

Technical Report 1182

Locus of Control, Attribution Theory, and the “Five Deadly Sins” of Aviation

John E. Stewart II
U.S. Army Research Institute

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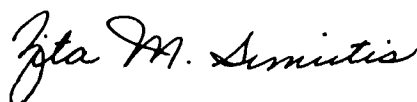
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**Locus of Control, Attribution Theory, and the “Five
Deadly Sins” of Aviation**

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LOCUS OF CONTROL, ATTRIBUTION THEORY, AND THE "FIVE DEADLY SINS" OF AVIATION

EXECUTIVE SUMMARY

Research Requirement:

Locus of Control (LOC), a concept based on social learning theory, has proven useful in predicting a broad range of behaviors. A small number of researchers have examined its relevance to attitudes and behaviors in aviation settings, with an emphasis on the five hazardous thought patterns (HTPs) which are believed to be related to poor judgment among pilots. Attribution theory, based upon field theory, imputes motives and expectancies to actors in various situations. It has received less attention than LOC from aviation researchers, although accident reports often attribute attitudes and motives as causal or contributing factors in aviation mishaps.

Procedure:

A critical review and analysis of the LOC and attribution research literature was conducted. Other research on attitudes, beliefs, and thought processes considered relevant to risk taking and decision making in aviation settings, such as the HTPs, were also explored. Throughout the review, potential application of these social psychological constructs to aviation was explored.

Findings:

Only a handful of research projects on LOC were located which dealt specifically with aviators. Even fewer studies employing attribution theory were located. Attempts to link individual differences to behavior in aviation settings (such as the five HTPs) were found to have considerable conceptual overlap with LOC, and with later attributional concepts having to do with the sense of personal control (e.g. the optimism bias). This would argue cogently for further research in the area, especially longitudinal research, over the career cycle of pilots.

Utilization and Dissemination of Findings:

The findings of the present review point to the usefulness of LOC and attribution theory as aids in understanding pilot performance. Future research in aviation settings may reveal another aspect of these constructs that has not received much attention in other research settings: that an extreme internal LOC and self-attributions of optimism may be related to overconfidence, which has been shown to have a negative impact on aviation safety. In fact, aviation accident reports frequently cite the attribution of overconfidence. An early draft of this report was

presented to the U.S. Army Combat Readiness Center at Fort Rucker, AL in February, 2006, for informal review and reaction. A synopsis of this research was presented at the 55th Human Factors Engineering Technical Advisory Group Meeting in Las Vegas, NV, on 17 May 2006.

LOCUS OF CONTROL, ATTRIBUTION THEORY, AND THE "FIVE DEADLY SINS" OF AVIATION

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LOCUS OF CONTROL, ATTRIBUTION THEORY, AND THE "FIVE DEADLY SINS" OF AVIATION

Introduction

"Don't be a show-off. Never be too proud to turn back. There are old pilots and bold pilots, but no old, bold pilots."

E. Hamilton Lee, 1949

Perceived Control (Locus of Control)

Extensive research over the past three decades has shown Rotter's (1966) construct of Locus of Control (LOC) to be predictive of a broad range of human behaviors, including risk taking and risk management, the management of multiple tasks, distractibility and time estimation. Some of these behaviors, especially risk and workload management, may be pertinent to aviation situations. Pilots may face emergency situations in which they must choose between several alternatives under conditions of time pressure, in which the consequence could include a possible loss of the aircraft or even the crew. Likewise, it would seem worthwhile to investigate the relationship between the perception of control and pilot confidence. There has been no longitudinal research showing how perceived internal locus of control covaries with flight hours or other measures of flight experience. Only limited research has been done probing the relationship between LOC, hazardous attitudes, crew errors, and operational aviation accidents and incidents. Most of this work has involved correlations of self-report data, without behavioral measures. The present paper will examine several areas in which LOC research can be applied to aviation problems and issues.

LOC and Expectancy Theory

One misconception about LOC that has pervaded the literature for many years is the assumption that it is a personality construct. This could be due to the fact that the popular notion of internality-externality (I-E) is superficially similar to introversion-extraversion (Jung, 1928), a personality construct with similar descriptors. Based upon Rotter's social learning theory conceptualization, it may not seem fitting to characterize LOC as a personality orientation, but instead as a set of outcome expectancies acquired through experience. LOC had its origin in Rotter's (1954) social learning theory, which is an outgrowth of reinforcement and expectancy or field theories. Whether personality is primarily genetically determined (Eysenck, 1967), or due primarily to habits acquired as a result of social learning, is a controversial topic that is beyond the scope of this paper. Nevertheless, the concept of *personality* suggests relatively enduring dispositions, having constancy across time and situations. Rotter's social learning orientation, by contrast, conceptualizes personality as more of a

situational *state* than a dispositional *trait*, comprising self-attributions and expectancies which can change over time. LOC consists of a set of attitudes and beliefs about the relationship of one's behavior to dispositional and situational factors. Broadly stated, Rotter's social learning theory can be represented as: $NP = f(FM + NV)$ where NP is need potential, FM is freedom of movement, and NV is need valence. To paraphrase Rotter, the potential for a behavior leading to the satisfaction of a need (NP) is a joint function of the expectancy that it will lead to reinforcement and the perceived value of the reinforcement. So the original concept of LOC was within the context of the expectation that reinforcement was under personal or environmental control. The reason why this dispositional-situational distinction is important is because it has implications for the stability and change of LOC over time. Expectancies are influenced by situational factors and are therefore changeable, whereas stable dispositions tend to be resistant to change across situations. When one mentions LOC, the Rotter (1966) scale comes to mind. The reader should keep in mind that a large number of LOC scales, many of them adapted to specific age groups (e.g., children) and situations (e.g., health, safety) have evolved since the original Rotter scale. Hunter (2002) has developed and validated an LOC scale specific to aviation, derived from an industrial safety LOC scale (Jones & Wuebker, 1985).

