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Cognitive Learning Bias of College Students in an Aviation Program

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ABSTRACT

Students are attracted to university aviation programs for a number of reasons. How well they learn from instruction in a classroom, an airplane, a simulator or in other environments is impacted by their ability to react to stimuli and to process different types of information. Research into cognitive learning style and preferences addresses the processing of information. This paper presents data on a study designed to assess aviation students' cognitive processing bias (the preference for learning and organizing information using one side of the brain or the other, or both sides) at a four year university aviation program. It further investigates whether patterns or correlations exist between the biases and factors such as class standing, age, gender and aviation program choices. Results of the study provide a basis for further research and study into cognitive processing capabilities and the factors that influence student development, such as instructional techniques and instructor methodologies.

INTRODUCTION

All students enrolling in a university aviation curriculum bring with them a wide variety of skills and capabilities. The education process is intended to help develop and refine those skills and capabilities in both the behavioral and cognitive domains. A review of students' interests and backgrounds at Bowling Green State University in Ohio showed new freshman and transfer students from within the university often had an artistic or music background. Such a background has been associated with right brain hemisphere processing capabilities. Somewhat interestingly, it appeared many of those students tended to struggle academically in classroom courses or very structured courses such as math and physics. Yet, they performed well in the hands--on experiential part of the curriculum, such as flying, maintenance, or laboratory.

This observation raised questions as to why students would have difficulty mastering various classroom courses yet do well when involved in the hands--on and experienced--based type of instruction which necessitated understanding of the classroom material. Were the students their own worst enemies by not applying themselves? Could the method of instruction used in the program impair their performance? Is there a different pattern of cognitive processing in those individuals who are attracted to the aviation program or career field versus those who continue to do well in the program or who actually succeed in the field? What is the cognitive processing capabilities of successful individuals? How might instructional practices influence or affect the students' success rate?

The questions raised led to an investigation into learning style and its application to aviation curriculums. An extensive amount of information and research exists related to various learning styles (Grady, 1984; Dunn, Beaudry and Klavas, 1988). The literature suggests that faculty should modify their teaching methods to better address the learning styles of students (Kolb, 1985; McCarthy, 1987). Previous studies have been conducted to correlate the so called ``hemispheric bias theory" with occupational choice (Bakan, 1969; Dabbs, 1980; Kolb, 1985; Veehof, 1992; Wenham and Alie, 1992), but none address the integrated functions of cognitive hemisphere processing. Also, aviation students have not generally been the focus of these studies. Galotti (1992) did study air traffic control candidates and found reason to suggest further study into learning styles as a criteria for candidate selection.

The investigation into learning style did not satisfy the author's curiosity about how the information was being processed. The instruments used to determine learning style tended to be lengthy or difficult to administer. Also, learning style research generally addresses the separate nature of each hemisphere. Crane (1992), however, has focused on studying the bilateral individual, or how the two brain hemispheres work together. Crane's approach differs from learning style research in that he attempts to identify the degree to which the relational and sequential hemispheric cognitive functions integrate and process information.

The hemispheric bias theory is associated with how cognitive processing occurs in the brain and how each hemisphere of the brain performs different cognitive activities. The left side primarily processes information using a logical sequence while the right side primarily uses relational patterns. Crane contends that the same information is processed differently in both hemispheres with the majority of individuals responding to situations by integrating the hemisphere processes depending upon the situation.

The current study attempts to delineate the cognitive (a.k.a., hemisphere) processing bias of aviation students at different age, grade and experience levels. The premise for conducting the study was that students entering the aviation program had a bias for more relational cognitive processing than sequential processing, while students in the upper grade levels or who had recently graduated had more sequential or combined relational/sequential cognitive processing capability. It is also hypothesized that as students progress through an aviation program, a natural process occurs in which those students with strong tendencies will eventually leave or transfer from the aviation program. In addition to assessing the students' yearly transition, data were collected to assess whether differences existed in factors such as age, gender, or aviation program

Strong Sequencing (SS)	Moderate Sequencing (MS)	Specialized-Alternating-Combination-(SB-AB-CB)	Moderate Relating (MR)	Strong Relating (SR)

Figure 1. Continuum of Cognitive Preference (Crane)

Class rank	*n*	*%*	*Age*	*n*	*%*

choices. This collection of data would serve as a basis for further study and analysis.

