence of rules, routines, and procedures to handle the situation. Kontogiannis and Embrey (1990) and Reason (1990) describe a wide range of failure modes under these conditions. For example, the "out of sight, out of mind" syndrome means that only information that is readily available will be used to evaluate the situation. The "I know I'm right" effect occurs because problem solvers become overconfident of the correctness of their knowledge. A characteristic behavior that occurs during knowledge-based problem solving is "encystment" where the individual or the operating team become enmeshed in one aspect of the problem to the exclusion of all other considerations (the Three Mile Island accident is a notable example). The opposite form of behavior, "vagabonding" is also observed, where the overloaded worker pays attention superficially to one problem after another, without solving any of them. Janis (1972) provides detailed examples of the effects of stress on performance.

2.6.4.4. *Error Recovery*

In the skill-based mode, recovery is usually rapid and efficient, because the individual will be aware of the expected outcome of his or her actions and will therefore get early feedback with regard to any slips that have occurred that may have prevented this outcome being achieved. This emphasizes the role of feedback as a critical aspect of error recovery. In the case of mistakes, the mistaken intention tends to be very resistant to disconfirming evidence. People tend to ignore feedback information that does not support their expectations of the situation, which is illustrated by case study 1.14. This is the basis of the commonly observed "mindset" syndrome.

2.6.5. The Stepladder Model

The GEMS model is based on a more detailed model of human performance known as the **stepladder model** developed by Rasmussen (see Rasmussen 1986) and illustrated in Figure 2.7. In this model, Rasmussen depicted the various stages that a worker could go through when handling a process disturbance.

