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Resilience Attributes of Certificated Flight Instructors

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The aviation industry has extensive vocabulary, data sources, and theoretical models to investigate human errors. However, the industry does not have commensurate ways to think about and analyze human success. Learning from successful routine operations is challenging because the corresponding common language and data streams are less robust. This paper explores the use of the critical incident debrief method to collect data on routine resilient performance among Certificated Flight Instructors (CFI). CFI thoughts and behaviors were coded in accordance with resilience theory. The critical incident debrief method is a valuable source of data for exploring resilient performance as it provides researchers with insights into CFI thoughts and intentions that may not be observable through their behaviors. CFI performance can be analyzed through the lens of resilience theory, but coding reliability remains a challenge.

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The aviation industry has robust ways to analyze human errors but lacks corresponding widely accepted data sources, vocabulary, and models to analyze positive human performance. The overwhelming majority of flights across all facets of the aviation industry end successfully, yet the behaviors that lead to the successful handling of unexpected events in routine operations are rarely studied.

Because human error has been implicated in 80% of aviation mishaps (deSant'Anna & deHilal, 2021; Erjavac et al., 2018; Kelly & Efthymiou, 2019), reliable and valid models (Wiegmann & Shappell, 2017; Chen et al., 2019; Lower et al., 2018), reporting sources (NASA, n.d.), and observation techniques (FAA, n.d.) have been developed. Partly due to these efforts, the mishap rate in commercial aviation has been steadily decreasing worldwide (ICAO, 2021). However, continued gains in aviation safety will require new approaches that expand the data stream to include all operations.

Fortunately, the gap in knowledge concerning routine pilot performance is beginning to be addressed with the development of new models, data sources, and observation techniques (Broderick, 2021; Holbrook et al., 2019; Kiernan, 2019; Kiernan, Cross, & Scharf, 2020). The intent of this paper is to continue that trend and open a discussion about how best to study positive human contributions to aviation safety.

Purpose

The purpose of this pilot study was to identify behaviors that increase system resilience in university Part 141 school certificated flight instructors (CFI; commonly referred to as instructor pilots) and to explore whether CFI behavior can be categorized according to resilience theory.

Background

Traditional perspectives on human performance have sought to reduce error and variability. These approaches have successfully reduced aviation mishaps due to human error. However, as aviation systems become more complex, with more dependencies between subsystems, the notion that an error or failure in a single subsystem is the locus of hazard and risk becomes more difficult to defend (Leveson, 2020). Instead, it is the interaction between elements of a complex sociotechnical system where hazards lie. These hazards are difficult to identify and mitigate with traditional risk management approaches (Leveson, 2020). Therefore, as a complement to these traditional approaches, the properties of systems that make them more resilient to disturbances should also be studied. The concept of resilience engineering helps clarify and articulate the mechanisms by which systems can withstand disturbances, whether those disturbances are errors or exogenous events that are difficult to predict.

Resilience Theory

Resilience refers to "the intrinsic ability of a system to adjust its functioning prior to, during, or following changes and disturbances, so that it can sustain required operations under both expected and unexpected conditions" (Hollnagel et al., 2011, p. xxxvi). The role of resilience theory is to form a safety system that is flexible and can accommodate both expected and unexpected operational challenges.

At its core, the model posits four essential abilities, shown in Figure 1 and explained below, through the example of an instructional flight on a summer afternoon:

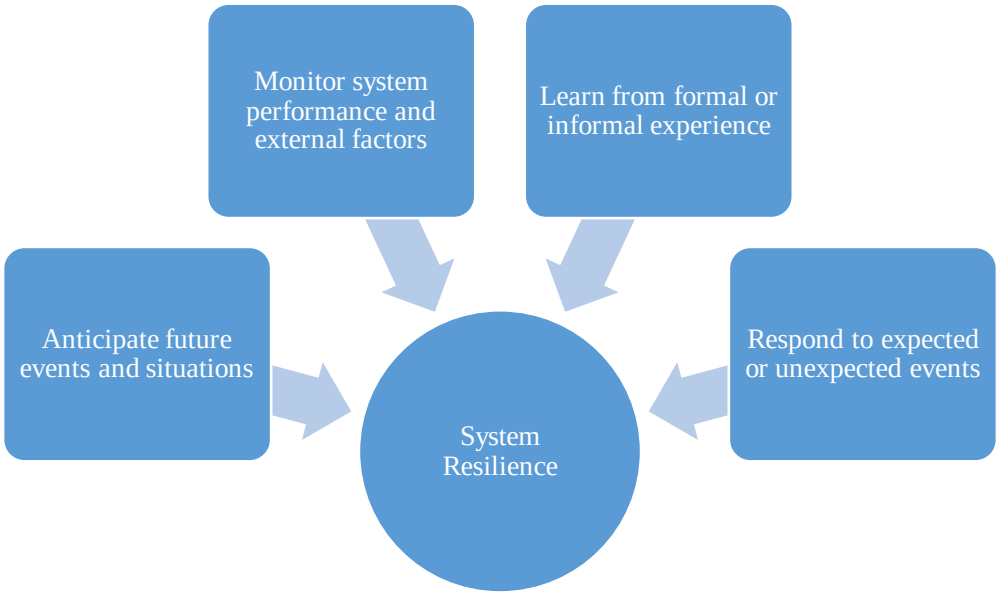
- The ability to anticipate future system states or events. A resilient system assesses its own adaptive capacity and whether or not it can meet upcoming challenges, and whether a sufficient buffer exists. A resilient system can shift priorities dynamically as the environment changes. Example: Knowing that weather can build rapidly in their area on summer afternoons, the instructor considers their own personal minimums and factors that into flight planning.

