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Measurement of Hazardous Attitudes Among Pilots

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I present data on the psychometric characteristics and construct validity of two Likert-type scales constructed to assess pilots' attitudes. These new scales were developed to assess the factors (Antiauthority, Macho, Invulnerability, Impulsivity, and Resignation) that have been suggested by previous research as being related to pilots' involvement in accidents. I compared results from the new scales with results from an ipsative scale contained in training developed by the Federal Aviation Administration. The results clearly demonstrate the superiority, both in terms of psychometric characteristics and construct validity, of the Likert-type scales. I suggest that the new scales should be used in those instances in which accurate measurement of the attitudes is needed, specifically to assess the contribution of pilots' attitudes to accident involvement and to assess of the impact of training.

Although the notion of "accident proneness" as a personality type has largely been abandoned (Grey, Triggs, & Hawarth, 1989; McKenna, 1988), the role of personality as an influence on behavior is generally well accepted. The current concept of differential accident liability holds that personality characteristics may, at different times and in different situations, place an individual at greater risk of accident involvement; however, the effects are situation specific and not a general tendency of the person to have accidents.

Personality may be defined as "the complex of characteristics that distinguishes an individual … *esp*[ecially]: the totality of an individual's behavioral and emotional characteristics" (Merriam-Webster, 1989). Personality components are clearly recognized in the models of pilot behavior proposed by Jensen (1995) and in the more general accident causation model of Sanders and Shaw (1988, as cited

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in Sanders & McCormick, 1993). In addition to many, generally unsuccessful attempts to use personality measures in pilot selection (see Hunter & Burke, 1994), several researchers (e.g., Lubner, Hunter & Struening, 2001; Platenius & Wilde, 1986; Sanders & Hoffman, 1975, 1976) have evaluated the relationship of attitudes to accident involvement among pilots, with mixed results.

Although not synonymous with personality, attitudes are a closely related construct. Wilkening (1973) defined *attitude* as "a learned and relatively enduring perception, expressed or unexpressed, influencing a person to think or behave in a fairly predictable manner toward objects, persons, or situations" (p. 28). Berlin et al. (1982) developed an ad hoc program to improve the decision making of pilots that focused heavily on pilots' attitudes, or what Berlin et al. termed *hazardous thought patterns*. From that initial work, the Federal Aviation Administration (FAA) published a series of documents (e.g., *Aeronautical Decision Making* [Advisory Circular 60–2]; FAA, 1991) that, among other things, have addressed the issue of hazardous thought patterns. The documents included a self-report scale that pilots used to identify their characteristic hazardous thought patterns (i.e., macho, antiauthoritarian, impulsive, resigned, invulnerable), and the documents then provided guidance on how to control those patterns. Several studies (e.g., Buch & Diehl, 1984; Diehl, 1991) have found that the training program was effective at improving the in-flight decision making of pilots, at least immediately after completion of the training. However, the design of those studies made it impossible to determine the effect of the hazardous thought pattern components.

Another significant obstacle to evaluating the contribution of the hazardous attitudes training has been the scale used to assess the attitudes. Specifically, the scale that was included in the training program to measure the hazardous attitudes was designed mainly for pedagogic use and utilized an ipsative format. An *ipsative* scale is one in which "the strength of each need is expressed, not in absolute terms, but in relation to the strength of the individual's other needs … an individual responds by expressing a preference for one item against another" (Anastasi, 1968, p. 453). In the usual implementation, the scores on an ipsative scale must total to a specified sum. Thus, having a high score on one subscale forces the scores on the other subscales to be low. This restriction imposes significant psychometric limitations on that scaling method and generally makes the interpretation of the traditional statistical analysis methods (such as correlation) problematic. (For a discussion of the difficulties associated with ipsative scoring methods, see Baron, 1996; Bartram, 1996; Hicks, 1970; Johnson, Wood, & Blinkhorn, 1988; Saville & Wilson, 1991.)

Holt et al. (1991; Holt, Boehm-Davis, Amendola, & Sweeney, 1994) designed a new instrument consisting of simple declarative statements with a Likert-type response scale that they believed would be superior to the old ipsative measurement scale. However, because of the difficulty associated with evaluating the instrument with pilots, they developed an equivalent form suitable for drivers and administered that version to a sample of 238 undergraduate students. Factor analysis showed that the instrument had factors that generally corresponded to four of the factors (macho, impulsivity, antiauthority, and resignation) purported to be measured by the FAA's instrument. Additionally, a factor representing confidence or competence in driving was found.

Holt et al. (1991; 1994) found that factor scores from the new instrument were significantly correlated with a number of criteria of interest including, seat belt usage, drinking and driving, moving violations, and accidents and incidents. Although Holt et al. appropriately limited their discussion of the results to drivers, their findings raise the question of whether similar outcomes could be obtained with pilots.

