A Dissonance Theory Explanation for Visual Flight Rules (VFR) into Instrument Meteorological Conditions (IMC) Accidents

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In the U.S. in 2008, accidents resulting from VFR flight into IMC accounted for 2% of all general aviation (GA) accidents, but 8% of all fatal GA accidents. Furthermore, 88% of VFR into IMC accidents were fatal, compared to 17% of other aviation accidents. Dissonance theory is a model of attitude change associated with making difficult choices. Attitude change reduces cognitive dissonance arising from favourable aspects of a not-chosen alternative and unfavourable aspects of a chosen alternative, through spreading of alternatives. Under dissonance theory, pilots in marginal weather who repeatedly revisit their choice to either continue their flight or divert to an alternate destination progressively distort their perception of weather conditions, making them more likely to commit decision-making errors leading to VFR into IMC accidents. Many aspects of general aviation are consistent with factors that increase spreading of alternatives. Dissonance theory resolves inconsistent results from simulator-based studies of weather decision-making.

Visual flight rule (VFR) flight into instrument meteorological conditions (IMC) is a significant causal factor in general aviation (GA) accidents involving fixed-wing aircraft under 12,500 pounds maximum takeoff weight (MTW) in the United States, accounting for 2% of all GA accidents, but 8% of all fatal GA accidents. These accidents are disproportionately lethal. In 2008, 22 of the 25 VFR into IMC accidents were fatal, for a fatality rate of 88% compared to the 17% fatality rate of all other GA accidents.

Canadian VFR into IMC accident statistics are similar. Between 1995 and 2004, the Transportation Safety Board of Canada identified 80 aviation occurrences as VFR into IMC accidents. Although VFR into IMC accidents comprised only 2.5% of the 3,256 accidents involving Canadian-registered aircraft in that period, they comprised 12% of all fatal accidents, and took 96 lives (14% of all aviation fatalities). Furthermore, 55% of VFR-into-IMC accidents were fatal, compared to 10% of all other accidents involving private pilots.

Despite a substantial number of communications, tools and countermeasures training offered by the FAA, the NTSB, the AOPA and others to GA pilots regarding VFR into IMC accidents, these accidents continue almost unabated. Figure 1 (U.S. accident data from AOPA ASF database of NTSB data through 2008, flight hours from AOPA 2008 and 2009 NALL Reports) shows only a small but statistically significant decrease in the US VFR into IMC accident rate for GA aircraft under 12,500 lbs MTW ($R^2 = .439, p = .037$), and no significant decrease in the fatal VFR into IMC accident rate ($R^2 = .218, p = .17$).

**Simulator Research on Cognitive Models of Weather Decision-Making**

Wiegmann, O’Hare, Goh and others have conducted a substantial body of pilot decision-making research using simulated cross-country flights (Goh and Wiegmann, 2001a, 2001b; O’Hare and Smittheram, 1995; O’Hare and Wiegmann 2003; Wiegmann, Goh, and O’Hare, 2001, 2002). They have suggested that a number of “failures at different stages of the decisional process” lead to VFR into IMC accidents. Several categories of human information processing factors and models that have been proposed and/or tested for VFR into IMC accidents are:
• **Situation assessment.** Inaccurate assessments of weather conditions. To counter this factor, Wiggins and O’Hare (2003) developed the “WeatherWise” computer-based training program for the FAA. The training program incorporates pictures and video clips to train pilots to identify critical weather cues during flight. The AOPA Air Safety Foundation and FAA sent the foundation’s WeatherWise CD to all instrument-rated pilots in the United States (AOPA, 2008).

• **Risk perception.** Accurate assessment but without correct appreciation of risks, also often identified as pilot over-confidence (Goh and Wiegmann, 2001c).

• **Motivational factors.** “Get-home-itus”, “sunk costs” or other personal or social errors, or corporate culture / operational / commercial pressures. A variant of the “sunk costs” model is the prospect theory (Kaneman and Tversky, 1979, 1984) explanation of decision framing offered by O’Hare and Smitheram (1995). Prospect theory offers a cognitive explanation for why decision-making is inherently riskier if framed in terms of losses than if framed in terms of gains. Indeed, O’Hare and Smitheram found that pilots in their decision scenario study made more conservative decisions if they framed their decision in terms of a gain from their current position than if they framed their decision as a loss (e.g., “sunk costs” such as fuel used, or time and money spent) from their starting position (leading to risky decision-making). They recommended that new pilots should be trained to frame their decisions to continue or divert on the basis of gains or benefits from their current position rather than on the basis of losses or resources spent from the start of the flight.

However, none of these models can account for the startling inconsistency between the simulator study findings of Wiegmann, Goh, and O’Hare (2001, 2002) and O’Hare and Wiegmann (2003).

