cally, the term now tends to be applied to works created for popular consumption that incorporate techniques but not ideological content from avant-garde movements that existed earlier in the century. Meanwhile, the avant-garde artist's mission as iconoclast and social rebel has been assumed by a broad range of 'micropolitical' movements outside the arts.

See also: Art and Culture, Economics of; Art: Anthropological Aspects; Art, Sociology of; Censorship and Transgressive Art; Cultural Policy: Outsider Art; Popular Culture

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D. Crane

Aviation Safety, Psychology of

Aviation psychology arose as a unique discipline within the field of psychology as the result of technological developments during World War II. Prior to this point in history, most aviation accidents occurred as a result of some structural failure of the aircraft or the failure of the engine to continue to produce power (Koonce 1999). Because of the military demands of World War II, however, the sophistication and reliability of aircraft were improved considerably. Nonetheless, these technological improvements, like many more recent advancements in aircraft capabilities, increasingly challenged the abilities of pilots. Consequently, aircrew error began to play a progressively larger role in aviation accidents, as aircraft became more sophisticated and reliable (Shappell and Wiegmann 1996). Consequently, the need to address the psychological or 'human' side of aviation safety sparked the emergence of aviation psychology.

At the beginning of the twenty-first century, aviation psychology continues to be a primary discipline responsible for addressing and preventing human error in aviation. Specifically, aviation psychologists attempt to understand the fundamental nature and underlying causes of aircrew error and unsafe acts that significantly impact flight safety. However, just as many professionals in other areas of psychology have different opinions or theories about human behavior, aviation psychologists also have varied perspectives on pilots' performance in the cockpit (Hollnagel 1998). There are primarily four perspectives: (a) cognitive, (b) ergonomics, (c) psychosocial, and (d) organizational. In turn, these different perspectives have historically led to different approaches for addressing pilot error in the cockpit. The purpose of this article therefore, is to provide an overview of these error perspectives and their associated approaches to improving aviation safety. A brief discussion of more recent applications of aviation psychology to safety issues outside the cockpit will then be provided.

1. *Cognitive Perspective*

The principal feature of the cognitive perspective is the assumption that the pilot's mind can be conceptualized as an information-processing system, much like a modern computer. As such, the cognitive perspective assumes that once information from the environment makes contact with one of the senses (e.g., eyes, ears, nose, etc.), it progresses through a series of stages or mental operations to produce a response or action (Wickens and Flach 1988). These intervening mental operators include such things as information recognition, problem diagnosis, goal setting, and strategy selection (O'Hare et al. 1994). Other factors such as attention, memory capacity, and prior knowledge or experience with similar environmental conditions also affect pilots' interpretation of information and their reactions to it. Consequently, pilot errors are believed to occur when one or more of these mental operations fail to process information appropriately (Wiegmann and Shappell 1997).

According to the cognitive perspective, reducing aircrew errors and improving aviation safety necessarily requires an enhancement of pilots' information-processing abilities. However, unlike computers that can be improved by upgrading the hardware, the information-processing hardware of the human (i.e., the brain) is generally fixed inside the head! Therefore, in order to improve performance, cognitive psychologists have attempted to improve the manner in which pilots process information. One way this is accomplished is through improved training methods. Better training methods are often developed by examining the techniques used by expert pilots to solve problems and allocate their attention to the different sources of information in the cockpit. This information is then used to train novice pilots to improve their techniques and flight performance. Another way of improving information processing is through the standardization of procedures and the use of checklists. These methods facilitate information processing and performance by reducing mental workload and task demands on pilots' memories during normal operations and emergencies, thereby reducing the potential for errors and accidents.

2. *Ergonomics and Systems Perspective*

According to the ergonomics and systems perspective, pilot performance (both good and bad) is the result of a complex interaction among several factors (Edwards 1988). After all, flying an airplane is a very complicated and dynamic task. Indeed, military and commercial pilots interact with high-tech airplanes and cockpit equipment and must safely operate their aircraft in all types of weather conditions. According to the systems perspective, therefore, a pilot should not be viewed as a sole source of an error or cause of an accident. Rather, pilot error is believed to occur when there is a mismatch or breakdown in the interface between the aircrew and the technology. Consequently, aircrew errors are often referred to as 'design-induced' because they are viewed as resulting from a failure to design the interface in a way that optimizes the pilot–airplane interaction.

