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How to Apply Mnemonic-Methods for Improving Pilots' In-flight Decision-making

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Abstract

Background: Two ADM mnemonic-based methods, SHOR (Wohl, 1981) and DESIDE (Murray, 1997), have been demonstrated to significantly improve military pilots' in-flight decision-making performance in six different tactical situations (Li & Harris, 2005). However, there is little research concerning how to apply these mnemonics in real world. **Method:** This research applied focus groups consisting of three senior flight instructors and one aviation human factors specialist, to investigate how to apply the SHOR and DESIDE techniques in different types of decision-making scenarios. **Results:** The qualitative data suggested that SHOR was the best mnemonic in the recognition-primed decision making scenarios; DESIDE was the best mnemonic for the scenarios concerning non-diagnostic procedural decisions and creative problem-solving. **Discussion:** Pilots would apply SHOR in time-limited and urgent situations as a result of its concise, logical structure. They chose to use DESIDE when time was available for a more comprehensive consideration of the situation.

Keywords: Aeronautical Decision-making, Focus Group, Mnemonics

INTRODUCTION

Pilots frequently make important decisions under time pressure situation and these may have very serious consequences. Some decisions are made with ambiguous information, in hostile environments, and with very little time available. A critical component of pilot proficiency is the ability to make good decisions. Decision skills might be trainable (Kaempf & Orasanu, 1997). Diehl (1991) found that decision errors contributed to 56% of accidents in airlines and 53% of accidents in military aviation between 1987 and 1989. Shappell and Wiegmann (2004) also found that decision errors contributed to 45% of accidents in the USAF, and 55% in the US Navy. The early concepts of pilot decision-making were based on models that reflected the level of thinking in cognitive psychology. These models remain the underlying premise of many contemporary decision training programs in aviation (Kaempf & Klein, 1994). The research paradigm of naturalistic decision-making (NDM) has provided an alternative approach for understanding how pilots make decisions and for designing training interventions that will help pilots when making decisions under uncertain, high pressure, high stakes, and in time-limited situations (Jensen, 1997). There are a number of strategies embodied in the mnemonics describing the processes and procedures concerned with ADM mnemonic-based methods that could potentially improve pilots' in-flight decision-making (Li & Harris, 2005). O'Hare (2003) described several acronyms/mnemonics to guide and structure decision-making. The aim of these techniques is to form a systematic approach to decision-making that should be less affected by human biases and should also reduce the cognitive workload for pilots. However, Orasanu (1993) has pointed out that there was no evidence to support the development of *generic* training techniques to improve all-purpose decision making skills, as there were different component skills involved in making the different basic types of decisions.

Decision-making is a complex cognitive process and is affected by situational and environmental conditions (Payne, Bettman, & Johnson, 1988). One of the factors that negatively influences pilot's decision-making is psychological stress. Keinan (1987) found that under stress the range of alternatives and dimensions that are considered during the decision-making process is significantly restricted compared with normal conditions. For over 30 years the importance of aeronautical decision-making has been recognized as critical to the safe operation of aircraft. Jensen & Benel (1977) reported that 51% of fatal general aviation accidents from 1970 through 1974 were associated with decision errors. The key issues of pilot's decision-making are time pressure and risk. Mjos (2001) suggested that in emergent situations, uncertainty might outweigh time pressure as the key stressor bearing on the decision-making strategy.

Aviation environments are often complex and different factors such as problem patterns, aircraft types, missions, available time, or risk may influence pilots' in-flight decision-making. Aeronautical knowledge, skill, and judgment have always been regarded as the three basic faculties that pilots must possess (Diehl, 1991). The requisite knowledge have been imparted in academic and flight training programs and have subsequently been evaluated as part of the pilot certification process. In contrast, ADM has usually been considered to be a trait that good pilots innately possess or an ability that is acquired as a by-product of flying experience (Buch & Diehl, 1984). There is an increased need for military pilots to be trained specifically in making in-flight decisions in different tactical environments to improve aviation safety.

METHOD

This research applied focus group to develop the contents of two mnemonic methods for ADM training. The main purpose of focus group research is to draw upon respondents' beliefs, experiences and reactions toward a specific topic. Kitzinger (1994) suggested that interaction is the crucial feature of focus groups as the individuals in a focus group are expressing their own definitive individual view. In this study, the participants are speaking in a specific context (aviation training), within a specific culture (military).

Participants: The focus group consist of three senior instructor pilots with over 3000 flight hours and one aviation human factors specialist.