State vs. trait. Another explanation for the misconception of LOC as a trait, as opposed to a state, variable, could be founded in methodology. The Rotter I-E scale does not establish a typology. However, LOC scale score distributions are often dichotomized in order to create a between-subjects variable, for a typical mixed factorial design. Obviously, performing a median split to dichotomize the data sacrifices variation in the data set (hence, information) for simplicity and convenience. The present author must admit to having done this (Stewart & Moore, 1978). Lefcourt (1982, p.148) emphasizes that not surprisingly, the practice of dichotomizing the I-E continuum into internals and externals has led to the erroneous assumption by many that LOC is a stable dispositional trait within the person. This notion has been perpetuated in much of the literature where it is referred to as a personality trait. Consequently, it is not difficult to fall into the trap of assuming that LOC is more enduring and stable than it actually is. LOC scores are best interpreted as momentary samples of one's beliefs about causality, or rough expectancies regarding one's personal control. Thus, the terms: internals and externals, in summarizing research on LOC, should just be interpreted as characterizing those who scored above or below the median on a questionnaire purporting to measure LOC, at the time, and in the context in which the research was conducted.

Change in LOC over time. Cross-sectional surveys of cohorts of college students have shown LOC scores to change over time, with a trend toward increasing externality (Phares, 1976, p. 163). More recently Twenge, Zhang, and Im (2004), in two meta-analyses of the LOC scores of college students and middle school-junior high school students in the United States, confirmed the trend toward increasing externality of these age cohorts over time. The reader should note that the lower the LOC score, the greater the level of internality (the Rotter LOC scale consists of 23 items, with only

external responses scored, for a possible range from 0 to 23). The average college student in 2002-2003 was more external on the Rotter LOC Scale ($M = 11.38$) than 80% of his or her counterparts in the 1960s ($M = 8.70$). Data consisted of 97 samples of college students ($N = 18,310$), and 41 samples of children, aged 9 to 14 years ($N = 6,554$). The same trends found for college students were replicated for children, using the Nowicki-Strickland Children's LOC Scale (Nowicki & Strickland, 1973). From an evaluative standpoint, implications of these findings are negative, in the sense that externality is associated with alienation, diminished sense of personal control, and lower achievement. Generational variations in social values between cohorts could explain these differences, or alternatively, unique historical events that happened to the different cohorts. These results are based on cross-sectional cohorts, so it cannot be determined what changes over time are life cycle changes and which ones are generational. A longitudinal study would be desirable, but to this author's knowledge, none is currently in progress. The only published longitudinal studies of LOC known to the present author (Wilkins, 1975; Wolfle & List, 2004; Wolfle & Robertshaw, 1982) were limited in scope in that they only examined changes in LOC over a brief time period in the life cycle. Wilkins found no overall differences in total LOC scores, but a slight increase on the Personal Control subscale, between the ages of 19 to 29 years. Wolfle and Robertshaw, in their study on the effects of college attendance on LOC, using a sample of 8,650 Caucasian males, reported a small increase in internality in the four years immediately following high school. It is interesting to note that these researchers found that education beyond high school had negligible impact on LOC. It is understandable why few longitudinal studies have been done, and why these have had limited time perspectives. Cost and demands on the researcher's time are probably the most salient deterrents to conducting this kind of research.

Do specific experiences change LOC? A related question concerns itself with the degree to which LOC is modifiable due to direct intervention or life experiences. Research on college populations (Duke, Johnson & Nowicki, 1977; Phares, 1976) would indicate that it is. Likewise, Harvey (1971) discovered that the longer a person had occupied an executive government position, the more internal was his or her score on the Rotter LOC scale. Senior administrators with over 10 years' experience had mean scores of 5.4 vs. 7.2 for those with ten or fewer years' experience. Age has been shown to be another factor. Penk (1969), using the Bialer (1961) LOC Questionnaire, found internality to be positively and significantly correlated with chronological age. Consistent with this finding Hunter (2002), in a validation study of his Aviation Safety Locus of Control (ASLOC) scale, using a sample of 477 civilian pilots, found a significant trend of increasing internality with age. The ASLOC combined index ranges from 20 to 100, with higher scores keyed to internality. We should note that these studies were not longitudinal comparisons and that other differences between age cohorts besides experience could have accounted for this trend. Interestingly, Hunter found no significant correlations between LOC and total flight hours, though it would be a reasonable intuitive hypothesis that sense of personal control would grow with experience.

Studies that examined changes in LOC have not been truly longitudinal in design. Also, very few have been conducted in military or aviation settings. Examining systematic changes of LOC at different stages of an aviator's career may serve to clarify some of the issues about the desirability of an internal control orientation. The treatment of LOC as a dichotomy, besides being artificial, obscures the possibility that the relationship between LOC and pilot performance may be curvilinear. In other words, the safe aviator may be one who believes himself/herself to be in control of the aircraft in most instances, but also recognizes realistically that situations exist over which he or she has no control. Such a person should strive to minimize the probability of encountering the latter situations. As we shall see, the illusion of invulnerability has been identified as a hazardous attitude among aviators. Self-confidence is valued in our society; however, it can become illusory if it is out of proportion to real-world odds of success and failure.

LOC and Cognitive Processes

Attention and Vigilance

Attentiveness. A large number of studies on LOC have shown the internals' ability to attend to relevant cues as well as to ignore those that are not so relevant (DuCette & Wolk, 1973; Gregory & Nelson, 1978; Sanders, Halcomb, Fray & Owens, 1976). Stewart and Moore (1978) discovered that those classified as internals (i.e., below the median on the Rotter LOC scale), were more capable than were externals in disregarding irrelevant and distracting cues while attempting to estimate the passage of time. In a postexperimental probe, Stewart and Moore found that external participants were significantly less likely to report awareness of the false cues, than were internals, implying that the former were more likely to be influenced by these cues because they were not vigilant enough to be aware of them. Internals were able to rely more on their own time sense, while externals' time estimates seemed dependent upon deliberately false cues presented by the experimenter. Lefcourt (1982) in his comprehensive review of LOC, cites this and other studies as demonstrating how externals require that their environment be structured, while internals actively restructure ambiguous situations, looking for information that will assist them in solving problems and making decisions. This finding may have pertinence to the area of safety, since Hansen (1989), using a path-analytic model, found only two variables, distractibility and general social maladjustment, to be directly related to frequency of accidents among industrial workers.

