THE LOGIC OF FAILURE:

RECOGNIZING AND AVOIDING ERROR IN COMPLEX SITUATIONS

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INTRODUCTION

- Problems occur when we don't consider the long-term repercussions and side effects.
- Some analysts complain that all our difficulties stem from the fact that we have been turned loose in the industrial age, equipped with the brain of prehistoric times. They see our tendency to think in simple chains of cause and effect as genetically preprogrammed and locate our inability to solve our problems in this genetic programming.
- What should we make of all this? The probability that there is a secret mental trick that at one stroke will enable the human mind to solve complex problems better is practically zero. It is equally unlikely that our brains have some great cache of unused potential. If such things existed, we would be using them. Nowhere in nature does a creature run around on three legs and drag along a fourth, perfectly functional but unused leg. Our brains function the way they function and not otherwise. We must make the best of that; there is no magic wand or hidden treasure that will instantly make us deep and powerful thinkers.

1: SOME EXAMPLES

- **The Lamentable Fate of Tanaland**
  - Tanaland is a fictional place in a computer simulation.
  - Participants tried to solve problems of famine and lack of water.
  - However, in the simulation, like in life, everything is connected. Get rid of the rats, small rodents, then bug population goes out of control, etc.
  - Some succeeded, some failed.
  - The participants established their modus operandi for Tanaland in the first few sessions and did not alter it much later. Their ultimate failure shows clearly, however, that more thinking and less action would have been the better choice.
  - "Helplessness generates cynicism."
  - Problems that they saw in participants:
    - Acted without prior analysis of the situation
    - Failed to anticipate side effects and long-term repercussions

        - Assumed that the absence of immediately obvious negative effects meant that correct measures had been taken
        - Let over-involvement in "projects" blind them to emerging needs and changes in the situation
        - Were prone to cynical reactions
- **The Not Quite So Lamentable Fate of Greenvale**
    - Another fictional computer simulated town.
    - Again, had successful and not successful participants.
    - Qualities of successful participants:
        - #1: Successful participants made more good decisions than bad ones.
            - If the goal was to get to Point B, these guys put forth several initiatives to make it happen rather than one. They acted more complexly. They took the entire system into account.
        - #2: They differed in the focus of their decisions.
            - Good participants focused on the right issues.
        - #3: Good participants tested their hypotheses more often.
            - Bad ones didn't form hypothesis to test. They went straight to accepting it as truth.
        - #4: Good participants asked more "why" questions.
            - Interested in causal links behind events.
            - Bad ones took events at face value.
        - #5: Bad participants changed the subject under discussion more frequently.
            - Not focused on solving. Jump from one issue to the next.
        - #6: Bad participants had a high degree of "ad hocism"
            - Just come up with solutions on the fly without thinking consequences through.
        - #7: Innovation and stability.
            - Good participants tend to have a lower innovation index and higher stability index than the bad participants.
            - Good participants focused on the right stuff and stayed focused on it over time.
            - Bad participants would alternate between jumping around to topics and focusing on the wrong topic.
        - #8: Differed in degrees of self organization.
            - The good and bad participants also differed in their degree of self-organization during sessions. While the good participants often reflected on their own behavior, commented critically on it, and made efforts to modify it, the bad participants merely recapitulated their behavior. The good participants also structured their behavior to a greater degree. Their thinking out loud more frequently displayed

sequences like "First I have to deal with A, then with B, but I shouldn't forget to think about C as well."

- But there is no significant correlation between scores on IQ tests and performance in the Greenvale experiment or in any other complicated problem-solving experiment.
- Are you solving the problem you can solve or solving the problem you need to solve?

- **Chernobyl in Tanaland**
  - This is a real-life failure.
  - This tendency to "oversteer" is characteristic of human interaction with dynamic systems. We let ourselves be guided not by development within the system (that is, by time differentials between sequential stages,) but by the situation at each stage. We regulate the situation and not the process, with the result that the inherent behavior of the system and our attempts at steering it combine to carry it beyond the desired mark. (In chapter 5, "Time Sequences," we will encounter further examples of this kind.)
  - The other reason was probably that, although the operators may well have known "theoretically" about the danger of reactor instability, they could not conceive of the danger in a concrete way. Theoretical knowledge is not the same thing as hands-on knowledge.
  - Another likely reason for this violation of the safety rules was that operators had frequently violated them before. But as learning theory tells us, breaking safety rules is usually reinforced, which is to say, it pays off. Its immediate consequence is only that the violator is rid of the encumbrance the rules impose and can act more freely. Safety rules are usually devised in such a way that a violator will not be instantly blown sky high, injured, or harmed in any other way but will instead stead find that his life is made easier. And this is precisely what leads people down the primrose path. The positive consequences of violating safety rules reinforce our tendency to violate them, so the likelihood of a disaster increases. And when one does in fact occur, the violator of safety rules may not have another chance to modify his behavior in the future.
  - What kind of psychology do we find here? We find a tendency, under time pressure, to apply overdoses of established measures. We find an inability to think in terms of nonlinear networks of causation rather than of chains of causation-an inability, that is, to properly assess the side effects and repercussions of one's behavior. We find an inadequate understanding of exponential development, an inability to see that a process that develops exponentially will, once it has begun, race to its conclusion with incredible speed. These are all mistakes of cognition.

