

## ORIGINAL RESEARCH

# Development of an Aviation Safety Locus of Control Scale

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**Introduction:** Individual differences in locus of control have been shown to be associated with differential risk for accident involvement among industrial and hospital workers. Previous research has also demonstrated that pilots are higher on internality than externality. **Hypothesis:** This study was performed to assess individual differences on a new scale developed to assess locus of control with respect to aviation safety. It was hypothesized that pilots would exhibit higher levels of internality than externality on this new scale. **Methods:** An existing safety locus of control scale was modified to place the items in an aviation context, and the items were administered to a sample of approximately 480 pilots. Internality and externality subscales were created, and construct validity was assessed by correlating these subscales with measures of resignation and involvement in hazardous aviation events. **Results:** The subscales exhibited acceptable internal consistency, and were negatively correlated ( $r = -0.419$ ,  $p < 0.001$ ). Consistent with previous research, pilots exhibited substantially higher internality than externality. Correlation of the subscales with the measures of resignation and involvement in hazardous events supported the construct validity of the scale. **Discussion:** Differences exist among pilots on the Aviation Safety Locus of Control scale that may be associated with increased accident risk. In its present form, the new scale might be employed as a self-awareness exercise for pilots or as a covariate in research investigating the effect of other factors on accident involvement.

**Keywords:** LOC, locus of control, pilots, safety, aviation safety, accidents.

LOCUS OF CONTROL (LOC) refers to the degree to which a person perceives that the outcomes of the situations they experience are under their personal control. Individuals with an internal locus of control orientation perceive that they can exert control over the outcome of the situation, while individuals with an external locus of control attribute outcomes to external factors, such as luck or the actions of other persons. Since Rotter (14) first proposed this construct, it has been widely used in a variety of settings (8,12).

Wichman and Ball (16) administered the Rotter Internal-External Locus of Control scale to 200 general aviation pilots. In comparison to Rotter's 1966 sample, these pilots were significantly more internal. Internal LOC and age were also found to significantly predict attendance at safety clinics. Pilots with higher internal scores were more likely to attend—indicative of safety orientation. Wichman and Ball suggested that for pilots who are more internal in LOC, "... their way of handling dangers is not just to make light of them, but to actively do something about reducing the dangers." (16, p. 509)

In addition to the original Rotter scale which assessed

general LOC, scales have also been developed to assess the degree of perceived control over specific issues. For example, specialized LOC scales have been developed to assess health LOC (12,15) and automobile driving (11). As Montag and Comrey (11) note, "Attempts to relate internality-externality to outside criteria have been more successful when the measures of this construct were tailored more specifically to the target behavior (e.g., drinking, health, affiliation), rather than using the more general I-E scale itself." (11, p. 339)

Jones and Wuebker (7) described the development and validation of the Safety Locus of Control scale, derived from the Rotter LOC scale, to predict employees' accident and injuries. They found that participants in the lower accident risk groups were significantly more internal than participants in the high risk groups. They noted, however, that it was not possible to determine whether the individuals who experienced accidents were lower on internality before their accidents, or became lower as a result of their accidents. Nevertheless, they concluded that the findings of their study strongly suggest that the "construct of safety locus of control can be assessed and used to predict behavior" (7, p. 160).

The Safety LOC scale was also used by Jones and Wuebker (8) in a study of accidents among 283 hospital workers. They reported that employees with more internal safety attitudes were significantly less likely to experience occupational accidents, and were less likely to have severe and costly accidents, compared with employees with more external attitudes. In that study, they also administered the original Rotter LOC scale and found that there was only a moderate correlation ( $r = -0.41$ ) between the general LOC scale and the safety LOC scale. They interpreted that finding as indicating that "the two scales... are measuring overlapping, yet different psychological constructs." (8, p. 451)

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TABLE I. TYPES OF PILOT CERTIFICATE OF RESPONDENTS.

Certificate	% of Respondents	% of Pilot Population*
Student	24%	16%
Private	52%	42%
Commercial	18%	20%
Airline Transport	4%	22%

\* Proportion of certificate holders in the total US pilot population. Source: FAA 1999 Annual Report on Aviation System Indicators.