BACKGROUND

The questionnaire used in the study allows for the grouping of responses into three general categories of cognitive preference: sequential, bilateral and relating. The three groups are further delineated along a continuum into strong sequencing (SS), moderate sequencing (MS), specialized bilateral (SB), alternating bilateral (AB), combination bilateral (CB), moderate relating (MR), and strong relating (SR) (see Figure 1). The differences among the cognitive modes is determined by the way information is processed or handled.

The sequencing preference is associated with the left hemisphere of the brain and relates to those cognitive processes and organization of thought that have an external focus relative to the individual. Individuals favoring this cognitive bias often tend toward analytical and reasoning processes and use objective criteria. They learn through a process of gaining knowledge, which leads to understanding, which in turn leads to action based on the knowledge and understanding. Functioning in the sequential mode results in abstract concepts being formed but it requires very specific or objective detail as a basis for forming the concepts.

The relating preferences are associated with the right hemisphere of the brain where the cognitive focus and organization of thought tends to be more internal to the individual. Individuals favoring this cognitive bias tend to be intuitive, have greater emotional awareness and response to subjective feelings. They learn through a process of acting, which leads to understanding, which in turn leads to knowing. Functioning in the relating mode results in more generalized ``big picture'' concepts being formed. However, concrete thought or activity is required as the basis for developing and relating the concepts.

The bilateral cognitive process involves preferences that are: specialized (i.e., about half the time information is organized or a particular task is performed in only one mode, while the other half of the time information is organized or a particular task is performed in the other mode); alternating (i.e., information is organized or a particular task is performed in either mode); or combination (i.e., both modes are used at the same time).

As an illustration of the concept of this study, the availability of statistically significant information is best processed by an individual having a sequential or left hemispheric bias. A graphic representation of the data, however, is best processed by an individual who has a relational or right hemispheric bias. The ability to process the data in either presentational mode is illustrative of a bilateral individual.

METHODOLOGY

All students and flight instructors involved in the aviation program at Bowling Green State University were asked to complete a 20 question instrument developed by Crane (1992). The instrument is designed to identify the cognitive hemispheric processing preference of respondents. Validation and reliability of the instrument is addressed by Crane (1992) in his studies and include correlational studies to EEG measures of students. Further validation is being accomplished through correlational studies using the Myers--Briggs instrument for psychological types. This study provides a basis from which further reliability testing can be conducted.

Of the 107 eligible undergraduate students, graduate students and flight instructors involved in the aviation program, 96 chose to participate. Of the 96 responses, 87 were considered valid for the study in that all 20 questions on the instrument were answered. Table 1 provides data on the demographics of the participants. Mean score responses were rounded off to two decimal places and percentages were rounded off to one decimal place. The differences in the demographic totals are due to missing data for that particular variable. The percentages shown have as a bast the number of valid responses for each demographic variable.

The voluntary self--report instrument took approximately 15 minutes to complete and involved anonymous and confidential responses from the students. There were no special conditions or procedures required of the students and there were no abnormal risks associated with participation. Students and instructors were requested to volunteer at a general student meeting and during classes in the fall of 1993. Study participants were required to either be enrolled or actively involved in the aviation program at the university.

Statistical analysis of the responses comprised a series of t--tests and chi--square analyses and was performed by the statistical processing center at Bowling Green State University.

RESULTS

Study results classify the student population into the following biases: 20 students (23.0 percent) have a sequencing bias (SS and MS), 15 students (17.2 per-

Pilot	76	(87.4)	Female	19	(21.8)
Management	7	(8.0)	Male	68	(78.2)
Maintenance	4	(4.6)			

Note: 87 responses are valid for class rank, curriculum, and gender while 79 responses are valid for age. Percentage totals may not equal 100 due to rounding.

TABLE 2
Cognitive Bias Continuum Results of Aviation Students' Class Standing

Class	*n*	*M*	*SD*
Freshman	13	4.23	2.13
Sophomore	15	4.40	1.92
Junior	23	3.52	1.65
Senior	29	3.76	1.79
Graduate	7	3.85	1.46
	% Sequencing	*% Bilateral*	*% Relating*

cent) have a relating bias (SR and MR), and 52 students (59.8 percent) have a bilateral bias. A breakdown of the 52 students having bilateral bias identifies 34 as having a specialized bilateral bias (SB), 15 as having an alternating bilateral bias (AB), and 3 as having a combination bias (CB). Data compiled previously by Crane on college students in a general education course and analyzed by this researcher indicates distribution will tend toward a normal curve for a general student population when specialized bilateral is combined with alternating combination bilateral.