2: THE DEMANDS

- **Complexity**
  - If we want to solve problems effectively in Tanaland, Greenvale, Chernobyl, or anywhere else, we must keep in mind not only many features but also the influences among them. Complexity is the label we will give to the existence of many interdependent variables in a given system.
  - Such attempts to measure the complexity of a system have in fact been made.' But it is difficult to arrive at a satisfactory measure sure of complexity because the measurement should take into account not only the links themselves but also their nature. And, in any case, it is misleading (at least for our purposes here) to postulate complexity as a single concept. Complexity is not an objective factor but a subjective one.
  - Take, for example, the everyday activity of driving a car. For a beginner, this is a complex business. He must attend to many variables at once, and that makes driving in a busy city a hair-raising experience for him. For an experienced driver, on the other hand, this situation poses no problem at all. The main difference between these two individuals is that the experienced driver reacts to many "super signals." For her, a traffic situation is not made up of a multitude of elements that must be interpreted posted individually. It is a "gestalt," just as the face of an acquaintance, instead of being a multitude of contours, surfaces, and color variations, is a "face." Super signals reduce complexity, collapsing a number of features into one. Consequently, complexity must be understood in terms of a specific individual and his or her supply of super signals. We learn super signals personals from experience, and our supply can differ greatly from another other individual's. Therefore, there can be no objective measure of complexity.
- **Dynamics**
  - We cannot wait forever before we act, nor can we be perfectionists in our information gathering and in our planning processes. We must often make do with tentative solutions because time pressure forces us to act before we can gather complete information or outline a comprehensive plan.
- **Intransparency**
  - The Chernobyl operator cannot see how many control rods are actually still in the reactor. The mayor of Greenvale cannot see the satisfaction levels of different population segments. The development director in Tanaland cannot see the current groundwater supply. Planners and decision makers may have no direct access, or indeed deed no access at all, to information about the situation they must address. dress. They have to look, as it were, through frosted glass. They must make decisions affecting a system whose momentary features they can see only partially, unclearly, in blurred and shadowy outline-or possibly not at all.

    - Intransparence thus injects another element of uncertainty into planning and decision making.
- **Ignorance and Mistaken Hypotheses**
    - Explicit knowledge: A + B = C
    - Implicit knowledge: Intuition. Can be very useful.
    - The ability to admit ignorance or mistaken assumptions is indeed a sign of wisdom, and most individuals in the thick of complex situations are not, or not yet, wise.
- **Steps in Planning and Action**
    - The steps
        - #1: Formulation of goals
        - #2: Formulation of models and gathering information.
        - #3: Prediction and extrapolation
        - #4: Planning of actions, decision making and execution of actions
        - #5: Review of effects of actions and revision of strategy.
    - Can't just gather information. Have to gather it in a structured format.
    - Many psychological experiments have demonstrated how people's range of action is limited by their tendency to act in accordance with pre-established patterns. To be successful, a planner must know when to follow established practice and when to strike out in a new direction. Recognizing the strategy appropriate to a particular situation—whether methodism or experimentation or some hybrid of the two—will help us plan more effectively.
    - Decisions follow planning. Actions follow decisions. Can be complex.

3: SETTING GOALS

- **Requirements of Goal Setting**
    - **Types**
        - **Positive or Negative**
            - Goals come in many forms. I have already introduced two different kinds: positive goals and negative goals. Sometimes we act to bring about certain conditions we consider desirable, and sometimes we act to change, abolish, or avoid conditions we consider undesirable. To work toward a desirable state of affairs is a positive goal; to correct or prevent a deficient state of affairs is a negative goal.
            - "Whether things will be better if they are different, I do not know, but that they will have to be different if they are to become better, that I do know," said the Enlightenment aphorist Georg Christoph Lichtenberg.