Pilots tested by Wiegman et al. (2001, 2002) flew in simulated scenarios under 5,000 foot ceilings and with 5 mile visibility until weather deteriorated over a distance of 15 miles to IMC either early or late in the flight. *Weather deterioration early in the flight led to more plan continuations than late weather deterioration*, which is contrary to the prospect theory or “sunk costs” prediction. Wiegmann et al. (2001) concluded that “VFR flight into IMC may be due in part to poor situation assessment and experience rather than to motivational factors and risk-taking behavior that increase with time and effort invested in the flight (p. 10)”.

On the other hand, O’Hare and Wiegmann (2003) presented pilots with short and long scud-running simulator scenarios with more marginal weather, which also degraded more gradually. That is, pilots all flew (i.e., chose to continue) at or near their personal minima (1500 foot ceiling) for either 22 nm or 66 nm after weather deteriorated 20 nm into their flights. O’Hare and Wiegmann found that “*those who had covered the greater distance were much more likely to continue with the flight than those who had only come half as far* (p. 28, italics mine)”. Their result is consistent with prospect theory and the “sunk costs” prediction.

None of the theories listed above can reconcile the contradictory findings of these two studies. However, dissonance theory, a model from social psychology, offers a compelling explanation for the contradiction.

**A Different Model: Dissonance Theory**

Dissonance theory is generally considered to be the most powerful theory to come out of social psychology within the last fifty years (Jones, 1985). This very general and powerful theory provides a compelling model for VFR into IMC decision-making, and may inform development of effective countermeasures for those accidents. Brehm (1956) and Festinger (1957) first proposed that a person’s actions could generate psychological discomfort, or cognitive dissonance, which the decision-maker would then attempt to reduce. Cognitive dissonance of the type relevant to this model is generated by the free-choice experimental paradigm, and the results have been generalized to many real-world situations.

According to dissonance theory, making a free (and difficult) choice between alternatives generates dissonance, due to the negative aspects of the chosen alternative, and the positive aspects of the non-chosen alternative (i.e., dissonant cognitions). Because those dissonant cognitions nearly overbalance the consonant cognitions, the decision-maker will tend to change the balance (and reduce dissonance) either by reducing dissonant cognitions (i.e., negative attributes of the chosen alternative and positive attributes of non-chosen alternatives), or by adding to or accentuating consonant cognitions (i.e., positive attributes of the chosen alternative and negative attributes of non-chosen alternatives), or both. Dissonance is thereby reduced by increasing the difference between the chosen and the non-chosen alternative by spreading of alternatives or post-decision distortion. This spreading is accomplished in many ways, such as by reducing the estimated probability of negative outcomes for the chosen alternative and increasing it for the non-chosen alternative, or by forgetting non-chosen alternatives.
A favourite technique for reducing the postdecisional dissonance, according to the theory, is to change cognitions in such a manner as to increase the attractiveness of the chosen alternative relative to the unchosen alternative(s). (Knox and Inkster, 1968, p. 319)

Overconfidence is another dissonance reduction mechanism, although confidence of judgment is uncorrelated with decision accuracy (Blanton et al., 2001).

Brehm and Festinger’s initial formulations allowed only for post-decision dissonance to be generated and reduced, but more recent investigations (see Brownstein (2003) for a comprehensive review) have unequivocally demonstrated that if one alternative is favored or preferred, pre-decision distortion may also occur, and may be up to two times more influential than post-decision spreading of alternatives (Russo, Medvec and Meloy, 1996).

Although much discussion and argument has been generated in the field of social psychology regarding the mechanisms underlying attitude change findings, those attitude change findings themselves, and in particular, those involving “spreading of alternatives” between chosen and not chosen alternatives are powerful and ubiquitous.

**Dissonance Theory and VFR into IMC Accidents**

Dissonance theory predicts that a pilot’s successive difficult decisions to continue a flight into marginal weather conditions rather than diverting to another airport or returning to the airport of departure, may cause subsequent judgements of the chosen alternative (i.e., to continue the flight) to be more favourable or positive, and judgements of the other alternative (i.e., to divert to an alternate or make a precautionary landing) to be more negative. Therefore, decisions to continue a flight as weather worsens may well become less conservative than the initial decision to begin the flight, leading the pilot to believe that a decision to continue a flight into marginal (or less) weather conditions (i.e., nearly IMC) is reasonable and within his or her personal risk management limits. Furthermore, as the flight continuation decision is revisited repeatedly, both pre-decision distortion and post-decision distortion may affect decision-making simultaneously, and finally, many small distortions may well sum to deadly effect. Paradoxically, a pilot who revisits the continuation decision more often may generate more distortion and make riskier weather decisions.

