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Current vs stagnant jet pilots' response times: a comparison.

Smittle, John Howard.

Monterey, California. Naval Postgraduate School

"CURRENT" VS "STAGNANT" JET PILOTS' RESPONSE TIMES: A COMPARISON

John Howard Smittle

NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

"Current" vs "Stagnant" Jet Pilots'

Response Times: A Comparison

by

John Howard Smittle

Thesis Advisor: J. K. Arima

March 1973

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by

John Howard Smittle
Lieutenant Commander, United States Navy
B.S., Oklahoma University, 1964

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ABSTRACT

An attempt was made to determine if one of the basic piloting skills was lost during prolonged periods of nonflying. "Current" and "stagnant" groups of jet Naval aviators were tasked with responding to a sequence of sixty slides of an aircraft attitude indicator. The subjects' response times were measured. The slides depicted twelve different aircraft attitudes. No significant difference was found between groups but a definite learning trend was established. The subjects were reassigned into "more experienced" and "less experienced" groups. The more experienced group performed significantly better.

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I. BACKGROUND AND PURPOSE

A 1971 questionaire study by Schrady and Hanley determined that pilots at the Naval Postgraduate School (NPS) thought that four flight hours per month were insufficient to maintain mission skills and personal confidence. Complete elimination of flying by students at NPS could be expected to jeopardize the functioning of the aviators at a later time, both as aviators and as flight leaders.

In December, 1971, the U. S. Congress ceased funding for proficiency flying by military flight personnel undergoing courses if instruction of six weeks or longer. Prior to this decision, flight personnel were required to fly four hours monthly to maintain a minimum flight proficiency. Most aviators believed that four hours were barely adequate. Some educational programs take anywhere from fourteen to thirty-six months. After prolonged periods of no flying such as this, most aviators believe that it will require an additional two to four weeks of refresher flight and ground school training before commencing standard Combat Replacement Air Wing training in their next aviation assignment.

One measure of proficiency is a pilot's ability to recover an aircraft from an "unusual attitude"; that is, one not consciously established by the pilot. It is not at all uncommon for the pilot to be distracted briefly from his flight instruments to make radio frequency changes, copy clearances, etc., and upon rescanning his flight instruments, find that the aircraft has entered an unusual attitude.

The primary reference instrument in a non-visual flight condition is the verticle gyro indicator (VGI). This device is a sphere, stabilized gyroscopically, that can be interpreted by the pilot to determine the aircraft's pitch and roll attitudes.

Milton (1947) found that the difference between comprehension and recovery time in instrument flying averages 1.7 seconds longer than when flying with external visual references. Add to this any sort of initial misinterpretation which must be recognized and recorrected, it is easy to see how a pilot can respond incorrectly or not at all to a situation that requires prompt, correct action.

It is apparent that a key factor in safe recovery from an unusual attitude is correct VGI interpretation and, equally important, proper initial input to the aircraft's control system to affect a recovery. The purpose of this experiment was to investigate the elapsed time required by pilots between awareness of the VGI position and the correct initial control input.

II. EXPERIMENTAL PROCEDURES

A. APPARATUS

A Monsanto model 100B electronic timer was used to measure the time between stimulus onset to response input. A Lafayette Data Systems Random Access model 12910 was used to select slides and time the tachistoscopic shutter mounted on a Kodak Ektagraphic RA960 projector. The flash terminals on the shutter were used to close the circuit initiating the timer.

A control stick, similar in shape and feel to that of a typical jet aircraft, was fitted with microswitches to detect approximately three inches of displacement from neutral in the four directions of travel possible (back, forward, left and right control inputs). Each of these microswitches was connected in series with a toggle switch on a selection box so that only a correct control response would complete the circuit to stop the timer operation.

A Hudson Photographic Industries Caritel rear projector cabinet was used with the projector mounted to project an image in front of the pilot at approximately normal instrument panel size and distance.

A control tape for the random access timer was punched, utilizing a Control Data Corporation 160 computer. This control tape was randomized within each block of slides.

All experimental trials were conducted at the Naval Postgraduate School Man-Machine Systems Design Laboratory, Monterey, California.