The approach to reducing errors and improving safety taken by most ergonomists and systems theorists is to improve the design of the interface between the pilot and the airplane. Such interface issues include the design of equipment used to manually control the airplane, such as the yoke and rudders. However, they more often include the design of better flight instruments that display the status of the aircraft, such as the altimeter and airspeed indicator. As technology has increased and airplanes have become more computerized, the tasks performed by the pilot and airplane have also been redesigned through the use of automation. A ready example is the development of the autopilot and other flight management systems (FMS) that can navigate and fly the airplane without pilot input. By sharing the responsibility with automation, the opportunity for pilots to commit errors is presumably reduced. However, even when errors do occur, they can often be 'caught' by the airplane's computer. Therefore, the system as a whole has become more 'error tolerant' and the negative consequences of pilot errors (i.e., accidents) are reduced.

3. *Psychosocial Perspective*

According to the psychosocial perspective, flight operations are best viewed as a social endeavor that requires aircrew to interact with one another, as well as with a variety of other flight support personnel, such as air traffic controllers, dispatchers, ground crew, maintenance personnel, and flight attendants. Aircrew performance, therefore, is directly influenced by the nature or quality of these interactions (Helmreich and Foushee 1993). These social interactions, however, are often influenced by both the personalities and attitudes of the individuals within each group. The major theme of the psychosocial perspective, therefore, is that errors and accidents occur when personality difference and conflicting attitudes disrupt group dynamics and interpersonal communications.

The psychosocial approach to reducing errors in the cockpit has focused on improving the social interactions among aircrew. One method used to achieve this goal is through systematic crew-pairing procedures. These procedures attempt to match aircrew based on their level of experience, flight skills, and personalities. Another method that has been developed is crew resource management (CRM) training. This training attempts to challenge and change pilots' traditional attitudes about differences in authority between the captain and the other aircrew (e.g. the copilot or first officer) that have been shown to hinder communication and cause accidents (Wiegmann and Shappell 1999). Other aspects of CRM training involve educating and training aircrew to use techniques for more effectively communicating problems, dividing task responsibilities during high workload situations, and resolving conflicts in the cockpit. Such improvements in aircrew coordination and communication ultimately result in fewer errors and improved aviation safety.

4. *Organizational Perspective*

According to the organizational perspective, pilot performance must be viewed in terms of the organizational context in which it takes place (Heinrich et al. 1980). Indeed, all professional pilots in both the military and commercial aviation industries operate within an agency or company that regulates their time and performance in the cockpit. Aviation organizations are therefore responsible for ensuring that only those pilots with the 'right stuff' are hired to fly their aircraft. In addition, these organizations are also responsible for instituting appropriate procedures that ensure safe operations of the aircraft (Shappell and Wiegmann 2000). From the organizational perspective, therefore, aircrew errors and subsequent accidents are believed to occur when managers and supervisors fail to set up basic conditions within the organization that promote flight safety (Reason 1990).

Given it is the organization's responsibility to ensure that only skilled and safe pilots get into the cockpit, a primary method used by organizational psychologists to prevent aircrew errors is the use of pilot selection tests. For those organizations that train their own pilots, as do many militaries around the world, these selection tests attempt to 'weed out' those applicants who exhibit less than adequate mental aptitudes or psychomotor skills necessary for learning how to fly. Other commercial organizations that hire trained pilots often use background and flight experience as employment criteria, while others also use medical screenings and interviews to select their pilots. In addition to selection techniques, however, another organizational approach to reducing errors in the cockpit is through the establishment of policies or rules that regulate what pilots can and cannot do in the cockpit. Such rules may restrict the type of weather in which pilots may operate their aircraft, or may limit the number of hours pilots can spend in the cockpit, in order to avoid the possible detrimental effects of fatigue on performance. By placing only safe and proficient pilots in the cockpit and limiting aircraft operations to only safe flying conditions, organizations are able to reduce the likelihood that pilots will make mistakes and cause accidents.