- The ability to monitor relevant indicators. A resilient system recognizes what needs to be known and uses objective, quantifiable, and available indicators to inform decision-making. For example, the instructor frequently checks home field weather during the flight.

- The ability to respond to disruptions or disturbances. A resilient system "must be both prepared, and prepared to be unprepared" (Hollnagel, 2011, p. 47). Inevitably, unanticipated circumstances will arise for which there is no template or procedure. The resilient system first recognizes these edge cases as beyond the boundary of what is expected and then combines readiness and creativity to meet the unexpected demands. For example: when the student suddenly gets airsick, the instructor accounts for both weather and unexpectedly flying single pilot with a sick crewmember.

- The ability to learn from success and failure. Learning in resilient systems can result from reinforcement of good decisions, not just from negative consequences of poor decisions. For example, the instructor learns that having a realistic plan of where to go if the weather closes in is an important preflight task.

Figure 1
Model of Resilient Performance (Hollnagel, 2011)



The defining drive of the resilience theory is anchoring models of successful behaviors by analyzing factors of human and system performance. It follows a logic similar to that of human behavior analysis, which analyzes and interprets not only errors and deformations but also successful patterns of cognition and information processing (Oster et al., 2013). Historically, models that are focused on analyzing accidents have typically been linear. They aim to prevent negative outcomes by identifying known factors that lead to mishaps. However, not all mishaps can be identified and understood through linear models. Such accidents are a result of a complex codependence of various events and factors that influence one another. Therefore, resilience theory provides a model that works through analyzing the accident causation and forming the ability to identify and accommodate the plausible due events (Hollnagel, 2011). Resilience theory provides a lens through which to analyze not just behaviors that lead to accidents but behaviors that improve the system's ability to withstand disturbances.

Examining human performance and its role in resilience is not without its critics. Leveson (2020b) points out that the safest systems are those which have taken a holistic approach to system safety, vice a narrow perspective that focuses solely on the operator. The intent of this research is not to deny the importance of the system within which CFIs operate, but rather to explore CFI behaviors that positively impact overall system resilience.

Data Sources and Observation Techniques for Studying Resilient Performance

Current data sources used in aviation safety include accident and incident investigations, the Aviation Safety Action Program (ASAP), the Aviation Safety Reporting System (ASRS), Line Operations Safety Audits (LOSA), and the Flight Operational Quality Assurance program (FOQA). Accident and incident investigations, ASAP, and ASRS generally collect data on

adverse events. LOSA collects data on routine operations, but within a framework of threat and error management. FOQA collects data on all routine operations.

In 2018, American Airlines and the Allied Pilots Association initiated a Learning Improvement Team (LIT) to develop methods to capture data on routine resilient performance (Jeffries et al., 2020). The team used two methods to collect data: a LOSA-style approach to categorize and quantify commercial pilot behaviors according to resilience theory, and "shop talk" conversations with line pilots. The LIT team produced an observation tool and trained observers to collect data on routine flights. To date, the team has collected observations on hundreds of flights, resulting in valuable insights into resilient performance in routine operations (Glavan et al., 2021). The shop talk conversations provided more insight into pilot reasoning than was possible with the observations alone.

The critical incident approach has been used to study unexpected events in routine operations among commercial airline pilots (Kiernan, Cross, & Scharf, 2020). While these approaches represent great advances in data collection for routine operations, widespread adoption of these data sources and exploration of their potential is still needed.

Problem

Aviation has tremendous data sources and robust models to study error, but insufficient ways to identify, categorize, discuss, and train success.

Importance of the Study

Understanding successful behaviors will contribute to system resilience, especially in flight training environments. As these behaviors can result in increased levels of safety, learning more about how positive behaviors contribute to system resilience can help training organizations, especially CFIs, create a culture of resilient performance and train positive outcomes.

Research Questions

Can university Part 141 CFI pilot behaviors be classified according to the four key attributes of resilient performance?

Can a taxonomy of resilient performance be articulated from investigating university Part 141 CFI pilot behaviors in routine operations?

Methodology

This project used a qualitative, case study approach based on incident debrief interviews with university Part 141 CFIs. A case study methodology was employed to examine the various aspects of the pilots' thought processes within the theory of resilient performance. From this case study, multiple perspectives were represented and analyzed, creating specific themes for the purpose of addressing the research questions.