**Flight Simulation Support for Dissonance Theory**

The earlier presented contrast between Wiegman, Goh, and O’Hare (2001, 2002) and O’Hare and Wiegmann (2003) offers the most compelling simulator study evidence for the influence of dissonance theory mechanisms on weather decision-making. Wiegmann et al. (2001, 2002) found that late weather deterioration led to fewer plan continuations than early weather deterioration, contrary to the predictions of the “sunk costs” theory or the “get-home-it-is” model, and concluded that VFR flight into IMC may be due in part to poor situation assessment and experience rather than to motivational factors and risk-taking behavior that increase with time and effort invested in the flight. (Wiegmann et al, 2001, p. 10)

In contrast, O’Hare and Wiegmann (2003) reported a significant difference between those who covered the longer and shorter distance before the critical weather change, with those who had covered the greater distance being much more likely to continue with the flight than those who had only come half as far (p. 28, italics mine).

The critical experimental difference between the two simulator studies, and the explanation of their opposite results, may be that pilots in the first study flew in the simulator with 5000’ ceilings and 5 mile visibility until weather deteriorated to IMC early or late in their flights, while in the second study, all pilots (by choice) continued their flights when the ceiling dropped to 1500’ (at or below their personal minimums in all cases) only 20 nm into the flight, and then dropped to IMC (800’) either 22 nm or 66 nm later. That is, the pilots in the second study incurred spreading of alternatives for either 22 nm (early IMC) or 66 nm (late IMC), causing substantially more distortion for late IMC pilots than for early IMC pilots and making them much more likely to commit plan continuation errors. However, all pilots in the first study flew in conditions far above their own personal minimums until weather deteriorated to below IMC over 15 miles, giving them the same brief opportunity to be influenced by dissonance theory mechanisms regardless of their assigned experimental condition, so that weaker factors prevailed.

Another VFR into IMC flight simulation finding also supports the dissonance theory model. Goh and Wiegmann (2001b) found that pilots who diverted made more accurate post-decision assessments of visual conditions than pilots who continued simulated flights into deteriorating weather, and suggested that this finding demonstrated “errors early in the decision-making process in the form of inaccurate assessments of visibility, …
compounded by other factors such as their greater willingness to take risks, greater confidence in their flight skills, and a reduced sense of vulnerability to weather hazards and pilot error (p. 5). However, the less accurate assessments made by the continuing pilots may instead have resulted from post-decision spreading of alternatives—that is, their initial assessments may have been equally accurate, but had become distorted by the time they were reported to the experimenter.

**Mapping Dissonance Theory onto Weather-Related Decision-Making**

The action-based model of cognitive dissonance (Harmon-Jones and Harmon-Jones, 2002) is an excellent fit for weather decision-making. “Spread of alternatives” is maximized by implementation of a decision (e.g., by taking off into marginally acceptable weather). Harmon-Jones et al. state that an essential function of the spreading of alternatives is to transform a decision into effective and unconflicted action, while noting that this may “be maladaptive and dysfunctional … when persons maintain and bolster a commitment to a decision that clearly harms themselves or others (p. 712)”. This concern particularly applies to pilots’ decisions regarding weather, in which the decision involves successive judgements about changeable conditions.

Numerous characteristics of dissonance theory map closely onto weather-related decision-making in aviation. Some aviation-related factors that may increase either the spreading of alternatives or pre-decision distortion or both, as shown in the literature, include:

- **Difficulty of decision** (Brehm, 1956; Harmon-Jones and Harmon-Jones, 2002) – weather close to pilot’s personal minimums makes decisions most difficult (maximizing the probability of VFR into IMC);
- **Immediacy of implementation** (Harmon-Jones and Harmon-Jones, 2002) – pilots take off almost immediately after assessing weather conditions;
- **Public commitment** (Festinger, 1957) – pilots must communicate their decisions to ATC and passenger(s);
- **Importance of decision** (Brownstein, Read, and Simon, 2004) – An incorrect weather-related decision can lead to fatalities or serious injuries, and aircraft loss or damage;
- **Action orientation increases spreading of alternatives** (Harmon-Jones and Harmon-Jones, 2002) – Pilots are very action oriented:
  - a decision to take off leads to very rigorous action sequence(s);
  - continuing to implement a flight plan involves very busy and ongoing action requirements to continue the plan;
- **Sequential presentation of information** – increases pre-decision distortion or confirmation bias through seeking information favorable to preference (pre-decision distortion) or to decision (post-decision - cognitive dissonance “spreading of alternatives”) (Jonas et al., 2001) – Pilot information scans and actions are sequentially organized (e.g., checklists, planning, instrument scans);
- **Favored alternative or “tentative preference” will tend to increase pre-decision distortion** (Brownstein, Read, and Simon, 2004; Russo, Meloy, and Medvec, 1998) – Clearly, a pilot’s favored alternative will be to begin, continue, and complete a planned flight;
- **Good mood increases predecisional bias in a free choice task** (Meloy, 2000) – Most pilots love to fly, and anticipation enhances their mood.

