Study on Evaluation of Airline Pilot's Flight Violation Behaviors and Psychological Risk

Jingyi Zhang and Lei Wang(✉)

Flight Technology College, Civil Aviation University of China,
Tianjin 300300, China
wanglei0564@hotmail.com

Abstract. This study aimed to evaluate the flight violation behaviors of airline pilots and examine the relationship between violation behavior and risk psychology based on Quick Access Recorder (QAR) data and surveys. Flight violation evaluation indexes were selected from airlines' Flight Operations Quality Assurance (FOQA) items. Then, an evaluation standard for violation behaviors was determined by investigating airlines, and a violation evaluation model for pilots was established. To examine the model's reasonableness and explore the relationship between violation behavior and risk psychology, flight QAR data were analyzed, and pilot's risk psychology characteristics were investigated by using psychological scales. In the case study, correlation analysis showed that landing vertical overload—a key factor in landing safety—was significantly negatively correlated with risk tolerance and significantly positively correlated with risk perception. Significant correlations among the violation indexes indicated interrelationships among the violation behaviors. This evaluation method can be applied to airlines' FOQA to effectively and efficiently identify and control pilot's violation behaviors. These findings are expected to provide a support for improving aviation safety.

Keywords: Violation behavior · Risk psychology · Flight data · Landing safety

1 Introduction

In the past two decades, nearly 75% of civil aviation accidents have been caused by human factors. Pilot's flight safety operations affect human error and safety in civil aviation. In its 2017 Annual Safety Report, the International Air Transport Association noted that 64% of flight accidents caused by flight crew errors could be attributable to manual handling and flight control by pilots [1]. Therefore, in the process of daily operations and management, airlines need to monitor and analyze Quick Access Recorder (QAR) exceedance warnings triggered by pilots to record their flight safety operations. Meanwhile, according to Boeing, while the takeoff, initial climb, final approach, and landing phases account for only 6% of total flight time, 61% of accidents and fatalities occur in these phases, and more than 70% are caused by flight crew errors [2]. Studies have indicated that pilot's ignorance of regulatory frameworks is the main cause of accidents during the final approach and landing phases [3]. In this regard, the

D. Harris (Ed.): HCII 2019, LNAI 11571, pp. 342–352, 2019.
https://doi.org/10.1007/978-3-030-22507-0_27

IATA noted that 50% of fatal accidents caused by flight crew errors pertain to Standard Operating Procedure (SOP) adherence and cross-verification issues [1]. Hence, studying pilot's violation behaviors is essential for civil aviation safety.

Previous studies have shown that pilots involved in aviation accidents are more likely to break with regulatory frameworks than those not involved in accidents [4–7]. Rebok et al. selected 3,000 pilots aged 45–54 as samples and tracked their violations for 11 years. The results showed that the risk of violation was negatively correlated with flight experience, and there was a significant positive correlation between age and violation [8]. English and Branaghan constructed a new classification based on pilot's violation intention, grouping the reasons for pilot violations into four categories: improvement, malevolent, indolent, and hedonic [9]. Luo suggested that most behavioral mistakes have to do with psychological characteristics arising from interactions among the crew, the machine, and environmental factors [10]. Liang also focused on psychological factors, investigating common unhealthy psychological factors affecting violations from a micro perspective [11].

While airlines monitor and manage cockpit exceedance by pilots as part of their daily operations, violation behaviors tend to be ignored until there is severe exceedance. An exceedance event is an unsafe event in which any QAR monitoring parameter exceeds the flight operations quality assurance (FOQA) standard, which specifically focuses on the collection and analysis system of flight data in daily flight [12, 13] and is reported by FOQA software. Exceedance event risk management based on QAR data comprises the core of airlines' FOQA. Similar to the idea of big data, QAR flight data can be used to analyze and evaluate pilot's operation levels and exceedance behaviors. Wang et al. investigated the evaluation of flight operation risk using QAR data. This included a study of the flaring operational characteristics of long landing and hard landing events, specifically focusing on the effect of flaring operation on landing performance [14–18]. Overall, even though research has been conducted on using QAR data in the detection, diagnosis, and prediction of exceedance events, few studies have investigated the relationship between risk-related personality traits and exceedance behaviors.

