Correlating Boredom Proneness and Automation Complacency in Modern Airline Pilots

Hemant Bhana
University of North Dakota

ABSTRACT

The research project determined whether boredom proneness and self-assessed boredom affect automation complacency in modern airline pilots. Modern transport category aircraft are increasing in automation sophistication. This paradigm shift is seeing pilots relegated to automation supervisory or monitoring roles instead of active participants in the flight. An unintended consequence is the potential for increased boredom. The study examines whether pilots who are more prone to boredom make a greater amount of automation complacency related mistakes. A sample of active professional airline pilots at a major airline in the United States completed an on-line survey (N=273). The survey incorporated four parts. The first segment collected general demographic data. The second portion administered the BPS, or Boredom Proneness Test (Farmer & Sundberg, 1986). The third segment administered the Pilot Automation Complacency Practices Scale, created by the author. Finally, the last portion queried the subject's self-assessed boredom level, and automation philosophy. The survey included numerous free comment sections for pilots to add information not specifically queried. Pearson Correlation Coefficients confirmed that boredom proneness does affect automation complacency in the sample. The BPS exhibited good validity with the self-assessment of boredom (r=.499, p=0.01). Boredom and boredom proneness also adversely affect attention span in airline pilots. The research is applicable to highly automated environments conducive to boredom where monitoring and supervision is required.

INTRODUCTION

Automation "…refers to systems or methods in which many of the processes of production are automatically performed or controlled by autonomous machines or electronic devices" (Billings, 1997, p. 6-7). Automation is silently prevalent in almost all aspects of daily life, all of which require different levels of monitoring. For example, pushing a requested floor in an elevator starts a complex process where the automated system delivers the elevator car to the desired floor and opens the doors when appropriate – all done silently to the user.

Aircraft automation is different in that it requires a high degree of monitoring by the user due to its dynamic nature (Billings, 1997). Sheridan and Parasuraman (2006) define eight levels of automation ranging from where the human operator must do everything to where the computer does everything, ignoring the human. The intermediate levels are most applicable to modern aviation, specifically the level where the automation "…executes the suggestion automatically, then necessarily informs the human" (p. 94). This rubric tasks the human operator, in aviation's case the pilot, with evaluating the computed suggestion and either stopping the automation or allowing it to continue. The pilot is now required to provide mostly supervisory control over the automation versus manually computing functions such as vertical and lateral navigation. This has effectively transformed the nature of the work an airline pilot performs from one where the pilot is an active participant in controlling the aircraft to one where the pilot is an overseer of the automation.

AUTOMATION COMPLACENCY

Automation complacency results when the operator over-relies or excessively trusts the automation and fails to exercise his or her vigilance or supervisory duties (Parasuraman & Riley, 1997). Alternatively stated, "Pilots may become complacent because they are overconfident in and uncritical of automation, and fail to exercise appropriate vigilance, sometimes to the extent of abdicating responsibility to it [which can] lead to unsafe conditions" (Research Integrations, 2007). The NASA Aviation Safety Reporting System (ASRS) publication Callback defines complacency throughout multiple issues as "…the state of self-satisfaction that is often coupled with unawareness of impending trouble" (Aviation Safety Reporting System, 2009). The definitions quoted clearly imply that complacency occurs when the automation supervisor is unaware of the current or impending actions of his or her respective machine, sometimes with tragic results.

One of the first studies of automation complacency tested subjects in a multi-task environment very similar to a modern aircraft flight deck (Parasuraman, Molloy, & Singh, 1993). The authors hypothesized that complacency is most evident when pilots are performing concurrent tasks such as simultaneously managing and monitoring the automation. They argued that the two most important elements of an automated system, its reliability and consistency, most directly influence how the operator is able to detect and respond to failures. The increased workload nature of the experiment is significant, since some cognitive scientists have argued complacency is a method of coping with the increase in workload (Elin Bahner, Huper, & Manzey, 2008). If the operator perceives the automation to be consistent and reliable, then he or she needs to allocate fewer cognitive resources to the monitoring aspect. Important to note is the workload threshold required for complacency is subjective, and varies between operators. How each operator perceives his or her individual cognitive load determines both the response strategy and how he or she allocates mental resources to cope with the situation (Prinzel, DeVries, Freeman, & Milulka, 2001).

Trust

A key element to the issue of complacency is operator trust. This construct allows the user to reallocate attention resources away from the close monitoring duties toward other activities by simply "trusting" the automation performs correctly. Unfortunately, an unwanted side effect is the decreased chances of detecting an automation abnormality. A good definition of trust is "…the attitude that…will help achieve an individual's goals in a situation characterized by uncertainty and vulnerability" (Lee & See, 2004, p. 54). According to this definition, the amount of trust guides the level of automation usage when the complexity or uncertainties of the situation make a complete understanding of the nuances of automation impractical. One factor affecting an operator's trust in an automated system is the perceived reliability of the system in question (Prinzel, DeVries, Freeman, & Milulka, 2001; Lee & See, 2004; Bailey & Scerbo, 2008).

Reliability

High levels of automation reliability and consistency tend to impart greater levels of trust in the operator, which he or she can then use as a coping mechanism. Rather than continue with the task of monitoring the automation, automation users can make assumptions on what the machine will do and concentrate on other duties. To prove this concept, Bailey et al. (2008) gave their subjects a flight task on a desktop simulator while simultaneously monitoring several displays for a single failure. The researchers repeated their experiment several times with the failure occurring in different places. Their results suggested that as the subjects gained experience with the overall system, their monitoring performance decreased at a level directly related to the level of familiarity and trust they had in the system. The researchers manipulated the system reliability, thus altering the amount of trust each operator had in the predictability of the machine. From this data, they could prove a direct relationship between the levels of trust and degraded monitoring performance. This is congruent with Lee and See, (2004), who also found that trust is directly responsible for monitoring level and operator oversight.