Error detection. Internals seem superior to externals in detecting errors while proofreading text, and in picking up subtle and incidental cues (Wolk & DuCette, 1974). This ability should be quite germane to aviation settings where malfunctions occur under conditions of high workload. Internals should be able to detect more quickly a system malfunction, and to concentrate only on those tasks critical to controlling the aircraft, if the malfunction turns out to be a serious one.

Simulated emergencies characterized by unanticipated malfunctions would seem to be well suited for an investigation into the effects of LOC on the pilot's ability to prioritize tasks quickly where the failure to do so may result in loss of situation awareness and consequently, control of the aircraft. Since cognitive performance of persons with high personal control beliefs tends to be better than for those with lesser control beliefs (Koivula, 1996; Soederberg-Miller & Lachman, 2000; Stewart & Moore, 1978), it would also appear worthwhile to investigate the effects of LOC on task prioritization and the management of cockpit workload. Based upon this research, one could expect that internals would show smaller latencies in detecting and responding to possible emergency situations than would externals.

Relationship of LOC to the Five Hazardous Attitudes

The five deadly sins. As has been stated before, aviators can be susceptible to expectancies about their performance that can produce hazardous consequences. A typology of hazardous thought patterns, or attitudes (Berlin, et al., 1982 ; Federal Aviation Administration, 1991) has become popular in the aviation safety community. Based upon the work of Berlin et al., the FAA published a series of documents that contained a questionnaire: the Hazardous Attitudes Scale (HAS) aimed at identifying hazardous thought patterns. These consist of five attitude clusters: *invulnerability* ("It won't happen to me"); *macho* ("I can do it"); *resignation* ("What's the use?"); *impulsivity* ("Do something, quickly"); *antiauthority* ("Don't tell me what to do"). These discrete types, especially macho and resignation, seem to correspond closely to differences in LOC.

Hunter (1995, 2005), explains that the format of the HAS is ipsative, which means that a high score on one subscale results in low scores on the other four. The questionnaire comprises ten scenarios, which require the participant to make a rapid decision under time pressure. Each alternative is keyed to one of the five hazardous attitudes. The participant is required to choose one of these alternatives. The alternatives are summed, thus providing a score for each hazardous attitude. The original purpose of the questionnaire was pedagogical, as a means of providing feedback to students. However, this dependency between subscales has serious psychometric implications that potentially detract from the validity of the questionnaire. This prompted Holt, et al. (1991) to design a new instrument employing a Likert-type format, the New Hazardous Attitudes Scale (New-HAS). For the validation study they used an equivalent form for drivers, administered to a sample of 238 undergraduate students (more accessible than pilots). The main advantage of the New-HAS was that evidence of the hazardous attitudes could be derived through factor analysis and not by fiat. They found four factors corresponding to macho, impulsivity, antiauthority, and resignation. Factor scores from the new instrument correlated significantly with several criteria, such as accident involvement, drinking while driving, moving violations, and seat belt use. Hunter (2005) conducted a web-hosted survey for general aviation and commercial pilots to validate and determine the factor structure of the New-HAS scales.

Exploratory factor analysis was followed by a Varimax rotation to simple structure. Analysis of the New-HAS revealed six factors, which seemed to support those found by Holt, et al. These were: macho, resignation, antiauthority, worry/anxiety, impulsivity, and self-confidence. Hunter discovered that items of similar content on the ipsative HAS (Old-HAS) and New-HAS scales yielded low correlations; he attributed this result to the ipsative nature of the Old-HAS, which makes interpretation of correlations difficult.

Invulnerability. Whether invulnerability would seem at first blush to be an extreme form of internality or externality is difficult to say because of a paucity of empirical data. Lester and Bombaci, (1984) found pilots whose dominant thought pattern was invulnerability to be moderately internal, as did Lester and Connolly (1987). Hunter (2005), using a larger sample of aviators (198), found some evidence that invulnerability, as measured on the Old-HAS, was positively and significantly correlated with the externality subscale of his ASLOC scale. Hunter emphasizes, however, the problems involved in interpreting correlations from the Old-HAS. If we add to this the consistent findings that pilots tend to show a greater degree of internality than the general population, the relationship between invulnerability and LOC becomes even more difficult to specify.

Macho and resignation. One could postulate that the macho and resignation attitude clusters represent polar extremes on the LOC scale; the first, an expectation of always being in control; the second, a classical description of the external mindset. Indeed, the original label for resignation was external control (see Lester & Bombaci 1984; Murray, 1999). Hunter (2005) did find that the resignation dimensions of both the Old-HAS and the New-HAS correlated significantly with the externality subscale of the ASLOC. However, Hunter also found that the Old-HAS produced few significant correlations overall with any construct validation measures, and that the significant correlations showed no consistent pattern. This finding reinforces the positions of Hunter and other critics of the HAS, who, though acknowledging it as a useful pedagogical tool, have shown that it is psychometrically inferior to the New-HAS.

Impulsivity. Impulsivity could likewise be a correlate of LOC. Rotter and Murly (1965) found internals to be more deliberative and less impulsive than externals when they were asked to make decisions having to do with skill and not luck. When subjects were led to believe that the outcome of the decision was chance-determined, the reverse was found. Thus, it could be that those high in impulsivity in a situation where flying skill is important, would be externals. Hunter (2005), in the previously referenced validation study, found impulsivity as measured by the New-HAS to be negatively and significantly correlated with the internality subscale of the ASLOC (Hunter, 2002), which seemed consistent with the notion that pilots who believe they are in control of situations would not endorse items denoting impulsivity.

Antiauthority. These attitudes are somewhat difficult to characterize according to the LOC dimension. Much of the research literature shows that internals resist social influence to a greater degree than do externals (Biondo & MacDonald, 1971; Cravens & Worchel, 1977). On the other hand, McCollaum and Lester (1995) found that an antiauthority orientation was associated with externality on the Rotter LOC scale. Hunter (2005) found that scores on the Likert-based Hazardous Attitudes Scale (New-HAS; Holt, et al., 1991), correlated significantly with the external subscale of the ASLOC, and the Zuckerman (1994) Thrill and Adventure-Seeking scale (TAS). Concurrent validation of the New-HAS by Hunter appears consistent with the earlier research. One limitation noted by Hunter is that the number of respondents on the web-based survey answering the ASLOC and New-HAS scales was relatively small ($n = 33$). For the Old-HAS, the corresponding n was 198. Hunter noted that although 200 participants completed the New-HAS, few in this subsample completed any of the other scales in the online survey. This restriction of sample size is a detriment to any comparison as to concurrent validity of the HAS and New-HAS.