Therefore, the current study screened exceedance events related to flight violation firstly. Then, an evaluation method for pilot violation was constructed whereby violation level could be quantitatively evaluated based on flight QAR data. Meanwhile, the scale of measuring pilot's psychological risk was also introduced and implemented. Methods and results can provide technical support for flight safety management and improve airlines' daily monitoring and safety management of pilot violations.

2 Evaluation on Airline Pilot's Flight Violation Behaviors Based on Flight QAR Data

2.1 Flight QAR Data Acquisition

The QAR is a system that includes equipment for recording data in the air and a software station on the ground for storing and analyzing the data. QAR can record all kinds of aircraft parameters, pilot operation parameters, environmental features, and alarm information during a flight. When a flight parameter exceeds the prescriptive normal range, it is called a QAR exceedance event. While most exceedance events do not produce severe results, they can increase the likelihood of an accident, potentially harming aircraft and even passengers. Based on related operational rules and regulations, commercial airlines always use flight data (such as QAR data) to monitor and analyze the aircraft and the pilot's operational performance in flight. FOQA monitoring standards are developed based on aircraft design principles and flight environments, and are combined with the operation requirements of different airlines. In this study, FOQA standards for the Boeing 737-800 (B737-800) were selected as the research foundation, and exceedance events and flight QAR data were collected to analyze pilot's violation behaviors and establish a violation operation evaluation model. A program based on VBA (Visual Basic for Applications) was written and applied to minimize file volume and mine target information from the massive QAR data.

2.2 Investigation of Violation Event in Airlines

Flight violation events in this study were defined as those exceedance events that were mainly caused by pilot's subjective intentions. This kind of exceedance events with violation were selected through discussion and analysis of the causes as well as the related operating manuals. To screen for reasonable and effective indicators, several airlines were investigated by communicating with expert pilots, flight instructors, and FOQA professionals. According to the task characteristics, exceedance events were classified preliminarily by different flight phases.

For the B737-800 aircraft, there are 82 indicators for QAR monitoring standards in the airline selected for the current research. Through discussion and investigation, 38 violation behavior items were eventually selected. Figure 1 shows the violation events involved in each flight phase.

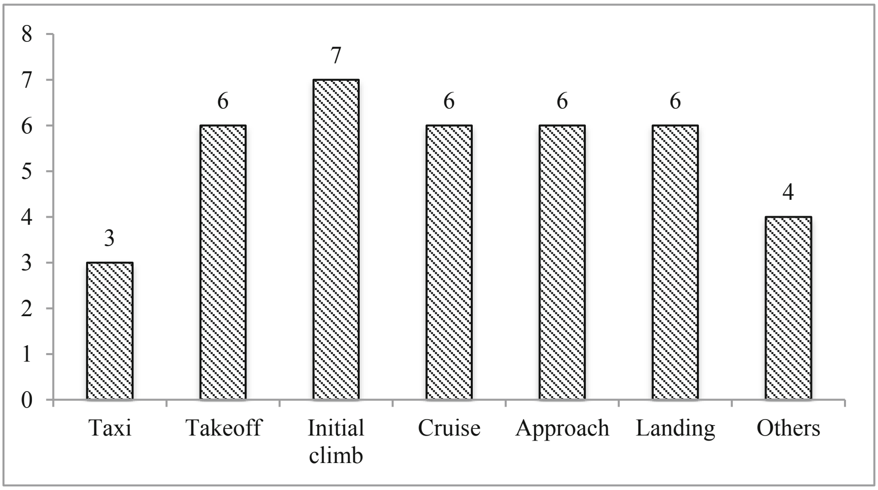

Fig. 1. Number of each violation type in different phases of flight

Violation types occurring at the selected airline from year of 2014 to 2017 were collected and calculated, and then sorted by frequency of occurrence. The results are shown in Table 1.