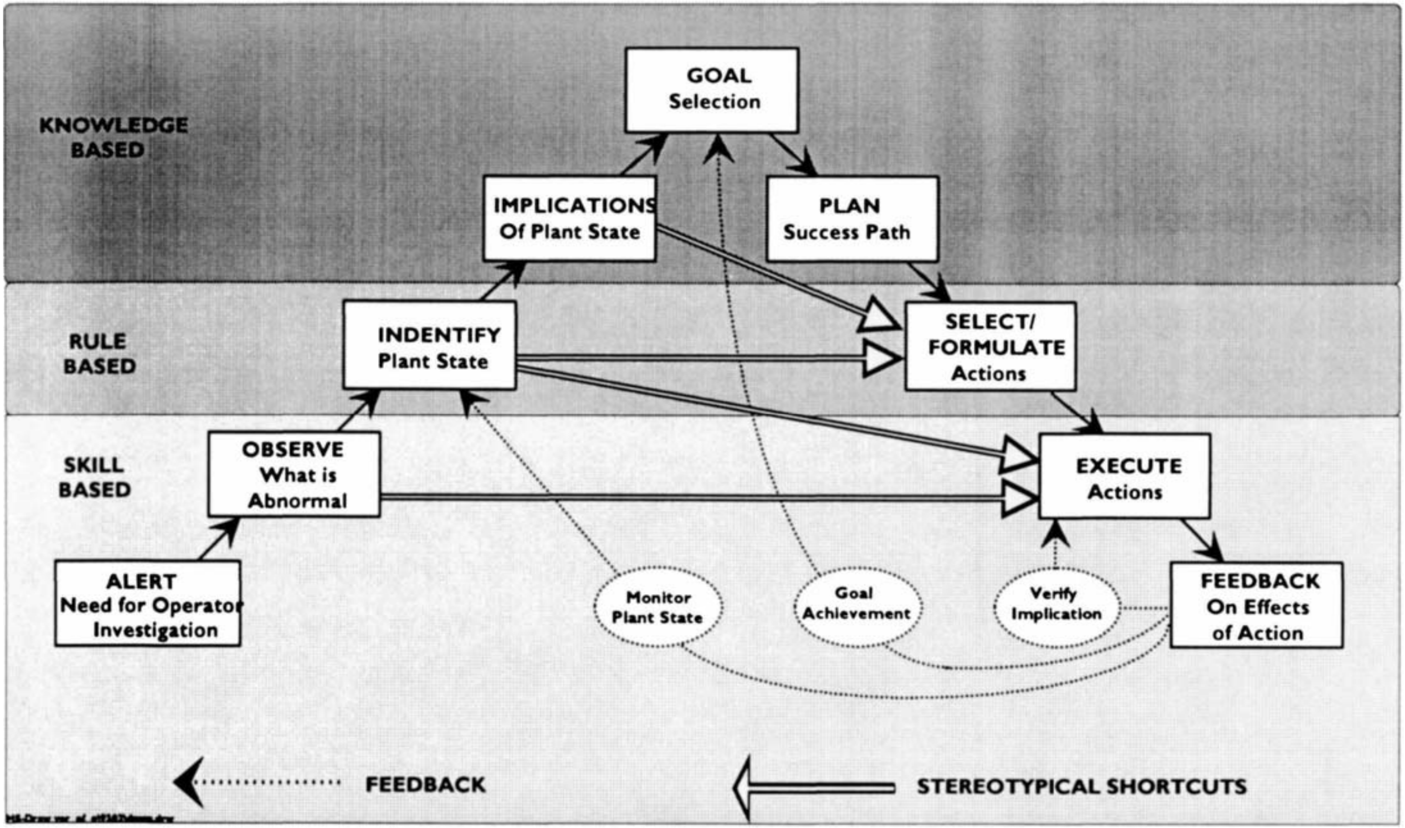

FIGURE2.7. **Decision-Making Model including Feedback (adapted from Rasmussen, 1986).**

Only if the worker has to utilize the knowledge-based mode will he or she traverse every information processing stage represented by the boxes connected by the black arrows. As in the GEMS model (Section 2.6.3), if the situation is immediately recognized, then a preprogrammed physical response will be executed in the skill-based mode (e.g., by moving the process on to the next stage by pressing a button).

If the nature of the problem is not readily apparent, then it might be necessary to go to the rule-based level. In this case a diagnostic rule will be applied to identify the state of the plant and an action rule used to select an appropriate response. Control will revert to the skill-based level to actually execute the required actions. More abstract functions such as situation evaluation and planning will only be required at the knowledge-based level if the problem cannot not be resolved at the rule-based level.

The lighter arrows represent typical shortcuts, which omit particular stages in the information-processing chain. These shortcuts may be "legitimate," and would only lead to errors in certain cases. For example, the worker may erroneously believe that he or she recognizes a pattern of indicators and may immediately execute a skill-based response, instead of moving to the rule-based level to apply an explicit diagnostic rule.

The dotted lines in the diagram indicate the various feedback paths that exist to enable the individual to identify if a particular stage of the processing chain was executed correctly. Thus, if the operating team had planned a strategy to handle a complex plant problem, they would eventually obtain feedback with regard to whether or not the plan was successful. Similar feedback loops exist at the rule and skill-based levels, and indicate opportunities for error correction. The application of the stepladder model to a process industry example is given in Appendix 2A at the end of this chapter.

2.6.6. How Can the Cognitive Approach Be Applied to Process Safety in the CPI?

Up to this point, various models have been described that provide a comprehensive description of the mental functions that underlie the whole range of activities performed by a process plant worker, from simple skill-based physical actions, to rule-based diagnosis, and more complex knowledge-based problem solving. Although these models are certainly not the only explanations of process control behavior available (see, e.g., Edwards and Lees, 1974, and papers in Goodstein et al., 1988) they have proved valuable in providing a link between the work of cognitive psychologists and the practical concerns of engineers in the process industries. A number of practical applications of these concepts will now be described. These applications include the development of error-reduction design strategies, error prediction for safety analysis, and identification of the root causes of errors in accident analysis.

Many of these applications require tasks or parts of a task to be categorized according to the SRK scheme. Although this is difficult in some cases, a simple flowchart may assist in this process. This is given in Figure 2.8. This assumes that the tasks will be performed by a worker of average competence. This assumption is necessary, since the actual mode that the task will be performed in (skill, rule, or knowledge) obviously depends on the characteristics of the individual (how well trained, how capable) as well as the task.