Risk

Along with perceived reliability, one of the major factors in determining the level of trust an operator places in the machinery is the risk involved with a particular action (Riley, 1996; Lee & See, 2004). The consequence of an action or inaction directly influences how much emphasis the operator places on the vigilance task associated with proper automation monitoring. Operators conducting a task with greater risk will monitor the automation with greater accuracy regardless of how much confidence or trust they have in the system. Riley (1996) identified this construct as a shortcoming of research on automation complacency. Previous research on complacency involved subjects performing automation monitoring tasks on static simulators where the consequences of a complacency error are extremely low. Riley (1996) argued that this research may not be indicative of "real world" applications since errors of omission and commission are often related to the seriousness of the potential outcomes. The introduction of risk may generate a new set of biases and emphasis points that directly affect a monitoring task.

Vigilance

The term vigilance commonly refers to the ability of an individual to maintain his or her attention for long and uninterrupted periods (Sawin & Scerbo, 1995). This ability is particularly important given the "monitoring" aspect to a pilot's job. Since automation now manages an increasing number of functions during a flight, vigilance becomes important at detecting subtle mode changes. Bailey et al. (2008) determined that vigilance performance varied directly with the complexity of the task. The more complex the task is, the greater the amount of monitoring errors they found in their sample, once again suggesting that the trust and reliance constructs are coping mechanisms. The more cognitively demanding a task is, the more the user is likely to "load shed" and assume the correct action of the automation rather than use resources to monitor it. More importantly, the vigilance performance decreased even more if the inflection or change was subtle.

Conventional theories by psychologists regarding reasons why vigilance performance decreases have centered on the monotonous nature of the activity. The monotony supposedly lulled the operator into a decreased state of vigilance through a lack of stimulation. However, new research has offered alternate theories for the performance decrement, instead arguing that vigilance is a demanding task associated with high levels of stress and concentration and not related to monotony (Sawin & Scerbo, 1995; Warm, Parasuraman, & Matthews, 2008). The reasons for this are complex. Typically, the research has found that the need to maintain high levels of vigilance for extended periods substantially increases the operator's workload by increasing the amount of stress (Hancock & Warm, 1989). In addition, a perceived lack of control over future events magnifies the stress factor in vigilance tasks. As the vigilance task extends, the stress and perceived lack of control tend to deplete cognitive resources and contribute to a feeling of dissatisfaction (Warm, Dember, & Hancock, 1996). The stress results in what cognitive scientists call the performance decrement, where vigilance performance in high workload situations can decrease rapidly from around five minutes of the onset of the task and stabilizes at a significantly lower level within 25 to 30 minutes (Warm, Parasuraman, & Matthews, 2008).

One of the factors that directly affect vigilance performance is boredom (Sawin & Scerbo, 1995; Kass, Vodanovich, Stanny, & Taylor, 2001). Kass et al. (2001) found that subjects with high scores on the Boredom Proneness Scale (discussed later in the review) experienced a performance decrement much sooner than less boredom prone subjects. They attributed this finding to the monotonous and under stimulating nature involved in vigilance tasks – concepts that directly contribute to boredom (Sawin & Scerbo, 1995). In summary, the performance decrement found in vigilance tasks is attributable to the stressful nature of the task itself, while the speed of onset depends on how prone to boredom a person is.

Boredom

Psychologists commonly define boredom "…as a state of low arousal and dissatisfaction attributed to an inadequately stimulating situation" (Mikulas & Vodanovich, 1993). Another definition adds the concepts of interest and attention. Fisher (1993) defined boredom as "…an unpleasant, transient affective state in which the individual feels a pervasive lack of interest in and difficulty concentrating on the current activity" (p. 396). The term "state" refers to a transitory period of consciousness that affects how a person views the world around them. For example, a person in a situation that meets the requirements posited by Mikulas et al. (1993) and Fisher (1993) of low arousal, dissatisfaction, inadequate stimulation, lack of interest, and difficulty concentrating may experience boredom. Due to its transitory nature, the "state" of boredom may be temporary. Boredom proneness, by contrast, is a trait referring to the propensity of an individual to become bored (Farmer & Sundberg, 1986). Individuals who are more prone to boredom may need lower arousal, dissatisfaction, and stimulation thresholds to experience the state of boredom than a person who is not as prone to boredom.

Theories on how people respond to arousal suggest individuals will seek out ways to cope with various stimulation levels in order to maintain the optimum arousal level (Mikulas & Vodanovich, 1993). If a person is in a situation with low arousal resulting in boredom, he or she is likely to seek ways to increase the arousal and avoid the boredom (Fisher, 1993). The perceived complexity of a particular situation is an important concept in this equation since people respond to stress and arousal according to their abilities. What may be an uncomplicated situation for one person may be extremely complex for another. Thus, boredom in individuals results in part from situations whose complexity is too low for that specific individual resulting in below optimum arousal levels (Mikulas & Vodanovich, 1993).

The second element of the definition, dissatisfaction, refers to an individual's perception of the action. For a person to be in a state of boredom, he or she must not enjoy the particular situation they are in (O'Hanlon, 1981). O'Hanlon (1981) reasoned the cause of this dissatisfaction is a person's "…aversion to monotonous elements of the situation [that are]…the source of the feeling" (p. 54). People have a natural aversion to monotony, which causes a person to feel dissatisfied with his or her current situation. O'Hanlon (1981) found boredom and job dissatisfaction strongly related.

The final component of the definition deals with inadequately stimulating situations. This concept is unique to each individual and depends on the individual's perception of the task, including any prior experiences with performing that task. O'Hanlon (1981) posited that monotony might be a driving factor in a person being bored. His work described the onset of boredom arriving within minutes especially if the person is engaged in a repetitive activity that he or she has done extensively in the past. Repetitive activities lose their complexity after continuous practice and fail to provide the level of arousal necessary to be stimulating. Research on job tenure found employees with longer tenure experienced greater boredom (Drory, 1982; Kass, Vodanovich, & Callender, 2001). Drory (1982) experimented on long haul truck drivers, and found significantly increased levels of boredom in drivers who had driven the same route repetitively. Kass et al. (2001) summed up the concept when they wrote "…repeated exposure to the same stimuli (e.g., job tasks) leads to lower levels of arousal, which results in less satisfaction and greater boredom" (p. 324). Therefore, for a person to stave off boredom there needs to be a source of stimulation either from the current environment or from somewhere else.