In this study, I modified the Jones and Wuebker (7) Safety LOC scale to create an Aviation Safety Locus of Control scale that would specifically address the construct of internality-externality among pilots. The items constituting this scale were worded so as to pertain to issues relevant to aviation safety. I hypothesized that pilots who were more internal on this scale would be at lesser risk of accident involvement. A situation-specific measure was created because, as Jones and Wuebker (7) noted, "Specific expectancies are assumed to play a greater role in determining one's future behavior in a specific situation than the more generalized expectancies" (7, p. 152). This assumption has been validated by Wallston, et al. (15) and by Donovan and O'Leary (4), who showed that their situation-specific measures were better predictions of situation-specific behavior than the generalized Rotter scale.

## METHODS

### Participants

Participants were recruited from visitors to a web site sponsored by the Federal Aviation Administration. Visitors to the site were invited to participate in this and several other research activities. The participants are, therefore, a sample of convenience and do not necessarily represent a random sampling of the pilot population. Over a period of approximately 6 mo, 477 pilots completed all 24 items of the scale. Demographic characteristics of the sample are as follows: (Mean [plusmin] SD) age = 46 [plusmin] 12.2 years; total flight time = 918 [plusmin] 2065 h; recent flight time 74 [plusmin] 101 h. The certificate types are described in **Table I**. This study was classified as exempt by the Institutional Review Board of the Federal Aviation Administration.

### Instrument Development and Data Collection

The 24 items of the Safety LOC (7) were rewritten, so as to place them in an aviation context. Four items were subsequently dropped, based on item analyses to be described later. The 20 remaining items are listed in **Table II**, along with an a priori scoring key developed through independent inspection of the items by myself and another experienced aviation psychologist. There were no items for which our assignments of the directionality of the scoring key differed.

Instructions for completing the scale were published on the web site, along with an assurance of anonymity for participants. Each of the items comprising the scale appeared one-at-a-time on the screen. Participants re-

sponded to the items using a 5-point Likert scale which ranged from Strongly Agree = 1 to Strongly Disagree = 5. Participants' responses were automatically recorded and saved in a database on the web server computer.

In addition to the LOC items, participants were also invited to complete a Hazardous Events Scale (HES; 5) and a Hazardous Attitudes Inventory (HAI; 2, 10). Participants were free to complete any or all of the scales in any order they wished. Because participants were free to complete one scale but not another, the sample size varies among the analyses reported later. Analyses based on less than the 477 participants who completed the LOC items are so identified.

## RESULTS

### Creating Internality and Externality Scores

Two approaches to scoring LOC scale have been reported in the literature. One scoring approach conforms to the theoretical position that internality and externality are not opposite ends of a single continuum, but represent distinct, separate constructs. Under this approach, separate Internality and Externality subscores are generated. The other approach conforms to the the-

TABLE II. AVIATION SAFETY LOCUS OF CONTROL ITEMS AND SCORING KEY.

Key*	Item
I	If pilots follow all the rules and regulations, they can avoid many aviation accidents.
E	Accidents are usually caused by unsafe equipment and poor safety regulations.
I	Pilots should lose their license if they periodically neglect to use safety devices (for example, seat belts, checklists, etc.) that are required by regulation.
I	Accidents and injuries occur because pilots do not take enough interest in safety.
E	Avoiding accidents is a matter of luck.
I	Most accidents and incidents can be avoided if pilots use proper procedures.
E	Most accidents and injuries cannot be avoided.
I	Most accidents are due to pilot carelessness.
E	Most pilots will be involved in accidents or incidents which result in aircraft damage or personal injury.
I	Pilots should be fined if they have an accident or incident while "horsing around".
I	Most accidents that result in injuries are largely preventable.
E	Pilots can do very little to avoid minor incidents while working.
E	Whether people get injured or not is a matter of fate, chance, or luck.
I	Pilots' accidents and injuries result from the mistakes they make.
E	Most accidents can be blamed on poor FAA oversight.
E	Most injuries are caused by accidental happenings outside people's control.
I	People can avoid getting injured if they are careful and aware of potential dangers.
E	It is more important to complete a flight than to follow a safety precaution that costs more time.
I	There is a direct connection between how careful pilots are and the number of accidents they have.
E	Most accidents are unavoidable.

\* I = Internal; E = External.

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oretical position that internality and externality are poles along a single continuum. Under this approach, a single score is generated which may range from extreme internality to extreme externality.