2.6.6.1. Error Reduction

If we can classify a task or a part of a task as being, for example, predominantly skill- rather than rule-based (given that no task falls exactly into each category), this has a number of implications for various approaches to error reduction. From a training perspective, this means that extensive practice of the largely physical and manipulative aspects of the task, together with frequent feedback, will be required in order to ensure that the required actions can be smoothly executed and coordinated without conscious thought. From the standpoint of procedures, there is no point in developing extensive step-by-step written procedures, since skill-based actions will be largely executed automatically when the appropriate cue for action is received. Thus, the most appropriate form of job aid is likely to be a simple checklist which specifies the starting point of each sequence of actions with perhaps specific checks to verify that each activity has been correctly performed.

2.6.6.2. Error Prediction

As implied in the diagram representing the GEMS model (Figure 2.5) and discussed in Section 2.6.3, certain characteristic error forms occur at each of the three levels of performance. This information can be used by the human-reliability analyst for making predictions about the forms of error expected in the various scenarios that may be considered as part of a predictive safety analysis. Once a task or portion of a task is assigned to an appropriate classification, then predictions can be made. A comprehensive set of techniques for error prediction is described in Chapter 5.

The SRK model can also be used as part of a approach for the elimination of errors that have serious consequences proactive for the plant. Once specific errors have been identified, based on the SRK model, interventions such as improved procedures, training or equipment design can be implemented to reduce their likelihood of occurrence to acceptable levels. This strategy will be discussed in more detail in Chapter 4.