The mean and standard deviation were calculated for the different variables. Comparison is to be made to a normal distribution curve. A chi--square analysis revealed that there were no statistical differences among the correlations due primarily to insufficient population numbers in the groups. Though considered a limitation to this study, the data are still useful for serving as a basis for further study. The student results which identify the cognitive learning biases for the different variables are shown in Tables 2 through 5.

For class standing (Table 2), it is noted that no freshmen indicated a SS preference while no junior or senior indicated a SR preference. Graduate student flight instructors, who might be considered to be successful because of their advanced position, demonstrated no SS or SR preferences (Note: for this study the term successful denotes the ability to have progressed through a four year degree program and having acquired the necessary cognitive and behavioral skills, knowledge, and attitudes to have obtained aviation employment through a screening process).

The mean for freshmen and graduates progress from 4.23 to 3.85 and in the direction of sequential processing. While this is the expected result, statistically it is not significant in this sample. The standard deviation progresses from 2.13 to 1.46 from freshman to graduate. These data, though not significant in this

Freshman	0.0	23.1	46.2	0.0	30.8	0.0
Sophomore	6.7	6.7	40.0	26.7	13.3	6.7
Junior	13.0	8.7	43.5	30.4	4.3	0.0
Senior	3.4	27.6	34.5	13.8	20.7	0.0
Graduate	0.0	14.3	28.6	42.9	14.3	0.0

Note: SS = strong sequencing; MS = moderate sequencing; SB = specialized bilateral; AB-CB = alternating-combination bilateral; MR = moderate relating; SR = strong relating. Percentage totals may not equal 100 due to rounding.

TABLE 3
Cognitive Bias Continuum Results of Aviation Students' Age

Age	*n*	*M*	*SD*
<18	12	3.75	1.76
19-20	27	4.14	1.87
21-22	20	3.80	1.73
23	20	3.65	1.72

	% Sequencing		*% Bilateral*		*% Relating*	
Age	*SS*	*MS*	*SB*	*AB-CB*	*MR*	*SR*

small sample, provide a basis from which further study and comparison can be made to better determine if statistical significance will occur with a large number of students.

The age continuum (Table 3) shows similar results to the class continuum. No SR exists for age 21 and older while no SS for age 18 and younger exists. It is noted that no older students (23 and older) were identified as SS or SR. The means show a slight progression from 3.75 to 3.65 for the overall results, but it is more dramatic from ages 19--20 to ages 23 and older (4.14 to 3.65).

Crane's research data have generally shown that cognitive bias is not affected by gender, though females do tend to use lateralization to a larger degree than males (Crane, 1992). Lateralization is the organizing and processing of information in both brain hemispheres. In the gender analysis (Table 4), it is inconclusive as to whether the gender graph would support the basic hypotheses or not because no SS exists and the sample size is too small to give any indication.

The program option choice for the students is identified in Table 5. It was surmised (but not substantiated) that due to the different nature and tasks of flying, management and maintenance, the distribution of the cognitive biases of students in each curriculum option would vary. The number of students indicating their program choice as ``pilots'' differs from official academic records. The difference is attributed to many students viewing themselves as primarily pilots and thus marking that particular program choice on the questionnaire. However, of those students clearly identified as management or maintenance, none had SS or SR tendencies.

Note: SS = strong sequencing; MS = moderate sequencing; SB = specialized bilateral; AB-CB = alternating-combination bilateral; MR = moderate relating; SR = strong relating. Percentage totals may not equal 100 due to rounding.

TABLE 4
Cognitive Bias Continuum Results of Aviation Students' Gender

Sex	*n*		*M*		*SD*	
Female	19		4.21		1.62	
Male	68		3.79		1.84	
	% Sequencing		*% Bilateral*		*% Relating*	
Sex	*SS*	*MS*	*SB*	*AB-CB*	*MR*	*SR*
Female	0.0	5.3	52.6	21.1	15.8	5.3
Male	7.4	20.6	35.3	20.3	16.2	0.0

Table 6 summarizes the results from chi--square analyses to determine if the demographic variables are related to a normal distribution of cognitive bias. The p--values show that the demographic variables and the cognitive bias are independent of each other. It should be noted that for each variable test, anywhere from 42 percent to 80 percent of cells had expected counts less than 5, which was the necessary number required to make the tests completely valid. Those cells having fewer than 5 counts for each of the variables were generally in the categories of strong sequencing, moderate relating, and strong relating.