In the present study, a principal components factor analysis of the item response data revealed a complex factor structure, in which seven factors with eigenvalues greater than 1.0 were obtained. Together, these seven factors accounted for 50% of the total variance. Failure to find a single dominant factor reflecting an internality-externality continuum was interpreted as supporting the multiple construct position.

On balance, the literature and the present data seem to favor the position that internality and externality are distinct constructs. However, readers are directed to Montag and Comrey (11), and Collins (3) for a discussion and review of the question of multidimensionality of the LOC construct. In the interest of presenting complete data for this new scale, I have computed and reported both the separate Internal and External scores and a single Combined score. However, congruent with the literature, the analyses to follow will utilize primarily the separate Internal and External scores.

### *Internal and External Scale Scores*

Separate Internality and Externality scores were generated from the item responses, using the scoring key given in Table II. Inspection of the internal consistency indices (Coefficient Alpha) for the scales suggested that reliability would be maximized by omitting certain of the items, leading to the formation of two scales (Internal and External), each with 10 items, as shown in Table II. Coefficient Alpha for the 10-item Internal and External subscales were, 0.69 and 0.63, respectively, based on a sample of 477 cases.

The Internal and External subscale scores were computed as the sum of the responses to the 10 keyed items for each subscale. The summed responses were then reversed (by subtraction from 60), so that each subscale score had a possible minimum value of 10 (lowest level of agreement) and a maximum value of 50 (highest level of agreement).

Coefficient Alpha for the Internal and External subscales were somewhat less than the Spearman-Brown split-half reliability coefficient (0.85) reported by Jones and Wuebker (7) for the original safety LOC instrument. However, the results are similar to that obtained for other, shortened LOC scales. For example, Regis (12) reported Coefficient Alphas ranging from 0.51 to 0.59 for his 18-item Health Locus of Control scale, while Wallston, Wallston, Kaplan and Maides (15), reported Alphas of 0.54 to 0.71 for their 11-item scale.

The correlation between the Internal and External subscales was  $-0.419$  ( $n = 477$ ,  $p < 0.001$ ). Comparison of the means, using the SPSS<sup>®</sup> paired-sample  $t$ -test, demonstrated that pilots in this sample were significantly higher ( $t = 69.1$ ,  $df = 476$ ,  $p < 0.001$ ) on the Internal subscale ( $M = 38.8$ ,  $SD = 4.34$ ) than on the External subscale ( $M = 17.2$ ,  $SD = 3.79$ ).

Wichman and Ball (16) questioned whether pilots become more internal as a consequence of experience. To address that question, I correlated the Internal and

External subscale scores with age and total flight time. The correlations between age and the Internal and External subscale scores were 0.237 and  $-0.213$ , respectively. Both these correlations are statistically significant ( $p < 0.05$ ). The correlations between total flight time and the Internal and External subscale scores were  $-0.050$  and  $-0.012$ , respectively. Neither of these correlations is statistically significant.

The partial correlations between total flight time and the Internal and External subscale scores, when controlling for age, are virtually the same ( $-0.003$  and  $-0.016$ , respectively) as the bivariate correlations. In addition, the partial correlations between age and the Internal and External subscale scores (0.238 and  $-0.226$ , respectively), when controlling for total flight time, are also essentially the same as the bivariate correlations. These results demonstrate that pilots become more internal and less external as they grow older. However, increasing flight time has no impact on internal or external orientation.

### *Combined Scale Score*

Items identified as externally oriented were left in the original response orientation (i.e., Strongly Agree = 1; Strongly Disagree = 5), while items identified as internally oriented were reversed (i.e., Strongly Agree = 5; Strongly Disagree = 1). This resulted in a score with a possible range of 20 (most external) to 100 (most internal). The same 20 items used in the separate Internal and External subscales were used to generate this single score. Coefficient Alpha for the 20-item scale was 0.75.

The mean score for the Combined Scale was  $81.7 \pm 6.85$  SD. The correlations of the Combined Scale score with age and total flight time were 0.266 ( $n = 201$ ;  $p < 0.001$ ), and  $-0.021$  ( $n = 471$ ; non-significant), respectively.