How many deadly sins are there, actually? Consequently, the question emerges as to whether LOC is closely correlated with all or part of this typology, and indeed, whether five somewhat arbitrary and discrete categories are necessary (Lester & Connolly, 1987, suggest that they are not). Lester and Bombaci (1984) examined the relationship of LOC to the five hazardous attitudes, as indicated on the ipsative HAS, using a small sample of general aviation pilots. This study found that invulnerability was the predominant hazardous attitude among the general aviation pilots in the restricted sample (43%) followed by impulsivity (20%) and macho (14%). No participants fell into the remaining two categories. The investigators found that macho aviators were the most internal of all on the Rotter LOC scale ($M = 3.4$; $n = 5$), followed by invulnerability ($M = 8.1$; $n = 15$) and impulsivity ($M = 10.3$, $n = 7$). It is noteworthy that none of the means obtained for these three categories was in the direction that one could call external; only the impulsivity group scored close to the median (11.5) on the LOC scale. The extreme internality of the macho group is intriguing; unfortunately, the small sample size limits generalizability. Nevertheless, mean scores for macho and Invulnerable, compared with those of the impulsive participants, seem consistent with much of what is known about LOC, in that (relative) externality has been found to be associated with impulsivity. Impulsivity as indicated on the HAS may not be the same as that measured by personality inventories. Lester and Bombaci (1984) found no significant relationship between the impulsivity dimension from the Old-HAS and the impulsivity scale of the 16 Personality Factor Questionnaire (16 PF [Cattell, Eber, & Tatsuoka, 1970]), but did find that macho participants scored significantly higher than invulnerables on the integration/self concept control scale of the 16 PF.

The results of Lester and Connolly (1987) appear to parallel closely those of Lester and Bombaci (1984). Again the predominant hazardous thought pattern was invulnerability (39%) followed by impulsivity (24%) and finally macho (19%). Resignation and antiauthority response patterns did not emerge. The investigators also

found that these three attitudinal dimensions were significantly and positively correlated, which is hardly surprising, given the ipsative format of the Old-HAS. Unfortunately, Lester and Connolly performed multiple *t*-tests contrasting the LOC scores of macho ($M = 7.1$), impulsive ($M = 10.1$) and invulnerable ($M = 9.8$) participants (it would have been better to use a post hoc multiple comparison test which controls the experimentwise error rate). Macho participants were significantly more internal than invulnerables ($p < .05$), and were more likely to report involvement in hazardous situations or accidents ($p < .05$), even though showing more conscientiousness on the 16PF ($p < .05$).

Other research has shown that pilots exhibit more internality than externality (Hunter, 2002; Wichman & Ball, 1983). Hunter (2002) found a mean score of 81.7 ($n = 477$) on the ASLOC, indicating overall internality. Wichman and Ball conducted a survey of 334 general aviation pilots, concerning safety attitudes and practices, using the Rotter LOC scale. They found these pilots to be significantly more internal than the general non-aviator population in the United States. For the three independent samples comprising this study, respective means on the Rotter LOC scale were: 6.9; 6.1; 6.2 (all in the internal direction). It is interesting that these pilots showed evidence of a self-serving bias (Ross, 1977) toward their own skill and safety. Those pilots with more flight hours showing more internality and bias than their less experienced counterparts. (The self-serving bias is a special case of attribution theory in which the person, or actor, attributes positive outcomes to his or her own efforts, and negative outcome to external factors, such as bad luck.) This finding provides a hint of overconfidence and the tendency to overestimate one's own flying skill and to underestimate the chances of accident involvement. It is not clear, though, at what point confidence becomes overconfidence. Finally, we must ask if the most experienced pilots, who tended toward greater internality, and greater self-serving biases, were more cavalier than their cohorts on matters of safety? Apparently not, since these were more likely than their less experienced peers to actually attend an FAA safety clinic. This behavioral measure could indicate that they not only believed themselves to be safer than the average pilot, but also behaved in a way consistent with this concept of themselves.

One can overestimate his or her degree of control over the environment, and anecdotal accounts indicate that test pilots often do this. Werrell (2005), provides historical, anecdotal examples of overconfidence and its dangerous ramifications among U.S. Air Force pilots during the postwar transition from propeller-driven to jet-powered aircraft. Werrell notes that during this time period (1946-1953), the Air Force seemed to accept accidents as part of the cost of flying. He attributes part of this attitude to jet pilots who had survived combat in World War II. These pilots manifested attitudes that can best be characterized as a combination of *machismo* and invulnerability, believing that if the enemy had failed to get them, then nothing else would, especially in peacetime. Added to this was the belief that "real" fighter pilots should not carry checklists and that preflight checks should be kept to a minimum.

The author believes that many accidents that occurred during this period were due to a need on the part of pilots to prove their manhood, plus the belief that they were "bulletproof." Werrell cites a concrete example of a veteran pilot who, eager to check out in the F-86, conceals the fact that he has had no time in the aircraft. He asked for minimal assistance on the flightline, used no checklist, and soon afterward survived a crash caused by his unfamiliarity with the aircraft's fuel system.

A person can believe that repeated success is due to good luck rather than effort. This may be a more realistic expectancy in hazardous situations such as war. Perhaps the stresses of war, in which chance *does* play a role in one's survival, create situational pressures that move a person's expectancies toward externality. (The early research of Phares [1957] showed that persons with external control orientations are more prone to the gambler's fallacy). Given the power of the situation, and the fact that in time of war pilots oftentimes fly a set number of missions before going home, it would be reasonable to expect even the most internally-controlled individual to be prone to the gambler's fallacy, especially toward the end of one's tour of duty. Anecdotal evidence abounds about pilots in combat becoming superstitious about their last mission. We can envision the aviator who has got out of tight situations in the past and has attributed this success to luck. One study by Gerbert and Kemmler (1986) seems to support this notion. They asked a sample of German pilots how they had managed to escape from hazardous situations they had encountered. Half attributed their success to luck, and 30 % to the application of proper procedures. In short, there may be a weakness in the current and past research on LOC among aviators, in that participants in the research have been overwhelmingly general and commercial aviation pilots operating in peacetime environments. Perhaps they are more "in control" because they can rely on their training and skills, and not worry about hostile fire.