The study was designed using a purposeful sample of 15 university Part 141 CFIs to glean their understandings and experiences regarding their decision-making processes in aviation. The case study method allowed the researchers a better understanding of CFI's thought processes within a resilient system.

Using research questions developed by NASA, we developed open-ended questions with follow-up questions to probe for deeper meaning (see Appendix A) (Holbrook et al., 2019). After receiving IRB approval, requests were sent to Part 141 CFIs. Every participant read and signed a confidentiality consent form and was assigned a code to ensure confidentiality.

The purpose of this qualitative research study was to explore the decision-making processes of CFIs within the theory of resilient performance. As a follow-on study of airline pilots' resiliency (Kiernan, Cross, & Scharf, 2020), this data is intended to support a foundational understanding of pilots' thought processes and behaviors within a resilient performance. As in any research, unintended or secondary findings, which are not the primary target of the planned procedures, can greatly contribute to the results of this study and, by proxy, that of the field. Further, understanding the thought processes in real-world situations was envisioned as a secondary function of this research.

The researchers voice-recorded each participant's discussion throughout the interview. A written transcript was developed for each participant after de-identifying each participant's information. Each of the participants' responses offered insight into their perceptions, opinions, and personal recommendations regarding the flight instruction environment. The MAXQDA qualitative analysis software was used to organize and analyze the data. The participants were identified as Participant 1 (P1), and so forth. Using the inductive approach to data analysis, the researchers then extracted key statements and phrases while organizing them into broad patterns that corresponded with the research questions and finally summarized what was being communicated within each statement. From this extraction, the researchers identified the primary themes.

While the researchers had specific interview questions that were asked during each of the semi-structured interview sessions, the interviewers allowed for the free flow of dialogue, which provided a broader set of information, yielding richer overall information than is presented in this discussion.

Limitations that could have been associated with the research study include whether the participants were available to be interviewed, the timing of the interviews, and that purposeful sampling was used.

Through the data collection process, the researchers were able to freely engage with the participants, which yielded additional unexpected findings. While not initially planned, the additional data provides a wealth of interpretive data to support the findings from the original structured research questions.

The data reduction process was helpful in further identifying these patterns and alignment to the research questions, and by proxy, the data aligned to the interview questions that support

the research questions. In the review of these themes, the above connections are drawn based on their similar responses and the interpretation of this data. What is important to be mindful of is that qualitative data analysis is ongoing, fluid, and in fact, sheds light on the broader study questions as indicated below.

Participants

Fifteen CFIs from three Part 141 universities were recruited for participation in this study. The saturation of the data was met through this number of participants by ensuring that adequate quality data was collected to support the study; no new information was expected to be added to the emerging patterns that would enhance or change the findings of this study. The three participating schools represent a diverse sample in terms of location, school size, CFI experience, and culture.

Results

Research Question One

The first research question aimed to ascertain whether university Part 141 certificated flight instructor behavior may be classified according to the four key attributes of resilient performance, namely, Anticipate, Monitor, Respond, and Learn. The main objective was to categorize pilot behaviors in terms of strategies for resilient performance. Eight themes were identified from the data. The coding process used in developing the main themes for the first research question is presented in Appendix B.

Anticipate

Two themes were identified with regard to pilots' behaviors of anticipating incidences, that is, *considering and preparing* and *taking action in anticipation.* These correspond to two distinct aspects of anticipation: on the one hand, thinking about what might happen in the future, and on the other hand, taking action based what might happen in the future.

Considering and Preparing. The theme outlines how different pilots predicted the imminent incident and postulated their resilience. The participants highlighted that anticipation of unexpected incidents prompted them to consider obtaining all essential information about it, holding discussions regarding appropriate actions, and deciding on the best steps to take. For instance, Participant 2 mentioned:

> However, I knew it was cloudy. So the entire time I was out there, I was kind of watching that, knowing what we're going to one of these next.

Similarly, Participant 6 explained,

> I mean clouds and stuff, especially here, I think I just, we talked thoroughly through it. We had a plan of action and then knew what we were going to do before that situation was to happen. So we talked about it before we even left.

Taking Action in Anticipation. The theme describes pilot behaviors relating to actions they take in response to anticipated events. From the interview responses, the participants

postulated that they knew of the imminent flight disruptions, and thus they engaged in precautious activities in their anticipation. For instance, Participant 9 explained:

> I knew that (this airport) was an uncontrolled airport and people, a lot of times, would do what they wanted there. Especially the skydive planes, they'll go up and then they'll land on an inactive runway that intersects with the runway that three other people are using. So I wanted to be very intentional about looking out for parachutists.

Similarly, Participant 7 shared an almost similar opinion as Participant 9 and explained:

> So, based on the run-up that we did, and the fact that it had come out of the necessary limits on our first try and we had to do the burn off procedure, which is part of our normal procedures, it kept me more alert to the fact that something might be going on here. So when we were actually going full power on the takeoff roll, I was watching for that. And I was checking for it continuously.

