Remembrance of Cases Past: Who Remembers What, When Confronting Critical Flight Events?

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Abstract:

Recent ‘naturalistic’ theories of decision making emphasize the role of stored prior experiences or cases as a guide to current action. However, there is little empirical evidence on the role that case-based remindings play in real-life decision making. The present study utilized a web-based survey to collect data about the role of prior cases in pilot decision making about critical flight events. Results showed that more than half the pilots who responded could provide details about utilizing a previous case in responding to a critical flight event. These events were most likely to involve weather or equipment failure. The cases were found to be useful in situational assessment rather than option evaluation. The use of cases increased with age and experience. Data obtained from a concurrent conventional survey showed broadly similar results. The implications of these results are that case-based remindings play an important role in expert pilot decision making and that training systems incorporating case-based learning would be a potentially useful means of improving pilot decision making.

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Short Title: Remembrance of Cases Past
Keywords: Aviation Safety, Decision Making, Survey, Internet
Intelligent behavior in the present requires the ability to profit from the past. This is true in all walks of life and especially so in aviation. After almost a century of aviation experience almost every conceivable kind of event has already taken place and it can be argued that there are no new classes of accidents, only repetitions of previous ones. An individual who failed to learn from previous experience would be deemed unintelligent, yet in aviation, and especially in general aviation, there seems to be a collective failure to learn the lessons of the past. Accident rates in GA remain stubbornly high compared to those in air transport (O’Hare, 1999) and accident types are endlessly reiterated.

At a theoretical level, recent formulations of decision making (e.g. Klein, 1989) give primacy to the individual’s recollection of previous cases. Expert decision makers are claimed to respond to critical situations by retrieving an example from previous experience and assessing the fit between the current and previous cases. If the match is a good one, the decision maker is able to utilize the expectancies, actions and outcomes associated with the analogous case as a guide to action in the current situation. Klein (1998) points out that “you need a certain amount of experience to use analogical reasoning reliably” (p.210). From this one may hypothesize that older and more experienced decision makers will be more likely than younger, less experienced decision makers to draw on previous cases in dealing with critical situations.

Most research on the use of analogs or previous cases in problem solving has been performed in laboratory settings with undergraduate students (e.g. Novick, 1988). However, Klein and Calderwood (1993) reported evidence that analogs were used in naturalistic decision making by experienced urban fire ground commanders and tank platoon leaders. They suggested that data collected by retrospective interview might underestimate the extent of analog use due to the phenomenon of
‘blending’ where individual episodes are amalgamated in memory over time to form a generalized or prototypical representation of an event or situation. The importance and ubiquity of case-based reasoning in human and machine intelligence has been stressed by Schank in numerous publications (e.g. Schank & Cleary, 1995).

The Critical Decision Method (Klein, Calderwood & MacGregor, 1989) is a widely used knowledge-elicitation technique that is based around the ability to recall a previous case. The case is then examined in detail using a series of probes, including questions about other recent, typical and unusual analogous cases. The CDM has been used to explore expert knowledge in a wide variety of domains (O’Hare, Wiggins, Williams & Wong, 1998). The success of the method derives from the propensity of expert knowledge to be organized around cases or stories rather than in verbalizable guidelines or distinctions (Klein, 1998).

There is probably no other field of activity where previous experiences are so well codified and easily available as in aviation. Major occurrences are thoroughly investigated and extensively reported. The accumulated experience of minor events is also available via databases provided by agencies such as the National Transportation Safety Board (NTSB) and the Federal Aviation Administration (FAA). Much of this information is now easily accessible via the World Wide Web. Personal experiences are described in articles published in numerous magazines devoted to flying and flight safety. From this, one might hypothesize that the use of previous cases as analogs would be especially prevalent amongst pilots. Lintern (1995), for example, has noted that informal sources of information in the form of stories may play an essential role in aviation safety. However, no formal study of the use of case-analogs in aviation has been reported in the literature.
The present study was designed as the first part of a program of research into the role of previous cases in aviation safety and training. There is anecdotal evidence to suggest that even under considerable pressure, pilots may be spontaneously reminded of a previous occurrence. For example, Martensson (1995) describes an incident where the crew of an MD-81 experienced the loss of both engines shortly after take off due to ice ingestion. According to Martensson, “…the captain and the co-pilot recalled a particular accident and did their very utmost to avoid making the same mistakes” (p. 315). The case that came to mind was the crash of a British Midland B737 at Kegworth, England in 1989.

