# IMPLEMENTING AIRCREW JUDGMENT TRAINING

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## INTRODUCTION - THE PROBLEM

A fighter pilot delays his lag roll for an extra second--and instead of flying too close to his target, falls into a perfect shot position; his timing is the result of years of experience. A Landing Signal Officer (LSO), guiding aircraft aboard his carrier, calls a pilot for power a moment before it is needed and thus prevents a settling approach; his acute sensitivity has taken hundreds of hours to develop. A Tactical Action Officer (TAO), in the Combat Information Center of his ship, correlates all of the information from an ambiguous radar signal with the weapons available to him and correctly assigns ship missiles to a low-altitude bomber; long months of training and practice have made the difference between survival and disaster.

Each of these jobs--and there are many more like them in the armed forces--is an example of what is generally called judgment. That is, each job requires more than perceptual or motor skills. Jobs such as these require the ability to select among methods of problem solving, to weigh alternatives under stress and with limited information, as well as the ability to be innovative when the situation requires. No one can argue that judgment is not a valid reflection of trained performance. Few, however, can define judgment in a fashion which is usable for efficient training development. The major stumbling block in previous efforts to develop methodologies for judgment training has been their attempt to work with too global a definition of what judgment is. This paper reviews some recent work in this area and suggests potential solutions to the problem of judgment training (specifically, for aircrew tasks) which, though limited in scope, lend themselves to relatively easy implementation.

## WHAT IS JUDGMENT?

One of the reasons, perhaps the major reason, why it is so difficult to obtain a useful definition of judgment is the large variety of performances to which the term judgment is applied. We are interested in judgment by the military equipment operator or tactical decision-maker, and thus we can confine ourselves to those military jobs which require judgment performance. A prime example is the job of the fighter pilot who has to fly his aircraft to a position where he can use his weapons against an active, thinking opponent who attempts to counter the fighter pilot with maneuvers of his own. It is this task which really separates the wheat from the chaff; i.e., the superior from the average pilot, or those who have good judment from those who don't. Two pilots may fly perfect practice maneuvers, each may know the capabilities of his aircraft and weapons, and each may possess the same levels of physical coordination and intelligence. Yet, during actual or simulated combat, one pilot achieves consistent victories while the other struggles just to avoid losing. What is the crucial difference? Is it primarily cognitive or affective in nature? What is the best way to describe this difference in a manner useful for training and training development?

A report, sponsored by the Federal Aviation Administration (Jensen & Benel, 1977), described pilot judgment as consisting of two components: 1) a cognitive component which deals with the establishment of alternative actions and the selection among them, and 2) an affective component or motivation which effects such selections among the alternatives. In a later paper (1978), Jensen expanded this definition to include a continuum between judgments which are perceptual and those which are cognitive, as a function of cognitive complexity of tasks and decision time (Figure 1).

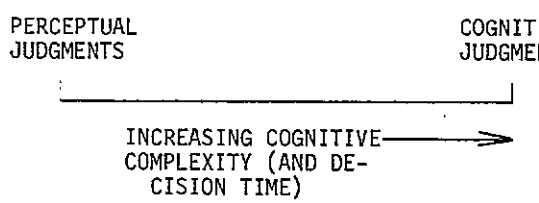


Figure 1. Judgment Continuum Based on Cognitive Complexity and Decision Time (Jensen, 1978)

According to Jensen, primarily perceptual judgment is associated with low cognitive complexity and little time available for decision making. At the other end of the continuum one finds more analytical forms of judgment, called cognitive judgment, under conditions of high cognitive complexity and plenty of available decision making time. This definition is the result of an extensive literature review and an in-depth analysis effort which included work that dealt with the judgment phenomenon in the context of a variety of jobs from aircrews to physicians.

Another study emphasizes the selection characteristics of aircrew judgment tasks (Saleh, et al. 1978) by proposing a training approach which teaches how to select among the relatively clear problem-solving techniques which are currently the "bread and butter" of most flight training programs. The need for a higher management scheme is identified in this study for sophisticated aircrew performance; an organized strategy to coordinate problem solving methods, to select and apply the most promising candidates. The skill of selecting among problem solving techniques has also been identified by Gagne and Briggs (1974), who call such skills "cognitive strategies". The position of these skills in the hierarchy of cognitive performances is shown in Figure 2. Gagné implies in his taxonomy that these cognitive strategies are internally organized (i.e., it would appear that these selection schemes are developed uniquely by each individual, over time and as a function of experience). Little can be said regarding the training of these strategies except that conditions should be made favorable for their acquisition.