Monitor

The category includes behaviors by pilots to keep a check on situations that might occur during flight. Two themes emerged from the interview responses, namely, *routine monitoring* and *increased surveillance*.

Routine Monitoring. The interview responses revealed that pilots routinely monitor aspects like weather, aircraft information, and flight areas or traffic. For instance, Participant 7 stated:

> So, I did go through the records of the airplane, which we do before every flight.
> Similarly, Participant 11 posited a response that highlighted how pilots monitor flight areas like airports. The participant explained that.
> Well, going into an uncontrolled airport. There's always a possibility traffic is a little more relaxed and people are doing their own thing. So yeah, I chose to go to (that airport). So I knew that was going to be an issue. It's always an issue at uncontrolled airports.

Participant 8 also posited a similar response regarding monitoring various aspects but focused on the weather issues. The participant said:

> Well, it was a little bit cold. So I mean, from the cold, it takes a little while for the engine to just actually act properly.

Increased Surveillance. Furthermore, the participants' responses highlighted that pilots might engage in certain activities in the face of situations that may arise during flights, such as diversion and bad weather. For example, Participant 7 said:

> Well, again, I knew from the trends of the (location's) weather. And then once I was in the air, I started noticing when it was about to happen. I was like, "Oh God, it's building."

Respond

This category describes pilot behaviors with regard to actions taken in response to unexpected events or situations. Two themes came up when the participants were asked about how they responded to the imminent event. The themes include *discussing and deciding* and *taking action in response*.

Discussing and Deciding. The interview responses indicated that when an event occurs, the pilots discuss it, identify the alternatives involved, and then decide on an action to take is made. For instance, Participant 6 said:

> We talked about it coming in, getting ATIS and everything. I took flight controls. He got ATIS and all that. We talked about it and then I flew us back and then once we were established on everything and we got everything done, then I gave him back flight control and he landed and did all that. So I think we cut up or divided work, I guess, in that sense.

Similarly, Participant 5 said:

> I can count on them. It's not like, "Hey, just sit down, let me think." I know I can count on them. They can help me. We can delegate tasks to each other. And that was the one biggest thing I got out of it. Me working alongside in par with my student, not as a source of authority, but like, "Hey let's think through this. What do we do now?"

Taking Action in Response. From the interviews, it was found that pilots take various actions in response to unexpected events or situations. For instance, Participant 8 said that,

> So that was just, it's all part of the checklist in our flow. So when it does sound weird, we always would look at the cylinder head temperatures, if... Because it's more with the cylinder and also with our exhaust gas temperatures.

Learn

The category describes learning as an aspect of resilient performance among pilots. It was the most discussed attribute of resilience performance by pilots. Under this category, two subthemes emerged, that is, *formal learning* and *informal learning*.

Formal Learning. Most interviews posited similar responses regarding how formal training of pilots helps build up a resilient performance that they display when they face unexpected situations mid-air. For instance, Participant 11, in response to the question on how he knew what to do when he faced the unexpected event, said:

> Training. When, yeah, from my training, through my flight instructors, if there's an issue always go around, always get altitude, always avoid traffic the best way you can.

Similarly, Participant 2 revealed that pilot training has theoretical and practical skills. The participant said:

> There's taught skills and there's untaught skills. The skill of climbing out at Vy is kind of here a theory, we talk about Vy.

Informal Learning. The participants indicated that they also learn from their previous experiences or from others. Most of the interview responses indicated that pilots discuss what occurred during an unexpected event to learn from it. For instance, Participant 2 explained:

> (The instructors) sit around and they talk about the flight they were just on and in that conversation, it's more than just like very basic textual information, and just a conversation. You get the (pilot report), you get advice on a student, you get an experience that they learned or had today. Going back, students do the same thing in their dorm rooms.

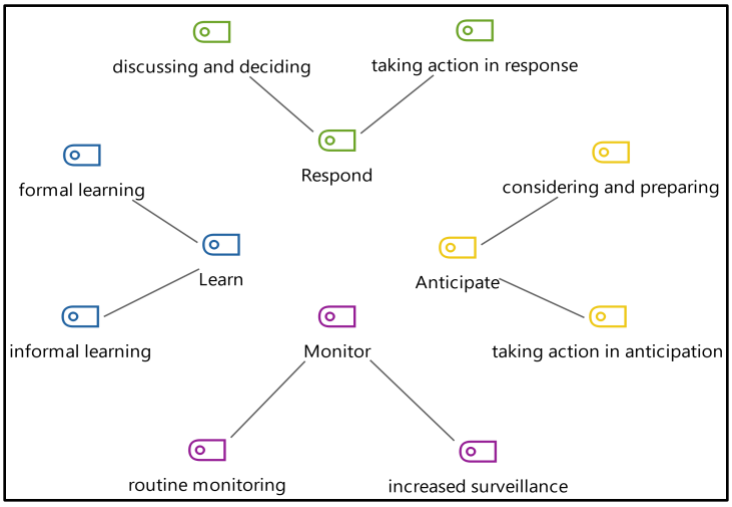
Based on the themes identified relating to the research question, the interviewees asserted that pilots inculcate resilient performance aspects in their behaviors in flight. The study found that anticipation, monitoring, learning, and responding enhance pilots' chances of safely and correctly responding to unexpected events. Besides, pilot training schools have procedures that promote the inculcation of resilient performance by pilots during flights.

