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# THE ROLE OF PSYCHOLOGY IN AVIATION SAFETY

***Abstract**: In this article, the issue of safety from the perspective of aviation psychology has been examined. We have seen that although flying in large commercial air carriers is quite safe, the situation is not so comforting in general aviation, where the risks of involvement in a fatal aviation accident are somewhat higher than being involved in a fatal motor vehicle accident. Curiously, anecdotal evidence (from the responses of many general aviation pilots when this topic is raised at flight safety seminars) suggests that general aviation pilots are largely unaware of this differential risk and generally believe that they are safer when flying than when driving their cars. Hence, programs to improve safety often receive little more than lip service, since the pilots involved do not really feel that they are at risk.*

***Key words**: aviation safety, aviation psychology, fatal, accident, at risk, commercial air carrier, anecdotal evidence, aviation pilot, human factor, aircraft, psychological stability.*
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**Introduction**

To begin, let us examine the incidence of aviation accidents, so that we may understand the extent of the problem. Table 1 shows the numbers of accidents and corresponding accident rates (number of accidents per 100,000 flight hours) for two recent years in the United States. From this table, the differences in accident rates between the large air carriers (very low rates), the smaller carriers, and general aviation are evident. Over that span of operation, the accident rate increases about 30-fold. To put these statistics in a slightly different light, on a per mile basis, flying in an air carrier is about 50 times safer than driving. However, flying in general aviation is about seven times riskier than driving. These accident rates are typical of the rates found among Western Europe, New Zealand, and Australia. For example, data from the Australian Transport Safety Bureau [1] show fixed-wing, single-engine general aviation accident rates (accidents/100,000 hours) of 10.26 and 7.42, for 2004 and 2005, respectively. Note that these rates are somewhat inflated, relative to the United States, since they do not include multiengine operations normally used in corporate aviation, traditionally one of the safest aviation settings.

[1] ATSB. 2007. Australian Transport Safety Bureau—Data and Statistics. Retrieved on June 7, 2007 from: http://www.atsb.gov.au/aviation/statistics.aspx

**Table 1.**

**Incidence of Accidents in the United States**

| | 2009 | | 2010 | |
|---|---|---|---|---|
| | **Number** | **Rate**[a] | **Number** | **Rate**[a] |
| Large air carriers | 30 | 0.17 | 30 | 0.16 |
| Commuter | 2 | 0.69 | 6 | 1.90 |
| Air taxi | 47 | 1.60 | 32 | 1.05 |
| General aviation | 1480 | 7.20 | 1436 | 6.87 |

*Source:* Federal Aviation Administration (FAA). 2012. *Administrator's Handbook*. Washington, DC: Author.

[a] Rate is given as accidents per 100,000 flight hours.

This brings up an important point that must be made regarding safety statistics. It is very important to note the basis on which the statistics are calculated. For example, in Table 1, the rates are given in terms of numbers of accidents per 100,000 flight hours. This is a commonly used denominator, but by no means the only one that is reported. Our comparison of accident risk in driving and aviation cited above used accidents per mile traveled. Some statistics are in terms of numbers of departures (typically, accidents per one million departures). It is important for the reader to make note of these denominators so that comparisons are always made between statistics using the same denominator. In addition, as in our comparison between the statistics from the United States and Australia, it is important to know exactly what has been included in the calculations. In this case, exclusion of the very safe, multiengine corporate operations could lead to the conclusion that general aviation is safer in the United States than in Australia – a conclusion that is not warranted by the data provided. Accident statistics can also be misleading, or at least confusing, when they fail to account for differences in the population from which samples (the people involved in accidents) are drawn. For example, in a recent edition of the Nall Report produced by the Aircraft Owners and Pilots Association[2], it is reported that holders of a private pilot certificate were involved in 43% of noncommercial fixed-wing general aviation accidents during 2012, while commercial pilots were involved in 29% of the accidents. One might conclude from those data that commercial pilots were considerably safer than private pilots. However, an examination of the data from the FAA[3] shows that private pilots constitute 43% of the pilot population, and commercial pilots make up 26%—approximately the same proportions as were reported to be involved in accidents. If there were no difference in accident propensity between private and commercial pilots, then we would expect to see exactly the results reported in the Nall Report. So, encouraging private pilots to obtain a commercial certificate would not, in all likelihood, prove to be an effective way to improve general aviation safety.