### *Construct Validity*

To assess the construct validity of the Aviation Safety Locus of Control scale, I examined its relationship to two measures of related constructs. These measures were the Hazardous Attitudes Inventory (HAI; 2,10) and the Hazardous Events Scale (HES; 5).

*Hazardous Attitudes Inventory:* The HAI was developed as a pedagogic device to assist pilots in learning about the factors that influence decision-making. The inventory consists of ten scenarios depicting hazardous aviation situations. Each scenario has five alternative explanations of why a pilot might have gotten into such a situation or made the decisions depicted. Pilots are expected to choose the alternative explanation that best describes what they would have done. Each of the five alternatives is keyed to one of five hazardous attitudes, and an ipsative scoring procedure is used to generate scores for each of the five hazardous attitudes. The Resignation score indicates the degree to which the pilot chooses alternatives that indicate a feeling of powerlessness to control the events. Therefore, I expected that higher scores on the Resignation scale would be associated with higher scores on the Externality Scale and lower scores on the Internality scale.

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The correlations between the Resignation score and the Internal and External subscale scores were 0.010 (non significant) and 0.157 ( $p < 0.05$ ), respectively. The significant correlation between Resignation and the External subscale score is in the expected direction, indicating that pilots who had a more external orientation also had higher scores on the Resignation scale from the HAI. This supports, albeit weakly, the construct validity of the new LOC scale.

The correlation of the Combined Scale score with the Resignation scale from the HAI was  $-0.082$  (non-significant;  $n = 196$ ).

*Hazardous Events Scale:* The HES assesses the number of instances in which a pilot has been involved in an accident or in an event which could have easily become an accident, had circumstances been slightly different. For example, this scale includes items which assess the number of times the pilot has run low on fuel or inadvertently entered adverse weather conditions. The HES is proposed as a surrogate for the preferred external criterion of involvement in aircraft accidents because the low incidence of accidents makes the use of that criterion problematic.

Of the 477 pilots with Aviation Safety LOC scores, there were 176 who had also completed the HES. The mean score for the HES equals  $2.99 \pm 3.36$  SD. The range of scores was 0 to 22. The correlations between the HES and the Internal and External subscale scores were  $-0.205$  ( $p = 0.007$ ) and  $0.077$  (non significant), respectively.

Because the earlier analysis had shown a correlation between age and the Internal and External subscale scores, the effect of age on the relationships between the subscale scores and the HES were also examined. The partial correlations between the HES and the Internal and External subscale scores, controlling for age, were  $-0.227$  ( $p = 0.006$ ) and  $0.155$  (non significant), respectively. Similarly, the partial correlations between the HES and the Internal and External subscale scores, controlling for total flight time, were  $-0.200$  ( $p = 0.009$ ) and  $0.109$  (non significant), respectively.

The significant correlation between the Internality score and the HES is in the expected direction, indicating that pilots with higher internal orientation experience fewer hazardous events. There was no apparent relationship between the externality score and hazardous experiences. The partial correlations between the HES and the Internal and External subscale scores are close to the bivariate correlations, suggesting that neither age nor total flight time is substantially influencing the observed relationship between the subscale scores and the HES.

The correlation of the Combined Scale Score and the HES was  $-0.162$  ( $n = 170$ ,  $p < 0.05$ ). The negative correlation indicates that pilots who scored higher on the Combined score (were more internal) experienced fewer hazardous aviation events.

#### *Limitations to Generalizability*

A potential problem in the interpretation of the results with respect to the HES is the non-normal distribution of scores. The HES exhibits a very skewed dis-

tribution, with most values equal to one or zero. A logarithmic transform was used which produced an approximately normal distribution of scores. However, this attenuates somewhat the correlation between the Aviation Safety LOC scores and the criterion, and constitutes an unsatisfactory solution to the continuing problem of research with infrequent events.

It should also be noted that the study included no measure to assess social desirability. Therefore, some bias may be present if participants attempted to present themselves in a favorable light. However, internality is likely to be perceived as more socially desirable than externality. Therefore, a bias to respond in that direction would attenuate, rather than inflate the finding that the more external pilots were more at risk of involvement in a hazardous aviation event.

In addition, since the study was cross-sectional, rather than longitudinal, it cannot be determined whether the differences associated with age are due to other cultural artifacts. It is possible that pilots who started flying 30 yr ago were more internal than those who have begun flying more recently.