Research Question Two

The second research question sought to ascertain whether a taxonomy of resilient performance can be articulated from an investigation of university Part 141 CFI behaviors in routine operations.

From the results obtained in research question one, it was possible to categorize behaviors in terms of strategies for resilient behavior, namely, anticipating, monitoring, responding, and learning. The model for the taxonomy of resilient performance is presented in Figure 2.

Figure 2
Taxonomy for Behaviors of Resilient Performance



However, as in our previous research (Kiernan et al., 2020) it was evident that some responses covered more than one aspect relating to resilient behaviors among pilots. For instance, Participant 5 explained:

> We know not to go into showers because it gets very bumpy. Like I told you earlier, a plane was brought down a month before that. So, I had historical records of what had happened that told me what to do. Also, just general flight training. Our flight training over here, they told you all the time, "Hey, be careful with this, be careful with that. In their weather classes, they tell you, with the thunderstorm, don't... Even if you're in a big…don't get in it. Stay clear of that. The planes are not made to fly through that." So I would say, overall, the training, and just historical records of what had happened, just work in conjunction to tell me what to do.

This response covered anticipation, learning, monitoring, and responding, making coding a challenge. The LIT team produced a validated taxonomy with mutually exclusive and collectively exhaustive categories for flight observations (Glavan, 2021). Because of the advantages of this taxonomy, we experimented with applying the LIT categories to the interview data, but as LIT focuses on observable behaviors, using the LIT categories resulted in data loss concerning attitudes and thought processes that are not relevant to LIT observations. Therefore, a categorization approach that incorporates both observable behaviors and the underlying attitudes and thought processes would be an important area for future research.

Enablers of Resilient Performance

Three factors that contribute to pilots' resilient performance were identified from the data, which include training, experience, and crew climate.

Training. The theme centers on the role that training plays in ensuring that a pilot displays resilient performance in the face of an unexpected event. The participants posited nearly identical responses regarding the *training* theme as an enabler of resilient performance among pilots. Multiple interview sessions revealed training as the aspect that guided one's response following an unexpected event. For instance, Participant 13 said:

> Based on my training, the instructor really taught me well and covered a lot of aspects of various different types of approaches.

Participant 6 also shared a similar response regarding the role that training plays in pilot's resilient performances. The participant said "I think my training prepared me."

Experience. The theme focuses on how pilots apply their experiences during routine airline operations. From the findings, pilots inculcate their professional expertise to raise their resilience when responding to an unintended event. Nearly all participants shared that their experience in the field drove their response to an unexpected event. For instance, Participant 10 said that "I guess correlating experiences to a new environment is the biggest thing I learned."

Similarly, Participant 5 explained:

> Because ATC alerted me coming in, like, "Hey, that wall of rain is moving in. Stop. Do something else." So, imagine it was an uncontrolled field, someone who didn't know, it would have been very easy to be like, "I can make it." And because I had that image very clear in my head of the runway, the wall of rain just moving down the runway perfectly. So, someone with no experience and not knowing what to do, it would have been very, very easy for them to just be like, "Hey, let's go for it."

Also, Participant 12 asserted:

> I wouldn't say it's common, but stuff like that has happened before or a lot of times, students will put their hands on the correct lever, but then say the wrong one.

Crew Climate. The theme focuses on how pilots' resilient performance is enhanced by the crew members' emotions and collective working strategies. Although not every instructor-student pair functioned as a crew, in the vast majority of cases the instructor and student worked together as a crew discussing options, formulating plans, and delegating tasks. The findings established that the crew climate and coordinative behaviors improve pilots' resilient performance. For instance, Participant 5 mentioned:

> Just because one is stressed, doesn't mean you have to go crazy. You have to keep your cool.

Additionally, Participant 1 posited a similar response and explained:

> We both saw that because the gauge was on the red straightaway. And yeah, that's what happened. We ended up following the appropriate checklist and it came back to normal.

The interview responses revealed that training, experience, and crew climate drive pilots' resilient performances when facing unexpected events. Moreover, resilient performance among pilots is enhanced when they include the above aspects in their behaviors.

Discussion

Anticipate

The pilots indicated that their resilient performance during routine flights was developed through their anticipation of events. The pilots showed that system resilience is increased by anticipating unexpected events, searching for all essential information, and discussing suitable actions and the best steps to take. Furthermore, the interviewees overwhelmingly showed that their resilient performance was enhanced by postulating that a flight disruption might occur, making them engage in preventive activities while anticipating it. The anticipate aspect of resilient performance reflected in the study fits well with the findings by Rankin et al. (2016). The authors asserted that pilots might adopt anticipation strategies that will enable them to counter being stuck or surprised by an unexpected event (Rankin et al., 2016).