Hunter (2002), in his efforts to develop and concurrently validate the ASLOC scale, found a significant, negative correlation between internality and self-reported involvement in hazardous events, as indicated by the Hazardous Events Scale (HES; Hunter, 1995). He defined a hazardous event as an accident or an incident which could have easily become an accident. One must note that the HES is a subjective measure, and, drawing upon other safety-related LOC research (e.g., Arthur, Barrett, & Alexander, 1991), a much less sensitive criterion than archival records of accidents. Nonetheless, Hunter's finding is of potential interest to the aviation safety community, in that it indicates that internal LOC may be a predictor of vigilance and avoidance of unreasonable risks. Since LOC is not conceptualized as a stable personality construct but as a set of expectancies about control over the environment, then these findings may also imply that the attitudes underlying the potential for hazardous behavior can be changed. Of course, an alternative explanation to Hunter's results could be differences in self-disclosure between internals and externals.

Locus of control, risk taking and accidents. Research relating LOC to risk taking and accidents is rare, and the preponderance of this research is concerned with

ground vehicle and general industrial accidents. Salminen and Klen (1994) demonstrated a relationship between LOC and risk taking behavior on a non-aviation sample, consisting of Finnish construction and forestry workers. They found that forestry workers were more external in LOC than were construction workers. Regardless of between-group differences, externals tended to take more risks than did internals. This study is cited because it provides more evidence consistent with the construct validity of LOC, and has implications for research in aviation safety. Other researchers (Arthur, Barrett, & Alexander, 1991; Guastello & Guastello, 1986; Ozkan & Lajunen, 2005; Stanton & Young, 2005) have examined the relationship between LOC, accidents, situation awareness, and workload, for operators of ground vehicles. The Rotter scale and derivations specific to automobile driving behaviors were employed. Likewise, different criteria were used in these studies: archival reports of accidents, and self-reports of accident involvement. Arthur, Barrett, and Alexander performed a meta analysis of the vehicle accident involvement literature, which had previously yielded equivocal results. The investigators obtained marginally to moderately significant results for selective attention, regard for authority, and LOC. One very important moderator variable in the case of regard for authority and LOC was whether the criterion variable entailed self-report vs. archival data, with the latter showing more significant correlations. Consequently, it is likely that the low correlations where the Rotter LOC scale has been used to predict accident involvement were due largely to the use of self-report measures.

Validity of the hazardous attitudes. The question remains as to whether or not five distinct hazardous attitudes exist. If they were not orthogonal, then fewer categories would have the same explanatory value. Recall that Holt, et al. (1991), and Hunter (2005), found some confirmation that attitude clusters corresponded to four of these factors, excepting invulnerability. At this point it may be informative to note a factor analytic study by Shaw and Sichel (1971), which employed a variety of personality measures for the purpose of discriminating between high and low-risk accident-prone employees in a variety of industrial settings. The primary factor, which discriminated the accident-prone employee from the one less so disposed, was characterized by extreme extraversion with sociopathic features. In terms of traits, the high-risk employee was described as self-centered, overconfident, aggressive, irresponsible, resentful, intolerant, impulsive, antisocial, and antagonistic toward authority. One should note that at least the verbal labels of three of these traits (overconfident, impulsive, antagonistic toward authority) seem to have some degree of correspondence with those from both new and old versions of the HAS. In order to determine what unique *behavioral* dimensions underlie the hazardous thought patterns, a factor analytic study, with a large sample, should be undertaken. Additionally, longitudinal research is needed, to determine how experience and age moderate these attitudes. As was previously mentioned, archival records of accidents should be exploited, and less reliance placed upon self-reports. Otherwise little will be learned beyond what is known now.

LOC and Confidence: The Dark Side of Internality?

Overconfidence: Overestimation of Control

A sense of personal control is usually considered to be socially desirable. It would seem reasonable to postulate that any training program intended to foster such as sense of control should have positive consequences on performance in situations where performance can directly affect outcomes. A caveat would be that such a program should instill an expectation of control but not overconfidence. The reason behind this last statement will become clear when we examine the more recent research on overconfidence in the context of the optimistic bias. Succinctly stated, one's sense of personal control should be realistic and situationally appropriate.

Unfortunately, most of the LOC research has not examined work environments where overconfidence can have fatal consequences, nor has it looked at long-term changes in LOC within an individual as the person acquires experience and progresses to higher levels of mastery. Unrealistically high perceptions of personal control may be maladaptive. One recent study (Anderson, Hattie, & Hamilton, 2005), purports to show evidence that, at least among school children, moderate levels of LOC are more adaptive than are extremely high or low levels. Rotter (1966) also acknowledged that, though he considered internals to be better adjusted psychologically than externals, it was nevertheless likely that those holding extreme beliefs in internality of control were just as maladjusted as those holding extreme beliefs in externality. Nonetheless, the concept of extreme internality has received little attention from researchers.