Table 1. Statistics for violation frequency from 2014 to 2017

Mild exceedance		Severe exceedance	
Event	Frequency	Event	Frequency
Landing vertical overload	281	Ground Proximity Warning System (GPWS) warning	26
Landing gear up late	19	Landing vertical overload	5
Cornering taxiing overspeed	16	Landing gear up late	4
Landing flaps in position late	12	Landing flaps in position late	2
Straight taxiing overspeed	5	Exceeding tire limit speed	1
Landing gear down late	5	Cornering taxiing overspeed	1

2.3 Evaluation Model of Airline Pilot's Violation Behaviors

Classification and Selection of Evaluation Indexes. The occurrence frequency of violation events from 2014 to 2017 was taken as an optimizing factor for the violation evaluation indexes. If a violation event had not occurred in nearly four years, the index was deleted; if a violation event had occurred within four years, the index could be retained. Table 1 shows that in the past four years, there were eight violation items triggered by pilots: straight taxiing overspeed, cornering taxiing overspeed, exceeding tire limit speed, landing gear up late, Ground Proximity Warning System (GPWS) warning, landing gear down late, landing flaps in position late, and landing vertical overload. However, since the exceeding tire limit speed event only occurred once, the index was deleted. Hence, the final evaluation indexes were as follows: E1, straight taxiing overspeed; E2, cornering taxiing overspeed; E3, landing gear up late; E4, GPWS warning; E5, landing gear down late; E6, landing flaps in position late; and E7, landing vertical overload.

In terms of object characteristics recognized by the human brain, perception can be divided into three categories: space perception, temporal perception, and motion perception [19]. Furthermore, airline pilots must also accurately judge the position and motion state of the aircraft. Also, given the close association between temporary perception and space perception, violation events can be classified into two categories: (1) caused by space perception errors and (2) caused by motion perception errors.

Using this method, the seven violation event items were classified. Table 2 shows the results, indicating that these seven indexes of violation evaluation can be covered.

Table 2. Classification of violation indexes

Space perception errors	Landing gear up late
	Landing gear down late
	Landing flaps in position late
	GPWS warning
Motion perception errors	Straight taxiing overspeed
	Cornering taxiing overspeed
	Landing vertical overload
	GPWS warning

Determination of Evaluation Standard. Further analysis of QAR data showed that although some parameters of flight operation did not exceed FOQA standards, they were very close to the critical value and tended toward exceedance. This part of the data is not marked in the monitoring system and is thus often overlooked in airlines' daily management. Although events tending toward exceedance are not recorded by FOQA, there is great potential for triggering exceedance in more complex situations. Therefore, in addition to exceedance events recorded by the FOQA software, violation tendencies should also be considered when determining the evaluation standard for violation behaviors. QAR flight data should be fully used to guarantee flight safety.

The evaluation standard for pilot's violation behaviors was based on the monitoring items and standards for severe and mild exceedance for the B737-800 at the selected airline. Tendency toward violation behavior was graded by the percentile method as the evaluation standard for each index. QAR flight data were collected and extracted corresponding to each index and then sorted from smallest to largest. The accumulated percentage was calculated using SPSS software. Due to different types of index data, some exceedance standards were on the large side and some on the small side; thus, 70 or 30 percentiles were selected as the classification standard for tendency violation. The percentile formula is shown as follows:

$$P_p = L_b + \frac{\frac{P}{100} \times N - F_b}{f} \times i \tag{1}$$

where P_p is the percentile of P, L_b is the exact lower limit of the group in which the percentile is located, f is the frequency of the group in which the percentile is located, F_b is the frequency sum for each group that is less than L_b, N is the total frequency, and i is the class interval.