The etiology of boredom can be isolated into five factors. In work environments, the most common factors are the need for stimulation from external sources and stimulation through internal methods (Vodanovich & Kass, 1990; Vodanovich, Craig, & J, 2005). External stimulation refers to the perceived need for novelty, excitement, and variety from external sources and may explain why men and extroverts are more prone to boredom (Vodanovich & Kass, 1990; Vodanovich, Weddle, & Piotrowski, 1997;

Gosline, 2007). The other major factor, internal stimulation, deals with methods to keep oneself interested and entertained through internal mediums. Subjects who are dependent on internal stimulation need to be proficient at concentrating on and maintaining self-created tasks and often possess better absorption and self-awareness levels (Seib & Vodanovich, 1998). These elements are often associated with introverted people who require fewer outside stimuli to stave off boredom (Gosline, 2007). Research on working conditions suggest extroverted individuals who are more prone to boredom are best suited for opportunities that offer external and tangible rewards, while introverted people who are less prone to boredom are better suited to positions that offer intrinsic rewards (Vodanovich, Weddle, & Piotrowski, 1997).

Perhaps the best method of quantifying boredom for research purposes is by measuring an individual's proneness to boredom, that in turn can help predict a number of personality constructs a person is likely to experience (Farmer & Sundberg, 1986; Vodanovich, 2003). The most widely used tool is the Boredom Proneness Scale (BPS) by Farmer and Sundberg (1986), which is a full scale measure of the boredom construct. Other boredom indicators tend to analyze only specific aspects to boredom such as job boredom, or are subscales of larger boredom scales (Vodanovich, 2003). The BPS showed satisfactory internal consistency (α=.79, N=233) and good test-retest reliability (r=.83) after one week, with greater stability demonstrated by females (r=.88) than by males (r=.74) (Farmer & Sundberg, 1986). The original test employed a true/false format that some researchers began changing to a 7-point Likert scale to increase the measurement sensitivity (Vodanovich & Kass, 1990).

Boredom Proneness Factors

The work by Vodanovich et al. (1990) is particularly significant since it established a factor structure within the BPS scale allowing researchers to isolate what dimension is causing the boredom. In addition to the two major factors listed earlier, External and Internal Stimulation, Vodanovich et al. (1990) found evidence of three more factors: Affective Responses, which deal with emotional reactions to boredom; Perception of Time, dealing with issues associated with the coping and conceptualizing of time; and finally Constraint, which addressed individual reactions to waiting such as restlessness or patience. Other researchers have found similar factors incorporated in the BPS (see Vodanovich, 2003, for a review). However, the consensus amongst the literature finds the two most common and dominant factors are the need for External Stimulation and Internal Stimulation (Vodanovich & Kass, 1990; Vodanovich, Weddle, & Piotrowski, 1997; Gordon, Wilkinson, McGown, & Javanoska, 1997; Vodanovich, Craig, & J, 2005).

State versus Trait Boredom

Research examining a correlation between trait and state boredom has centered on measuring job satisfaction metrics (Kass, Vodanovich, & Callender, 2001) and by correlating the BPS with other job boredom scales that measure state boredom (Farmer & Sundberg, 1986). Some of the strongest evidence for the trait versus state link in boredom comes from the research on boredom and vigilance by Sawin et al (1995). In their study, the researchers administered the BPS and other psychometric tests measuring state boredom to their subjects, about to undergo a vigilance test on a desktop simulator. Their results suggest the BPS is a good indicator of vigilance performance. The test significantly correlated with state boredom measures providing "…evidence for the long-sought, elusive link between trait boredom and performance in vigilance" (p. 763). Research examining a link between state and trait boredom has involved correlating boredom proneness (trait boredom) in individuals with job boredom at work (state boredom). The results by Sawin et al. (1995) are significant in that they permit utilization of the BPS in measures that examine how state boredom affects automation complacency issues. The BPS scores "…reflect the propensity to become bored as a result of completing a monotonous and under stimulating task" (Sawin & Scerbo, 1995, p. 763).

Boredom and Cognitive Failure

Research completed by Wallace, Vodanovich, and Restino, (2003) examined a possible association with boredom proneness as measured by the BPS to cognitive failure. Their sample used a combination of military personnel and undergraduate students to whom the researchers administered the BPS and the Cognitive Failures Questionnaire (CFQ). The overall results demonstrated that "…boredom proneness scores were found to be significant predictors of cognitive failures" (p. 641). However, examining the results in detail found the factor most applicable to aviation in the CFQ questionnaire is distractibility (perceptions on divided attention tasks), since pilots often deal with multiple tasks when monitoring and supervising the automation (Parasuraman, Molloy, & Singh, 1993). Wallace et al. (2003) found that subjects scoring high on the affective and time subscales of the BPS correlated the highest to the distractibility subscale of the CFQ ($r=0.52$ and 0.53 respectively, $p<0.001$). This finding suggests that subjects who have an emotional reaction to boredom and who cannot properly cope with extended time passing will experience greater cognitive failures during multiple tasks.

Work on boredom and attention continued with Cheyne, Carriere, and Smilek, (2006). In this study, the researchers postulated that the inability to engage in and sustain attention is caused by boredom. This argument parallels the definition of boredom by Fisher (1993), when she proposed that part of the effect of boredom is a lack of interest and a difficulty in concentrating. Cheyne et al. (2006) found that their subjects who were more prone to memory failures and attention lapses also scored high on the BPS. Their conceptual model showed statistically significant and positive correlations between boredom proneness and attention disorders ($r=.33$, $p<0.01$) along with depression ($r=.18$, $p<0.01$).