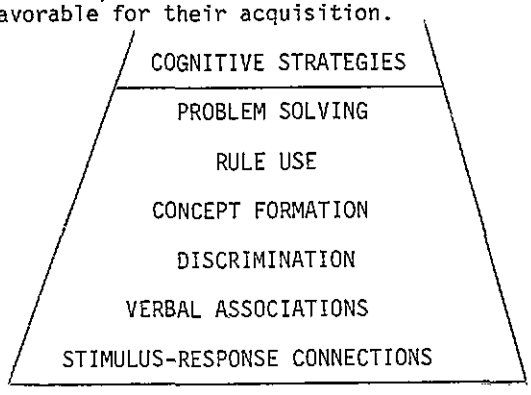


Figure 2. Intellectual Skills (Gagné and Briggs, 1974)

It would seem that judgment performance is characterized by the following components; although each model may emphasize different features, the basic properties appear to be:

1. Judgment involves a cognitive factor for generating candidate problem solutions, and strategies for choosing among them;
2. Judgment can involve selection strategies which manipulate probabilistic information--not all aspects of a situation may be known, but choices must still be made;
3. Judgment may be stress-dependent, in that motivation must exist to affect choices--if stress becomes extreme, however, judgment performance may be degraded.

Now, these definitions of judgment are all relevant to judgment performance, but are they all relevant to judgment training? Of the previously mentioned studies, those which propose training methods usually attempt to include all aspects of judgment in their programs. Such efforts are ambitious, and might be quite effective if properly implemented, but cost and personnel constraints weigh against this approach. What is left is a partial implementation of broad-based strategy for judgment training, or complete implementation of training focused on selected judgment characteristics. A case will be presented for the second option later in this paper.

## WHAT IS JUDGMENT - REALLY?

The definitions of judgment presented so far are all adequate to explain at least parts of the judgment task; the Jensen scheme appears to be the most comprehensive. What is the concept, however, of judgment by those who must actually teach it? It is the evaluation of current training (and its improvement, if possible) which is the focus of this paper and this conference. It seems that the word "judgment" is used in its broadest sense by the aircrew training community, and this conceptual latitude has resulted in only diffused efforts to help students acquire judgmental skills.

By way of example, a large portion of pilot training effort is expended in teaching judgment during landing. Runway line up, approach attitude, and timing of the landing flare are all spoken of as demonstrations of pilot "judgment", and instruction directed at such skills is considered judgment instruction. A closer examination, however, reveals that such activities are really examples of perceptual discriminations (in the Gagné system) or perceptual judgments which occupy (in the Jensen scheme) only a narrow band of possible judgment performance. Thus, the part can be frequently mistaken for the whole, with two implications for training.

1. If lower level skills are considered to represent judgment, then true judgment tasks may receive a leaner portion of instructional attention, or
2. These lower level skills may be approached with incorrect instructional strategies in the belief that the tasks are something other than what they really are.

This condition is not at all uncommon in the aircrew training community and reflects --at least in part--the lack of clear concepts regarding judgment and its components. The problem extends to selection procedures for pilot candidates which seem to have reached a

ceiling of success; attrition rates, always a drain to training costs, have not been significantly reduced in many years. Furthermore, the competence of even graduate pilots is not uniform, as the earlier comparison of fighter pilots exemplifies. A recent study, supported by the McDonnell-Douglas Company (1977), attempted to discriminate those qualities which characterized the superior fighter pilot. Despite a review beginning from World War I and proceeding through Vietnam, no clear factors were found which could serve as predictive indices of fighter pilot success. Unambiguous factors would have a quite significant impact on selection and training; it is entirely possible that this search was not more successful because elements of judgment, of decision-making under combat stress, were not sufficiently defined.

Two approaches to judgment and training have been discussed--the theoretical analysis of judgment (and its training implications), and the current understanding of judgment at the field training level (with its resulting implications). Obviously, the two can be reconciled to the benefit of both, but how can this be accomplished expeditiously and with minimal impact on current training resources? Once again, a case can be presented which permits full implementation of training for components of judgment performance (rather than limited applications of a full definition) and this case will be examined next. The behaviors which are now considered aircrew "judgment" must first be broken down into training domains, those critical components which remain must be accommodated in the training program, and the effects of stress must be included; all of this, hopefully, at minimal expense.