**Proposed Tests of Dissonance Theory Hypothesis**

The cross-country decision-making simulation scenarios developed by O’Hare and Wiegmann (2003) could be adapted to present the critical experimental conditions of both Wiegman, Goh, and O’Hare (2001, 2002) and O’Hare and Wiegmann (2003), by crossing high ceiling versus scud-running with early versus late weather deterioration to test the dissonance hypothesis that only in the scud-running conditions will pilots have a greater tendency to continue the flight into late marginal (and worse) weather than into early marginal (and worse) weather.

Several other variables could also be manipulated to test other predictions of the dissonance theory hypothesis, and to test the effectiveness of potential countermeasures:

- **Severity of weather at initial decision to depart** (less marginal weather yields less dissonance, hence reduced subsequent spreading of alternatives and reduced likelihood of continuing into weather below minimums.)
Gradual versus sudden onset of weather deterioration (fewer decisions regarding marginal conditions means less spreading of alternatives and reduced likelihood of continuing into weather below minimums.)

Fewer versus more decisions (termination decisions offered) controlling for flight length (more decisions yield more opportunities to generate dissonance, thereby increasing subsequent spreading of alternatives and the likelihood of continuing into weather below minimums.)

Pilot versus passenger perceptions (as passengers don’t make the decisions to depart or to continue the flight, they should feel little or no dissonance, so should be more able to accurately judge weather conditions.)

High Risk Situations and Potential Countermeasures

Given that dissonance reduction mechanisms increase the likelihood of VFR into IMC accidents, informing pilots of relatively high-risk situations that increase the likelihood of pre-decision distortion and post-decision spreading of alternatives, and suggesting countermeasures developed in accordance with the large body of dissonance theory literature may reduce the incidence of VFR into IMC accidents and fatalities.

For example, more gradual onset of weather deterioration increases the number of decisions regarding marginal weather conditions, resulting in more spreading of alternatives and distortion, and increasing the likelihood of continuing a flight into IMC. (Indeed, a paradox of dissonance theory is that the more frequently a careful pilot scans weather conditions in flight, the greater their risk of continuing a flight into IMC, all other things being equal.) However, because passengers don’t normally make the decisions to depart or to continue a flight, they should feel little or no dissonance, and may assess weather conditions more accurately. Therefore, pilots may make more accurate decisions if they solicit and consider the opinions of knowledgeable passengers.

Because perceptual distortion of weather assessment and decision-making is gradual and progressive, the strategy of separating a decision to divert from prior decisions to continue may offer an effective countermeasure for distortion. For example, if an in-flight pilot asks “Would I take off into these conditions?”, or even, “Would I recommend that an average pilot and my child or other loved one take off in these conditions?” and responds “No”, then the most reasonable choice is likely to divert to an alternate.

Another option for reducing the influences of prior and subsequent decisions may be for a pilot to carry pictures of weather conditions close to his or her personal weather minima, to provide an unchanging standard of comparison. Perhaps the WeatherWise training material (Wiggins and O’Hare, 2003) could be adapted to that end.

Dissonance theory literature contains substantial additional information regarding means for reducing or eliminating pre and post-decision distortion. For example, less biased weather decision-making may be facilitated by asking decision-makers to justify their information choice sources, by inducing accountability for the decision process (by auditing and evaluating that process) rather than accountability for decision outcomes, and in general, by focusing on information rather than on a prior decision or favored alternative (Jonas et al., 2001).

Dissonance may account for some other plan continuation errors as well. In 2008, fuel management accidents accounted for 73 non-commercial fixed-wing accidents, 9 of them fatal (AOPA 2009). Although accidents of this type have decreased by 50% over the last ten years, some still occur in part from “failure … to make timely decisions to divert for fuel in the face of changing circumstances. (ibid, p. 14)”.

Conclusion

Research is needed to determine if many weather decision-making errors and accidents, and perhaps other plan continuation errors, result from an active, ubiquitous and powerful characteristic of human cognition that tends to bias even the most conscientious pilots toward distorted situation assessment and risky decision-making. If so, research is also needed to inform the development of effective tools and training to further reduce the number of VFR into IMC accidents, and perhaps the number of fuel management accidents as well.

References


Wiegmann, D., Goh, J. and O’Hare, D. (2002). The role of situation assessment and flight experience in pilots’ decisions to continue visual flight rules flight into adverse weather. *Human Factors, 44*(2), 189-197.