Coping with Boredom

Coping with boredom, particularly in the workplace setting, involves two general strategies (Fisher, 1993). The first requires refocusing attention on the task and the second involves seeking additional stimulation. Refocusing attention on a task involves subjects forcing themselves to pay attention regardless of how they feel about it. This is particularly true if the task carries an element of risk similar to the way risk affects monitoring and vigilance performance. Another coping strategy for task refocusing involves goal setting and working toward the final result by emphasizing specific steps. This technique is congruent with the findings by Shernoff, Csikszentmihalyi, Schneider, & Shernoff, (2003), who posited that achieving flow (the area when attention, focus, and absorption are effortless and come without much conscious thought) best occurs when the goals and tasks are within a person's skills and abilities.

The other method for coping with boredom is to seek out additional stimulation either from the current task or by changing activities. Seeking additional stimulation from the current task particularly during monotonous tasks often involves "subsidiary behaviors," or actions in addition to the requisite tasks to increase the level of stimulation (Kishida, 1977). These behaviors included actions such as daydreaming, talking to colleagues, playing mental games, fidgeting, and looking around. While some of these behaviors reduced the monitoring performance slightly, they proved effective in reducing boredom slightly (Kishida, 1977). Finally, another coping mechanism involved changing activities by engaging in things such as reading and other non-work related activities (chatting, etc.). These results indicate individuals will undertake additional activities to bring their individual workload to an optimum level consistent with their abilities (Shernoff, Csikszentmihalyi, Schneider, & Shernoff, 2003).

METHOD

The study utilized pilots employed by a major airline (as measured by revenue) in the United States. Each pilot was either a Captain or First Officer, and was experienced in a highly automated aircraft due to the nature of the airline's hiring practices and fleet make-up. Three hundred and one (301) subjects started the survey with 273 completing it, representing roughly 4.5% of the total pilot population at this specific airline. The sample yielded an error rate of 5.8% at a 95% confidence level. All participants voluntarily donated their time and expertise and were uncompensated for their efforts. Participants were under no time limits to complete the survey and could access the survey-related internet pages from a location of their choice.

The study recruited the sample subjects through posters placed on pilot domicile bulletin boards and through a recruitment message inserted in a "blast" e-mail sent to all pilots from the union representing them. Both the poster and e-mail message directed participants to a web site containing generalized information about the study along with a hyperlink to the survey.

The study utilized a 4-part survey consisting of 55 questions to measure both quantitatively and qualitatively, the dependent variables. The first portion of the survey requested general demographic information such as age and experience. The second portion administered the Boredom Proneness Scale (BPS) by Farmer and Sundberg (used with permission). The third portion administered the Pilot Automation Complacency Practices Scale (PACPS) created by the author. Finally, the survey ended by measuring some general attitudes toward automation. Survey respondents had several opportunities to insert free text regarding their individual practices or feelings toward automation.

Pilot Automation Complacency Practices Scale (PACPS)

The author-created PACPS derived its information from an examination of NASA Aviation Safety Reporting System (ASRS) data from a ten-year period ending in January 2009. The search criteria focused only on anomaly reports from Part 121 operations where the causal factor was flight crew human performance and contained variations of the terms FMC/FMS, automation, and complacency. The search criteria revealed 562 records. Since the ASRS program is voluntary and done primarily for immunity against certificate enforcement, the number of reports is under-representative of the actual number of events. A pilot may have had a complacency related event, but may not report it if no infraction occurred.

Automation complacency is a term interchangeable with automation overconfidence, and is broadly described as pilots "…becom[ing] complacent because they are overconfident in and uncritical of automation, and fail to exercise appropriate vigilance, sometimes to the extent of abdicating responsibility to it" (Research Integrations, 2007). Examining the evidence derived from the ASRS reports allows a factorial approach to the issue and reveals four subcategories pertaining to the causes of the broad issue of pilot automation complacency. They are:

1. Pilots fail to notice the automation mode or autopilot state after an FMS reprogram or other distracting event (Distraction Complacency).
2. Pilots do not crosscheck the automation for the correct restrictions, route, or information (Crosscheck Complacency).
3. Pilots fail to monitor the automation to ensure it is behaving as expected or required (Monitoring Complacency).
4. Pilots are using the automation, or relying on automation flight guidance, instead of exercising manual pilot skills or abilities (Automation Over-Reliance Complacency).

A panel of industry and academic experts reviewed the PACPS to ensure proper content validity, along with its efficacy in measuring the automation complacency concept. All of the behavioral questions on the scale originated from frequently observed actual flight crew experiences as reported to the NASA ASRS system. Thus, the scale is indicative of the "real world" practices and scenarios experienced by pilots in the course of their daily duties. The survey included questions assessing the participants' self-assessment to their boredom level during the majority of their flights (state boredom) along with questions regarding boredom coping mechanisms. Additional questions queried individual automation practices and philosophies. Finally, the survey ended with a qualitative open-ended question asking about general attitudes toward the overall topic.

Data Analysis

The Pearson correlation coefficient was the primary statistical tool used to analyze the results, looking for significant associations at both the 0.01 and 0.05 alpha levels (2-tailed). This allowed for a comprehensive cross referencing of all the variables and enabled identification of significant correlations between multiple dimensions of both the BPS and the PACPS. A phenomenological study type analyzed the free comments section of the survey regarding automation coping strategies, boredom coping strategies, and general comments.

Limitations

One of the problems inherent in surveys of this nature is the reliance on self-assessment. To counter this, survey question construction emphasized reporting of the deliberateness of a particular action (How often do you *deliberately…*). Finally, the study used participants of only one particular major airline, all of whom graduated from the same training facility.