There has been much speculation in the aviation community that pilot overconfidence is related to accidents, even among high-time pilots; in fact, overconfidence is frequently cited as a contributing or causal factor in the U.S. Army Combat Readiness Center's Risk Management Information System (RMIS). Is this just an ex post facto attribution or is there a point where aviators begin believing that they have more control over their fates than they actually have? In aviation, it is not unknown for thoroughly skilled and proficient pilots, with many hours to their credit, to have accidents. Is there a critical point in a pilot's career progression where the cumulative effects of thousands of hours of flight experience can lead to an illusion of invulnerability? What is being stated here is that another factor besides experience and skill may predict how safe a pilot is; a highly proficient pilot is more in control of an aircraft than one who is much less proficient. However, we need to ask if there is a point in time where the feeling of being in control becomes a feeling of infallibility. This is not to say that the more hours a pilot has, the more internal he or she is. Dunning, Heath, and Suls (2004), in a comprehensive monograph, demonstrated the pervasiveness of overconfidence and the illusion of control across institutions in settings as diverse as health, education, and the workplace. Few researchers have explored the interface of individual differences in LOC and the illusion of control. This may be due in part to the movement in social psychology toward conceptualizing the

need for personal control more as a situationally determined expectancy than as a dispositional trait. Regardless of this, some evidence indicates that perceived control is a key mediator of one's optimistic bias (Helweg-Larsen & Shepperd, 2001; Klein & Helweg-Larsen, 2002). Klein and Helwig-Larsen performed a meta-analysis of 21 studies, which had explored the relationship between perceived personal control and the optimistic bias. Control was found to have a sizable impact upon risk perception ($r = .49$). Those who believed they could control negative events and prevent their occurrence believed themselves to be less at risk than most others.

Though evidence is accumulating that the illusion of control and overconfidence are major heuristic biases in Western society, there is scant evidence as to how LOC mediates these biases. This would seem to be fertile ground for research in the field of aviation, where overconfidence is frequently a factor related to accidents. On its face, the term: *sense of personal control* seems similar to internality, but this is not to be assumed in the absence of empirical support. The meta-analysis by Klein and Helweg-Larsen is the most pertinent research in the context of what has been discussed thus far. The authors define optimistic bias as a perception that one's risks of negative outcomes (e.g. accidents, alcoholism, disease, divorce) are less than those of similar others. The research literature has shown this bias to be quite robust (Weinstein, 1987; Weinstein & Klein, 1996).

Sense of Control Trends over the Career Cycle

What should career cycle internality-externality look like for aviators? It would seem reasonable to expect a curvilinear relationship between LOC and flight hours, with internality peaking somewhere at mid-career. This may be due in part to a need to see oneself as in control, especially at the point where the pilot incurs increased status and responsibilities as he or she becomes an aircraft commander or pilot in command, or upgrades to more advanced aircraft. Past this point, it is possible that pilots begin to realize that an experienced aviator can still make errors. This may be attributable to a realization on the part of the aviator that he or she is not invulnerable, and that an accident could happen in spite of competence and proficiency. There is some evidence in the research literature (reviewed by Helweg-Larsen & Shepperd, 2001), that prior experience with a negative outcome can have a moderating effect on the optimistic bias. In short, persons can perceive themselves as being at greater risk than before, when it is discovered that bad things can happen, even if precautions are taken.

If this relationship actually exists, then it would be possible to design training programs to minimize the tendency for the perception of "being in control" in moderately experienced pilots from becoming the "illusion of unique invulnerability." According to Helweg-Larsen and Shepperd, there has been no empirical research into why prior experience reduces the optimistic bias. They do, however, see personal control as a potential moderator. The authors found evidence that a declining sense of personal control over negative events causes estimates of personal vulnerability to increase.

This trend was found in the meta-analysis regardless of whether the sense of personal control was measured as an individual difference variable (e.g., LOC), self-ratings of controllability of a target event, or inferred from a person's prior experience. One problem pointed out by Helweg-Larsen and Shepperd (2001) that makes these findings hard to explain, is the absence of any experimental research on the relationship between perceived control and prior experience on the optimistic bias.

Wilson and Fallshore (2001), who surveyed 160 commercial and general aviation pilots, found evidence for self-serving or optimistic biases among those pilots. Participants rated themselves, compared to other pilots, as less likely to experience accidents due to inadvertent flight into Instrument Meteorological Conditions (IMC), and overestimated their own ability to avoid and to escape these conditions. Though age and flight hours were unrelated to participants' estimates of likelihood of having an accident, these were significantly related to their estimates of the ability to escape from inadvertent IMC. Likewise, flight hours predicted estimates of the pilots' ability to avoid IMC altogether. Wilson and Fallshore admit that the latter findings were somewhat surprising, in that one would expect pilots to become more circumspect about hazards such as icing and IMC as they became more experienced. Unfortunately, actual flight hours are not reported in the study, making it difficult to determine just how experienced these pilots were. It should also be noted that these data consisted of self-reports, subject to self-presentation biases.

Illusion of Unique Invulnerability

Perloff and Fetzer (1986) posit the illusion of unique invulnerability as a cognitive process mediating excessive risk taking in people who should know better. This is similar to the optimism bias, but based more on cognitive consistency than on self-attribution. However, the assumptions and predictions that it makes seem to be highly similar. Perloff and Fetzer point to a mode of inconsistency resolution not unlike differentiation (Abelson, 1959). That is to say, actors make inappropriate and stereotyped interpersonal comparisons between themselves and those who fall victim to the hazards of the target behavior. Thus those who are seriously injured or killed in aviation accidents may be seen as different than those who survive the same hazards; they may be less intelligent, less skilled, or poorly trained when compared to the actor. As a means of maintaining cognitions that this is a just world, victims of accident and injustice are derogated. The less objective the evidence that the victim of an accident or incident was negligent or incompetent, the greater the need for derogation. Consequently, the need to maintain cognitive consistency can compound the degree of injustice. This just world phenomenon is a well-established process known for decades among social psychologists (Lerner, 1997, 2003; Lerner & Miller; 1978).

The point of the preceding discussion is that Perloff and others offer an explanation of the illusion of unique invulnerability based upon actors' needs to see themselves in control of the situation and not at the mercy of external environmental

forces. This in turn serves as an anxiety-reducing mechanism. (It can't happen to me; I am a much better pilot than they are). Unfortunately, the illusion of unique invulnerability may do more than just reduce anxiety and bolster one's self esteem; it can lead to a cavalier attitude toward safety and consequent laxity in following safety precautions.

The concept of invulnerability seems closely linked to the expectancy of personal control. In fact, there is good evidence that people, or at least subjects in experiments, systematically distort their degree of control over positive (successful) outcomes, so as to give themselves a heightened sense of personal control (Alloy, Abramson & Viscusi, 1981). This has been found to be particularly true of subjects who experience repeated successes. If the illusions of invulnerability and control also affect aviators, then we may have the "flipside" of internality of personal control; the point where a pilot begins to overestimate his or her abilities and underestimate personal and/or environmental limitations (and chances of falling victim to uncontrollable external forces). Some evidence that this may be true can be gleaned from a survey of general aviation pilots by Wichman and Ball (1983).