Before we begin to talk about the causes of accidents, we need to make clear what we mean by a cause. Step away from the flight line for a moment and into the chemistry laboratory. If we were to put a few drops of a solution containing silver nitrate (AgCl) into another solution that contains sodium chloride (NaCl), common table salt, we would observe the formation of some white particles (silver chloride, AgCl) that would sink to the bottom of our test tube. This simple test for the presence of chlorine in water by the addition of aqueous silver nitrate is, in fact, one of the most famous reactions in chemistry and is among the first learned by all budding chemists. The point to be made here is that this reaction, and the formation of the precipitate, will happen every single time that we mix solutions of silver nitrate and sodium chloride. Nor will the precipitate form, unless we add the silver nitrate. The addition of the silver nitrate to the sodium chloride solution is a necessary and sufficient condition for the formation of the precipitate. We may truly say that one causes the other. Now step back outside the laboratory and consider what happens in the real world. For example, let us imagine that you are driving to work one morning and the traffic is very heavy, so that you are following closely behind the vehicle ahead of you.

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[2] AOPA (Aircraft Owners and Pilots Association). 2015. The Nall Report. Frederick, MD: Author.

[3] Federal Aviation Administration (FAA). 2012. Administrator's fact book. Retrieved from March 1, 2016 from: http://www.faa.gov/about/office_org/headquarters_offices/aba/admin_factbook/

Occasionally, the vehicle you are following will brake sharply, so that you have to react quickly and apply your brakes to keep from hitting it. This happens dozens, perhaps hundreds, of times during your trip and you are always successful in avoiding an accident. During the same trip, you listen to music on the radio and occasionally change the station by glancing at the radio and pressing the buttons to make your selection. You may do this several times during the course of the trip, also without incident. There may even be occasions when, as you are changing stations on the radio, the vehicle ahead of you brakes, and you glance up just in time to notice their brakes and slow down. Fortunately, you are a careful driver and usually maintain an adequate spacing between you and the vehicle you are following, so that you are always able to react in time, even if you were temporarily distracted by the radio. You may do this every day for years, without incident. However, on one particular morning you are delayed leaving the house, so that you did not get your usual cup of coffee, and are feeling a little sleepy. You are also feeling a bit rushed, since you need to be at the office at your usual time, and you have gotten a late start. Perhaps, this has led you to follow the vehicle ahead of you a little more closely than usual, and now, as you are reaching over to change the radio, the driver ahead of you brakes more sharply than usual, you do not notice the vehicle's brake lights quite soon enough, or react quickly enough, to slow your vehicle. An accident occurs. But, what was the cause of the accident? From the official standpoint (the one that will go on the police report), you were the cause, and this is yet another example of human error. However, that is not a very satisfying explanation. It is not satisfying because it describes as an error, actions you have taken on almost every trip for many years. Surely, there have been many days on which you left the house late and hurried to make up time. Surely, there have been days when you felt a little sleepy when driving to work. Likewise, you have handled heavy traffic and changing radio stations innumerable times previously. All of these actions and conditions have existed previously and we have not called them errors and the causes of an accident, because until this particular day no accident had occurred. None of these conditions and events is necessary and sufficient for an accident to occur. However, each of them, in their own small way, increased the likelihood of an accident.