RESULTS

Of the 273 survey respondents, 87.8% were male. The majority (54.4%) fell between the ages of 41-50 years old, with the next highest group between the ages of 51-60 years old (28.2%). Examining flying operations found 64.3% flew narrow-body aircraft in domestic operations while 35.7% flew wide-body aircraft in the international realm. Finally, 54.5% had flown their respective airplane for greater than four years. The next highest group (22.3%) had flown their airplane between 2 to 4 years. The aircraft longevity groups of one to two years and less than one year comprised 9.9% and 13.4% of the sample respectively.

Table 1 summarizes the correlations between boredom proneness factors and automation complacency related factors. Of note are the correlations between internal stimulation and automation over-reliance, suggesting that pilots who are better able to find stimulation from internal sources are less likely to commit an automation complacency related behavior. Conversely, pilots who have an emotional reaction to boredom (as measured by the affective scale on the BPS) are more likely to commit an automation complacency related action. This data point suggests that the pilots who score higher on the affective scale of the BPS have not developed adequate coping mechanisms for their boredom, and subsequently react emotionally to their situation. Table 1 only displays significant correlations at the p=0.05 or less levels. Correlations displayed in bold are significant to the p=0.01 level.

Table 1: *Boredom Proneness Factors and Automation Complacency*

		Boredom Proneness Factors (from the BPS)					
		External	Internal	Affective	Time	Constraint	Total
Automation Complacency (from the PACPS)	Distraction			**.198**	.125		.120
	Crosscheck	.132		**.279**	**.219**	.140	**.187**
	Monitoring	.146		**.196**	.125		.127
	Automation Over Reliance	.137	**-.211**	**.175**	**.214**		
	Total	**.167**	-.138	**.291**	**.219**		**.181**

The Boredom Proneness Scale exhibited good validity with the self-assessment of state boredom in the survey (r=.499, p=0.01) and is consistent with other correlations of trait and state boredom (Farmer & Sundberg, 1986; Kass, Vodanovich, & Callender, 2001). The BPS dimension regarding internal stimulation correlated negatively (p=-0.190, p=0.01) with attention lapses suggesting pilots who can find stimulation from internal sources experience fewer self-reported attention lapses.

The self-assessment of state boredom when correlated to the BPS factors indicated several significant correlations and summarized in Table 2. The data suggests that, in an airline environment, pilots who have an emotional reaction to boredom (the Affective scale), problems conceptualizing time (the Time scale), or require external sources of stimulation (the External scale) are considerably more likely to experience boredom than those who can find internal sources of stimulation (the Internal scale). The BPS factor of constraint (individual reactions to waiting such as restlessness and patience) was not statistically significant. All correlations in Table 2 are significant to the p=0.01 level.

Table 2: *Boredom Proneness Factors and Self-assessed Boredom*

	Boredom Proneness Factors (from the Boredom Proneness Scale, or BPS)				
	External	Internal	Affective	Time	Constraint
Self-assessed Boredom	**.470**	**-.255**	**.489**	**.452**	

Finally, the data in Table 3 indicates pilots are much more likely to commit an automation complacency related action and have an attention lapse when they self-assess themselves as bored. Table 3 summarizes the results comparing complacency related actions and attention lapses to self-assessed boredom. When pilots become bored, as measured by the Self-Assessed Boredom metric, they are less likely to monitor the actions of the automation and are more likely to over-rely on the automation instead of exercising basic piloting skills (recall the definitions of the Complacency related factors, which are part of the PACPS created by the author and explained earlier). Moreover, pilots who self-report themselves as bored are more likely to experience an attention lapse. Again, Table 3 only displays significant correlations at the p=0.05 level. Correlations displayed in bold are significant to the p=0.01 level.

Table 3*: Complacency Related Factors and Self-Assessed Boredom*

	Complacency Related Factors (from the PACPS)					Attention Lapses
	Distraction	Crosscheck	Monitoring	Over-reliance	Total	
Self-Assessed Boredom	.140	**.190**	**.252**	**.251**	**.305**	**.293**

DISCUSSION

The data clearly associates both boredom proneness and self-assessed boredom to automation complacency actions and attention lapses. Boredom is becoming a significant factor in modern aviation. In the free comment section, one pilot wrote, "boredom is a huge problem which increases with the length of trip. by [sic] day 4 i [sic] am gone." Another pilot observed, "After boredom on a long flight, it's [sic] hard to 'speed-up' to the [sic] brain activity to fly conscientiously!" The increase in boredom is also associated with the increased level and emphasis on aircraft automation. Modern pilot to aircraft interface designs center the aircraft on the automation, meaning a pilot is required to input many of the operational instructions through the FMC. One pilot observed, “The automation is getting harder to turn off on newer airplanes – need to go heads down into the FMC just to tune a VOR for example.” Other comments paralleled this theme and added the concept of dissatisfaction (an element of boredom) echoing one of the criteria necessary for boredom (Mikulas & Vodanovich, 1993). A pilot described the effect of automation as “…force[ing] us to become system monitors more than pilots. I must force myself to be actively engaged. Huge decrease in job statisfaction [sic].” Both the quantitative and qualitative responses indicate boredom as an increasingly important issue in modern aviation.

Internal and External Stimulation

Examining some of the personality constructs identified in the Boredom Proneness Scale helps identify some of the underlying dimensions of boredom reported in the sample. Table 2 summarizes the correlations between self-assessed boredom and the BPS subscales. The external, affective, and time subscales of boredom proneness correlated positively to state boredom while the internal subscale correlated negatively. This finding suggests that pilots who are more adept at finding internal sources of stimulation are less likely to self-report themselves as bored. Table 1 also displays a statistically significant negative association between the need for internal stimulation and automation complacency, especially the complacency subscale of over reliance. Thus, pilots who are better adept at finding internal sources of stimulation are less bored, and engage in less complacency related behaviors. Of the survey respondents, 85.3% indicated they hand fly as much as possible, an action that offers intrinsic rewards and could satisfy the need for internal stimulation. These pilots may be more practiced at hand flying due to their need for the intrinsic satisfaction found in the action and thus less reliant on the automation. This could explain why pilots who scored higher on the internal dimension of boredom proneness committed less automation over-reliance complacency related actions. The survey question that queried participants on how they occupied their time revealed the vast majority, 85.3% and 64.5%, engaged in an internally stimulating behavior such as reading and logic puzzles respectively. Another pilot wrote how he or she admired the scenery at altitude, an intrinsically pleasing act, by writing, “When weather permits, I enjoy watching the world go by below. In doing so, I mentally keep tabs on where we are (big picture)…” Another wrote how he or she enjoys “observ[ing] night sky, landscape etc.” One pilot described the importance of internal stimulation through reading by writing, “If it were not possible to read during cruise my boredom level would be significantly higher.” All of these actions are intrinsically rewarding activities and constitute an internal source of stimulation.