If the QAR flight data exceeded the severe exceedance standard, it was scored as 30 points. Similarly, 20 points were allocated for mild exceedance and 10 points for tendency exceedance. Finally, the evaluation standard for airline pilot's violation behaviors is as shown in Table 3.

Table 3. Evaluation standard for airline pilot's violation behaviors

Violation event	Severe exceedance		Mild exceedance		Tendency exceedance	
	Exceedance standard	Scoring	Exceedance standard	Scoring	Exceedance standard	Scoring
E1 Straight taxiing overspeed	$\geq$40Kts	30	$\geq$30Kts	20	<23Kts $\geq$23Kts	0 10
E2 Cornering taxiing overspeed	$\geq$18Kts	30	$\geq$14Kts	20	<12Kts $\geq$12Kts	0 10
E3 Landing gear up late	$\geq$500Ft	30	$\geq$300Ft	20	<104.4Ft $\geq$104.4Ft	0 10
E4 GPWS warning	Detected	30	–	–	–	–
E5 Landing gear down late	$\leq$1300Ft	30	$\leq$1500Ft	20	>1991.6Ft $\leq$1991.6Ft	0 10
E6 Landing flaps in position late	$\leq$1000Ft	30	$\leq$1200Ft	20	>1852.6Ft $\leq$1852.6Ft	0 10
E7 Landing vertical overload	$\geq$1.89 g	30	$\geq$1.68 g	20	<1.455 g $\geq$1.455 g	0 10

Calculation of Index Weight. The entropy weight method, an objective weighting method, was used to calculate the weight of the evaluation indexes. The entropy value reflects the disorder degree of information. The smaller the value, the smaller the disorder degree of the system. For the discrete degree of the indexes, the larger the value, the greater the discrete degree; that is, the greater the effect on the violation evaluation system. The steps for weight calculation are shown as follows:

(1) Standardization of QAR flight data

$$X_i = \{x_{i1}, x_{i2}, \ldots, x_{in}\} \tag{2}$$

$$Y_i = \{y_{i1}, y_{i2}, \ldots, y_{in}\} \tag{3}$$

$$y_{ij} = \frac{x_{ij} - \min(x_{ij})}{\max(x_{ij}) - \min(x_{ij})} \tag{4}$$

where X_i is the original indexes given for violation evaluation, Y_i is the standardized indexes, i = 1,2,…,7, and j = 1,2,…,n.

(2) Calculation of entropy:

$$D_j = -\ln(n)^{-1}\sum_{i=1}^{n} p_{ij} \ln p_{ij} \tag{5}$$

where D_i is the entropy of index i, $p_{ij} = Y_{ij} \Big/ \sum_{i=1}^{n} Y_{ij}$, if $P_{ij} = 0$, $\lim_{p_{ij}=0} p_{ij} \ln p_{ij} = 0$

(3) Calculation of weight:

$$W_i = \frac{1 - D_i}{7 - \sum D_i} \tag{6}$$

where W_i is the weight of index i.

Evaluation Model for Violation Behavior. 348 sets of QAR flight data corresponding to 27 pilots were collected. For each index, the necessary parameters were extracted using MATLAB. Then, the extracted parameters were calculated according to the evaluation standard for each index. The calculating formula is shown as follows:

$$X_i = \frac{\sum_j^n Z_j}{n} \tag{7}$$

where X_i is the pilot's score of index i, n is the number of flights, and Z_i is the score of flight j.

$$Z_j = \left\{ \begin{array}{l} 0,\ Normal \\ 10,\ TendencyExceedance \\ 20,\ MildExceedence \\ 30,\ ServerExceedence \end{array} \right\}$$

Through the comprehensive quantification of each violation index, the violation evaluation model was established:

$$L_k = \sum W_i X_i \tag{8}$$

where L_k is the comprehensive violation evaluation result for each pilot, W_i is the weight of index i, X_i is the score of index i, i = 1,2,..., 7, and k = 1,2,..., 26.