## CONCLUSIONS

An Aviation Safety Locus of Control scale was constructed based on an LOC scale previously developed to assess industrial worker safety. The items comprising this new scale were set in aviation terms and administered over the internet. Two methods of scoring were utilized, consistent with previous research on the LOC construct. Both the combined score scale and the subscales assessing internality and externality of pilots exhibited acceptable internal consistency for a large sample of pilots.

Consistent with previous research (16), pilots exhibited substantially higher internal orientation than external orientation on the new scale. Construct validity was assessed by comparison of the combined and separate scales with the Resignation score from the HAI and with a measure of involvement in hazardous aviation events.

For the combined scale score, there was a significant correlation with involvement in hazardous events. Direction of the relationship was such that pilots with a more internal orientation were involved in fewer hazardous events. This supports the construct validity of the new scale. However, the combined scale score did not correlate significantly with the Resignation score from the HAI. The lack of an apparent relationship for the combined score could be due to lack of construct validity for the scale, or it could be viewed as evidence against the single-factor LOC theoretical position. The latter interpretation is supported by the analyses of the separate internality and externality subscales.

When separate internality and externality scores were generated, the internality score was found to be significantly and negatively correlated with involvement in hazardous aviation events. In addition, the externality score was found to be significantly and positively correlated with the Resignation score from the HAI. Both of these correlations are in the expected directions. That is, pilots who held a greater external

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orientation tended to have higher resignation score, while pilots who were more internal tended to have experienced fewer hazardous aviation events. However, externality did not relate to involvement in hazardous aviation events, nor did internality relate to the resignation score. Clearly, on the basis of these results, these two subscales are measuring different constructs, which are not simply mirror images, one of the other. Each subscale seems to measure a unique aspect of the global construct of LOC and, hence, may make a unique contribution to the understanding of human behavior and the prediction of later behavior. It should be noted, however, that the different pattern of results among the scales and criteria might also be attributed to variations in the sample characteristics and changes in the statistical power due to the varying sample size used in the various analyses. Additional research is certainly needed to clarify these relationships.

Of particular interest in the area of aviation safety is the relationship between the internality subscale and involvement in hazardous aviation events. Although correlations with past behavior are no guarantee of predictive validity (6), the results raise the possibility that pilots who are at greater risk for accident involvement might be identified beforehand. Readers should note, however, that although the results are statistically significant, and interesting from a theoretical perspective, the magnitude of this effect is very small, accounting for only 4% of the variance in the external criterion.

This may seem like a negligible amount; however, to researchers familiar with the difficulties associated with the prediction of low base-rate events, this is not a trivial finding. It is a common theme in accident research that there is almost never a single cause for an accident. Accidents are the result of the junction of a number of events and conditions that culminate in tragedy. In a system with multiple redundancies and levels of defense, each small causal factor must align precisely to eventuate in an accident. Changing any causal factor by even a small amount may be enough to prevent the accident sequence from proceeding. Changing, or as is perhaps more likely, instituting defenses against personality factors which place pilots even minutely more at risk can have a significant beneficial effect.

While the initial results are promising, additional research is required to improve the internal consistency of the Aviation Safety LOC scales and to further assess the convergent and divergent construct validity. The finding that pilots become more internally oriented as they grow older, but not as they become more experienced, is also intriguing. This implies that the mere accumulation of flight hours is not sufficient to bring about a change in the pilot's orientation. Rather, it is their total life experience that leads to such a change. This is consistent with the general view of LOC as a stable personality variable. Clearly, if such is the case, then attempting to train pilots to become more internal (and hence, safer) might be exceptionally difficult; although, some authors (1,9) have suggested that personal experiences, directed cultural teaching, and therapeutic interventions can influence the development of internality. Indeed, much of the training in cockpit re-

source management which is prevalent throughout the aviation industry might be viewed as an attempt to make just such a fundamental change in how pilots view themselves and their environment.

In its present form, the scale might be employed as a self-awareness exercise for pilots wishing to explore potential aspects of their personality that could place them at greater risk for accident involvement. It may also prove useful as a covariate in research investigating the impact of other factors on accident involvement. Although the obtained effect size is small, every reduction in unexplained variance helps us refine our future studies as we slowly chip away at the problem of understanding the human factors that are associated with aircraft accidents.

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