By contrast, the pilots who indicated a greater need for external stimulation indicated a small but positive association with automation complacency behaviors (see Table 1) and self-assessed boredom (see Table 2). The increase in self-assessed state boredom is possibly due to the limited environment in a flight deck that is largely devoid of external stimulation sources. In some aircraft, the flight deck space is small, making movement difficult. Moreover, many airline policies forbid some externally stimulating activities, such as video entertainment, thus limiting those sources for the pilots who need them. Of all the survey respondents, 97.8% indicated that chatting with their fellow aviators in the flight deck (an external source of stimulation) was a means of preventing boredom. One pilot rather candidly wrote, “…for me, the boredom level is directly related to how interesting my F/O [first officer] is. I get more bored when I cannot engage anyone in conversation.” In a similar vein, another pilot wrote that he or she enjoyed “chat[ing] with [the] flight attendants” and yet another stipulated “…boredom is a very large part of my flying time, thank God for the other guy in the cockpit.” Since external sources of stimulation are limited in the flight-deck environment, pilots who are more adept at internal stimulation sources appear better able to cope with boredom, and are less likely to engage in a complacent behavior.

The key term is the word cope, since the pilots the sample generalizes all require individual ways to deal with the boredom on their flights. Each person has found an individual coping mechanism to deal with the boredom for their unique situation, whether they are flying short legs in domestic operations or extended legs in the international realm. According to the free comments in the completed surveys, these mechanisms can range from "…eat[ing] pistachios on red eyes…" to "study[ing] for law school." One particular pilot developed a game he or she could play with the other pilot using the navigation fix page in the airplane's FMC. In each case, the individual pilot has determined his or her own unique strategy to remove the emotional aspect of boredom found when there is inadequate stimulation.

Affective and Time Responses

The affective subscale of the BPS is described as an individual having a "…emotional reaction to boredom" (Vodanovich & Kass, 1990, p. 118; Vodanovich, 2003, p. 571; Wallace, Vodanovich, & Restino, 2003, p. 638). An individual with a high score on the BPS questions that relates to this subscale suggests that he or she has not developed an adequate boredom coping mechanism and is dealing irrationally with his or her boredom. Thus, a high score on the affective subscale in this survey might indicate a pilot has difficulty finding an optimum method to deal with his or her boredom and then reacts emotionally to boredom inducing situations.

A similar concept exists with the BPS subscale of time, defined in the literature as "…items related to the use of time" (Vodanovich & Kass, 1990, p. 118). As with the affective subscale, a high score on the questions related to time could indicate inadequate coping strategies. All of the questions on this subscale involve how a subject perceives the passage of time, and whether he or she has developed adequate mechanisms to relieve any potential boredom caused by this construct.

Table 2 displays the correlation between self-reported boredom and Boredom Proneness factors. Of the five boredom dimensions, subjects who scored high on the affective subscale reported high self-assessed, or state, boredom ($r=.489$, $p=0.01$). Contrast this with the statistically significant negative correlation between the internal dimension of the BPS and self-assessed boredom ($r=-.255$, $p=0.01$) symptomatic of pilots adept in finding internal stimulation reporting less state boredom. In the free comments section, a pilot described his or her emotional reaction to boredom in the following manner:

> I was much more attentive on the 737-200 than I have been on the Airbus. Despite my intent to not rely too heavily on automation, it is easy to do. I am so bored/unhappy at [redacted] that I just put in for a voluntary furlough. I was more attentive when I was happier in my job, which is part of my reason for leaving.

Interestingly, this individual pilot self-assessed his or her boredom level as "very bored most of the time," which is one level below the maximum self-assessment level. Only 9.2% of the pilots in the sample rated themselves in this category. Of all the survey respondents, only one person (0.4%) self assessed their boredom level at the maximum level.

This finding parallels the data listed in Table 3, which positively associates greater self-assessments of boredom with automation complacency related actions ($r=.305$, $p=0.01$) and attention lapses ($r=.293$, $p=0.01$). In summary, pilots who have a greater emotional reaction to boredom self-report higher states of boredom as described in Table 2. Finally, the pilots who self-report higher states of boredom are also associated with greater complacency related behaviors and attention lapses as demonstrated in Table 3. The data in Table 1 support this hypothesis. Isolating the affective subscale of the BPS finds a statistically significant positive correlation to automation complacency practices.

Attention Lapses

Isolating the BPS affective subscale with the self-reported frequency of attention lapses measure also indicates a statistically significant positive association ($r=.288$, $p=0.01$). This association is significant especially when compared to how the BPS internal subscale associates with attention lapses ($r=-.190$, $p=0.01$). As with the issue of complacency practices, this could indicate that pilots who respond emotionally to boredom or who have not developed coping mechanisms experience attention lapses or cognitive failures at an increased frequency. This finding also parallels the work by Wallace et al. (2003) who reported subjects who scored high on the affective and time subscales of the BPS positively correlated with a greater amount of cognitive failures during multiple tasks ($r=.52$ for affective, $r=.53$ for time, $p<0.001$). According to Parasuraman et al. (1993), the airplane environment is a multiple task environment particularly when monitoring and supervising the automation is involved.