B. SUBJECTS

Twenty-two volunteer male military officers assigned to the Naval Postgraduate School (NPS) and the the Naval Aviation Safety School

were tested. All the subjects were experienced Naval Aviators from the U. S. Navy, enrolled as students at NPS or at the Safety School. The median number of years of designation as an aviator was 6 years, ranging from 4 to 23 years Their median total flight time was 1700 hours, ranging from 750 to 6,000 hours. All the subjects were jet (fighter and attack) pilots who encounter all descriptions of flight attitudes as a normal consequence of their missions.

To determine if prolonged periods of nonflying reduced proficiency in unusual attitude recovery, 11 of the subjects were chosen that had been at NPS since proficiency flying was halted and 11 were chosen that were in their first quarter at NPS or at Safety School; i.e., they had all flown within a 24 to 60 day period. It was hypothesized that there should be a significant difference in response times between the two groups.

C. SLIDES

Twelve slides were used in the test. The attitudes depicted were a representative sample of attitudes that can be attained. The attitudes were divided evenly between upright and inverted; six upright and six inverted. Five were in a nose high, four in a nose low, and three in a nose level attitude.

Slide #	Attitude Depicted	Correction Required
1	Nose level, upright, right wing down	Left
2	Climb, inverted, wings level	Back
3	Dive, upright, wings level	Back
4	Nose level, inverted, left wing down	Right
5	Climb, upright, right wing down	Forward
6	Nose level, inverted, right wing down	Left
7	Dive, upright, right wing down	Left
8	Dive, upright, left wing down	Right
9	Climb, inverted, right wing down	Back
10	Climb, inverted, left wing down	Back
11	Climb, upright, wings level	Forward
12	Dive, inverted, left wing down	Right

See Appendix G for pictures of Slide #9 and a picture of the attitude indicator in normal flight.

D. METHOD

Prior to the experiment, each subject was given a brief explanation of the equipment and the purpose of the experiment. The experimenter then read the instructions to the subject (Appendix D).

In order to determine what each subject's reaction time in each direction of control stick movement was, he was asked to move the stick five times for each of the four directions of movement. An average basic movement time for each direction was then computed.

After the twenty basic movement time slides, the subject was shown twelve VGI slides in five trial sets of twelve, randomized within each block (Appendix E). Each slide was projected for eight seconds

with nine seconds between slides. This nine second period was used by the experimenter to record the time for the last slide, select the correct response (L, R, U, D) toggle switch for the next slide, and reset the timer to zero. An eight second response time was recorded if no correct response was given.

The average movement time for the correct response direction was subtracted from each VGI response. This enabled only his decision time (Decision + Movement = Response) to be utilized for the analysis.

III. RESULTS AND DISCUSSION

Table I gives a summary of the results of the experiment.

TABLE I

Mean Response Times by Groups, Slides, and Trials and Over All Groups, Slides, and Trials: Stagnant vs Current

Groups	Slides	Trials					Over All Trials
		1	2	3	4	5	
STAGNANT	1	1.45	0.69	0.99	0.64	1.52	0.86
	2	3.37	2.34	1.67	1.09	0.83	1.86
	3	1.09	0.80	0.72	0.58	0.57	0.75
	4	2.23	1.31	0.92	0.84	0.99	1.26
	5	3.04	2.23	1.14	1.78	1.45	0.93
	6	2.98	1.13	0.57	1.26	0.95	1.38
	7	2.72	1.65	1.19	0.96	0.94	1.49
	8	3.85	1.81	0.67	1.49	1.34	1.84
	9	1.88	1.96	0.92	0.95	1.28	1.40
	10	6.28	2.83	1.52	1.61	1.19	2.69
	11	1.08	0.82	0.69	0.84	0.71	0.83
	12	2.27	2.86	1.51	1.27	2.36	2.05
	Over All Slides	2.69	1.70	1.05	1.11	1.10	1.53
CURRENT	1	1.29	0.69	0.56	0.52	0.44	0.70
	2	2.85	1.60	1.11	0.86	0.73	1.43
	3	0.90	0.98	0.78	0.65	0.57	0.78
	4	2.10	1.69	0.86	0.95	0.77	1.27
	5	1.85	1.58	1.18	1.20	0.99	1.36
	6	2.78	1.08	0.71	1.04	0.81	1.29
	7	1.25	2.44	0.96	0.79	1.00	1.29
	8	2.29	1.62	0.65	1.76	1.33	1.53
	9	2.39	1.76	0.93	1.37	1.35	1.56
	10	6.97	1.71	1.69	1.37	0.91	2.53
	11	1.07	0.87	0.49	0.76	0.62	0.77
	12	2.46	1.72	1.38	2.19	1.35	1.82
	Over All Slides	2.35	1.48	0.94	1.12	0.91	1.36
Over All Groups and Slides		2.52	1.59	0.99	1.12	1.00	1.45