        - **General or Specific**
            - We can also distinguish between general and specific goals. A general goal is one that is defined by a single criterion or by a few. A specific goal is defined by many criteria; it can be described and conceptualized very precisely. In chess, for example, a general goal is to checkmate your opponent's king. Whether a given situation on the chessboard is a checkmate or not is easy to determine, but there are a great many checkmate situations possible. Therefore, the criterion of checkmate leaves the goal of achieving checkmate only vaguely defined.
        - **Clear or Unclear**
        - **Simple or Multiple**
        - **Implicit or Explicit**
    - It is important to understand the links among goal criteria. As we have seen, in complex situations we cannot do only one thing. Similarly, we cannot pursue only one goal. If we try to, we may unintentionally create new problems. We may believe that we have been pursuing a single goal until we reach it and then realize-with amazement, annoyance, and horror-that in ridding ourselves of one plague we have created perhaps two others in different areas.
    - When possible, we should try to convert negative goals into positive goals. To want to avoid something, to want to make a given situation "different," these goals lack specificity and are inadequate as guideposts for planning and action. By virtue of its origins—a desire not to have something—a negative goal is often too general.
- **General Goals and "Repair Service" Behavior**
    - Goes through examples of prior concepts in a simulation.
- **Liberty, Equality, and Voluntary Conscription**
    - In complex situations it is almost always essential to avoid focusing on just one element and pursuing only one goal and instead to pursue several goals at once. In a system complicated by interrelationships, however, partial goals often stand in contradictory relation to one another.
    - Contradictory goals are the rule, not the exception, in complex situations.
    - Unrecognized contradictory relations between partial goals lead to actions that inevitably replace one problem with another.
    - Resolving these conflicts can lead down bad paths. Flip flopping, contradicting strategies and concepts. Conspiracy theories...blaming others for the failure.
        - In my view, self-protection, the need to preserve a sense of our own competence, plays a key role here. It is difficult for us to admit to ourselves that, despite the best of intentions, we have failed. Such failures suggest that our understanding of prevailing conditions is inadequate. This inadequacy means in turn that our

capability to act is limited and that we should move very cautiously. We reject that conclusion and the guilt feelings that accompany it, and so we invent conspiracy theories.

- When we must deal with problems in complex systems, few things are as important as setting useful goals. If we do not formulate our goals well and understand the interactions between them, our performance will suffer.

4: INFORMATION AND MODELS

- **Reality, Models and Information**
  - Changing a bad situation was equated with making the garden pool stop stinking now. This was accomplished, but the benefit was short-lived. Because of the way the goal had been defined, all effort had gone toward treating a symptom and none toward solving the underlying problem.
  - What precisely is a system? A system is a network of many variables in causal relationships to one another. Within a system, a variable may even have a causal relationship to itself, as it were.
  - Considering the system means more than simply acknowledging edging the existence of many variables, however. It means recognizing the different ways the variables can affect one another and themselves. These interrelationships can be grouped into the categories of positive feedback, negative feedback, buffering, critical variables, and indicator variables.
    - Positive feedback in a system means that an increase in a given variable able produces a further increase in that variable; a decline, a further decline.
    - Negative feedback in a system means that an increase in one variable produces a decrease in another and vice versa. This kind of feedback tends to perpetuate the status quo. It maintains equilibrium in a system and, should a disturbance occur, works to return the system to equilibrium.
    - The critical variables in a system are those that interact mutually with a large number of other variables in the system. They are, then, the key variables: if we alter them, we exert a major influence on the status of the entire system.
    - Indicator variables are those that depend on many other variables in the system but that themselves exert very little influence on the system. They provide important clues that help us assess the overall status of a system.
- **Solving Problems One at a Time.**
  - Goes through application of prior concepts to computer simulation.
  - Lots of the failures occurred because they didn't look at the entire system.