Risk

The issue of risk may be a mitigating factor in automation complacency (Riley, 1996). This issue may help explain the relatively weak association between boredom proneness and automation complacency actions. Riley (1996) argued that previous research on vigilance, an important component in automation supervision, neglected the concept of risk due to the reliance on desktop simulators for their practical data. The qualitative portion of the survey strongly supports the concept of how perceived risk influences automation vigilance and supervision. When asked about what strategies pilots utilize to ensure proper automation behavior, the variations of the term "crosscheck" appeared 25 times in the free text. This suggests that despite any perceived reliability, consistency, or level of trust, many of the pilots in this survey are deliberately monitoring the automation to ensure proper operation. One pilot emphatically wrote that he or she, "Do[es] NOT trust the auto system so avoid surprises [sic] that it seems to produce." Another wrote how after "…15000 PIC hours and 35 years…most mistakes have been witnessed or personally executed already." These pilots appear to be aware of the consequences of an automation vigilance mistake, and are taking active steps to increase their monitoring during critical phases. As an example, one pilot wrote,

> Always confirm the Flight Mode Annunciations (FMA). Keep your eyes moving and ears listening. Do not lean back in your seat and think nothing bad can/will happen. Always think about what to do next before the automation actually does it.

The concept of risk is a critical bias when considering automation vigilance and monitoring issues and strongly supportive of the findings by Riley (1996).

The common thread with almost all of the free comments regarding this issue involves an acute awareness of the consequences of an automation mistake. Many of the comments written by pilots involve their individual strategy to prevent altitude violations. One individual pilot summed up the concept when he or she wrote how the "fear of FAA punushment [sic] causes more attention to detail."

Finally, 55% of the pilots in the sample indicated they were more likely to experience an abnormal event, such as an unstabilized approach, when supervising the automation versus hand flying. This finding strengthens the argument regarding risk and automation complacency. Since the majority of respondents believe they are more likely to have an event of some sort while flying on automation, they may be more inclined to monitor the automation a little closer to avoid any abnormal happenings. One pilot wrote,

> I never trust the automation. My first 'glass' was the 737-300 where we were dual qualified with the -200 [737-200, a non-glass airplane]. We had no school or simulator so we learned by 'trial and error.' This resulted in a healthy distrust of the automation.

In a similar vein, a pilot described a flight that utilized a procedure new to crew. Since this was a new technique associated with considerable risk, the vigilance performance by the crew increased. They described the experience by writing,

> Just last week I flew a TA (tailored arrival) test into LAX. The automation reduced thrust to flight idle about 50 NM east of "FICKY" and remained in idle until the turn to final at LAX. Perhaps 12-15 mins of throttles in idle. Since this was a test program we were monitoring the flight VERY closely.

Another pilot described his or her level of trust in the automation by writing, "Treating the automation like a bad copilot and watching everything the airplane is doing while in 'transitional' mode." Finally, a pilot described an automation related incident he or she had as a young helicopter pilot in the Coast Guard that almost resulted in an accident with numerous fatalities. At the end of the comments the pilot concluded, "Since then, I trust nothing." Clearly, the amount of risk involved in an operation determines the vigilance performance in the population group the sample generalizes.

Similar to the individual techniques pilots utilize to cope with boredom, the pilots in this survey have developed individual strategies to cope with the automation. A pilot wrote how he or she, "hold[s] my ID in my hand for a cockpit 'reminder' of this that I need to do." However, this concept is not limited to just remembering tasks. Several pilots described how their individual method to solving the issue of automation over-reliance and boredom involves utilizing the automation in sub-optimum ways as a means of coping. For example, one pilot wrote, "Very rarely do I let VNAV [computer controlled vertical navigation] descend the plane. Will use Vertical speed or level change. Will reference VNAV TOD." Another wrote, "I prefer VSpd to VNav for descents, utilizing the green arc." Both of these pilots have found coping strategies that decrease the level of automation and increase the level of pilot involvement. Numerous comments reflect how pilots have developed other unique methods to ensure proper automation performance.

APPLICATIONS

The implications of this research could involve topics such as employee selection, training, and operational procedures and are not limited to the airline industry. The data suggests that individuals who are better able to find internal sources of stimulation are better at staving off boredom, commit less complacency related actions, and have fewer attention lapses. This may influence how organizations select individuals tasked with vigilance and monitoring duties especially over extended periods of low stimulation where boredom might become an issue. Individuals who are better able to generate internal stimulation may be better in environments that emphasize intrinsic rewards, and may perform better on vigilance and monitoring actions.

An organization's training syllabus could also reflect the findings in the data. Since the concept of risk directly affects vigilance, training courses could expose and emphasize high-risk scenarios to students along with potential consequences of improper automation related actions. One pilot wrote very candidly how:

> The fleet tries all sorts of ridiculous solutions with no success but refuses to accept that the problem [a Boeing 757 fuel configuration issue] is the over reliance to automation and the mindset it has produced in the pilots assigned to this fleet.

This individual described a perceived training shortcoming where the training department has not adequately emphasized the risks involved with a particular action through demonstrated practice.

Finally, operating procedures need to recognize the impact of boredom on vigilance and provide individuals with some latitude in finding sources of stimulation. One particular pilot summed up this issue by writing:

> Unlike what official FAA and airline policy dictates, I find it absolutely crucial to find non-aviation items to engage the mind. In over 30 years of flying I have yet to encounter a by-the-book pilot that

> focuses entirely on the flying that I considered safe. All it does is put you to sleep or to make [sic] you so bored that you miss the obvious.

This parallels the findings of Kishida (1977), who found that individuals would seek additional stimulation during monotonous tasks by engaging in "subsidiary behaviors." These behaviors may have the effect of slightly reducing monitoring performance, but prove effective in reducing boredom. Therefore, policies that ban hand flying and activities such as non-essential reading could prove counterproductive. While these activities may slightly degrade monitoring performance, the benefits gained in reducing boredom and its associated problems outweigh the risks. Operational policies and training need to emphasize the risk involved with engaging in a "subsidiary behavior" at an inappropriate time, but should provide some latitude for individuals to utilize this as a coping mechanism when appropriate.