As part of a nationwide probability sample survey of pilots, Hunter (1995) developed a 27-item attitude scale that also used a Likert response scale. This scale contained two items worded to reflect each of the five hazardous thought patterns, whereas the remainder of the items addressed other attitudes believed to be reflective of safety, or conversely, risky flying. A subsequent study (Hunter, 2001) of the retrospective and prospective validity of the items for aircraft accident involvement found that only the items that assessed the pilots' opinion of how careful and cautious they were consistently predicted accident involvement. A limitation to this study was that only the individual item responses were evaluated, and summated scales from the attitude items were not created or evaluated. Subsequently, an initial analysis of the scale found that a 7-item subscale generated from the original 27 items significantly correlated with a criterion of involvement in hazardous aviation events (Hunter, 2002a).

As noted earlier, the traditional hazardous thoughts scale developed by the FAA used an ipsative format that has undesirable psychometric properties. The Holt et al. (1991; 1994) scale and the Hunter (1995) scale have attempted to overcome that shortcoming by using a Likert-type response format. Prior to this study, however, no data were available on pilots for the Holt et al. scale, and only a limited evaluation had been conducted of the Hunter scale. In this study, all three attitude scales were evaluated to address some of the limitations of current research. Specifically, the psychometric properties of the scales and their construct validity using a number of measures were examined. Because this was the first study to explore the characteristics of those scales, there were no specific a priori hypotheses, although the well-known difficulties associated with ipsative scales suggested that the newer summated scales would likely prove to have better psychometric characteristics.

METHOD

Participants

Participants in the development sample were recruited from visitors to a Web site sponsored by the FAA. Over a period of approximately 12 months, visitors to the site were invited to participate in this and several other research activities. Participation was voluntary and anonymous. Participants were identified, for purposes of matching information from the various scales, using a self-selected alias. Because participants were free to complete whichever scales they chose, the numbers of participants for whom data are available vary across scales, and the overlap of information across scales is incomplete. Table 1 provides the cross-tabulation of participants for all variables and shows that except for the New Hazardous Attitude Scale (New–HAS) taken from Holt et al. (1991), sample sizes for each of the variable pairs are adequate for analysis. Although almost 200 participants completed the New–HAS, relatively few of them completed the other scales. I address limitations that this imposed on the data analysis and interpretation later.

When registering on the Web site, each participant was asked to provide certain biographical information including highest pilot certificate, total flight time, and recent flight time. Table 2 summarizes those data for participants who completed the three attitude scales. For comparison, the corresponding data for all registered users of the Web site and, when available, the total pilot population are also provided. Clearly, users of the Web site and study participants reflect a higher proportion of private pilots and a correspondingly lower proportion of airline transport pilots than are found in the pilot population.

Measures

ASAS. The Aviation Safety Attitude Scale (ASAS; Hunter, 1995) consists of 27 items, each designed specifically to assess pilots' attitudes with respect to avia-

TABLE 1
Matching Cases Across Variables

	Demo	*ASAS*	*Old–HAS*	*New–HAS*	*SJT*	*TAS*	*LOC*	*RISK*
ASAS	434							
Old–HAS	1,566	209						
New–HAS	188	45	130					
SJT	448	116	292	23				
TAS	419	156	183	32	103			
LOC	469	162	198	33	107	392		
RISK	627	372	262	35	122	183	195	
HES	484	442	230	52	122	168	174	394

Note. Demo = demographic measures; ASAS = Aviation Safety Attitude Scale; Old–HAS = Old Hazardous Attitude Scale; New–HAS = New Hazardous Attitude Scale; SJT = Situational Judgment Test; TAS = Thrill and Adventure Seeking Scale; LOC = Locus of Control; RISK = risk perception and tolerance; HES = Hazardous Event Scale.

TABLE 2
Demographic Information for Study Participants

Demographic	*ASAS*	*New–HAS*	*Old–HAS*	*Web Users*
Certificate[a]				
Student (14%)	55 (13%)	41 (22%)	402 (25%)	1,362 (21%)
Recreational (< 1%)	0 (0%)	1 (1%)	10 (1%)	46 (1%)
Private (40%)	267 (61%)	86 (45%)	807 (50%)	2,499 (39%)
Commercial (20%)	91 (21%)	44 (23%)	259 (16%)	1,198 (22%)
ATP (24%)	20 (5%)	13 (7%)	70 (4%)	439 (7%)
Total flight time				
N	434	188	1,566	5,576
M	899	1,173	977	1,425
SD	1,995	2,941	2,666	3,553
Mdn	300	294	200	270
Recent flight time				
N	433	188	1,562	5,553
M	83	93	78	99
SD	112	144	144	169
Mdn	50	50	40	45

Note. ASAS = Aviation Safety Attitude Scale; New–HAS = New Hazardous Attitude Scale; Old–HAS = Old Hazardous Attitude Scale; ATP = Airline Transport Pilot.

tion safety issues. Ten items reflect the five hazardous attitudes suggested by Berlin et al. (1982). Additional items assess attitudes regarding weather, the risks encountered in aviation, the likelihood of experiencing an accident, and self-perceived skill. The 27 items comprising the scale are listed in Table 3.