The aim of the present study was to determine if pilots do indeed spontaneously recall previous cases when confronting a critical flight event. If so, then it would be important to examine the nature of these remindings by determining the characteristics of the events and the associated cases. We wished to test the hypothesis that the incidence of such remindings will be a function of the pilots’ age and experience. Finally, we aimed to collect data on pilots’ opinions about the nature of remindings and the role of personal experience.

In order to canvass a wide range of pilots of all backgrounds and experience levels, we decided to develop a survey that would be available to anyone with access to the internet. Internet survey research is still a relatively novel tool, although there is evidence that the results of experimental studies conducted on the internet closely replicate results obtained by conventional laboratory means (Birnbaum, 1999). To determine whether or not this was the case for our internet-based survey we simultaneously undertook a conventional survey with printed questionnaires distributed to pilots in three different countries.
METHOD

Participants

There were 1081 surveys completed during the time the form was available on-line. The 750 printed survey forms were sent to flight training organizations in Australia, New Zealand and the U.S.A. In New Zealand, the flight training organizations were randomly selected from a published directory of all such organizations in the country. In Australia the hard-copy questionnaires were distributed to students enrolled in a tertiary education course in aviation. All of the students enrolled in the course had accumulated experience as a pilot in command. In the U.S.A. 27 flight schools were randomly selected from the website www.beapilot.com. The questionnaires were distributed by mail and were returned by post-paid envelope. In all, 162 completed survey forms were returned for analysis.

Survey

The survey was designed in three sections. The first section contained 10 questions about the respondent’s age, gender, education, nationality, flight experience, licences and ratings, and dominant area of activity (e.g. recreational, airline etc). The second section was constructed to elicit as much information as possible about an occurrence where the respondent could recollect having recalled a previous case during a critical flight event (CFE). Following definitions of ‘case’ and ‘critical flight event’, respondents were asked: “Can you think of at least one instance where you recalled a case during a critical flight event?” They were then asked to describe one specific critical flight event by typing text into a text box. In the hardcopy version, a large (10cm x 15cm) blank box was provided. This was followed by seven questions
about the nature of the CFE (e.g. phase of flight, number of crew etc). This procedure
was then repeated for details of the remembered case with a text box followed by 7
questions about the case (e.g. source, usefulness etc).

The final section of the survey involved 7 opinion items consisting of a
statement of opinion (e.g. “I would say that similar sorts of cases tend to merge into
one generalized case and it is this composite picture that I recall at a critical moment”) and a five-point Likert response format (“Strongly Agree” to “Strongly Disagree”).

**Preparation and Dissemination of On-Line Survey**

The survey text document was converted to .html format using Microsoft
Frontpage and was loaded onto a network server. Participants either entered
information into text boxes or responded to questions by selecting an appropriate
check box. All of the information was displayed on a scrollable, single page and
participants were able to vary any or all of their responses prior to submitting the data
using a push button. The responses were entered automatically into a Microsoft
Access database using an Active Server Page (.asp). A request was sent to AvWeb
(www.avweb.com) to publicize the survey on their electronic ‘Avflash’ newsletter. A
brief description of the study and a link to the survey URL was posted on August 28th
2000. The survey URL was also publicized in AOPA Pilot and Flight Deck
International publications.

**RESULTS AND DISCUSSION**

**On-Line Survey**

*Basic demographics.* The vast majority of respondents (91.2%) were male.

Ages ranged from 17 to 79 years (\( \bar{X} = 46.3 \) yrs, sd = 13). The most common
educational level was to have a Bachelor’s degree (45.6%) with another 34.6%
holding a postgraduate degree. Only 1.3% had not completed a high school education. For the remaining 18.6%, high school was their highest level of education.

Thirty-three different nationalities were represented from Australian (n = 36) to Venezuelan (n = 2). Other nationalities included Bermudan, Danish, Kenyan, Slovakian and Taiwanese. The overwhelming majority of participants (82.3%) were from the U.S.A. The only other nationalities to account for at least 1% of the total were Australian (3.3%), Canadian (2.8%), New Zealander (2.8%) and German (1%).