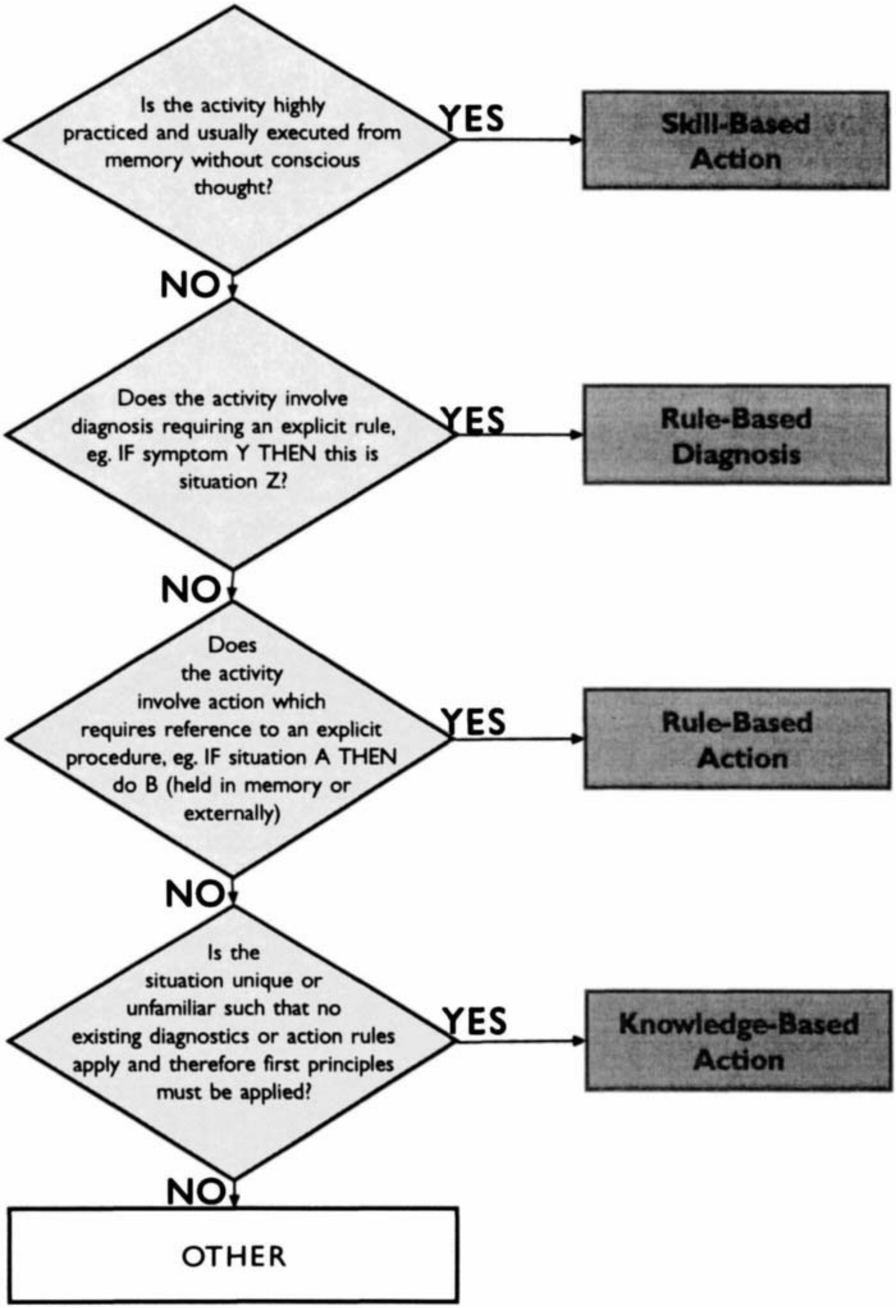

FIGURE 2.8. **Flow Chart for Classifying Skill-, Rule-, and Knowledge-Based Processing.**

2.6.6.3. Analysis of Incident Root Causes Using the Sequential Error Model

In addition to the proactive uses of the SRK model described in the two previous sections, it can also be employed retrospectively as a means of identifying the underlying causes of incidents attributed to human error. This is a particularly useful application, since causal analyses can be used to identify recurrent underlying problems which may be responsible for errors which at a surface level are very different. It has already been indicated in Section 2.4.1 that the same observable error can arise from a variety of alternative causes. In this section it will be shown how several of the concepts discussed up to this point can be combined to provide a powerful analytical framework that can be used to identify the root causes of incidents.

The block diagram shown in Figure 2.9 was developed by Rasmussen (see Rasmussen 1981, 1986) as a sequential model of the causal chain leading to an error. Basically, the model identifies the various processes that intervene between the initiating or triggering event, and the external observable form of the error, referred as the external error mode. This external error mode may or may not lead to an accident, depending on the exact conditions that apply. The internal error mechanisms have been discussed in earlier sections (e.g., the strong stereotype takeovers discussed in Section 2.6.4.2). They are intrinsic error tendencies. The "internal error mode" represents the point in the various stages of handling a situation (e.g., failed to detect problem, failed to act) where the failure occurred.

For each of the stages of the model, Petersen (1985) provided a series of flow diagrams to assist analysts in using the model for incident analysis. These are given in Appendix 2B. The use of the model and the flow charts for detailed psychological analysis of incidents is illustrated by a case study in Appendix 2C.

2.6.7. Summary of the Use of Cognitive Models in CPI Safety

The applications of the SRK, GEMS, stepladder and sequential block diagram models to human error in process safety can be summarized as follows:

Error Reduction by Design

This is a proactive process which involves the following stages:

1. Perform task analysis (see Chapter 4) and identify skill, rule or knowledge-based tasks or aspects of tasks (the flow diagram in Figure 2.7 may be used to assist in this classification).
2. Depending on the results of the classification select an appropriate error reduction strategy in areas such as training, procedures or equipment design, as illustrated in Table 2.3.