Note: SS = strong sequencing; MS = moderate sequencing; SB = specialized bilateral; AB-CB = alternating-combination bilateral; MR = moderate relating; SR = strong relating. Percentage totals may not equal 100 due to rounding.

TABLE 5
Cognitive Bias Continuum Results of Aviation Students' Program Standing

Program	*n*		*M*		*SD*	
Pilot	76		3.99		1.79	
Management	7		3.14		1.68	
Maintenance	4		3.25		1.89	
	% Sequencing		*% Bilateral*		*% Relating*	
Program	*SS*	*MS*	*SB*	*AB-CB*	*MR*	*SR*
Pilot	6.6	15.8	38.2	22.4	15.8	1.3
Management	0.0	28.6	42.9	14.3	14.3	0.0

TABLE 6
Chi-square Analyses of Cognitive Bias to Demographic Variables

	N	*df*	*Computed x2*	*p*
Gender	87	5	6.63	0.25
Class	87	20	9.62	0.98
Age	79	15	17.26	0.30
Curriculum	87	10	11.03	0.36

Note: Test variables had from 42 percent to 80 percent of cells with expected counts less than 5. Chi-square may not be a valid test. p = .05.

DISCUSSION

This study attempts to determine if there is a predominant preference of cognitive processing bias among aviation students. Although the sample size is too small to determine statistical significance of the results, the information is still valuable to aviation educators as a basis for further study, investigation and debate.

The data suggest that graduates of aviation programs have a higher percentage of bilateral capabilities than those first entering the undergraduate program. This is evidenced by a progression in the means from relational toward bilateral and the smaller standard deviations from freshmen to graduate students. Fewer students at the senior or graduate level have a bias for strong sequencing or strong relational cognitive processing than at the freshman level.

That most classroom aviation instruction tends to be sequentially biased needs to be affirmed. However, the argument for the notion that a shift occurs in the cognitive bias processing capabilities is rooted in how aviation classroom instruction occurs. Learning about checklists, flight theory, aircraft systems and federal regulations generally involve using logical or sequential thought processes.

Students who have a relational preference will find it difficult or frustrating to comprehend or learn the instructions or tasks taught in a logical or sequential process. Subsequently, those students encountering academic difficulty are likely to transfer or drop from the aviation program. At the higher grade levels, then, students strongly favoring a relational processing bias will not be in evidence. It is recognized that many factors exist that can influence a student in transferring or changing from an aviation program. Such factors can be lack of funding, personal problems, or change of interests. However, the primary assertion being made by this author is that instructional techniques and an instructor's own cognitive bias are two factors that will have a major effect on the academic progress of aviation students. This author believes the predominance of bilateral and sequential processors in the upper levels occurs as a result of classroom instruction favoring the sequencer and those students who can adapt to sequencing techniques.

The reason for this belief is that if problem--solving or task assignment is presented in only one mode of instruction, approximately half of the students may have difficulty completing the assignment or task. If students have difficulty completing the assignment or task, then academic performance will generally receive a negative evaluation. Aviation classroom instruction tends to favor the sequential process, as exhibited by standardized FAA guidelines for flight courses. If aviation educators' instructional techniques effectively reach only half the students, then educators are abrogating their responsibility to their students, their university, and to their profession.

It is further contended that aviation tends to attract a large number of relaters who tend to learn best through action and discovery techniques. Exposure to the sequential mode of course delivery proves to be frustrating for them. If a student has limited ability for processing information in that mode, they will become frustrated and either transfer or drop out of the program. As more and more rule memorization and similar sequential instruction is encountered and rewarded, those not able to adapt or otherwise compensate intellectually will invariably find it more difficult to remain and do well in the program.