**Flight experience.** Reported total flight hours ranged from 4 to 33,000 ($\bar{X} = 2710.5, \text{sd} = 4909$). The years of flying experience ranged from 0 to 61 ($\bar{X} = 16.4, \text{sd} = 13.4$). The reported number of flight hours in the previous 12 months ranged from 0 to 1,300 ($\bar{X} = 128, \text{sd} = 168.8$). Most of the sample had a Private Pilot Licence (50.5%), followed by Commercial Pilot Licence (30.1%), an Airline Transport Pilot Licence (15.1%), or a Student Pilot Licence (4.3%). The majority identified themselves as predominantly recreational pilots (58.3%), with flight instructors (14.7%), airline (5.3%) and corporate (5%) the only other categories accounting for at least 5% of respondents. The most commonly held additional rating was an instrument rating (59.7%), followed by a multi-engine rating (36.8%). Only 6.5% held a rotary-wing rating.

**Access to safety material.** A mere 2.1% claimed not to read any aviation safety material at all. The most commonly listed materials were ‘AOPA Pilot’ followed by ‘NTSB Reports’, ‘Plane & Pilot’, and ‘AvWeb’. Since the sample was recruited through notices on ‘AvWeb’ and to members of AOPA, these results are not necessarily indicative of the reading patterns of the pilot population in general. There
was a significant effect of licence group on safety reading patterns ($\chi^2 (3) = 11.7, p = .009$) with holders of student and commercial licences reporting less reading of safety materials than private and airline transport licence holders.

*Recall of Critical Flight Events (CFEs).* Just over half the respondents (52.5%) were able to report an instance where they had recalled a previous case during a critical flight event. The two most common CFEs were weather-related, cited by 46.1% of the respondents, and equipment-failure, cited by 33.3% (see Figure 1). Cruise was by far the most frequently reported flight phase (45.6%) for these events, particularly for private pilots (see Figure 2). Airline pilots were more likely to recall CFEs related to approach and landing whereas more than half the CFEs (52.4%) recalled by student pilots occurred during takeoff or climb ($\chi^2 (15) = 37.5, p = .001$).

![Figure 1](image-url)  
*Fig 1* Characteristics of the critical flight event (CFEs). Respondents could endorse more than one label.
Two-thirds of the CFEs involved just one pilot whilst the remainder involved 2 or 3 crew members in total. Interestingly, CFEs were likely to have occurred some time ago, with 30.7% more than 5 years old compared to 21.1% from the previous 6 months (see Figure 3). However, this varied as a function of the reporter’s age (F (3) = 32.5, p = .0001). The CFEs recalled by respondents in the upper age quartile were older on average than those recalled by other respondents.

*Recall of cases.* Cases were more commonly recalled during the early stages of the CFE rather than when deciding between options (see Figure 4). This is consistent with the RPD model of decision making (Klein, 1989). Nearly every respondent (89.3%) found the recalled case to have been ‘moderately’ or ‘very’ useful. Almost as many (84%) considered the case to have been a key factor in the decision they took at the time, with only a very small proportion (4.4%) finding the
case to have been misleading. The most experienced pilots (top quartile of total flight hours) were most likely to have found the case misleading ($\chi^2(3) = 9, p = .029$).

Fig 3  Estimated time since the critical flight event (CFE) took place.

As shown in Figure 5, the majority of respondents found the recalled case to be helpful in evaluating the current situation (57.8%) or in deciding what to do (58.8%). In contrast, around a quarter felt that the case was helpful in suggesting an appropriate procedure (23.8%) or evaluating intended actions (27.6%).
Fig 5  Functions and activities that were aided by the recalled case. Respondents could endorse more than one label.