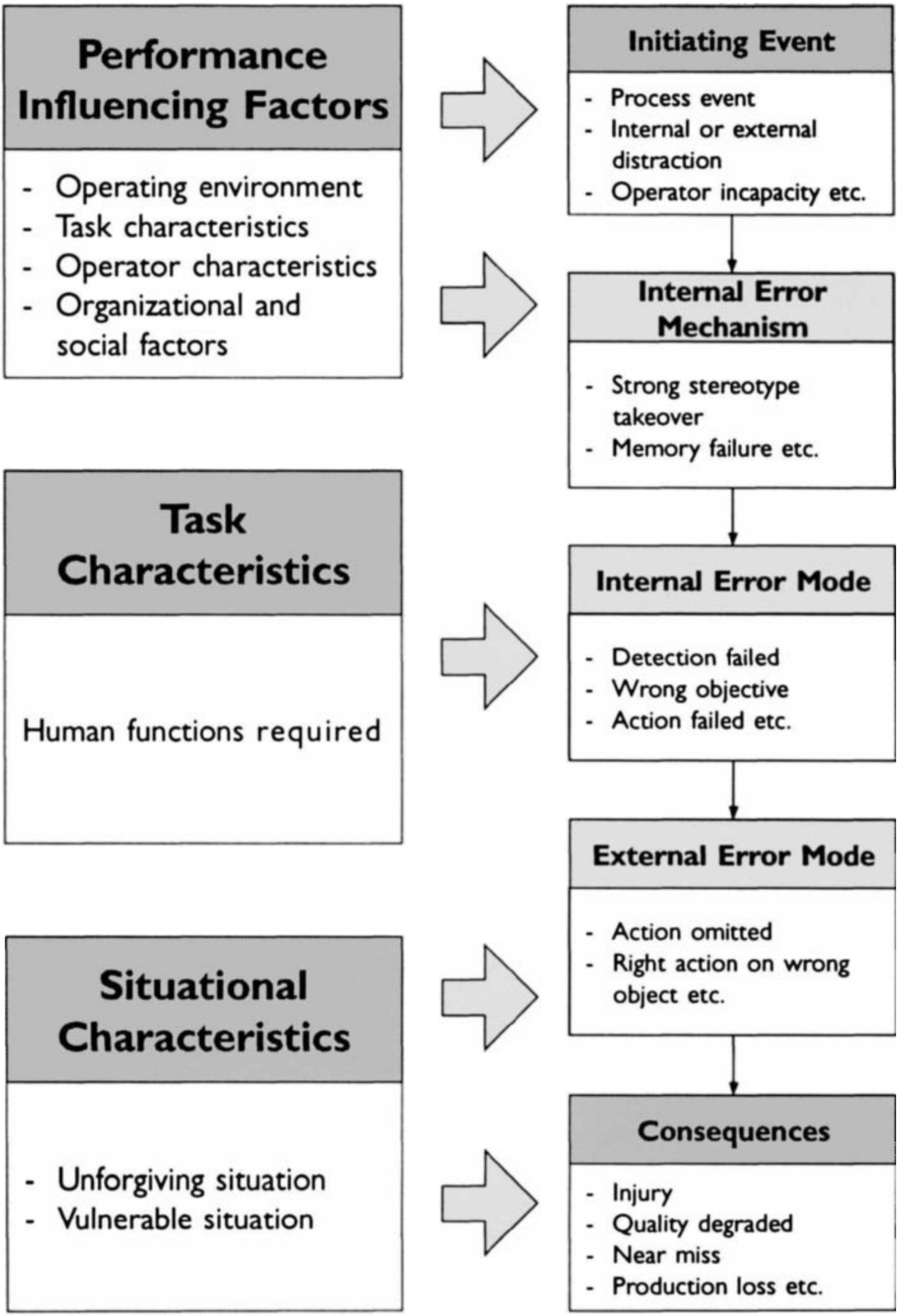

FIGURE 2.9. **Sequential Model of Error Causation Chain (based on Rasmussen, 1982).**

3. Evaluate the effectiveness of the strategy by reviewing operational experience when the task has been performed for some time, and identifying the error root causes by the process set out below.

TABLE 2.3
Example Error Reduction Recommendations Arising from the SRK Model

TYPICAL ERRORS ASSOCIATED WITH DIFFERENT INFORMATION PROCESSING LEVELS	EXAMPLES OF ERROR REDUCTION STRATEGIES		
	TRAINING	PROCEDURES/JOB AIDS	EQUIPMENT DESIGN
Skill-based Errors • manual variability • strong but wrong action sequences	Train for physical and manipulative skills (repeated practice and feedback)	Checklists setting out starting and finishing activities and checks	Layout and labeling of controls and process lines Distinguish between plant areas with similar appearance but different functions Provide feedback
Rule-based Errors • incorrect diagnosis due to strong but wrong rule • incorrect action chosen due to incorrect or inappropriate rule	Identify diagnostic and action rules required to perform job. Ensure worker is given extensive practice in using rules. Explain exceptions and possible errors due to confusing symptoms and strong rules	For complex or infrequently used rules, provide job aids, for example, fault/symptom matrices to facilitate correct diagnosis and to support selection of appropriate actions	Ensure information displays designed so that workers do not use inappropriate rules based on similar symptoms with differing causes Provide feedback
Knowledge-based Errors • information processing • perceptual tunnel vision	Where possible provide simulations of complex events to encourage development of strategies in forgiving environment. Provide training in principles of process dynamics	Provide data on plant (P & I diagrams, plant configuration) in readily accessible form. Provide problem-solving schematics to ensure all information taken into account	As above

Error Prediction for Safety Analysis and Proactive Error Reduction

This procedure is performed when error modes are being identified (e.g., critical action omitted, alternative unsafe action carried out) as part of a predictive safety analysis (e.g., CPQRA) or as part of a proactive error reduction process (see Chapter 4).