3 Measurement on Pilot's Psychological Risk

3.1 The Scale of Risk Psychology

On the basis of previous studies [20], three risk psychological characteristics were selected as the evaluation indicators of risk psychology. To measure pilot's risk psychology characteristics during flight operation, a scale was established by modifying and translating the risk tolerance, risk perception, and hazardous attitude scales. The test results showed that the scales had good reliability and validity.

Scale Structure. The risk tolerance scale for pilots comprises 17 kinds of flight scenarios, established according to Hunter [21] and Ji et al. [20]. The risk tolerance score is measured in five grades: 5, pilot is extraordinarily willing to accept, or agree with, the flight scenarios given on the scale; 4, pilot is willing to accept, or agree with, the flight scenarios given on the scale; 3, pilot is not sure or indifferent to the flight scenarios given on the scale; 2, pilot is reluctant to accept, or agree with, the flight scenarios given on the scale; and 1, pilot is very reluctant to accept, or agree with, the flight scenarios given on the scale.

The risk perception scale for pilots consists of 26 kinds of flight scenarios. It has been widely applied in research since its creation by Hunter [21]. The grades of risk scenarios listed in the scale range from 0 to 100.

The hazardous attitude scale for pilots comprises 24 kinds of behavior that are closely related to modern airline activities. It is a 5-point Likert scale: 5, pilot is extraordinarily willing to accept, or agree with, the flight situation given on the scale; 4, pilot is willing to accept, or agree with, the flight situation given on the scale; 3, pilot is not sure or indifferent to the flight situation given on the scale; 2, pilot is reluctant to accept, or agree with, the flight situation given on the scale; and 1, pilot is very reluctant to accept, or agree with, the flight situation given on the scale.

The final score for each scale is the average score for all of the topics. The higher the final score, the higher the level of risk psychology characteristics.

Scale Implementation. The average age of the 27 male pilots who participated in the flight data acquisition and questionnaire survey was 29.22 years. The average total flight hours for three years was 2,636.81 h. Table 4 shows the basic statistical data of the subjects.

Table 4. Basic statistical data of the subjects

	Hierarchy	Number	Proportion
Age	21–25	4	15.38%
	26–30	17	65.38%
	31–35	3	11.54%
	36–41	3	7.69%
Technical grade	Instructor	3	7.69%
	Captain	10	38.46%
	First officer	14	53.85%
Flight hours in three years (2015–2017)	1000–1500	1	3.85%
	1501–2000	1	3.85%
	2001–2500	4	11.54%
	2501–3000	21	80.77%

3.2 Correlation Between Risk Psychology Characteristics and Airline Pilot's Violations

Finally a case was given by using the evaluation method and survey results. The Pearson correlations between the scores of risk psychology characteristics and flight violation behaviors in landing was analyzed. Since the 27 pilots scored the same on the GPWS warning index, this item was excluded from the correlation analysis. Landing vertical overload was significantly negatively correlated with risk tolerance ($r = -0.474$, $p < 0.05$) and significantly positively correlated with risk perception

($r = 0.585$, $p < 0.05$). The negative relationship between cornering taxiing overspeed and risk perception was significant *($r = -0.468$, $p < 0.05$)*. Furthermore, there was a significantly negative correlation between risk tolerance and risk perception *($r = -0.547$, $p < 0.05$)*. For violation behaviors, landing gear up late showed a significantly negative correlation with straight taxiing overspeed ($r = -0.444$, $p < 0.05$). Further, landing gear down late showed significantly positive correlations with landing gear up late *($r = 0.441$, $p < 0.05$)* and landing flaps in position late *($r = -0.686$, $p < 0.05$)*.