Old–HAS. The Old Hazardous Attitude Scale (Old–HAS) consists of 10 scenarios depicting aviation situations that call for a timely decision on the part of the pilot and descriptions of the course of action that the depicted pilot took. Five alternative explanations of why the pilot might have taken that particular course of action are given, and participants are instructed to choose the explanation that best describes why they would have taken that action. Each alternative is keyed to one of the five hazardous attitudes. Summing the keyed alternatives generates scores for each hazardous attitude. Thus, the scores of all the hazardous attitudes must sum to 10. Following is an example of an item from this scale with the keyed attitude for the alternatives shown in parentheses (not seen by the participants).

> You are forty minutes late for a trip in a small airplane, and since the aircraft handled well on the previous day's flight, you decide to skip most of the preflight check. What leads you to this decision?
>
> - You simply take the first approach to making up time that comes to mind. (Impulsivity)

TABLE 3
Aviation Safety Attitude Scale (ASAS)

Factor No.	*Factor Loading*	*Item No.*	*Question*
1	.720	8	I am very skillful on controls.
1	.707	9	I know aviation procedures very well.
1	.695	6	I am a very capable pilot.
1	.618	2	I am capable of instrument flight.
1	.548	13	I have a thorough knowledge of my aircraft.
1	.534	22	I know how to get help from ATC if I get into trouble.
1	.526	10	I deal with stress very well.
1	.524	21	I fly enough to maintain my proficiency.
1	–.514	25	I often feel stressed when flying in or near weather.
1	.503	18	I find it easy to understand the weather information I get before flights.
1	.460	20	It is very unlikely that a pilot of my ability would have an accident.
1	.436	23	There are few situations I couldn't get out of.
1	.411	7	I am so careful that I will never have an accident.
1	.360	4	I never feel stressed when flying.
2	.598	26	Sometimes you just have to depend on luck to get you through.
2	.535	5	The rules controlling flying are much too strict.
2	.469	24	If you don't push yourself and the aircraft a little, you'll never know what you could do.
2	.469	27	Speed is more important than accuracy during an emergency.
2	.463	19	You should decide quickly and then make adjustments later.
2	.460	1	I would duck below minimums to get home.
2	.445	12	Most of the time accidents are caused by things beyond the pilot's control.
2	.317	16	The pilot should have more control over how he/she flies.
3	.655	15	I am a very cautious pilot.
3	.537	3	I am a very careful pilot.
3	.480	11	It is riskier to fly at night than during the day.
3	.434	17	Usually, your first response is the best response.
—	—	14	Aviation weather forecasts are usually accurate.

Note. Likert response scale ranging from 5 (*strongly agree*) to 1 (*strongly disagree*). ATC = air traffic control.

- You feel that your reputation for being on time demands that you cut corners when necessary. (Macho)
- You believe that some of the preflight inspection is just a waste of time. (Antiauthority)
- You see no reason to think that something unfortunate will happen this flight. (Invulnerability)
- If any problems develop, the responsibility would not be yours. It is the maintenance of the airplane that really makes the difference. (Resignation)

New–HAS. The New–HAS (Holt et al., 1991) consists of 88 simple declarative statements such as "I like to do spins," or "I like to fly on the edge." A Likert scale ranging from 5 (*strongly agree*) to 1 (*strongly disagree*) was used for responses.

SJT. The Situational Judgment Test (SJT; Driskill, Weissmuller, Quebe, Hand, & Hunter, 1998; Hunter, 2003) consists of descriptions of aviation scenarios in which some decision is required of the pilot. For each scenario, there are four plausible alternatives, and the pilot must choose one of the alternatives as his or her solution to the scenario. There are 51 items in the test, and they are scored (right or wrong) by reference to a key consisting of the alternatives recommended by a group of subject matter experts (highly experienced flight instructors). Higher scores indicate greater agreement with the recommendations of the experts.

TAS. The Thrill and Adventure Seeking Scale (TAS; Zuckerman, 1994) is a nine-item scale that assesses the degree to which participants would like to participate in a number of activities that could be described as adventurous and potentially physically dangerous. A Likert scale ranging from 5 (*strongly agree*) to 1 (*strongly disagree*) was used for responses. Higher scores indicate greater willingness to participate in the activities.

LOC. The Aviation Safety Locus of Control (LOC; Hunter, 2002b) consists of 20 Likert-format items ranging from *strongly agree* to *strongly disagree* that assess the degree to which a person perceives that the outcomes of the situations they experience are under their personal control. Two scores are generated that reflect the degree of internality (LOC–I) and externality (LOC–E). Higher scores reflect greater amounts of each of those orientations.

RP. Risk perception (RP) is measured using two scales (Hunter, 2002c) that assess perceived risk for a third party (RP–A) and perceived risk for self (RP–B). Both scales are comprised of brief descriptions of situations that vary in their degree of potential risk. Most items deal with aviation situations; however, a few items from the RP–B describe nonaviation situations. There are 17 items in the RP–A and 26 items in the RP–B. For each of the two scales, participants use a common rating scale to assign a risk rating to the scenario. This rating scale ranges from 1 (*low risk*) to 100 (*high risk*), and anchor descriptions are given for the two extremes and for the midpoint (50). The development and initial evaluation of the risk perception and risk tolerance measures (described following) are given in Hunter (2002c). Higher scores indicate that the person perceived the situations as involving greater risk.