REFERENCES

Aviation Safety Reporting System. (2009, October). *Callback*. Retrieved from Aviation Safety Reporting System: http://asrs.arc.nasa.gov/publications/callback.html

Bailey, N., & Scerbo, M. (2008). Automation induced complacency for monitoring highly reliable systems; the role of task complexity, system experience, and operator trust. *Theoritical Issues in Ergonomics Science , 8* (4), 321-348.

Billings, C. E. (1997). *Aviation automation: the search for a human-centered approach.* Mahwah, N.J: Lawrence Erlbaum.

Cheyne, J. A., Carriere, J. S., & Smilek, D. (2006). Absent-mindedness: lapses of conscious awareness and everyday cognitive failures. *Consciousness and Cognition , 15*, 578-592.

Drory, A. (1982). Individual differences in boredom proneness and task effectiveness at work. *Personnel Psychology , 35*, 141-151.

Elin Bahner, J., Huper, A., & Manzey, D. (2008). Misuse of automated decision aids; complacency automation bias, and the impace of training experience. *International Journal of Human-Computer Studies , 66*, 688-699.

Farmer, R., & Sundberg, N. D. (1986). Boredom proneness - the development and correlates of a new scale. *Journal of Personality Assessment , 50* (1), 4-17.

Fisher, C. D. (1993). Boredom at work: a neglected concept. *Human Relations , 46* (3), 395-417.

Gordon, A., Wilkinson, R., McGown, A., & Javanoska, S. (1997). The psychometric properties of the boredom proneness scale: an examination of its validity. *Psychological Studies , 42* (2-3), 85-97.

Gosline, A. (2007, December 27). Bored? *Scientific American Mind* .

Hancock, P., & Warm, J. (1989). A dynamic model of stress in sustained attention. *Human Factors , 31*, 519-537.

Kass, S. J., Vodanovich, S. J., & Callender, A. (2001). State-trait boredom: relationship to absenteeism, tenure, and job satisfaction. *Journal of Business and Psychology , 16* (2), 317-327.

Kass, S. J., Vodanovich, S. J., Stanny, C. J., & Taylor, T. M. (2001). Watching the clock: boredom and bigilance performance. *Perceptual and Motor Skills , 92*, 969-976.

Kishida, K. (1977). A study of subsidiary behavior in monotonous work. *Internal Journal of Production Research , 15* (6), 609-621.

Lee, J., & See, K. (2004). Trust in automation: designing for appropriate reliance. *Human factors , 46* (1), 50-80.

Mikulas, W. L., & Vodanovich, S. J. (1993). The essence of boredom. *Psychological Record , 43* (1).

O'Hanlon, J. F. (1981). Boredom: practical consequences and a theory. *Acta Psychologica , 49*, 53-82.

Parasuraman, R., & Riley, V. (1997). Humans and automation: use, misuse, disuse, abuse. *Human Factors , 39*, 230-253.

Parasuraman, R., Molloy, R., & Singh, I. (1993). Performance consequences of automation induced "complacency". *International Journal of Aviation Induced Psychology , 3*, 1-23.

Prinzel, L., DeVries, H., Freeman, F., & Milulka, P. (2001). *Examination of automation induced complacency and individual difference variates.* Hampton: NASA Langley Research Center.

Research Integrations. (2007). *ASRS Incident Report Analysis*. Retrieved September 2009, from Flight Deck Automation Issues: http://www.flightdeckautomation.com/incidentstudy/incident-analysis.aspx

Riley, V. (1996). Operator reliance on automation: theory and data. In R. Parasuraman, & M. Mouloua (Eds.), *Automation and Human Performance: Theory and Applications* (p. 19-35). Mahwah, New Jersey: Lawrence Erlbaum Associates.

Sawin, D. A., & Scerbo, M. W. (1995). Effects of instruction type and boredom proneness in vigilance: implications for boredom and workload. *Human Factors , 37* (4), 752-765.

Seib, H. M., & Vodanovich, S. J. (1998). Cognitive correlates of boredom proneness: the role of private self-consciousness and absorption. *The Journal of Psychology , 132* (6), 642-652.

Sheridan, T. B., & Parasuraman, R. (2006). Human-automation interaction. *Human Factors and Ergonomics* , 89-129.

Shernoff, D. J., Csikszentmihalyi, M., Schneider, B., & Shernoff, E. S. (2003). Student engagement in high school programs from the perspective of flow theory. *School Psychology Quarterly , 18* (2), 158-176.

Vodanovich, S. J. (2003). Psychometric measures of boredom: a review of the literature. *The Journal of Psychology , 137* (6), 569-595.

Vodanovich, S. J., & Kass, S. J. (1990). A factor analytic study of the boredom proneness scale. *Journal of Personality Assessment , 55* (1 & 2), 115-123.

Vodanovich, S. J., Craig, W. J., & J, K. S. (2005). A confirmatory approach to the factor structure of the boredom proneness scale: evidence for a two-factor short form. *Journal of Personality Assessment , 85* (3), 295-303.

Vodanovich, S. J., Weddle, C., & Piotrowski, C. (1997). The relationship between boredom proneness and internal and external work values. *Social Behavior and Personality , 25* (3), 259-264.

Wallace, J. C., Vodanovich, S. J., & Restino, B. M. (2003). Predicting cognitive failures from boredom proneness and daytime sleepiness scores: an investigation within military and undergraduate samples. *Personality and Individual Differences , 34*, 635-644.

Warm, J. S., Dember, W. N., & Hancock, P. A. (1996). Vigilance and workload in automated systems. In R. Parasuraman, & M. Mouloua (Eds.), *Automation and Human Performance; Theory and Applications* (p. 183-200). Mahwah, New Jersey: Lawrence Erlbaum Associates.

Warm, J. S., Parasuraman, R., & Matthews, G. (2008). Vigilance requires hard mental work and is stressful. *Human Factors , 50* (3), 433-439.