## REDUCING THE JUDGMENT DOMAIN

Taking note of the training situation for teaching landing performance cited earlier, the first step in formulating a plan for judgment instruction is to reduce its domain. This would involve an examination of each skill or scenario in a given training program and assignment of that skill/scenario to the type of learning which it truly represents. As stated before, not all flight tasks are really higher level judgment skills; in the landing example, a perceptual discrimination is being taught (i.e., the ability to detect whether visual cues are "right" or "wrong" for the desired position; once this is known, what to do in response becomes a matter of rule use--the reader is referred to the Gagné hierarchy, Figure 2). The point of this example is that existing ISD principles can be applied, once the skill is identified as belonging to the more deterministic types of learning. Furthermore, the ISD techniques chosen for this skill are appropriate; that is, ISD techniques relevant to perceptual discrimination and rule use are used to teach those skills, and this might not be the case if the skills were thrown into the grab bag known as "judgment". Judgment is popularly thought of as being a function of experience. It is not unreasonable, therefore, to trust the improvement of substandard or average performance to additional experience with the particular task. In this example, marginal landings may result in assignment of additional practice (for better judgment) when a quicker, cheaper solution would be presentation of correct runway "sight" pictures to the pilot, to improve his discrimination performance. The latter method was applied with good effect by the second author while conducting research at Williams Air Force Base, Arizona.

This principle applies up through fairly complex levels of learning, including problem-solving and concept mastery. If a fighter pilot is consistently executing an inappropriate maneuver for a given tactics situation, it might be the case that he has not established a necessary problem-solving routine (e.g., "I'm closer to a sparrow shot than I am to a sidewinder shot, but at this altitude the sidewinder has a better chance of success so I'll continue to work for the "winder envelope"), or has not mastered a critical concept, (e.g., "I can pull up and turn behind this high bogey, but when I get there I'll be too slow because whenever you gain altitude, you lose airspeed or energy, so I'd better add power now"). To the instructor, these cases may appear as instances of bad judgment when, in fact, they represent weaknesses in lower-level skills, which current ISD methods should be capable of handling.

In summary, it can be stated that judgment is a complex range of skills which may be manipulated under external conditions of time and stress. To make the process of judgment training more manageable, it is important to first establish what judgment is not; the remaining domain of skills can then be given the full attention required to teach them.

## TRAINING FOR JUDGMENT

Those characteristics which were found to apply to judgment tasks (generation and selection of alternatives, probabilistic input, and stress effects) still account for a large and critical realm of the training mission. Such tasks as altitude positioning, airspeed and aircraft formation during the attack vector, and the myriad decisions involved in combat maneuvering during tactical engagements all include significant cognitive and affective components which comprise judgment performance. Jensen (1978) proposes a comprehensive plan for training judgment in general; what is proposed here is an abbreviated strategy for implementing some areas of judgment training on a more limited (and hopefully, more economical)

scale.

First, the probabilistic nature of the flight task must be appreciated. Combat maneuvering against a thinking, skilled, aggressive opponent always implies the risk that the assumptions about his battle plan and his abilities are wrong. Decisions must, nevertheless, be made if the fighter pilot is to establish his own plan. Although hindsight may permit a perfect analysis of what tactics should have been employed, the pilot in combat does not have the luxury of complete problem input and must make the best (i.e., most accurate and reliable) assessments that he can in a hostile environment. A simple decision paradigm is shown in Figure 3. At each level of the decision-making process, uncertainty exists regarding the results of that level. For example, if the problem cannot be precisely defined (due, say, to a lack of sufficient cues), then alternate solutions for two or more possible problems may have to be generated at the second level in this fashion, uncertainty is cumulative; if the decision-maker is unable to constrain or order the results of each phase--through additional input, training, or a judgmental decision--the entire process becomes unwieldy and a "random guess" may result.

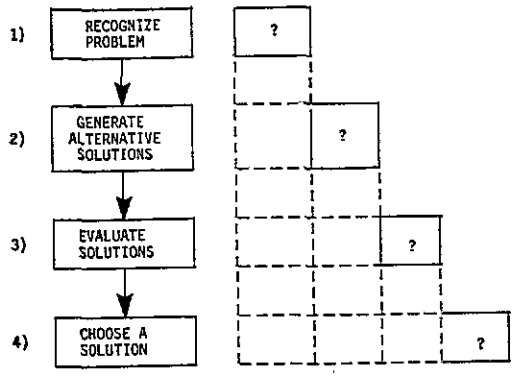


Figure 3. Judgment Under Uncertainty

The worst case for making a selection among alternatives is when each alternative is equally likely to the person who must make the selection; the more alternatives available, the lower the probability that any choice, at random, is the optimum one. There may in fact be a priority ranking or a probability distribution of the alternatives, but if this is unknown the decision is, at worst, a chance event. Now air combat training is far from such a random situation, and the novice pilot enters each tactical engagement with an extensive set of skills intended to present him with a realistic assessment (that is, one which accurately corresponds to the actual conditions) of each situation. The complexity of any scenario, however, can easily generate conditions for which no such ready-made assessment exists and the pilot is required to do his own analysis of the novel conditions and make an innovative or unusual choice of actions. Those pilots who are best able to appropriately respond to unexpected, complex events can be said to possess the best "judgment". Such pilots are frequently those with the most extensive and varied experience. What is suggested here is that a pilot (or any person who exercises true judgment) learns, over time, to modify an essentially random set of alternatives into an ordered set which permits the optimal choice for a given set of external conditions; a strategy is established for figuring out what is most likely to succeed and what is not.