It would seem that LOC and the distortions that result in the illusion of control are parts of the same social learning process. A person strives to achieve a goal, learns that his or her efforts have been successful, and perceives a causal connection between effort and outcome. After repeated successes at the task, the sense of personal causation (being an origin rather than a pawn) becomes systematically distorted in the direction of greater personal causality. This conceptualization should provide a better view of the social learning-expectancy theory origins of LOC.

Discussion

Critical Research Issues

Research addressing LOC in the context of aviation has concentrated primarily upon its relation to the five hazardous attitudes. Initially, researchers attempted to validate the Rotter LOC scale against the older, ipsative HAS scale. Subsequent research by Hunter (2002, 2005) developed and validated a new version of the LOC scale, with content items specific to aviation, along with the Likert-based New-HAS and HES scales. This research provided a much-needed concurrent validation of these psychometrically improved scales. Still, there are questions concerning the generalizability of all of the research, in that samples consisted of civil aviators. This alone could be cited as justification for future research on samples consisting of military as well as civil aviators. Other critical research issues have not been addressed, and this could be due to the fact that, though LOC is hardly a new concept, its application to aviation is quite recent. Research employing the new instruments such as the ASLOC and New-HAS should not be limited to their concurrent validation on military aviators. New areas should be explored, which can link hazardous attitudes and LOC to behavioral and attributional variables that would serve as means of construct validation.

A rich heritage of research in applied social psychology exists (e.g., attributional biases, cognitive consistency, risk taking) which are eminently applicable to aviation. Some potential research issues will be discussed below. This is obviously not an exhaustive list, but it should provide a starting point for further research.

Perceived personal control and risk taking. It is clear that attitudes toward control over one's environment are related to risk taking preferences and overt behaviors. What is not clear is their effects on the risk taking behaviors of military aviators at different stages of their careers. Are old pilots not bold pilots, due to object lessons from personal bad experiences, or from observing the misfortunes of others? Or can we say that young, inexperienced pilots are more prone to risk taking than their older and supposedly more mature, counterparts? Are differences in risk taking and risk-management by aviators related to any of the hazardous attitudes, and if so, to which ones (e.g. antiauthority, macho, or invulnerable)? It would be worthwhile knowing the trends in sense of personal control among aviators with different levels of experience. This could be ascertained by administration of Hunter's ASLOC scale, but this would only provide a partial answer to the question. We would not learn the degree to which individual differences in ASLOC scores are influenced by situational factors. In fact, more recent research looks at sense of personal control as situationally determined, and therefore variable within the person (state) rather than as an enduring disposition (trait).

Cross-sectional trends in sense of personal control. We have seen how instruments that purport to measure LOC and hazardous attitudes have been psychometrically refined over the past decade. Much of the research has been hampered by small sample sizes; replication on larger samples of aviators would determine the extent to which the relationships found are stable and reproducible. Likewise, a representative sample of military aviators would demonstrate if there are any consistent and stable differences that distinguish this group of aviators from the general and commercial aviation samples. One hypothesis that emerged in the course of this review is whether combat experience changes one's perception of personal control and optimism when facing hazardous situations. The relationship between flight experience, age and sense of personal control, as well as risk taking, could also be investigated. This may answer some questions about LOC changes in response to aging (at what point in the life cycle does one become more cautious?).

Although it would be highly desirable to perform a longitudinal study of changes over the career cycle of pilots, this would be very difficult, since such comprehensive tracking systems do not now exist, for civil or military aviation. Instead, researchers will have to make do with cross-sectional comparisons among cohorts, with age and flight hours as blocking variables. Sense of personal control can be measured as an individual difference by administering the ASLOC and LOC. Similarly, sense of personal control and optimistic bias can be measured as situationally determined attributional styles via questionnaires developed by Weinstein (1980). Similar to other

studies of accident involvement, self-reports such as Hunter's HES, as well as archival data, can be used. Chapin (2001) points out that the optimistic bias, though quite robust, may not be universal. To some degree, optimism grows with successful experience, but this can be tempered by the knowledge that one is not invulnerable to negative outcomes. The two dimensions of experience among military aviators, obviously correlated, are total flight hours and years as an aviator.

Mediating variables. Confidence should grow with increased pilot experience, and with it, perceived control. Likewise, the optimistic bias should increase. The question emerges as to whether this is a linear or curvilinear trend. It could be curvilinear, insofar as experience can also make one more aware of potential hazards. Some of the research evidence shows that the optimistic bias is muted by the closeness of the comparison group (Klar, Medding, & Sarel, 1996). In short, the bias is stronger when comparing one's possible fate with the abstract "average aviator" vs. another pilot from one's own unit or a close friend.

Most of the previous research on LOC among aviators, it should be recalled, used samples of general and commercial aviation participants. It would be reasonable to suppose that exposure to the stresses of combat may directly affect one's sense of control as well as expectancies about the probability of negative outcomes. Some researchable questions are whether combat experience among military aviators (a) diminishes the strength of the optimistic bias; (b) diminishes the degree of sense of personal control; (c) reduces the amount of risk taking, causing the aviator to take more precautions.

Laboratory research on risk taking. The research proposed above would essentially be correlational; this should be supplemented by laboratory simulations and simple experiments to establish causality, based on the findings of these uncontrolled field studies. This would also serve as a means of convergent validation. Aviators differing on dimensions relevant to the previously stated hypotheses would serve as participants. The experiments would entail various choice dilemmas varying in degree of risk (high/low stakes; high/low payoffs). The scenarios used would be relevant to risk situations in which aviators often find themselves. Some would relate to hazards all pilots can encounter; others would be specific to threats encountered in combat. In these studies mixed-factorial designs would be employed, with LOC and contingency/non-contingency of outcome would serve as blocking variables. Repeated trials would be run with trials varying in probability of success, with some outcomes contingent on subject input, others randomly determined. Participants would be asked to estimate probability of success after each trial. The primary question that this research would seek to answer is whether or not those with internal loci of control are more susceptible to the optimistic bias when compared to externals, and how quickly they detect non-contingencies between their own actions and outcomes.