Therefore, we suggest that the best way to understand the causes of accidents is to view them as events and conditions that increase the likelihood of an adverse event (an accident) occurring. None of the usual list of causes –following too close, inattention, sleepy driver, distraction – will cause an accident to occur each and every time they are present. However, they will each independently increase the likelihood of an accident. Moreover, their joint presence may increase the likelihood far more than the simple sum of their independent effects. For example, following too closely in traffic and driving while drowsy both increase the risk of an accident, let us say by 10% each. However, following too closely in traffic while drowsy might increase the risk of an accident by 40%, not the 20% obtained by simply summing their independent contributions. So, the combination of these two conditions is far more dangerous than either by itself. Causes are best understood not as being determinants of accidents, but as being facilitators of accidents. They increase the probability that an accident occurs, but they do not demand that it occurs. This argument implies that accidents generally have multiple facilitating components (causes). Most authors, at least in recent years, acknowledge in the introduction to their research that there is no single cause for accidents, and then proceed to ignore that statement in the conduct and interpretation of their research. Arguably, the present authors could be included in that indictment. However, to atone for those past literary indiscretions, let us now reiterate that point. There are no single causes for accidents. Usually, the "cause" is simply the last thing that happened before the crash. Only a few years ago, an Airbus landed in the Hudson River after both engines failed at 3200 feet while taking-off from LaGuardia Airport. The newspapers report that the cause of the crash was the ingestion of a flock of geese. However, they also report that the captain of the flight was an experienced glider pilot, with an exceptional interest in safety. Clearly, multiple causes are at work here – the flock of geese may have caused the engines to quit, but the experience and skill of the captain may have been the cause of the relatively benign water landing resulting in no fatalities. In exploring causes and effect relationships, we may move away from the final cause to whatever extent results in a comprehensive understanding of the event. For example, we might ask what caused the geese to be in the flight path of the aircraft. Did placing a major airport along a river in the flyway for migratory waterfowl play some part? We might also ask what part the pilot's gliding experiences played in the outcome. Did they "cause" a catastrophic event to become an exciting, but injury-free event? When we take a more situated view, we recognize that there are no "isolated" events. Everything happens in a context. The need to view accidents in context is best articulated by Dekker[4], who noted that "Human actions and assessments can be described meaningfully only in reference to the

[4] Dekker, S.W.A. 2001. The disembodiment of data in the analysis of human factors accidents. Human Factors and Aerospace Safety 1: 39–57.

world in which they are made." In a subsequent paper[5], he argued cogently for the abandonment of the construction of causes as the explanations for accidents, but rather for the deepening of our insights into the patterns of failure and the mechanisms by which failure occurs. To borrow yet another quote from Dekker, "The point in learning about human error is not to find out where people went wrong. It is to find out why their assessments and actions made sense to them at the time, given how their situation looked from the inside"[6]. This general world view of accident causes is also evident in the work of Leveson and Dismukes et al. Leveson[7] criticizes the event chain analysis model of accidents and argues for a more systems approach. He cites Rasmussen[8], who argued that "an explanation of the accident in terms of events, acts, and errors is not very useful for design of improved systems." Dismukes et al.[9] also advocate a view of accidents in terms of multicausality and the need to understand the deep structure underlying accidents. Dismukes et al. note two fallacies about human error that pervade accident analysis:

- Myth: Experts who make errors performing a familiar task reveal lack of skill, vigilance, or conscientiousness.
- Fact: Skill, vigilance, and conscientiousness are essential but not sufficient to prevent error.
- Myth: If experts can normally perform a task without difficulty, they should always be able to perform that task correctly.
- Fact: Experts periodically make errors as a consequence of subtle variations in task demands, information available, and cognitive processing[10].

Each accident occurs because of a complex web of interacting circumstances, including environmental conditions, pilot attributes, aircraft capabilities, and support system (e.g., air traffic control, weather briefer) weaknesses. A complete explanation of how those elements interact to produce an accident is far beyond our current science. Science does not, at this time, allow us to predict with anything approaching certainty that under a well-specified set of circumstances an accident will occur; this is definitely not the chemistry laboratory.

To begin with, we do not know the set of circumstances that should be specified. Nor do we know the values to assign to the various elements so that they combine properly. Despite this abundant ignorance, we are able to make some statements regarding probabilities. That is, we are able to say with some confidence that accidents are more likely to occur under some circumstances than under other circumstances. The identification of these circumstances, and the establishment of the degree of confidence with which we may assert our beliefs, is the topic to be considered next.