Any training system which can facilitate the efficiency of this mechanism (somewhat akin to "cognitive strategies" in the Gagné hierarchy) or shorten its acquisition, should be quite valuable. Two methods for achieving this are suggested:

1) Situational Control--Although most training programs are carefully structured to present situations (i.e., simulator and flight events) which enhance perceptual/motor and procedures learning, little emphasis has been given to the presentation of situations which teach judgment performance. This is not to say that this training is absent, only that it has received insufficient attention in relation to its significance. If, as is proposed, judgment skills are a function of accurate selection among alternative actions, then the presentation of situations which match real-world probabilities should provide the shortest method for acquiring an understanding of those probabilities. Thus, a realistic probability distribution can be instilled in the flight student without the requirement to know the details of his internal decision-making processes. An academic example of this approach is the "situational training" of the Air Force, which attempts to develop prudent response strategies based on scenarios of emergencies rather than training each response procedure independently.

2) Academic Control--This approach was treated quite well in the Saleh (1977) study and involves an analysis of strategies for choosing between alternative courses of action and training these cognitive skills in addition to problem-solving procedures themselves. This approach is more complex and costly than the gross analysis required for the prior method, but is much more comprehensive and makes up a major part of the Jensen plan.

A simpler application of this approach is the presentation of scenarios which require the flight student to practice judgment skills; that is, configurations of flight tasks and

procedures into groups which tax the student's coordination of individual tasks and encourage the rapid development of cognitive strategies. As skills are taught through current syllabi, students learn an increasing number of procedures, but are left largely on their own in the establishment of coordination strategies. Again, an in-depth analysis of such strategies is not required--only the assembling of realistic and significant scenarios, and their incorporation into judgment training sequences of existing programs. A variation of this technique is currently employed for F-14 aircrew training which involves the presentation of a "canned" tactical engagement to the student. This is accomplished with the playback features of the air combat maneuvering range (ACMR), which can display a recorded flight in three dimensions. The entire event is shown, followed by a step-by-step replay of key maneuvers (much like a detailed account of a chess game), allowing the student to comment on or evaluate each decision point for himself. Once the student has become familiar with each component of the engagement and its overall "flavor", he is then ready to fly in an identical situation and make use of the strategic foundations he has developed through prior analysis; he already has a sophisticated set of algorithms--based on experience--regarding what will work and what will not.

The final major characteristic of judgment performance--stress effects--remains to be considered. Stress can enhance skilled performance by generating higher levels of motivation, but this is true only to a point, beyond which performance is degraded. In general, the lower the level of training or the more complex the skill, the greater the degradation for any given level of stress. Training should profit from those methods which can keep stress low enough to permit application of those skills.

Obviously, confidence in one's skills has a lot to do with how much stress can be self-generated precisely because the student is not sure of his procedures and skills. The solution of ACMR playback, discussed previously, is also relevant in this context because the student is allowed to analyze and understand a complex, dynamic event at his own pace; this luxury is not a usual application of such training media but a conversion like this is not impossible for simulators, part-task trainers, mission recorders, etc.

## SUMMARY

As technology provides the means for handling the simpler tasks of most military jobs, the role of the equipment operator as a decision-maker, required to exercise complex judgment, becomes more critical to the military mission. The requirement grows, therefore, for the instructional design community to accommodate the special demands for judgment training in new and existing programs; indeed, the requirment has already existed for some time now.

Several studies of judgment and judgment training have been presented here. Each of these efforts has proposed a training implementation plan, some more extensive than others. This paper has attempted to evaluate the most practical features of each judgment analysis and convert them to training suggestions which could be easily and inexpensively incorporated into ongoing programs, including:

1. Reducing the domain of tasks which actually represent judgment performance,
2. Training this judgment performance using control of learning situations and academic presentation, and;
3. Considering (and, therefore, reducing) the effects of stress.

These suggestions are intended as a minimal cost, minimal intervention approach to fulfill the need for training judgment. Eventual expansion of these ideas could, hopefully, result in a comprehensive program along the lines of the Jensen proposal.

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