The present study also revealed that a pilot's resilient performance is enhanced by considering that an unexpected event may occur and preparing ways to respond to it. The above

finding resonates with the assertion by da Silva and Nunes (2019). The scholars explained that resilience training entails using situation awareness techniques to teach pilots about anticipation (da Silva & Nunes, 2019). Situational awareness highlighted by da Silva and Nunes relates to the consideration and preparation actions that the interviewed pilots revealed to be necessary to anticipate an unexpected event in the present research. Similarly, Rankin et al. (2016) mentioned that anticipatory thinking helps pilots cope well with an unexpected event and enables them to avoid being caught in surprise by an event.

Monitor

In the interview responses, the pilots revealed that they enhance their resilience during flight operations by routinely monitoring the flight areas, airplane information, and weather. Besides, the respondents also demonstrated that pilots had enhanced surveillance as a monitoring strategy during flights. The pilots stated that an instructor needs to be vigilant towards the student's emotions to identify when to take the controls. The above findings on how pilots use the monitoring aspect to enhance their resilient performance correspond to the assertions by Rankin et al. (2016). According to Rankin et al., pilots may monitor their captain's cognitive demands, surroundings, and an aircraft's status and prepare to take complete control of the plane if the present situation requires it. Rankin et al. further explained that pilots might monitor an aircraft to ensure that they identify potential abnormalities and anticipate them earlier.

Respond

The response attribute was evident in the findings established in the present study. The pilots posited the significance of collaboration whereby the pilot trainers and their students discuss an unexpected event, identify alternatives, and decide on suitable action. Thus, the study indicates that team orientation is essential when responding to emergencies during flights. Additionally, taking action in response was also communicated by the pilots. The study showed that most pilots engage in different event-suitable actions in response to unexpected events. The above findings were also highlighted by Ohlander et al. (2019), who asserted that collaboration, where the flight team discusses how to respond to the event, enhances pilots' performances during stressful situations. Besides, the team orientation when pilots work together to respond to an unexpected event occurs because all on-board assume that they can trust anyone that has passed training and recruitment (Ohlander et al.).

Learn

The findings also revealed that training was a significant aspect of resilience performance whereby the pilots overwhelmingly highlighted that their formal and informal learning formed the basis for their decisions following an unexpected event during routine flights. The formal learning theme has been previously highlighted by da Silva and Nunes (2019). The researchers asserted that after aeronautical accidents, analysis of incidents occurrence enables pilots to learn from the mistakes and enhance successes of real unexpected situations. Similarly, Landman et al. (2017) also posited that when pilots are faced with an abnormal event during a flight simulation, they act based on previously learned mental knowledge structures. Therefore, pilots enhance

their resilient behaviors during unexpected events by using what they learn during formal and informal learning sessions.

Limitations

It is important to remember that for this research, only CFIs from university Part 141 flight schools were interviewed. Although Part 141 certification entails a high level of standardization, each university may further define their individual operations. These considerations may limit the generalizability of the findings beyond the specific sample.

Conclusion

The resilient performance theory is practically significant in the aviation sector. The purposefully sampled university Part 141 CFIs revealed that they had exhibited resilient performance in more ways than one during flights. The pilots understand how they benefit from anticipating, monitoring, responding, and learning aspects of resilient performance. The study's findings provide evidence of the positive impacts of their behaviors on resilient theory tenets and how their experiences positively influence other pilots around them. Therefore, the results of this study support the principles of resilience theory regarding its application in the aviation sector. From the findings, the categories of Anticipate, Monitor, Respond, and Learn were exhaustive, but not mutually exclusive. Thus, the tenets of resilience theory are initially validated but operationalizing a taxonomy will require more work.

Recommendations

Recommendations for Practice

The present study postulates adequate information regarding the significance of anticipating, monitor, responding, and learning tenets in enhancing university Part 141 CFI pilots' resilient performance. Thus, we make the recommendations below for practice in instructional settings. First, it is important to enhance pilots' knowledge of responding to unexpected events by creating a myriad of such situations and the appropriate response strategies to improve their resilience. Instructors can build in-ground training scenarios where students need to think through a situation, such as abnormal engine indications, unexpected weather, and equipment malfunction. This gives the student the opportunity to chair fly (practice on the ground) the thought process and resources available. Enhancing pilots' understanding of techniques for responding to unforeseen circumstances may make them more confident when handling unexpected events during flight.

Second, instructors should ensure that all resilient performances are noted. Capturing positive performance gives pilots an opportunity to reinforce correct thought processes. Often, people critique negative or incorrect applications, yet fail to reinforce the overwhelming part of the process that was done correctly. This is a great opportunity to correct faulty thoughts, but also praise and reinforce correct thought processes. Pilots may benefit from identifying the best course of action used to handle an unexpected event successfully. Besides, the knowledge of mistakes made by other pilots during an unexpected event may form the basis for pilots' decisions about what they need to avoid when faced with similar situations.