RT. Three measures of risk tolerance (RT) were used (Hunter, 2002c). Using the general risky-gamble paradigm, these measures assessed risk tolerance associated with an aircraft maintenance risk (RT–A), turbulence due to a thunderstorm

(RT–B), and lowering ceilings in mountainous terrain (RT–C). For each of these subscales, higher scores indicate that the person was willing to take greater risk.

HES. The Hazardous Event Scale (HES; Hunter, 1995) is a 10-item scale that assesses participants' involvement in hazardous aviation events. Participants are asked to indicate how often during the previous 24 months they had been involved in the event. The response scale ranged from 0 to 6 or more. Responses of 6 or more were recorded as 6. Higher scores indicate the person had experienced more hazardous events.

Procedure

Instructions for completing each of the scales were published on the Web site along with an assurance of anonymity for participants. Each of the items comprising the scales appeared one at a time on the screen. Participants were free to complete the scales in any order. Participants' responses were automatically recorded and saved in a database on the Web server computer.

RESULTS

Exploratory principal components analyses of the ASAS and New–HAS item responses followed by Varimax rotation to simple structure were conducted using SPSS (Version 9.0). The number of factors to be retained and rotated was determined by inspection of the scree plot. Analysis of the ASAS yielded an interpretable three-factor solution that accounted for 27% of the variance. These factors were interpreted as representing self-confidence, risk orientation, and safety orientation. The factor loadings for the items defining each of the three factors are given in Table 3. The analysis of the New–HAS responses yielded an interpretable six-factor solution that accounted for 36% of the variance. The factor loadings for the items defining each of the factors are given in Table 4. These factors generally corresponded to those previously identified by Holt et al. (1991) and included Macho, Resignation, Antiauthority, Worry/Anxiety, Impulsivity, and Self-Confidence.

Summated scales were created based on the results of the factor analyses. For all the attitude subscales, higher scores indicate a greater degree of that particular attitude. For example, higher scores on the ASAS self-confidence factor indicated that the person expressed greater confidence in their ability as a pilot. To improve reliability, unit weights were used for the items in lieu of factor weights. Use of the unit weights reduces variability due to capitalization on chance by the factor extraction process.

The means, standard deviations, and reliability indexes for each of those subscales are given in Table 5. Table 5 also contains the corresponding data for the

TABLE 4
New Hazardous Attitude Scale (New–HAS)

Item No.	*Factor Loading* 1	2	3	4	5	6	*Item Text*
11	787						I like to practice unusual aircraft attitudes.
3	755						I like to practice unusual attitudes in flying.
9	730						I like to practice spins.
70	723						I like to practice stalls.
72	671						I like to practice steep turns.
12	560						I like making turns steeper than 60 degrees, just to see if I can do it.
74	514						When its windy out, I like to work on my cross-wind landings.
8	492						If I hear other pilots discussing a maneuver that can be done on my airplane, I'll try it out.
2	486						If there was a flying competition in my area, I'd participate in it.
73	485						If I find a sod (grass) field, I'll practice soft-field take off and landings.
1	480						I'd like to be a bush pilot.
6	458						If gusty cross-winds were keeping other pilots on the ground, I'd consider flying anyhow to see if I could do it.
10	430						I like to fly on the edge.
4	427						I like to see how close I can cut things.
5	409						I like landing on short fields just to show I can do it.
57		702					In flying, what will be, will be.
53		682					In a tight situation, I trust to fate.
54		625					When I'm in a tough spot, I figure if I make it, I make it, and if I don't, I don't.
49		615					Sometimes I feel that I have very little control over what happens to the aircraft.
47		544					Sometimes I feel like the airplane has a mind of its own.
56		531					If I had an accident, it would be the result of bad luck.
55		522					If I think an accident is going to happen when flying, I tend to freeze at the controls.
59		518					The strange noises in my airplane will just go away.

(continued)

TABLE 4 (Continued)

Item No.	Factor Loading 1	2	3	4	5	6	Item Text
45		494					I might dip into my fuel reserve to avoid a fuel stop and save time.
51		485					You don't go until your number is up.
46		436					Either an accident is going to happen to you or it isn't.
48		428					In a congested area, I figure that if I keep the correct altitude and heading I'll get through safely.
52		401					I'll die when it's my time to go, but not before.
61			752				The FAA is more of a hindrance than a help.
76			690				Air traffic control is often more of a hindrance than a help.
88			675				The FAA is more concerned with restricting access to aviation than in providing the services aviation needs.
86			630				Most of the Federal Aviation Regulations do not promote safety.
83			–630				In general, I find ATC to be very helpful.
84			–629				FAA inspectors for GA are very competent.
87			583				Ramp checks by FAA are a nuisance.
79			–568				I will follow the FAA regulations even if they inconvenience me, because it's the right thing to do.
77			–530				In general, I get good service from Flight Service Stations.
80			461				The FAA should do better things with their time than prosecuting pilots for minor airspace violations.
81			447				Random drug testing without any reason violates the rights of pilots.
24				731			I really worry about having to make an emergency landing.
20				636			I always worry about an accident when I'm flying.
21				636			I really worry about mid-air collisions.
22				630			While flying at night, I worry about not seeing navigation landmarks and getting lost.
30				623			If I fly over water, I worry about having to ditch if the engine quits.