Scenarios: There are three different decision-making scenarios as following described by Orasanu (1993) and Li & Harris (2005). (1) Recognition-primed decisions: : F-5E right engine fails as a result of Foreign Object Damage (FOD) just as the nose gear leaves the ground at a speed 165 knots; (2) Non-diagnostic procedural decisions: Both the leader and wingman in a formation of F-5Es are unable to land at home-base in a 'bingo' (low fuel) situation during instrument flight in bad weather; (3) Creative problem-solving: When flying an F-5F both left and right generators fail at the same time during a tactical manoeuvre.

ADM Mnemonics: Two ADM mnemonic-based methods, SHOR (Stimuli, Hypotheses, Options, Response; Wohl, 1981) and DESIDE (Detect, Estimate, Set safety objectives, Identify, Do, Evaluate; Murray, 1997), could potentially improve the quality of pilots' decision-making were selected from a review of the literature (Li & Harris, 2005).

Data collection: The participants had participated three focus groups, each focus group concentrated on one scenario. The participants were asked to using both SHOR and DESIDE mnemonics in those six different scenarios, and describing how to step by step applying the procedures of both SHOR and DESIDE mnemonics in each scenario according to the specific context and situations.

RESULT AND DISCUSSION

In the Recognition-primed decision scenario an engine failure as a result of FOD (Foreign Objects Damage), pilots must make a quick decision to deal with urgent situation. The findings confirm the quicker the better, as the result SHOR was the best fitted for this urgent situation. As soon as pilots assessed the situations properly (hypotheses) and quickly evaluated the options for safe actions, the response strategies were retrieved on the basis of their past training experience in this situation. The experts found that SHOR was effective with specific actions specified for completion in a very short time. On the other hand, there was no enough time to take a full detail consideration (DESIDE) to generate the best strategy to deal with this situation, as DESIDE has too many steps, requires more consideration, more time consuming and more dangerous in this urgent situation (see table 1).

In the scenario where both the leader and wingman are unable to land in a 'bingo' situation in bad weather (non-diagnostic procedural decisions), it was not particularly urgent situations, however, pilots may perceive potential risk in front of them for the nature of this problem is unclear. The results indicate that low fuel is not an emergency situation and needs comprehensive considerations, SHOR is not the best strategy. There is a need to consider more risks and benefits for other alternative landing airfields, SHOR is not capable of analyzing a complex situation. However, DESIDE is good for situation assessment (Estimate) and provides specific analysis for safe operations (Identify) as this scenario is not urgent allowing pilots to think thoroughly. Furthermore, DESIDE has a logical order - easy to remember for pilots in the aviation environments (see table 1).

In the creative problem-solving scenarios such as both left and right generators failure, these tasks are the most complex involved both diagnosis to determine the nature of the situation and response generation. Once the nature of the problem has been determined, it may be found that there are no recommendations in the manuals. Pilots must determine what their goals are, develop a plan and candidate strategies, and evaluate these strategies and planned actions based on projections of outcomes (Orasanu, 1993). According to the results, the SHOR has a positive effect in quick and simple for making response if the participants feel it was an urgent situation. However, if participants think that it was not an urgent situation DESIDE would be applied. The qualitative comments of Instructors revealed that DESIDE was regarded as promoting an effective response in a non-time-limited situation (the backup battery has about nine minutes power for both generators failures). It was also regarded as progressing in a logical order and was easy to remember for the re-evaluate (Evaluate) new situation promote the situation awareness by counting 9 minutes for knowing battery's available time and calculating the distance to home base (see table 1).

Table 1: Summary of Applying SHOR and DESIDE Mnemonics Step-by-step in Three Different Decision-making Scenarios Generated by Focus Groups