Again, these data are consistent with the view that decision making consists, in the main, in recognizing a situation and its action implications (Klein, 2000). Written materials appear to be an important source of the remembered cases, with 29.1% coming from ‘safety magazines’ and a further 20.8% from ‘accident reports’. There were significant differences between pilot licence groups in the sources of their recalled case. Student and private pilots were less likely to remember a case related to them verbally than were commercial or airline pilots. Airline pilots were most likely to recall a case from an official accident report but were least likely to have recalled a case from a safety magazine ($\chi^2 (9) = 17.8, p = .038$).
Differences between those who recalled a case and those who didn’t. As hypothesized, the demographic profile of those who reported being reminded of a previous case during a critical flight event was slightly older and more experienced than average. Amongst the oldest quartile of respondents, 60.2% reported using a case during a CFE compared to only 45% of the youngest respondents ($\chi^2 (3) = 13.1, p = .004$). Similar results were obtained for total flight hours. Amongst the most experienced quartile, 58% reported using a case during a CFE compared to only 38% of the least experienced respondents ($\chi^2 (3) = 28.7, p = .0001$). These differences are summarized in Table 1.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Recallers</th>
<th>Non-Recallers</th>
<th>Test Statistic</th>
<th>Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (Years)</td>
<td>47.04</td>
<td>44.77</td>
<td>$F(1) = 8.3$</td>
<td>$p = .004$</td>
</tr>
<tr>
<td>Total Hours</td>
<td>3090</td>
<td>2298</td>
<td>$F(1) = 6.97$</td>
<td>$p = .008$</td>
</tr>
<tr>
<td>Years Flight</td>
<td>17.96</td>
<td>14.75</td>
<td>$F(1) = 15.3$</td>
<td>$p &lt; .0001$</td>
</tr>
<tr>
<td>Hours (12 mths)</td>
<td>145.5</td>
<td>109.2</td>
<td>$F(1) = 12.4$</td>
<td>$p &lt; .0001$</td>
</tr>
<tr>
<td>Flight Activity Category</td>
<td>Commuter / Corporate / Airline</td>
<td>Recreational</td>
<td>$\chi^2 (9) = 22.4$</td>
<td>$p = .008$</td>
</tr>
</tbody>
</table>

Table 1 Differences between respondents who recalled a case whilst dealing with a critical flight event (CFE) and those who didn’t.

There was no difference between the reporters and non-reporters in terms of educational level or licence category, but there was a difference in terms of their reported area of activity ($\chi^2 (9) = 22.4, p = .008$). Pilots who were involved in
commuter/charter, corporate or airline operations were disproportionately likely to report recalling a case during a CFE.

**Opinions about role of cases.** The overwhelming majority of respondents (88.3%) agreed or strongly agreed that the likelihood of a case being useful in decision making increased with the amount of time available for the decision. A majority (62.3%) also agreed or strongly agreed with the view that similar cases tend to blend or merge into one composite case. Only a minority (46.7%) agreed or strongly agreed with the view that you learn better from your own experiences than those of others.

**Comparison Between On-Line Results and Hardcopy Survey Results**

A total of 162 completed hardcopy surveys were obtained from respondents in the U.S. (31), New Zealand (53) and Australia (78). Of these, 144 were completed by respondents describing themselves as U.S., Australian or New Zealand nationals. As noted above, the on-line data were obtained from respondents of 33 different nationalities. To enable comparisons with the hardcopy data, respondents with nationalities other than U.S., New Zealand or Australia were deleted from the file. This left 958 on-line surveys.

Respondents in the hard-copy survey were younger ($\bar{x} = 34.4$ yrs; range 18-74yrs) and had fewer years of flight experience ($\bar{x} = 11.75$) than those in the on-line survey ($F(1) = 102.9$, $p < .0001$; $F (1) = 16.5$, $p < .0001$ respectively). The mean total flight hours, ($\bar{x} = 2895$) however, was not significantly different. This is accounted for by the fact that respondents in the hard-copy survey were accumulating flight hours at almost twice the annual rate (231.6 hrs vs 123.6 hrs) of those in the on-line
survey (F(1) = 50.8, p < .0001). The proportion of males and females did not differ between the surveys.

The hard-copy sample was less highly educated, with the modal level of education being high school ($\chi^2 (3) = 97.1, p < .0001$). The hard-copy sample had a greater proportion of commercial pilot licence holders and a smaller proportion of private pilots ($\chi^2 (3) = 31.8, p < .0001$). There were proportionately more flight instructors and fewer recreational pilots in the hard copy sample ($\chi^2 (9) = 129.5, p < .0001$). There was no difference between the two surveys in the proportion reading safety material.