(continued)

TABLE 4 (Continued)

Item No.	Factor Loading 1	2	3	4	5	6	Item Text
23				617			I really worry about running out of fuel.
28				606			I feel very vulnerable to accidents.
26				580			At night I worry about not being able to see an emergency landing field if the engine quits.
18				550			In an uncontrolled area with lots of traffic, I worry about the possibility of a mid-air collision.
13				464			I feel uncomfortable flying VFR in 3 miles visibility haze.
19				–443			I feel comfortable flying at night.
31				409			If I'm on base leg and the wind shifts so I'd land with a tailwind, I'll go around to make a different approach.
33					695		I really hate being delayed when I fly on a trip.
38					629		If I want to fly somewhere, I want to do it now.
82					574		If you want to protest a license suspension by the FAA, the odds are stacked against you.
35					557		I'm basically an impatient pilot.
16					–542		If the weather is marginal, I don't mind waiting at the airport until it clears up.
43					441		If I could cut off a lot of time on a cross country flight by taking a short cut through an MOA, I'd do it.
34					417		I feel like yelling at people who don't clear the runway fast enough when I'm on final approach.
37					417		I get angry if I'm on approach on base leg and someone cuts in front of me doing a straight-in approach.
69						606	The thoroughness of my preflight mostly determines the likelihood of my having mechanical trouble with the aircraft.
64						603	I am a pilot due entirely to my hard work and ability.
78						529	A successful flight is solely due to good planning and good execution.
60						435	If I have done something illegal while flying, I will report it myself because I figure someone will report it anyway.

(continued)

TABLE 4 (Continued)

Item No.	Factor Loading 1	2	3	4	5	6	Item Text
66						424	I can learn any flying skill if I put my mind to it.
51						409	You don't go until your number is up.
68						407	In a tight situation, I believe in doing anything rather that doing nothing.

Note. *N* = 197. Decimal points omitted. Factor 1 = Macho; Factor 2 = Resignation/External Locus of Control; Factor 3 = Antiauthority; Factor 4 = Worry/Anxiety; Factor 5 = Impulsive; Factor 6 = Self-confidence; FAA = Federal Aviation Administration; ATC = air traffic control; GA = general aviation; MOA = military operations area.

TABLE 5
Means, Standard Deviations, and Reliability of Attitude Scale Components

Scale	*M*	*SD*	*No. of Items*	α	*N*
ASAS					
Factor 1: Self-Confidence (ASAS–SC)	46.13	6.67	14	.76	428
Factor 2: Risk Orientation (ASAS–RO)	17.21	3.26	8	.59	438
Factor 3: Safety Orientation (ASAS–SO)	15.97	1.74	4	.40	440
New Hazardous Attitude Scale					
Factor 1: Macho (NEW–M)	34.84	7.69	15	.86	191
Factor 2: Resignation/External (NEW–R)	23.85	6.10	13	.82	188
Factor 3: Antiauthority (NEW–A)	23.99	5.60	11	.82	190
Factor 4: Worry/Anxiety (NEW–W)	38.22	6.67	12	.83	191
Factor 5: Impulsive (NEW–IM)	19.68	4.48	8	.74	190
Factor 6: Self-Confidence (NEW–SC)	23.46	3.57	7	.59	191
Old Hazardous Attitude Scale					
Macho (OLD–M)	1.56	1.39	10	.46	400
Resignation (OLD–R)	1.88	1.13	10	.22	400
Antiauthority (OLD–A)	1.12	1.08	10	.29	400
Impulsive (OLD–IM)	1.77	1.28	10	.36	400
Invulnerable (OLD–IN)	3.38	1.71	10	.50	400

Note. ASAS = Aviation Safety Attitude Scale.

Old–HAS. Those results demonstrate that with the exception of the ASAS–SO scale that contains only four items, the new Likert scales are superior in internal consistency to the ipsative scales.

Intercorrelations among the attitude scale indexes are given in Table 6. In general, the overlap among the three attitudes measures was, at most, moderate, although the self-confidence scale from the ASAS seems to have correlated fairly consistently with the scales of the New–HAS. These modest correlations may be attributed to the relatively modest reliability of the measures, or they may indicate that the measures are indeed assessing slightly different constructs. The correlations between factors of apparently similar content from the Old–HAS and the New–HAS were remarkably low: the largest correlation was –.124 between the old and new versions of the Impulsivity factors. However, as noted earlier, the properties of the ipsative scale used in the Old–HAS makes interpretation of the correlations involving that scale problematic.

Because there is no single instrument that is accepted as the standard of measurement in this area, several measures were used to evaluate the construct validity of the attitude scales, each representing slightly different convergent external constructs or measures of interest. These measures included Zuckerman's (1994) TAS and the LOC, measures of pilots' risk perception and risk tolerance, a measure of pilots' situational judgment, and a measure of their involvement in hazardous aviation events including accidents. The means, standard deviations, and reliability for each of the measures are listed in Table 7. Intercorrelations among the measures are presented in Table 8. Apart from the correlations among clearly related measures (such as Internal and External LOC), the correlations were, as before, only moderate at best, again suggesting that a variety of constructs were being measured.