5. *Future Directions: Aviation Safety Outside the Cockpit*

Historically, the majority of safety efforts by aviation psychologists have focused on the performance of aircrew. However, there is a growing concern within the aviation community over safety issues that arise outside the cockpit, and an increasing number of aviation psychologists are being called upon to address some of these issues. Two such areas of growing concern are air traffic control and aircraft maintenance.

During the early years of aviation, aircrew avoided becoming lost by using simple cockpit instruments and visual landmarks on the ground. However, both military and commercial demands gradually required pilots to fly in poor visibility conditions and at night. The job of air traffic control was subsequently established to help maintain safe separation between aircraft and to ensure that pilots would not fly their planes into the ground or other obstacles (Hopkin 1995). Still, as the number of aircraft and demands on air traffic control services has increased over the decades, so has the number of accidents, incidents, and runway incursions (loss of safe separation among aircraft and other ground vehicles). As with most aviation accidents today, most of these occurrences have not been due to faulty control equipment, but rather to human error, including mistakes made by air traffic controllers.

Another important factor affecting aviation safety is aircraft maintenance. Indeed, despite all the technological advances and improvements in the reliability of aircraft equipment and systems, modern aircraft still need maintenance. This maintenance often requires that the aviation maintenance technician repeatedly disassemble, inspect, and replace millions of removable parts over the long working life of the aircraft (Reason 1997). During the early years of aviation, aircraft equipment and engines were 'simple,' compared to their modern-day counterparts. As such, these maintenance inspections were relatively easy and resulted in frequent detections and replacement of failed components that often caused accidents. Today, however, aircraft components and systems are very complex and hardly ever fail. Still, the intricate nature of inspecting and maintaining modern aircraft often lead to errors by the mechanics doing the work. As a result, the contribution of maintenance and inspection errors to aviation accidents and fatalities is on the rise.

Given these growing concerns for safety issues outside the cockpit, aviation psychologists have begun to examine the 'human' side of both air traffic control and aircraft maintenance. However, compared to the long history of efforts by aviation psychologists to address aircrew error in the cockpit, efforts to address human error in the air traffic control and maintenance arenas have only recently begun. Nevertheless, just like aircrew performance in the cockpit, the methods used by aviation psychologists to address errors made by controllers and maintenance personnel depend heavily upon the perspective they take concerning the underlying nature and causes of these errors. These perspectives are generally very similar to those taken by aviation psychologists when addressing aircrew error in the cockpit. Consequently, these perspectives will undoubtedly produce a variety of approaches for addressing human error in air traffic control and aircraft maintenance and will each make an important contribution to future improvements in aviation safety.

6. Conclusion

Aircrew error has played a progressively more important causal role in aviation accidents as aircraft have become more reliable. The field of aviation psychology, therefore, studies aircrew error and other pilot actions that can significantly jeopardize the safety of flight. More recently, aviation psychologists have also begun to address errors in air traffic control and aircraft maintenance, which are quickly becoming additional safety concerns within the aviation industry. Aviation psychologists, however, often have different viewpoints or perspectives when it comes to explaining the causes of human errors, both inside and outside the cockpit. These viewpoints are not necessarily incompatible. Rather, they focus on the different cognitive, engineering, social, and organizational factors that frequently contribute to a breakdown in human performance. As such, each perspective has uniquely contributed to the development of intervention techniques and methods for reducing errors and increasing aviation safety. More information regarding these approaches outside the aviation domain can be found in this volume, including discussions of the ergonomics and systems approach (e.g., *Engineering Psychology*), group dynamics and team work (e.g., *Group Processes in Organizations*; *Teamwork and Team Training*), and personnel selection (e.g., *Personnel Selection, Psychology of*).

Finally, there are other fields outside of aviation psychology that have also contributed specifically to improvements in aircrew performance but are not discussed here. One of the most significant contributors is the field of aviation medicine that has revealed several aeromedical factors that impact aircrew performance during flight (Reinhart 1996). For example, the field of aviation medicine has led to a better understanding of the physiological and behavioral factors that lead to stress and fatigue in the cockpit. This knowledge has led to more 'biocompatible' flight schedules for aircrew, particularly when traveling overseas or across several time zones. More information about the general effects of stress on human performance can be found in *Stress in Organizations, Psychology of*.