A smaller proportion of respondents (32.6%) in the hard-copy sample reported recalling a case when encountering a CFE ($\chi^2 (1) = 19.2, p < .0001$). There were no differences between the samples in terms of how long ago the CFE occurred, the source of the case, or the point in the CFE when the case was recalled. There was a difference in the proportions judging the case to have been ‘very useful’ (94% vs 46%; $\chi^2 (3) = 66.4, p < .0001$). There were no differences between the on-line and hard-copy samples in the characterizations of the CFE (weather, equipment etc) or the phase of flight during which the CFE occurred.

There was no difference between the samples in terms of their opinions about the value of personal experience or the use of cases increasing with time available. There was a marginally significant difference in opinions on the tendency of cases to blend into a composite case with a smaller proportion (49.7% vs 62.3%) of hard-copy respondents endorsing this view ($\chi^2 (4) = 9.72, p < .045$).
GENERAL DISCUSSION

Over half the pilots who responded to the on-line survey were able to provide an instance where their response to a critical flight event (CFE) was mediated by the recall of a previous case or example. These CFEs most commonly involved weather or equipment failure. The cases recalled were almost invariably regarded as a help rather than a hindrance. Cases came to mind as part of the initial process of assessing the situation and the potential courses of action. Many cases were reportedly sourced from written materials such as magazines or accident reports.

As hypothesized, there was an increasing tendency for older and more flight experienced respondents to recall CFEs in which case recall played a part. Pilots involved in air transport operations were more likely to have recalled a case during a CFE than other categories of pilots. The majority of respondents were of the opinion that cases were most likely to be useful when there was sufficient time available for decision making. This seems to be borne out by the actual instances cited which most commonly involved non-time critical situations such as weather or equipment failure. The majority of respondents also endorsed the value of learning from the experiences of others, and this too seems consistent with the high reported incidence of using cases derived from written materials.

A comparison hard-copy survey was conducted in Australia, New Zealand and the U.S. by mailing questionnaires to flight training organizations. Compared to the on-line survey, the respondents were younger, less educated, flying more hours currently but with equivalent total flight hours. This profile reflects the preponderance of flight instructors and commercial pilot licence holders in the hard-copy sample compared to a preponderance of recreational, private pilot licence holders in the on-line survey. This is consistent with previous studies (e.g. Birnbaum, 1999) that have
also found internet samples to be older and more highly educated than comparison samples.

Significantly fewer respondents in the hard-copy survey reported an instance where a recalled case had played a part in a CFE. However, there were very few differences between the samples in characterizing the CFEs, the cases or in the opinions held about case recall. This replication of results from the on-line survey strengthens the substantive findings of the present study and suggests that web-based surveys can be a useful tool in human factors research.

**IMPLICATIONS**

Although case-based training has been extensively employed in some areas (e.g. medicine, law) it has not been formally utilized in aviation training. Based on work on case-based reasoning (e.g. Kolodner, 1983; Schank, 1999), Edelson (1996) describes a case-based teaching architecture for elementary school biology. The ‘Creanimate’ system aimed to provide an interesting multi-media environment including a library of 200 cases. The cases are used to provide concrete examples of the principles covered, or similar cases to promote generalization. Schank (1997) describes several examples of virtual learning environments developed for corporate clients that incorporate the presentation of relevant cases or stories at opportune moments.

Given the prevalence of case-based reasoning in in-flight decision making reported in our survey, it is reasonable to suggest that training systems could be developed along the lines suggested by Edelson (1996) and Schank (1997). Kolodner (1997) describes some further examples. PC-based flight simulations provide a naturally interesting virtual environment for the general aviation pilot. The optimal
way of incorporating case-based tutoring elements into such an environment remains to be determined.

ACKNOWLEDGEMENTS

This research was funded by NASA-Ames Research Grant NAG-2-1395. Technical monitor is Dr Immanuel Barshi. The assistance of Adele Arnold in setting up the on-line survey and Rachel Avery in the analysis of survey data, is gratefully acknowledged. We are grateful to Dr Alan Stokes for distributing copies of the survey to training organizations in the U.S.

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BIOGRAPHIES

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