The correlations of each of the attitude scales indexes with the construct validation measures are given in Table 9. The number of cases on which each correlation was based is also shown, in parentheses, as a reminder that particularly for the New–HAS, these numbers vary substantially and must be considered when evaluating the results.

Examination of Table 9 reveals that only 7 of the 50 correlations for the Old–HAS were statistically significant (readers should note that no attempt was made to control for experiment-wide error rate), there was no clear pattern to the significant correlations, and that the largest correlation was –.213. Similarly, 8 of the 60 correlations for the New–HAS were statistically significant (even with the much smaller sample sizes); however, these correlations were generally substantially larger than those obtained by the Old–HAS. In particular, patterns of substantial, significant correlations were found for the Antiauthority scale and the Worry/Anxiety scale. The Antiauthority scale was significantly correlated with the TAS Scale and with the LOC scales. The Worry/Anxiety scale was significantly correlated with both of the risk perception measures and with one of the risk tolerance measures. As would be expected, the Resignation scale was correlated

TABLE 6
Intercorrelations Among the Attitude Scales

	ASAS–SC	*ASAS–RO*	*ASAS–SO*	*NEW–M*	*NEW–R*	*NEW–A*	*NEW–W*	*NEW–IM*	*NEW–SC*	*OLD–AA*	*OLD–IM*	*OLD–IN*	*OLD–M*
ASAS–RO	–.085												
ASAS–SO	–.005	.142*											
NEW–M	.115	–.172	.203										
NEW–R	.373*	.176	–.197	–.114									
NEW–A	.489*	.045	–.013	.050	.242								
NEW–W	–.161	.125	–.544*	–.097	.096	–.285							
NEW–IM	.388*	–.066	.339*	.112	.061	.427*	–.381*						
NEW–SC	.152	–.007	–.143	.249	.309*	–.092	.199	–.174					
OLD–AA	.089	–.070	–.034	–.217	–.028	.052	.199	.110	–.150				
OLD–IM	.106	.086	–.128	–.144	.097	–.030	–.066	–.124	–.012	–.086			
OLD–IN	–.184*	–.030	.021	.302	.083	.043	.005	–.072	.241	–.445*	–.436*		
OLD–M	–.026	–.017	.119	.067	–.180	–.276	–.147	.095	–.152	–.109	–.219*	–.290*	
OLD–R	.099	.001	–.055	–.112	–.048	.238	.085	.049	–.019	–.003	–.085	–.187*	–.455*

Note. ASAS = Aviation Safety Attitude Scale; SC = Self-Confidence; RO = Risk Orientation; SO = Safety Orientation; NEW = New Hazardous Attitude Scale; M = Macho; R = Resignation/External; A = Antiauthority; W = Worry/Anxiety; IM = Impulsive; In = Invulnerability; OLD = Old Hazardous Attitude Scale.

$^*p < .05$.

TABLE 7
Means, Standard Deviations, and Reliability of the Construct Validation Measures

Scale	*M*	*SD*	*No. of Items*	α	*N*
Thrill and Adventure-Seeking (TAS)	28.70	6.29	9	.78	428
Hazardous Event Scale (HES)	3.17	3.48	10	.65	488
Situational Judgment Test (SJT)	24.54	5.21	39	.75	107
Locus of Control–Internal (LOC–I)	38.79	4.34	10	.69	473
Locus of Control–External (LOC–E)	17.19	3.75	10	.63	478
Risk Perception 1 (RP–A)	66.46	9.83	17	.85	633
Risk Perception 2 (RP–B)	57.89	12.79	26	.94	517
Risk Tolerance 1 (RT–A)	4.85	1.36	10	.91	401
Risk Tolerance 2 (RT–B)	4.67	2.17	20	.86	420
Risk Tolerance 3 (RT–C)	3.73	2.43	20	.90	403

significantly with the LOC Externality scale. In addition, the Impulsivity scale was negatively correlated with the LOC Internality scale, suggesting that those pilots who believed themselves to be more in control of the situation were less likely to agree with statements reflecting impulsivity.

For the ASAS, 14 out of 30 correlations were statistically significant. Most notably, the ASAS Risk Orientation subscale was significantly correlated with 7 out of the 10 validation measures, the largest was a correlation of .523 with the LOC Externality scale. This indicates that those pilots with the greatest risk orientation also believed that the outcome of situations was largely due to external influences beyond their control. It is also interesting to note the relation between the ASAS Self-Confidence scale and the Risk Perception and Risk Tolerance measures. Specifically, those pilots with the highest self-confidence scores (i.e., believed themselves to be very competent) judged the situations to be less risky than other pilots and were also willing to accept greater risk as part of a flight.

One-way analyses of variance (ANOVAs) using certificate level as the independent variable were conducted for each of the ASAS and New–HAS scales. An ANOVA was not conducted on the Old–HAS because the ipsative scoring procedures makes interpretation of the results problematic.