In conclusion, the field of psychology has a long history of involvement in the process of improving aviation safety. These efforts, combined with the efforts for those in other behavioral, social, and biological sciences, have contributed significantly to the reduction of human error and aviation accidents, making aviation one of the safest modes of transportation.

See also: Ergonomics, Cognitive Psychology of

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Avoidance Learning and Escape Learning

Avoidance learning in animals is studied using an instrumental (operant) training paradigm that was created and first reported by L. H. Warner (1932a) in a study of the 'association span of the white rat.' In this procedure, a warning signal (WS) predicts the subsequent occurrence of an aversive event, typically a mild electric shock delivered to the feet of the animal. A response defined by the experimenter, e.g., pressing a lever in a 'Skinner box' or running and/or jumping over a hurdle to the opposite side of a two-compartment chamber (a 'shuttle box'), terminates the WS and prevents the occurrence of the shock. This is an avoidance response. Failure to avoid in the presence of the WS results in the predicted shock, which, in most procedures, can be terminated by the 'same' response, which is then classified as an escape response. Warner's procedure had its roots in one used by Yarbrough (1921), in which a mild shock was used as a cue for turning right or left for food reward in a maze; he found that the rats would respond similarly to a light signal that preceded the shock cue. Warner used what is now known as a 'trace-conditioning' procedure in which the warning signal was presented for 1 s, and the shock occurred 1, 10, 20, or 30 s after the onset of the WS in separate groups of animals (the trace intervals were 0, 9, 19, and 29 s, respectively). Difficulty of learning increased as a function of the WS-shock interval, which is, of course, confounded with the duration of the trace interval. Essentially no learning occurred in the 30-s group.

1. *Procedural Variations*

There are two forms of avoidance training: active and passive. In the active form, pioneered by Warner's early work noted above, the avoidance contingency requires the occurrence of a specific response, whereas in the passive form the avoidance contingency requires the nonoccurrence, i.e., the suppression, of some specific response. This is often called punishment. The punished response may occur because it is 'spontaneous,' i.e., innate, or because of prior reward or avoidance training. One form of the passive procedure that depends on innate behavior is the so-called one-trial passive avoidance procedure. A rat or mouse, both of which are nocturnal species, will readily leave a brightly lit, elevated platform to enter a dark compartment. If this photophobic response is then punished with a brief shock in the dark compartment, latency to re-enter the dark compartment is increased on subsequent tests, which is taken as a measure of the strength of the memory of the previous experience. This procedure has been used extensively to study the neuropsychological and neuropharmacological bases of memory, because the learning is exceptionally fast (one trial often suffices) and the learning event that establishes the memory is relatively fixed in time. The procedure has been especially useful in the study of retrograde amnesic events, such as electro-convulsive shock, stress, and hypothermia (see Duncan 1949, for an early example of this approach). If the punished response is learned and based on reward, the passive avoidance contingency usually results in suppression of the response, whereas if it is based on prior avoidance or escape training, the response is often facilitated or enhanced, at least temporarily, which can be viewed as a somewhat paradoxical effect of punishment. Note that in the active form, what the animal does to avoid the aversive event is well-defined and measured, whereas in the passive form, the avoidance response is not defined and rarely measured; only the punished response is defined and measured.

There are two kinds of avoidance training procedures: discrete-trial and free-operant. The experiment by Warner is an active form of the discrete-trial kind, but the passive form may also be of this kind. In such a case, a response in the presence of a discriminative stimulus or cue is punished. For example, an animal such as a rat may be trained to press a lever for food reward, and each response may be rewarded. However, in the presence of a specific cue, the responses may also be punished, either at every response or only some responses (partial punishment). In the active form of the free-operant kind of procedure, which originated with Sidman's (1953) initial publication of this method, there is typically no WS to predict the impending shock, only the passage of time since the last response or shock. Operationally, two timers control events: a response-shock (R-S) timer set, for example, at 30 s and a shock-shock (S-S) timer set, for example, at 5 s. Training begins with the S-S timer in control, and brief, e.g., 0.5 s, shocks occur every 5 s. A response interrupts the S-S timer and starts the R-S timer. If the R-S interval elapses, a shock is presented and the S-S timer takes over until another

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