1. Perform task analysis and classify skill, rule or knowledge-based behaviors involved in the scenario being evaluated.
2. Perform a preliminary screening analysis to identify aspects of human performance where failures can have serious consequences.
3. For these tasks identify likely internal and external error modes using flow charts and methods described in Chapter 6.
4. Quantify error probabilities for these error modes using methods described in Chapter 5.
5. For errors with serious consequences and/or high likelihood of occurrence, develop appropriate error reduction strategies.

Analysis of Operational Experience
Detailed methods for incident analysis are described in Chapter 6. The methods described in this chapter provide the basis for a psychological analysis of incident causes.

1. Taking the observed error or near miss as a starting point, perform task analysis (see Chapter 4) to describe overall context of the error.
2. Use methods such as STEP (see Chapter 6) to evaluate the event sequence.
3. Use the flow charts as a basis for asking questions relating to each stage of the sequential causal block diagram. Work backward from the observable error to the initiating event. A careful analysis of the performance-influencing factors (Chapter 3) will form part of this analysis.

These various aspects of evaluating, predicting, and reducing human error form part of a general strategy for managing error which will be described in Chapter 5.

2.6.8 Conclusions Regarding Application of the Cognitive Modeling Perspective to Errors in the CPI

The previous sections have presented an extensive description of some of the central concepts from the cognitive modeling perspective. These topics have been dealt with in some depth because they provide a comprehensive basis for the reduction of human error in the CPI.

Several examples have already been provided of the use of cognitive models of error to evaluate the possible causes of accidents that have already occurred. This form of retrospective analysis performs a vital role in providing information on the recurring underlying causes of accidents in which human error is implicated. The advantage of an analytical framework driven by a model of human error is that it specifies the nature of the questions that need to be asked and the contextual information that should be collected in order to establish root causes and therefore develop effective remedial strategies. In the longer term, it also provides the basis for the evaluation of the effectiveness of these strategies by indicating if the same underlying causes recur even after error reduction measures are implemented (see Chapter 6).

The use of a model of human error allows a systematic approach to be adopted to the prediction of human failures in CPI operations. Although there are difficulties associated with predicting the precise forms of mistakes, as opposed to slips, the cognitive approach provides a framework which can be used as part of a comprehensive qualitative assessment of failure modes. This can be used during design to eliminate potential error inducing conditions. It also has applications in the context of CPQRA methods, where a comprehensive qualitative analysis is an essential precursor of quantification. The links between these approaches and CPQRA will be discussed in Chapter 5.

2.7. THE SOCIOTECHNICAL PERSPECTIVE

The approaches described so far tackle the problem of error in three ways. First, by trying to encourage safe behavior (the traditional safety approach), second by designing the system to ensure that there is a match between human capabilities and systems demands (the human factors engineering approach) and third by understanding the underlying causes of errors, so that error inducing conditions can be eliminated at their source (the cognitive modeling approach). These strategies provide a technical basis for the control of human error at the level of the individual worker or operating team.

The control of human error at the most fundamental level also needs to consider the impact of management policy and organizational culture. The concepts introduced in Chapter 1, particularly the systems-induced error approach, have emphasized the need to go beyond the direct causes of errors, for example, overload, poor procedures, poor workplace design, to consider the underlying organizational policies that give rise to these conditions. Failures at the policy level which give rise to negative performance-influencing factors at the operational level are examples of the latent management failures discussed in Chapter 1 and in Section 2.2.2.

Another way in which management policies affect the likelihood of error is through their influence on organizational culture. For example, a culture may arise at the operational level where the achievement of production objectives is given greater emphasis than safe practices. Of course, no responsible company would sanction such a situation if they knew it existed. However, without effective communications or incident feedback systems, management may never realize that safety is being compromised by an inappropriate culture and the working practices it produces.

Next Page