This suggests that two reasons exists for the fewer relational mode students in the upper levels shown in Table 1. Students either learn to become better at lateralization and move away from solely relying on relational processes, or they leave the program to pursue other career choices. The reasons for the latter stem from the frustration of trying to learn from primarily sequential instructional techniques, or an instructor's biases do not reward students' relational strategies. For the former, further study into cognitive processing can help to assess whether lateralization occurs and whether it might be a predictor of success.

This raises the question of how flexible should aviation instructors be in their instructional techniques and methodologies. This author suggests that an instructor should be versed in a variety of teaching skills and be able to use various instructional methods that will address and nurture the different cognitive biases and learning styles of the students. This suggestion is confined to only the secondary schools and university setting were the goal of education is to develop individuals capable of functioning in various career fields. At the more specialized corporate or airline pilot level, it may be beneficial to have a higher percentage of individuals with a particular cognitive capability and instructional delivery should address those capabilities.

STUDY LIMITATIONS

Cognitive bias is the preference for processing information using sequential versus relational patterns. It is theorized that students desiring to be successful in an aviation program need to use cognitive hemisphere lateralization (i.e., integrate information from both hemispheres together) and incorporate several cognitive processing modes. A comparison of means shows a progression toward lateralization from entry level students to graduate students. A comparison of standard deviations shows a narrowing of the distributions from entry level students to graduate students. However, the shifts did not carry significance due in part to the small sample size. That is one limitation to the study.

Analyses were also made to see if the bias preferences could be correlated with such factors as class standing, age, gender and aviation program choices. The results indicated that no correlations exist, again, primarily due to the small sample size. This study assessed the cognitive hemispheric preferences of students in a 4--year aviation program. It was undertaken primarily to see if there existed support for a hypothesis of cognitive preferences in aviation students. It was intended to lay the basis for future hypotheses and investigation into the cognitive capabilities of aviation students and into learning and instructional styles. For that reason the study was designed as a snapshot of students in an aviation program. Not having a corresponding control group to make direct comparison of the results is a second limitation of the study. Control group generalizations are made to Crane's studies of college students. Based on those generalizations, the results are interpreted as encouraging continued research. Further comparison of aviation students to students in other specialized curriculums and to the general student population will enhance the results of both this study and Crane's.

Finally, though Crane's work has a solid basis in psychological research, his instruments are not widely known or utilized. Questions about validity and reliability can b e answered from more thorough correlational studies. Such studies are being undertaken.

RECOMMENDATIONS

Additional evidence to demonstrate that aviation educators may need to modify or improve their teaching skills and teaching effectiveness can be gathered by further study. Investigation into the cognitive capabilities of aviation students at other universities will add to the reliability of the data. Conducting a study using more varied control groups will further substantiate the findings. A multi--year longitudinal study is also recommended to help clarify and better assess the factors affecting the changes seen in the cognitive progression of aviation students. That kind of a study would help to address the issue of whether students change or remain the same in their cognitive capabilities over four years, or identify whether a correlation exists between the biases and those who remain in the program and those who do not.

A study of successful aviation individuals is suggested as being an important body of knowledge from which to draw substantive conclusions. Such a study has been completed on corporate pilots (Quilty, 1995) and the findings support a higher degree of sequential processing and bilateral capabilities in pilots.

Further study to identify instructional methods that provide examples of how aviation education and training can become more effective is also of importance. Of course, if the intent of any program is to produce a particular type of cognitive processing student, then focusing on one instructional technique will more than likely result in that end.

There may also be implications from the additional studies for the currently popular concept of crew or cockpit resource management (CRM) and ab initio training. Since one emphasis of CRM is to understand how different ways of communicating data are perceived, interpreted or processed by individuals, it is suggested that communication, coordination and task completion can be optimized if cognitive preferences or biases are understood and appropriately considered in teaching CRM concepts.

The concept of ab initio training centers on the use of the relational mode of processing where a student is immediately introduced to flying (action), and from the flying, understanding and knowledge result. This is a departure from the standard sequential methodology of instruction where knowledge is introduced first in the classroom and from which understanding then occurs and the student flight activity and actions follow. Correlation studies between successful ab initio trainees and cognitive processing bias would be of value and interest to educators in the aviation field.

McCarthy (1987) developed a system incorporating hemispheric research and learning style research to enhance teaching abilities. Research into actual delivery of different teaching and training methodologies and/or techniques that address the varied cognitive processing biases of students would be of further interest for many aviation educators.

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