- **It's the Environment**
  - To deal with a system as if it were a bundle of unrelated individual systems is, on the one hand, the method that saves the most cognitive energy. On the other hand, it is the method that guarantees neglect of side effects and repercussions and therefore guarantees failure.
  - The fact that reductive hypotheses provide simplistic explanations for what goes on in the world accounts not only for their popularity but also for their persistence. Once we know what the glue is that really holds the world together, we are reluctant to abandon that knowledge and fall back on an unsurveyable system made up of interacting variables linked together in no immediately obvious hierarchy. Unsurveyability produces uncertainty; uncertainty produces fear. That is probably one reason people cling to reductive hypotheses. People use many dodges to defend their pet hypotheses against logical argument or the evidence of experience.
  - We are infatuated with the hypotheses we propose because we assume they give us power over things. We therefore avoid exposing them to the harsh light of real experience, and we prefer to gather only information that supports our hypotheses. In extreme cases, we may devise elaborate and dogmatic defenses to protect hypotheses that in no way reflect reality.
- **Prime Numbers, Tourist Traffic, or Moltke and Forest Fires**
  - The formation of abstract concepts by means of generalization is an essential mental activity. We could not begin to cope with the multitude of different phenomena we encounter if we did not put them together in categories. If we had to determine whether an object before us was a chair every time we were faced with an object that looked like other objects we had been given to understand were chairs, we would not get very far in our daily endeavors. We need an abstract concept "chair" that lets us dispense with complex deliberations and simply operate with the idea of a chair, whether we have a concrete example in front of us or not.
  - Essential as it is to put aside "unimportant" features and to stress "important" ones in formulating classes, the dangers of this intellectual operation are great. A necessary generalization can easily evolve into an overgeneralization. And as a rule we have no opportunity to test in advance whether a concept we have developed has struck just the right degree of abstraction or is an overgeneralization.
  - Situations of this kind are doubtless what the nineteenth-century Prussian field marshal Graf von Moltke had in mind when he wrote, "Strategy is a system of makeshifts. It is more than a science. It is bringing knowledge to bear on practical life, the further elaboration of an original guiding idea under constantly changing circumstances. It is the art of acting under the pressure of the most demanding conditions...That is why general principles, rules derived from them, and systems based on these rules cannot possibly have any value for strategy."

- What Moltke had in mind about strategic thinking in war applies in general to the manipulation of highly interdependent systems. Schematizations and the formulation of rules obscure the constant need to adapt action to context. A sensible and effective measure in one set of circumstances can become a dangerous course of action when conditions change.

- **The Pale Cast of Thought**
  - Anyone who has a lot of information, thinks a lot, and by thinking increases his understanding of a situation will have not less but more trouble coming to a clear decision. To the ignorant, the world looks simple. If we pretty much dispense with gathering information, it is easy for us to form a clear picture of reality and come to clear decisions based on that picture.
  - A business executive has an office manager; presidents have councils of advisers; military commanders have chiefs of staff. The point of this separation may well be to provide decision makers with only the bare outlines of all the available information so that they will not be hobbled by excessive detail when they are obliged to render decisions. Anyone who is fully informed will see much more than the bare outlines and will therefore find it extremely difficult to reach a clear decision.
  - The two modes of behavior are opposite sides of the same coin. We combat our uncertainty either by acting hastily on the basis of minimal information or by gathering excessive information, which inhibits action and may even increase our uncertainty. Which of these patterns we follow depends on time pressure or the lack of it.

5: TIME SEQUENCES

- **Time and Space**
  - We live and act in a four-dimensional system. In addition to the three dimensions of space, this system includes the fourth dimension of time, which moves in one direction, and that direction is toward the future.
  - A tourist in Hong Kong during the typhoon season, for example, could well become convinced of the colony's imminent watery end; any resident, however, would view the heavy rains as unremarkable in the context of an entire year's weather. Fixation on linear future development may prevent us from anticipating changes in direction and pace: a purely linear extrapolation of the growth of a six-year-old child would produce ridiculous predictions about her height as, say, a forty-year-old.
- **Lily Pads, Grains of Rice, and AIDS**
  - Understanding linear growth vs. exponential growth. Both can cause us to underestimate or overestimate the future.
  - The one conclusion we should take away from these considerations if we take away nothing else is that we cannot interpret numbers solely on the

basis of their size. To understand what they mean, we have to take into account the process that produced them, and that is not always ways easy.