4 Discussion

4.1 Theoretical Model for Airline Pilot's Violations

An evaluation model was established based on the investigation and statistical analysis. The correlations among violation indexes—such as landing gear down late, landing gear up late, and landing flaps in position late—indicated close associations among certain flight operation violation behaviors, indicating that it is reasonable to classify these seven violation behavior items based on the perspective of perception. However, the interrelationships were not entirely consistent with the basis of classification—that is, the different characteristics of perceptual objects. For motion perception errors, landing gear down late significantly positively correlated with landing gear up late and landing flaps in position late, though there were no significant interrelationships among the four violation indexes of space perception errors. Instead, straight taxiing overspeed showed a significantly negative correlation with landing gear up late, which might be attributable to the close association between space perception and motion perception. Previous studies have shown that an interrelationship exists between space perception and motion perception. That relationship still needs further experimental exploration; thus, the model needs to be further optimized. This could also be attributable to sample size restrictions; thus, the model should be verified by further case studies in follow-up research.

4.2 Effect of Risk Psychology Characteristics on Landing Operation

Contrary to previous findings, correlation analysis showed that landing vertical overload was significantly negatively correlated with risk tolerance and significantly positively correlated with risk perception [22–27]. Relevant surveys and investigations indicated that, today, airlines emphasize hard landing monitoring and adopt more severe punishment measures for hard landing exceedance events than for other events. Therefore, pilots tend to deliberately prolong flare time and touchdown distance to minimize the landing vertical load. Wang et al. found a significant correlation between touchdown distance and average landing vertical load [14], indicating that flights with a longer touchdown distance generally have a lighter vertical load in landing. However, a long flare time or touchdown distance can lead to another exceedance, long landing, which can trigger a more severe accident—overshooting the runway—which can cause serious economic losses and even casualties. So, when pilots lengthen flare time and extend touchdown distance to avoid a hard landing, they increase the risk of running off the runway. With increased flare time, the touchdown point becomes more distant, which can increase pilot's psychological pressure. In this case, pilots have higher risk tolerance. Meanwhile, pilots with higher risk perception would prefer a shorter flare time due to fears of running off the runway. In that case, the aircraft would touchdown in a relatively shorter range, which could produce a larger vertical load than would be the case with flights performed by pilots with lower risk perception.

5 Conclusion

In the current study, 38 flight violation event items mainly caused by subjective risk taking by pilots were identified. Furthermore, an evaluation method for pilot's flight violation behaviors was developed, which can be applied to airlines' FOQA to effectively and efficiently identify and control pilot's violation behaviors.

The correlation analysis between violation behaviors and risk psychology indicated that pilots with high severe exceedance rates had higher hazardous attitude scores than pilots with high scores for landing vertical overload violations, who generally possessed low levels of risk tolerance and risk perception. This could be attributable to strict systems of punishment and safety cultures in airlines. These findings are expected to provide new ways for airlines to establish effective management systems and positive safety cultures, thereby improving aviation safety.

Acknowledgments. We appreciate the support of this work from the National Natural Science Foundation of China (Grant No. U1733117) and the National Key Research and Development Program of China (Grant No. 2016YFB0502405).

References

1. International Air Transport Association.: IATA Safety Report 2017 (2018)
2. Boeing Commercial Airplanes.: Statistical Summary of Commercial Jet Airplane Accidents Worldwide Operations 1959–2015 (2016)
3. Civil Aviation Administration of China.: Annual report on aviation safety in China 2017. Civil Aviation Administration of China (2018)
4. Burg, A.: Traffic violations in relation to driver characteristics and accident frequency (Rep. No. 74–55). Los Angeles: University of California Los Angeles, Institute of Transportation and Traffic Engineering (1975)
5. Civil Aviation Administration of China: Implementation and Management of Flight Operation Quality Assurance. Advisory Circular: 121/135–FS–2012–45. Beijing, China (2012)
6. Chen, W., Cooper, P.J., Pinili, M.: Driver accident risk in relation to the penalty point system in British Columbia. J. Saf. Res. **26**(1), 9–18 (1995)
7. Lourens, P.F., Vissers, J.A.M.M., Jessurun, M.: Annual mileage, driving violations, and accident involvement in relation to drivers' sex, age, and level of education. Accid. Anal. Prev. **31**(5), 593–597 (1999)