For the ASAS, significant differences were found for Factor 1 (Self-Confidence), $F(3, 433) = 42.296$, $p < .0005$, and Factor 2 (Risk Orientation), $F(3, 433) = 2.959$, $p < .05$). Differences for Factor 3 (Safety Orientation) approached but did not achieve statistical significance, $F(3, 433) = 2.482$, $p = .06$. Post hoc comparisons were conducted using the Bonferroni correction. For Factor 1, each certificate level was significantly different from all other certificate levels, with self-confidence scores rising steadily from student to Airline Transport Pilot (ATP) certificate levels. Differences between student ($M = 17.91$, $SD = 3.41$) and

TABLE 8
Intercorrelations Among the Construct Validation Measures

	TAS		*HES*		*SJT*		*LOC–I*		*LOC–E*		*RP–A*		*RP–B*		*RT–A*		*RT–B*	
Measure	*Correlation*	*N*	*Correlation*	*N*	*Correlation*	*N*	*Correlation*	*N*	*Correlation*	*N*	*Correlation*	*N*	*Correlation*	*N*	*Correlation*	*N*	*Correlation*	*N*
HES	.080	170	—															
SJT	–.132	105	–.197*	122	—													
LOC–I	.042	392	–.199*	174	.137	107	—											
LOC–E	.047	395	.058	174	–.287*	108	–.420*	466	—									
RP–A	–.109	183	–.054	394	.305*	122	.088	195	–.078	194	—							
RP–B	–.147	154	–.118*	359	.166	103	.019	165	.077	162	.571*	517	—					
RT–A	.110	132	–.039	360	–.277*	90	–.035	141	.017	141	–.078	401	–.096	370	—			
RT–B	–.104	141	–.029	388	.279*	95	.272*	150	–.201*	149	.251*	420	.223*	386	–.199*	389	—	
RT–C	.154	137	–.039	386	–.266*	89	–.130	146	.208*	145	–.163*	403	–.136*	370	.212*	374	–.485*	402

Note. TAS = Thrill and Adventure Seeking Scale; HES = Hazardous Event Scale; SJT = Situational Judgment Test; LOC = Locus of Control; I = Internal; E = External; RP = Risk Perception; RP–A = RP for a third party; RP–B = RP for self; RT = Risk Tolerance; RT–A = RT for aircraft maintenance risk; RT–B = RT for turbulence due to a thunderstorm; RT–C = RT for lowering ceilings in mountainous terrain.

$^*p < .05$.

TABLE 9
Construct Validity of the Attitude Scales

Scale	HES Correlation	HES N	SJT Correlation	SJT N	TAS Correlation	TAS N	LOC–I Correlation	LOC–I N	LOC–E Correlation	LOC–E N	RP–A Correlation	RP–A N	RP–B Correlation	RP–B N	RT–A Correlation	RT–A N	RT–B Correlation	RT–B N	RT–C Correlation	RT–C N
ASAS–SC	.208*	446	.025	118	.153	161	.107	165	–.161*	165	–.167*	376	–.329*	376	.108*	373	–.069	371	.100	369
ASAS–RO	.022	446	–.234*	118	.229*	161	–.322*	165	.523*	165	–.206*	376	–.169*	376	.075	373	–.086	371	.180*	369
ASAS–SO	–.051	446	.045	118	.011	161	.397*	165	–.261*	165	.068	376	–.009	376	.046	373	–.021	371	.059	369
NEW–M	.261	53	–.074	23	.289	32	–.070	33	.219	33	–.297	35	–.043	35	.184	32	.084	30	–.052	28
NEW–R	–.191	52	–.157	24	.019	30	–.129	30	.485*	31	.063	34	.114	34	–.150	31	–.220	29	–.032	27
NEW–A	.140	55	.039	23	.424*	31	–.562*	32	.446*	32	.043	35	.019	35	.065	32	–.181	30	.129	28
NEW–W	–.176	54	.353	24	–.073	31	.081	32	.087	32	.602*	36	.571*	36	–.347*	33	.277	31	.174	29
NEW–IM	.029	54	.069	25	.212	30	–.402*	31	.339	31	–.255	36	–.281	36	–.017	33	–.169	31	–.014	29
NEW–SC	.131	55	.067	24	.204	32	.214	33	–.036	33	–.074	36	.039	36	–.221	33	.257	31	–.205	29
OLD–M	.075	235	.060	299	–.031	185	–.055	195	.117	200	.062	262	–.062	251	–.160*	195	.117	182	–.213*	175
OLD–R	–.005	235	–.205*	299	–.018	185	.010	198	.139*	200	–.012	262	.076	251	.101	195	–.133	182	.207*	175
OLD–A	.074	235	–.033	299	.023	185	–.062	198	.050	200	.048	262	.043	251	–.151*	195	.060	182	.056	175
OLD–IM	–.096	235	–.040	299	–.098	185	.134	198	–.013	200	.007	262	.047	251	.106	195	–.137	182	.079	175
OLD–IN	–.027	235	.116*	299	.061	185	–.018	198	–.203*	200	–.047	262	–.032	251	.092	195	.082	182	–.069	175

Note. TAS = Thrill and Adventure Seeking Scale; HES = Hazardous Event Scale; SJT = Situational Judgment Test; LOC = Locus of Control; I = Internal; E = External; RP = Risk Perception; RP–A = RP for a third party; RP–B = RP for self; RT = Risk Tolerance; RT–A = RT for aircraft maintenance risk; RT–B = RT for turbulence due to a thunderstorm; RT–C = RT for lowering ceilings in mountainous terrain.