Limitations of the Research

Range restriction and sample size. One possible limitation of any LOC research in aviation settings would be the strong possibility of a restriction in range of LOC scores among pilots, a highly select population whose survival depends upon the exercise of control over one's environment. This has been a recurrent finding in the small number of studies that have been conducted, using American civilian pilots (e.g., Hunter, 2002). However, the hypothesis that pilots are higher in the need for control than are other previously tested populations, though logically consistent, has not been conclusively demonstrated on samples of adequate size. This is true, to varying degrees, for all of the aviation LOC studies cited here. For example, Hunter (2005), in his online concurrent validation study, encountered sample size problems, chiefly because many participants dropped out before completing all of the scales. This resulted in small subsamples for some of the most critical intercorrelations, as between the ASLOC and the New-HAS. These limitations were probably due to the need to include large numbers of scales, to the point where respondents decided to quit after completing only a subset of them. This may also be a methodological issue for online data gathering, under conditions of anonymity. It is much easier to opt out of a survey in a situation where no one will see the person leaving the room.

Military vs. civil aviation. Military pilots may differ in many ways from their general aviation and commercial airline counterparts. These may be dispositional differences, or situational (e.g., ex-military pilots currently flying for an airline). A few tentative hypotheses were presented concerning differences in orientation toward risk taking and self-perceptions of invulnerability and confidence. Besides concurrent validation of the ASLOC, New-HAS and HES scales, on samples of military pilots, another advantage of research in military settings is the availability of archival accident reports, which could be content analyzed for wording consistent with such variables as hazardous attitudes and overconfidence.

Stability and change over time. Previous research does not tell us much about how the need for control is maintained over time, especially in the face of repeated success and failure. This would necessitate a theoretical underpinning, and a return to Rotter's social learning-expectancy theory. Unfortunately, many researchers seem to have drifted away from the close relationship between LOC and expectancy theory. In order to demonstrate hypotheses derived from this theory, criterion measures other than self-reports (i.e., behavioral measures) are needed. Instead of factor-analytic and attitudinal studies, it would be worthwhile examining in situ behavioral differences between internals and externals. A positive outcome of this research would be additional insight into the relationship between LOC and more recent personal control-based expectancy theories, which may be better suited for examining changes in expectancies concerning one's control over the environment, as a function of time and experience. It could answer questions such as: how do behavioral outcomes and their valences affect LOC, and when is too much internality a bad thing?

Conclusions

The goal of the foregoing review and discussion of LOC was to illustrate that human performance situations in aviation lend themselves quite well to applications of this construct, as well as others from the social psychological research literature. Many of the skills required for flying an aircraft depend upon the development of a sense of control, as well as the ability to anticipate situations where one's control over the aircraft may be challenged by external circumstances such as weather. Similarly, I have stated in this paper that the tendency to endorse an internal LOC as the desirable state in a person may not hold true across all aviation situations. The hazardous attitudes, as we have seen, appear to suggest strongly that pilots can get into trouble if they overestimate their degree of control over the aircraft, and, concomitantly, over their fate.

Although extensive research has been done on the LOC construct, little has been said about the possible consequence of extreme internality: overconfidence. Perhaps a reason for this is that much of the research has involved mostly college undergraduates in laboratory settings far removed from the high workload and potentially dangerous situations that are inherent to aviation. In many social settings, exaggerating one's sense of personal control can result in positive outcomes such as an enhanced self-concept and the rewards that go with it. It will not result in high-risk behaviors or risky decisions whose consequences could prove fatal. If we add to the potential risks of civil aviation settings the additional risks associated with combat, then the hazards of an exaggerated sense of personal control become even more apparent. Thus, the attributional style of the "internal" could foster the tendency to attribute a successful flight under dangerous conditions to piloting skill. Extreme internals may conclude that since they flew through a storm before and came out unscathed, they should be able to do this again under similar circumstances. The foregoing discussion of possible training countermeasures has suggested that with proper planning, the aviation training community can increase an aviator's level of awareness of the hazards concomitant to this kind of thinking, thus maintaining congruency between personal sense of control and the actual amount of control which the pilot has in the environment in which he or she must operate.

In short, the level of perceived personal control should be flexible and adaptable to the situation, allowing a pilot to maintain the vigilance and confidence required to perform successfully in a variety of potentially hazardous situations. Situations exist in which the "Can Do" (macho) attitudes that are prevalent in military aviation and other high-pressure professions may be appropriate; in others (e.g., peacetime aviation), much more cautious, deliberative attitudes are more appropriate. The key, then, is flexibility, in terms of both LOC and the other attitudes that we have discussed in this review. LOC and the hazardous attitudes should be variable and situation-appropriate. Making situation-specificity salient to pilots at all stages of their careers should become an important goal of aviation training. Risks acceptable in a military combat situation, where aircraft and crews may be expendable, are obviously not acceptable in non-combat or peacetime situations. There may also be a point in an aviator's career

progression where repeated success and mastery of difficult situations foster an exaggerated sense of control, in an environment where this is no longer adaptive.

Since LOC has been shown to be influenced greatly by one's reinforcement history, the payoff from such research could be an understanding of conditions which would likely promote shifts in LOC, as well as systematic training interventions aimed at maintaining a pilot's sense of control a realistic level. Such research would be somewhat novel, since it would treat LOC as a dependent variable, with the independent variable being training interventions designed to influence the participant's perception of personal control. It would also constitute longitudinal research, looking from short and intermediate term changes in LOC. At the present time, we know little about the variation in LOC among student pilots, journeyman pilots, or senior pilots. Knowing this could provide additional insight as to how flexible and adaptable these attitudes are, and at what stage of one's professional life. Other potential dependent measures would be self-reports on the New-HAS, as well as behavioral measures of risk taking and decision making in laboratory tasks and gaming situations. Simply stated, research opportunities abound in an area that seems to relate quite closely to risk taking, the perception of self-efficacy, and decision making in aviation settings.

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