Finally, curriculum developers and flight training organizations should build in opportunities for "hangar flying," or the informal exchange of stories and experiences for students and instructors. While the majority of CFIs remarked that they learned a lot from the experiences they described, and they shared their stories and experiences with colleagues, none of them thought the events were important enough to file ASAP-style reports, even though they reported such avenues were available. This kind of informal training should be encouraged, as many CFIs also reported that they knew what to do as a result of such informal exchanges.

Recommendations for Future Research

Further research is recommended to develop a more robust taxonomy of resilient performance and behaviors, especially outside of the university Part 141 CFI environment, such as non-university Part 141 flight schools and Part 61 flight schools. Such an examination would enable instructors to understand how they can establish and encourage resilient performance among their students. Besides, the research will provide additional information to the existing literature on the human behaviors that enhance resilient performance among pilots. In comparing our results to the results of our previous study with airline pilots (Kiernan et al., 2020), we noticed that the quantity and variety of resilient behaviors seemed to differ between airline pilots and university Part 141 CFIs. This could be due to differences in the complexity of the operating environment, or to the increased experience level of the airline pilots. Further study of the effect of experience on the exhibition of resilient performance would be important.

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Appendices
Appendix A: Interview Guide

Initial Question: Unplanned and unexpected events happen routinely during operations in the NAS. We are interested in how pilots make adjustments before, during and after these unplanned or unexpected events in order to maintain safe operations. Can you tell me about a specific unplanned or unexpected event that you have experienced in the course of routine operations?

Follow-up Questions:

 Were there things you were aware of at the start of your flight that you thought increased the likelihood that this event might occur during that flight?
 How did you know that this event might occur?
 How else might you have been able to anticipate that this event would occur?
 Were there things that you experienced during that flight that you thought increased the likelihood that this event might occur?
 What signaled/indicated to you that this event was about to occur, was occurring, or had occurred?
 How did you know what indicators of this event to look for during your flight?
 What other indicators could have alerted you to this event?
 How did you respond to this event?
 How did you know what to do in response to this event?
 If you had not already known what to do to respond to this event, how would you have figured out what to do?
 What did you learn from this event?
 How did what you learned impact the remainder of your flight or that operation?
 How did what you learned impact how you prepare for future flights or operations?
 Have you shared what you learned with others in your organization? How did you do that?
 In general, what practices are in place in your organization for pilots to share lessons learned?
 Is there anything further you'd like for us to know about this event that we haven't already discussed?

Appendix B: Coding Table for Research Question One

Table 1

Codes, Interview Corroborations Used, and Themes

Categories	Codes	Interview Evidence	Themes
Anticipate	Pilots may consider the day's weather and prepare for the possible course of action in anticipation of an unintended event.	"However, I knew it was cloudy so the entire time I was out there, I was kind of watching that, knowing what we're going to one of these next."	Considering and preparing
	Considering the imminent problem and preparing the options for responding to it builds on resilient performance's anticipation aspect.	We called to (the ops desk), I asked the supervisor, and I was like, "Hey, what's going on?" Because he has way more tools than we have in a plane. He's like, "Yeah, it's building fast. You either have to come back or divert."	Considering and preparing
	Being cautious of an imminent problem in anticipation of it enhances resilient performance.	"I knew (that airport) was an uncontrolled airport and people, a lot of times, will do what they want there. Especially the skydive planes, they'll go up and then they'll land on an inactive runway that intersects with the runway that three other people are using. So I wanted to be very intentional about looking out for parachutists."	Taking Action in Anticipation
	Constantly checking for signs that a problem may occur enhances resilient performance among commercial pilots.	"So, based off of the run up that we did, and the fact that it had come out of the necessary limits on our first try and we had to do the burn off procedure, which is part of our normal procedures, it kept me more alert to the fact that something might be going on here. So when we were actually going full power on the takeoff roll, I was watching for that. And I was checking for it continuously."	Taking Action in Anticipation
Monitor	Pilots assess a plane's records before a flight commences as a routine procedure.	"So, I did go through the records of the airplane, which we do before every flight."	Routine Monitoring