*$p < .05$.

commercial ($M = 16.40$, $SD = 3.43$) certificate levels were significantly different ($p = .038$) for Factor 2 (Risk Orientation). The value for private pilots was intermediate between the student and commercial pilot levels, but differences were not statistically significant.

Analysis of the New–HAS scales revealed significant differences among the certificate levels for the Macho factor, $F(3, 180) = 4.37$, $p = .005$, and Resignation factor, $F(3, 176) = 3.450$, $p = .018$. None of the other factors achieved statistical significance. Post hoc comparisons for the Macho factor demonstrated significant ($p = .013$) differences between the student ($M = 31.73$, $SD = 8.67$) and commercial ($M = 36.80$, $SD = 6.66$). The Macho scores for ATPs ($M = 38.46$, $SD = 5.35$) were also significantly ($p = .032$) different from student pilots. None of the other comparisons were significant, although inspection of the means plot showed a clear tendency to increasing Macho scores as certificate levels increased. For the Resignation factor, significant ($p = .012$) post hoc comparisons were obtained only between the student ($M = 25.70$, $SD = 6.15$) and commercial ($M = 21.62$, $SD = 5.89$) certificate levels.

DISCUSSION

With regard to the psychometric properties of the three scales, it is clear from these results that although the ipsative scale used in the aeronautical, decision-making, training material may have been suitable for pedagogic purposes, it was psychometrically inferior to either of the Likert-scale attitude measures. The measures of internal consistency reported previously show the Likert scales generally had substantially better reliability. In addition, plots of the score distributions (not shown) indicated that their distributions better approximated the normal distribution.

If the set of external measures used here are accepted as collectively representing valid aspects of the constructs of interest, then the results strongly suggest that the Likert-type scales were better measures than the old ipsative scale. For the Old–HAS, significant correlations of at most .213 were obtained with the construct validation measures. In addition, there was no consistent pattern of significant results, suggesting that the observed significant correlations may have been an artifact of the number of correlations computed. Recall from elementary statistics that with no correction, about 5 out of 100 correlations may be statistically significant simply by chance. In contrast, both the ASAS and the New–HAS produced substantially higher correlations with the validation measures, with maximum correlations of .523 and .602, respectively. Moreover, although these results are also subject to the artifact mentioned earlier, the patterns of results for both of these scales were much more consistent. For example, the ASAS Risk-Orientation subscale was correlated significantly with six of the nine validation measures, whereas the Antiauthority and Worry/Anxiety subscales from the New–HAS were both correlated significantly with three of the measures. Comparisons of the relative validity of the two Likert scales are made difficult, of course, by the relatively smaller sample for the New–HAS.

Taken together, these results demonstrate that researchers who wish to measure these constructs should not rely on the Old–HAS for measurement purposes. Rather, they should use one or both of the new scales. The choice of measurement instrument is important because the accurate measurement of such attributes as are addressed by these scales is essential for an evaluation of their contribution to criteria of interest such as accident involvement or training impact. Using these more accurate measures, researchers may address the previously untested assumptions that hazardous attitudes are related to accident involvement and may also assess the degree to which training has been successful at changing those attitudes that place pilots at increased accident risk.

Although these results clearly demonstrated the superiority of the new scales over the old ipsative scale, there are still issues regarding the new scales that remain to be resolved. One issue that should be addressed in future studies is the reliability of the ASAS scales that, at present, are adequate, although hardly impressive. Efforts should be made to improve the items and add items to the scales (particularly for the Safety Orientation factor) to improve internal consistency. At the same time, the test–retest reliability of the ASAS and the New–HAS should be assessed. Additional data are also needed to further assess the construct validity of the New–HAS, which in this study was restricted by the limited number of participants with data on both the scale and the construct validation measures.

Additional data would allow for a better comparison of the New–HAS and the ASAS. Inspection of the content of the items from the New–HAS and the ASAS suggests that they measure similar constructs, and there was certainly some degree of overlap as indicated by the correlations of the ASAS Self-Confidence factor with the New–HAS. However, the relatively low correlations overall between the New–HAS subscales and the ASAS subscales are troubling. It is tempting to speculate on why two so apparently similar instruments fail to show stronger interrelationships; however, it is a matter better determined by the data from future studies in which reliability is improved and samples are larger.

According to Flin (1997), "Our behaviour is governed to a significant degree by the attitudes we hold, and any attempt to change behaviour should begin with an attempt to identify underlying attitudes and beliefs relevant to the behaviours in question" (p. 125). The construct validation conducted in this study has supported that assertion by showing that attitudes may be significantly and substantially related to important criteria of interest. Therefore, these constructs should be included in our studies of pilot behavior, particularly with respect to safety. Although the effects of these attitudes on behavior are often small, a complete theory of the factors influencing pilot behavior would certainly be incomplete if they were absent. Knowledge, skill, personality, and perhaps other constructs each have the potential to explain a portion of the variance in individual differences, and each must be addressed.

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