Mnemonics	SHOR	DESIDE
Scenario of Recognition-primed decisions: F-5E right engine fails as a result of Foreign Object Damage (FOD) just as the nose gear leaves the ground at a speed 165 knots.	**Stimuli** (1) The attitude for taking off had been set up. (2) Right engine had blast sound and then power off. (3) Left engine was normal. (4)Speed for taking off was changed. **Hypotheses** (1) Assumed that right engine's power off was resulted from FOD or IOD. **Options** (1)Abort take-off immediately. (2)To continue taking off with single engine. (3)Eject or not? **Response** (1)Continue taking off with single engine (2)The remaining runway and present speed are enough to abort take-off, but the risk to stop aircraft safely is high.	**Detect** (1) When the attitude for taking-off had been set up and nose gear left runway, right engine had blast sound and power was out **Estimate** (1) The right engine should be damaged by FOD or IOD **Set Safety Objectives** (1) Abort take-off and stop the aircraft immediately. (2)To make use of the remaining runway to take off safely. **Identify** (1) The attitude for taking-off had been set up and the speed was enough for taking off. (2)Left engine could provide enough power to take off. (3)The remaining runway and the speed were enough for aborting take-off safely. **Do** (1) Take action for taking off with a single engine. **Evaluate** (1) The left engine's reliability. (2) The difficulty for single engine operation. (3) The extra burden for emergency procedure.
Scenario of Non-diagnostic procedural decisions: Both the leader and wingman in a formation of F-5Es are unable to land at home-base in a 'bingo' (low fuel) situation during instrument flight in bad weather.	**Stimuli** (1)Home base weather was worse. (2)One mile on final with 600 ft altitude from runway the formation was out of cloud but the angle between the flight line and the runway was too great to land. (3)No.2 could not land and requested go-around. (4)No.2 had remaining gasoline of 1300 lb. **Hypotheses** (1) It was predicted that home base weather was improper for landing. (2) No.2 was inexperienced in operation. (3) Ground controller was inexperienced. **Options** (1)To land the other base. (2)To re-join GCA pattern. **Response** (1) It was the safest option to land YU base.	**Detect** (1)Home base weather had to rely on GCA for landing. (2)No.2 couldn't land and had low fuel **Estimate** (1)Both pilot's ability of instrument flight and controller's experience were uncertainty. (2)The determination had to be made immediately to avoid unnecessary fuel consumption. **Set Safety Objectives** (1)To land YU safely. **Identify** (1)The safest determination was to land YU base. **Do** (1)Call ground controller guiding No.2 to land at YU. (2)Ask ZN Approach to guide No.2 landing at YU with the first priority. (3) Instruct No.2 adjust TACAN frequency to YU and climb to the top of clouds. **Evaluate** (1)To avoid spatial disorientation. (2)To avoid consuming fuel for unnecessary operation. (3)To follow ground controller's direction.
Scenario of Creative problem-solving: When flying an F-5F both left and right generators fail at the same time during a tactical manoeuvre.	**Stimuli** (1)The master caution light was blinking. (2)Left and right generators' alert lights were lit. (3)It didn't work to reset the switch. **Hypotheses** (1)The situation was the battery for 9 minutes, some equipment couldn't be operated. **Options** (1)Stop training immediately. (2)Ask GCA to locate aircraft's position and request guiding to home base with first priority. (3)To economize power with the greatest possibility. **Response** (1)Stop training immediately and announce the emergency situation to ground control. (2)Shut off unnecessary electrical equipment for saving battery power. (3)Join long final straight-in without flaps. (4)Operate landing gear alternate extension when necessary.	**Detect** (1)The master caution light was blinking. (2)Both left and right generator caution lights were lit. (3)It didn't work to reset the switches. **Estimate** (1)Lots of equipment would be failed. (2)The battery could only provide power for 9 minutes. (3)To rely on ATC's guidance for the navigation data was unreliable after generators failed. **Set Safety Objectives** (1)To master aircraft's situation for safe landing. **Identify** (1) To request ground control to locate aircraft position and guide to home base with first priority. (2) It would increase safety if the other wingman nearby could assemble together to return base. (3) To identify the possibility to fly under clouds. **Do** (1)To stop training immediately. (2)To request ground control to locate aircraft position and guide to home base with first priority. **Evaluate** (1)If there were other wingman for formation, it would be the main reference. (2)To count 9 minutes for knowing battery's available time and calculating the distance to base.

CONCLUSION

The narrative data that the participants provided describing how experts would deal with the problems presented in each scenario suggested that the SHOR mnemonic was generally applied in the urgent situations such as recognition-primed decision-making scenario; DESIDE was most commonly used in non-urgent situations such as the non-diagnostic procedural decision-making scenario and creative problem-solving. A similarity of these two mnemonic-based methods is that they all start from situation assessment for gaining situation awareness, including fast changing abnormal situations in a dynamic environment. Both of SHOR and DESIDE follow a logical structure to form the safest strategy. They share some common characteristics but have certain differences (1) SHOR have only four steps for quick decision-making; DESIDE have six steps for more comprehensive considering a changing situation resulting from the pilots original actions. (2) SHOR was originally developed for use in the Air Force Tactical Command and Control situations; DESIDE been developed for using in Civil Airlines, as parts of CRM training. (3) SHOR was an extension of the stimulus-response (S-R) paradigm of classical behaviourist psychology (Wohl, 1981), however, the DESIDE model is also based on conflict-theory model (Janis & Mann, 1977). The results obtained in this study support the conclusions of the earlier opinion survey. These two mnemonics do promote better ADM and there is now empirical evidence to demonstrate how to step-by-step applying SHOR and DESIDE mnemonics for improving pilots in-flight decision-making.

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