	Routinely monitoring an airport enables pilots to be aware of what to expect in every different area.	“Well, going into an uncontrolled airport. There's always a possibility traffic is a little more relaxed and people are doing their own thing. So yeah, I chose to go to (that airport). So I knew that was going to be an issue. It's always an issue at uncontrolled airports.”	Routine Monitoring
	Routine monitoring of the weather enables pilots to predict a possible difference in how plane engines work.	“Well, it was a little bit cold. So I mean, from the cold, it takes a little bit while for the engine to just actually act properly.”	Routine Monitoring
	Monitoring is used to increase surveillance of the weather and make appropriate decisions pending harsh conditions.	Well, again, I knew from the trends of the Florida weather. And then once I was in the air, I started noticing when it was about to happen. I was like, "Oh God, it's building."	Increased Surveillance
	Monitoring enhances pilot trainer's surveillance of their student's reactions and aid in identifying when it is appropriate to take control of the plane from them.	“My student pointed out, "Hey, look at (that airport). It's clear." I'm like, "Awesome." So doing the approach, let's go into (that airport) this time. He shot the approach. Again, I think it's all the storms. They just have down bursts all the time. And he started getting hit pretty badly. And he got uncomfortable, I was getting a little bit uncomfortable. I was like, "Okay, I have the flight control. I took the plane from him at that point. I took the plane, flew around.”	Increased Surveillance
Respond	Discussing and deciding enables pilots to respond to unexpected events well.	“We talked about it coming in, getting ATIS and everything. I took flight controls. He got ATIS and all that. We talked about it and then I flew us back and then once we were established on everything and we got everything done, then I gave	Discussing and Deciding

		him back flight control and he landed and did all that. So I think we cut up or divided work, I guess, in that sense."	
	Discussing and deciding enhances task delegation and togetherness among pilots during flights.	"I can count on them. It's not like, "Hey, just sit down, let me think." I know I can count on them. They can help me. We can delegate tasks with each other. And that was the one biggest thing I got out of it. Me working alongside in par with my student, not as a source of authority, but like, "Hey let's think through this. What do we do now?"	Discussing and Deciding
	Pilots use the appropriate procedures to determine the action they take in response to an unexpected event.	"So that was just, it's all part of the checklist in our flow. So when it does sound weird, we always would look at the cylinder head temperatures, if... Because it's more with the cylinder and also with our exhaust gas temperatures."	Taking Action in Response
Learn	Formal training guides pilots' behavior when a challenge faces them during flights.	"Training. When, yeah, from my training, through my flight instructors, if there's an issue always go around, always get altitude, always avoid traffic the best way you can."	Formal Learning
	Formal learning teaches both practical and theoretical skills among pilots.	"There's taught skills and there's untaught skills. The skill of climb at VY is kind of here at theory, we talk about VY."	Formal Learning
	Pilots may display resilient performance due to what they learn informally via conversing with other scholars on their flight experiences.	"(The instructors) sit around and they talk about the flight they were just on and in that conversation it's more than just very basic textual information and just a conversation. You get the pilot, you get advice on a student, you get an experience that they learned or had today. Going back students do the same thing in their dorm rooms."	Informal Learning
	Pilots trade stories about experiences that	I've shared the story with some of my flight instructor friends, but it's	Informal Learning

	they consider interesting enough to convey in informal settings, but not 'important' enough to make a formal report.	not like I've stood up and spoken in front of a panel.	

Appendix B: Coding Table for Additional Themes

Table 2

Codes, Interview Corroborations Used, and Themes

Categories	Codes	Interview Evidence	Themes
Enablers of resilient performance	Training may enable a pilot's resilient performance.	"Based on my training instructor really taught me well and covered a lot of aspects of various different types of approaches."	Training
	Pilot training prepares pilots on how to behave when faced with a challenge during flights.	"I think my training prepared me."	Training
	Pilot experiences help them to respond well even in new flight environments.	"I guess correlating experiences to a new environment is the biggest thing I learned."	Experience
	A pilot's experience determines how they act if a flight problem arises.	"Because ATC alerted me coming in, like, "Hey, that wall of rain is moving in. Stop. Do something else." So, imagine it was an uncontrolled field, someone who didn't know, it would have been very easy to be like, "I can make it." And because I had that image very clear in my head of the runway, the wall of rain just moving down the runway perfectly. So, someone with no experience and not knowing what to do, it would have been very, very easy for them to just be like, "Hey, let's go for it."	Experience
	Pilot trainers' experiences build their resilient performance. It shapes how they respond to situations due to their experiences with students.	"I wouldn't say it's common, but stuff like that has happened before or a lot of times, students will put their hands on the correct lever, but then say the wrong..."	

	Pilots enhance their resilient performance by managing their emotions when they are faced with a challenge.	"Just because one is stressed, doesn't mean you have to go crazy. You have to keep your cool".	Crew climate
	Togetherness among pilots enhances their resilient performance.	"We both saw that because the gauge was on the red straightaway. And yeah, that's what happened. We ended up following the appropriate checklist and it came back to normal."	
Categories that are not mutually exclusive	Pilots' action in anticipation, monitoring, responding, and learning from an unexpected event enhances their resilient performance.	"First, trends of what has happened before. We know not to go into showers because it gets very bumpy. Like I told you earlier, a plane was brought down a month before that. So, I had historical records of what had happened that told me what to do. Also, just general flight training. Our flight training over here, they told you all the time, "Hey, be careful with this, be careful with that. In their weather classes, they tell you, with the thunderstorm, don't... Even if you're in a big, even if you were [inaudible 00:06:59], don't get in it. Stay clear of that. The planes are not made to fly through that." So I would say, overall, the training, and just historical records of what had happened, just work in conjunction to tell me what to do."	