8. Rebok, G.W., Qiang, Y., Baker, S.P., Mccarthy, M.L., Li, G.: Age, flight experience, and violation risk in mature commuter and air taxi pilots. Int. J. Aviat. Psychol. **15**(4), 363–374 (2005). https://doi.org/10.1207/s15327108ijap1504_4
9. English, D., Branaghan, R.J.: An empirically derived taxonomy of pilot violation behavior. Saf. Sci. **50**(2), 199–209 (2015)
10. Luo, F.: The Psychological analysis on the behavior mistakes of the civil aviation crews. J. Wuhan Univ. Technol. (4), 687–705 (2002)
11. Liang, L.: An analysis of violation behavior and psychological factors. China Saf. Sci. J. **8** (2), 4–8 (2006)
12. Civil Aviation Administration of China: Implementation and Management of Flight Operation Quality Assurance. Advisory Circular: 121/135–FS–2012–45. Beijing, China (2012)
13. Yan, H.: Building model for relationship between road traffic accident and drivers' psychological quality. China Saf. Sci. J. **26**(2), 13–17 (2016)
14. Wang, L., Ren, Y., Wu, C.: Effects of flare operation on landing safety: a study based on ANOVA of real flight data. Saf. Sci. **102**, 14–25 (2018)
15. Wang, L., Sun, R.S., Wu, C.X., Cui, Z.X., Lu, Z.: A flight QAR data based model for hard landing risk quantitative evaluation. China Saf. Sci. J. **24**, 88–92 (2014)
16. Wang, L., Wu, C., Sun, R.: Pilot operating characteristics analysis of long landing based on flight QAR data. In: Harris, D. (ed.) EPCE 2013. LNCS (LNAI), vol. 8020, pp. 157–166. Springer, Heidelberg (2013). https://doi.org/10.1007/978-3-642-39354-9_18
17. Wang, L., Wu, C., Sun, R., Cui, Z.: An analysis of hard landing incidents based on flight QAR data. In: Harris, D. (ed.) EPCE 2014. LNCS (LNAI), vol. 8532, pp. 398–406. Springer, Cham (2014). https://doi.org/10.1007/978-3-319-07515-0_40
18. Wang, L., Wu, C., Sun, R.: An analysis of flight Quick Access Recorder (QAR) data and its applications in preventing landing incidents. Reliab. Eng. Syst. Saf. **127**, 86–96 (2014)
19. Peng, D.: Common Psychology, 4th edn. Beijing Normal University Publishing Group, Beijing (2015)
20. Ji, M., You, X.Q., Lan, J., Yang, S.: The impact of risk tolerance, risk perception and hazardous attitude on safety operation among airline pilots in China. Saf. Sci. **49**(10), 1412–1420 (2011)
21. Hunter, D.R.: Risk perception and risk tolerance in aircraft pilots (2002)
22. Hunter, D.R.: Measurement of hazardous attitudes among pilots. Int. J. Aviat. Psychol. **15** (1), 23–43 (2005)
23. Hunter, D.R., Stewart, J.E.: Locus of control, risk orientation, and decision making among US Army aviators (2009)
24. O'Hare, D.: Pilots' perception of risks and hazards in general aviation. Aviat. Space, Environ. Med. (1990). https://doi.org/10.1080/15298669091369853
25. Platenius, P.H., Wilde, G.J.: Personal characteristics related to accident histories of Canadian pilots. Aviat. Space Environ. Med. **60**(1), 42 (1989)
26. Wiggins, M., Connan, N., Morris, C.: Weather-related decision making and self-perception amongst pilots. Appl. Aviat. Psychol.- Achiev. Chang. Chall. 193–200 (1996)
27. Ji, M., Liu, Z., Yang, S., Bao, X., You, X.Q.: A study on the relationship between hazardous attitudes and safe operation behaviors among airline pilots in China. J. Psychol. Sci. **35**(1), 202–207 (2012)