Many efforts have been conducted to identify the causes for aircraft accidents over the years. Although they suffer from the implicit assumption of single causes, which we have dismissed as naive, they nevertheless can make a contribution to our understanding of accident causality by identifying some of the circumstances and attributes associated with accidents. In recognition of the importance of decision-making to accident involvement, the FAA, in cooperation with a coalition of aviation industry organizations, formed a Joint Safety Analysis Team (JSAT) to examine general aviation aeronautical decision- making (ADM), and to develop a program to improve ADM so as to reduce the number of accidents attributable to poor decision-making. The JSAT, in turn, chartered an international panel of human factors experts to address the technical issues of how poor decision-making contributed to accidents, and what might be done to improve aviation safety. That panel's recommendations, listing over 100 specific items, were adopted without change by the JSAT and provided to the FAA as part of its final report[11]. Reflecting a pragmatic approach to applying the current knowledge of accident causality among general aviation pilots, the panel's recommendations covered a wide range of possible interventions. Some examples include:

- Create and disseminate to pilots a weather hazard index which incorporates the weather risks into a single graphic or number.
- Reorganize weather briefings so as to present information related to potentially hazardous conditions as the first and last items given to the pilot.
- Increase the use of scenario-based questions in the written examination.
- Include training for Certified Flight Instructors (CFIs) on risk assessment and management in instructional operations.

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[5] Dekker, S.W.A. 2002. The Re-invention of Human Error. Technical Report 2002-01. Ljungbyhed, Sweden: Lund University School of Aviation.
[6] Dekker, S.W.A. 2002. The Re-invention of Human Error. Technical Report 2002-01. Ljungbyhed, Sweden: Lund University School of Aviation.–P. 7.
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[11] Joint Safety Analysis Team. 2002. General Aviation Aeronautical Decision-making. Unpublished Report. Washington, DC: General Aviation Coalition.

- Produce a Personal Minimums Checklist training program expressly for use by CFIs in setting their instructional practices.
- Establish a separate weather briefing and counseling line for low-time pilots.
- Require pilot heat to be applied automatically, whenever the aircraft is in flight.
- Develop displays that depict critical operational variables in lieu of raw, unprocessed data (e.g., have fuel indicators that show remaining range or endurance, as well as remaining gallons of fuel).
- Develop and disseminate training which explicitly addresses the issues involved in crash survivability; including crash technique, minimizing vertical loads, and planning for crashes (water, cell phone, matches, etc.) even on flights over hospitable terrain.
- Develop role-playing simulations in which pilots can observe modeled methods of resisting social pressures and can then practice those methods.

Regrettably, these interventions have not yet been implemented, even though they were accepted by both industry and government regulators. This is a reflection, perhaps, of the difficulty of making even well-regarded changes in an established bureaucracy and cost-conscious industry. Clearly, it is not enough for researchers to find better ways to keep pilots safe. They must also find ways to get their discoveries implemented – arguably, the more difficult of the two tasks. Nevertheless, some progress is being made in training pilots to be more safety conscious.

In 2006, the AOPA Air Safety Foundation (ASF) began sending a free DVD on decision-making to all newly rated private and instrument pilots. The scenarios contained on the DVD focus on VFR into instrument conditions and IFR decision-making – two areas that the ASF has found to be particularly troublesome [12].

The advanced technology formerly found only in air carriers and executive jets is now working its way into the general aviation fleet. This technology will make some tasks easier (e.g., navigation), but it will present its own set of unique problems, and will still require pilots to make reasoned judgments about when, where, how, and if they should undertake a flight. The influence of pilots' personality and their skill at acquiring and using information will still be great, even in the aircraft of tomorrow. Safety requires a proactive approach to assessing and managing all the elements that influence the outcome of a flight, including the most important element, the human at the controls.

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