- **Laymen and Experts**
  - Laymen focus on simpler models, experts on more complex...both can have issues.
- **28 Is A Good Number**
  - Sometimes things affect other things, but there is a delay in the effect. If we don't know of that delay, or don't consider it, it can cause problems.
  - Come up with "magical hypotheses"
    - Overgeneralize, don't know what is causing it, so just make up a theory.
    - We then protect these theories, develop rituals and protect those.
  - In addition to these two modes of hypothesis formation-generalizing from local experience and the progressive conditional Ming of local experience to the point of ritualization-there is a third mode: "You have to set the regulator high to lower the temperature." "High settings produce low temperatures." The participants who voiced these hypotheses no longer trusted the instructions or the experiment director but suspected instead that they were the victims of some malevolent deception. They may have been told that low settings of the regulator would produce low temperatures, and high settings high temperatures, but now they had seen through the whole rotten setup. Just the opposite was true! Hypotheses of this third sort are in a sense "meta hypotheses." They imply a revolution in the participant's worldview and call into question the entire structure of the experiment.
- **Predators and Prey**
  - Oscillation is one way in which time sequences can change direction. Another equally common phenomenon is a sudden reversal in the direction reaction of a development over time. Growth in an economy is interrupted by a recession. It is suddenly impossible to move a product that has sold well for years.
- **The Moths of Kuera**
  - Kuera is a village in the Nile delta. Both cotton and figs are grown there. The cotton crop depends on the activity of the death's-head moth (Acherontia atropos), which pollinates the blossoms of the cotton plant. But this same moth damages the fig crop by boring holes in the figs to feed on the juice, not only destroying fruit mass but also opening a passageway for pests that produce rot in the fruit. So on the one hand the death's-head moth is essential, but on the other it is a pest. What is clearly desirable in this situation is to limit the moth population to the absolute minimum necessary for the cotton ton crop.

- All the counterproductive behaviors we have seen before turn up again in this experiment. We find massive countermeasures, ad hoc hypotheses that ignore the actual data, underestimations of growth processes, panic reactions, and ineffectual frenetic activity.
- The solution is nothing arcane. All it requires is keeping a few utterly simple rules in mind: Try to understand the internal dynamics of the process. Make notes on those dynamics so that you can take past events into account and not be at the mercy of the present moment. Try to anticipate what will happen. Elementary, my dear Watson!

6: PLANNING

- If we want to deal rationally with a complex problem, the first thing we do (tentatively, at least) is define our goals clearly. Then we construct a model of the specific reality or modify an existing model. We may have to observe the system for quite a while to understand the connections between its variables and need to gather information on the present state of the system so that we know how it is behaving now and how it is likely to behave in the future. Once we have done all that we can move on to the planning stage.
- **Go Make Yourself a Plan**
  - What is planning? In planning we don't do anything; we just consider what we might do. The essence of planning is to think through the consequences of certain actions and see whether those actions will bring us closer to our desired goal. If individual actions will not achieve our purpose, pose, we have to lay out sequences of actions.
  - Planning consists of examining the consequences of individual actions, then of stringing individual actions together into sequences and examining the possible consequences of these sequences of action.
  - For reverse planning it is crucial to have a clear goal in mind. If the goal is foggy and unclear, we have no solid frame of reference for the question "What single action will result in the desired goal?" This is yet another reason we should be rigorous in clarifying our goals.
  - When possibilities are too immense (too many options on the chess board) need to narrow the focus to deal with less variables. Focus on a more finite universe and goal. Or break goals up into smaller pieces.
  - By identifying situations in which we should plan little, if at all, we have touched upon one extreme of a broader issue. In planning, as in information gathering, we are faced with the problem of scale. We can make plans that are too crude and plans that are too detailed. The trick is to plan with an appropriate degree of detail. But what is appropriate?
  - The difficulty of finding the correct scale for planning accounts for many failures. The more uncertain we are, the greater our tendency to overplan, for example. In a situation we find threatening to begin with, we try to foresee all possibilities and make allowance for every conceivable able mishap. This approach can have ruinous consequences. The more

extensive our understanding becomes, the more the planning process will impress on us the myriad possible results. Planning, like the gathering ring of information (for planning, too, is a form of information collection), can increase our insecurity rather than reduce it.

- **Rumpelstiltskin**
  - I have defined a planning unit as consisting of a condition element, an action element, and a result element. (The result element is, of course, an "expected result" element; what actually results from an action may not be what the planner expected.)
  - Discounting the conditions under which we will carry out our actions simplifies planning but not acting. We can describe our plans much more easily-as when a General outlines a campaign as simply a matter of capturing a series of towns-but our description may conceal problems. As Carl von Clausewitz, the author of a seminal work on the conduct of war, put it, "In war everything is simple, but it's the simple things that are difficult."
  - The effects of "methodism"-the unthinking application of a sequence of actions we have once learned-can have a significant impact in areas other than measuring quantities of water. The motivation is the same, however: we are most inclined to deconditionalize a form of action and use it over and over again if it has proved successful for us or for others.
  - Methodism is dangerous because a change in some minor detail that does not alter the overall picture of the situation in any appreciable way can make completely different measures necessary to achieve the same goal.
  - It is obvious from these two lists that the good problem solvers favored expressions that take circumstances and exceptions into account, that stress main points but don't ignore subordinate ones, and that suggest possibilities. By contrast, the bad problem solvers used "absolute" concepts that do not admit of other possibilities or circumstances.
  - Before making plans in disregard of conditions, we should perhaps meditate on Kant's warning: "Making plans is often the occupation of an opulent and boastful mind, which thus obtains the reputation of a creative genius by demanding what it cannot itself supply, by censuring what it cannot improve, and by proposing what it knows not where to find."
- **Learn by making mistakes? Not necessarily.**
  - In any case, unexpected results should give us pause. Even negative results provide us a chance to apply correctives and in that way help us improve our future behavior. Or so one would think.
  - The less clear a situation is, the more likely we are to prop up our illusion of competence with ballistic behavior. Such behavior reduces our sense of confusion and increases our faith in our own capabilities. And that isn't necessarily bad, is it?
  - Ballistic behavior is not the only way we can avoid confronting the negative consequences of our own actions. If there is no other escape and

we are forced to recognize them, we can always resort to what psychologists neatly term "external attribution." We can always say, "I had the best of intentions, but circumstances prevented me from achieving what I wanted." "Circumstances" can, of course, always be found, especially those "forces of evil" that sabotage and thwart our finest efforts with malevolent and underhanded tactics.

- "immunizing marginal conditionalizing" of our measures." As a rule, make sure A produces effect B, we can reason. But under certain limited conditions that are unfortunately prevailing just at this moment, make sure A produces other effects.

7: SO NOW WHAT DO WE DO?

- We have become acquainted with many inadequacies of human thought in dealing with complex systems. We have seen people fail to formulate their goals in concrete terms, to recognize when their goals contradict one another, and to set clear priorities. We have also seen them badly mishandle temporal developments. Above all, we have seen people fail to correct their errors. It may be possible to correct these failings by rote, but a more useful exercise will be to determine the main psychological reasons for these inadequacies so that we can attack them at their roots.
- Problems
  - #1: Slow thinking
    - In short, our tendency to economize, which prompts us to omit certain steps in the thought process or to simplify them as much as possible, seems to play a major role when we deal with complex systems.
  - #2: Preserving a positive view of one's competence contributes significantly to shaping the direction and course of our thought processes.
    - Another proven means of protecting our sense of competence is to solve only those problems we know we can solve.
  - #3: A third reason we have difficulty dealing with complex and time-dependent dependent systems is the relatively slow speed with which the storage system of the human memory can absorb new material.
  - #4: A fourth psychological mechanism seems responsible not so much for failings as for omissions in our thought processes. We don't think about problems we don't have. Why, indeed, should we? In solving problems that involve complex dynamic realities, however, we must think about problems we may not have at the moment but that may emerge as side effects of our actions.
- I think that the differences between the expert and the layman can be found here. We all know the basic rules of thumb. "Look before you leap." "Be clear about your goals." "Gather as much information as you can before you act." "Learn from your mistakes." "Don't act in anger." "Ask for advice." Who would not agree

to their usefulness? The troublesome thing about them, is that they don't always apply. There are situations in which it is better to act than to think. Sometimes we should cut short our information gathering. And so on.
    - Our practitioners not only knew these rules but applied the right rules at the right times.
- What can we learn from such training?
    - We can learn that it is essential to state goals clearly. We all know we should do that, but we rarely encounter the necessity.
    - We can learn that we cannot always realize all our goals at once, because different goals may contradict one another. We must often compromise between different goals.
    - We can learn that we have to establish priorities but that we cannot cling to the same priorities forever. We may have to change them.
    - We can learn that in dealing with a given configuration we should form a model of the system. We must anticipate side effects and long-term repercussions and not just let them roll over us.
    - We can learn how to adapt information gathering to the needs of the task at hand, neither going into excessive detail nor stopping too short.
    - We can learn the consequences of excessive abstraction.
    - We can learn the consequences of hastily ascribing all events in a certain field to one central cause.
    - We can learn when to continue gathering information and when to stop.
    - We can learn that we tend toward "horizontal" or "vertical" evasion and that the tendency can be controlled.
    - We can learn that we sometimes act simply because we want to prove to ourselves that we can act. We can learn the dangers of knee-jerk "methodism."
    - We can learn that it is essential to analyze our errors and draw conclusions from them for reorganizing our thinking and behavior.