An analysis of variance (Table II) of the data comparing "current" versus "stagnant" groups indicates that there was no significant difference in responses of the two groups. There was a strong difference among the twelve slides and the five sets of trials and a high degree of interaction between trials and slides.

Table II

ANALYSIS OF VARIANCE COMPARING CURRENT AND STAGNANT GROUPS BY SLIDES AND TRIALS

SOURCE	df	SUM OF SQUARES	MEAN SQUARE	F	P
TOTAL	1,319	2,947.389	---	---	---
BETWEEN SUBJECTS	21	159.112	---	---	---
GROUPS	1	9.247	9.247	1.234	n.s.
ERROR BETWEEN	20	149.866	7.493	---	---
WITHIN SUBJECTS	1,298	2,788.279	---	---	---
SLIDES	11	342.156	31.105	17.777	<.001
TRIALS	4	445.210	111.317	94.010	<.001
GROUPS X SLIDES	11	12.174	1.107	.633	n.s.
GROUPS X TRIALS	4	4.547	1.137	.960	n.s.
SLIDES X TRIALS	44	365.562	8.308	6.762	<.001
SLIDES X TRIALS X GROUPS	44	58.094	1.320	1.025	n.s.
ERROR 1	220	384.556	1.748	---	---
ERROR 2	80	94.928	1.184	---	---
ERROR 3	880	1,081.192	1.229	---	---

The slide difference reflected variations in the degree of interpretative difficulty for each slide. Table III shows the average response time over all subjects for each trial.

TABLE III

Mean Response Times by Slides and Trials and Over All Slides and Trials

Slides	1	2	3	4	5	Over All Trials
1	1.37	0.69	0.77	0.56	0.98	0.78
2	3.11	1.97	1.38	0.97	0.78	1.65
3	0.99	0.89	0.75	0.61	0.57	0.76
4	2.16	1.50	0.89	0.90	0.88	1.27
5	2.44	1.90	1.16	1.49	1.22	1.65
6	2.88	1.10	0.64	1.15	0.88	1.33
7	1.98	2.04	1.07	0.87	0.97	1.39
8	3.07	1.71	0.66	1.62	1.33	1.68
9	2.13	1.86	0.92	1.16	1.31	1.48
10	6.62	3.25	1.51	1.49	1.05	2.61
11	1.07	0.84	0.59	0.80	0.66	0.80
12	2.36	2.29	1.44	1.73	1.85	1.94
Over All Slides	2.52	1.59	0.99	1.12	1.00	1.45

A Duncan multiple range test was performed, Table IV, to attempt to determine a pattern of difficulty among the slide presentations. The results were rather inconclusive. The three easiest slides (3, 1, 11) were all of upright attitudes with only one correction needed (up, left, down) to place the aircraft in normal flight.

Slides 4, 6, 7, 9, 2, 5, and 8 comprised a middle group that contained all possible combinations of attitudes and corrections. If the first trial of slide 10 were disregarded it could be grouped with slides 9, 2, 5, 8, and 12 as being the hardest. There seemed to be no common denominator among this group except there was no slide requiring a left correction. The fact that the three slides requiring a left correction were not in this group may reflect a left turn

TABLE IV

Duncan Multiple Range Test For Differences Among Slides

(Slides) Means	(3)	(1)	(11)	(4)	(6)	(7)	(9)	(2)	(5)	(8)	(12)	(10)	Shortest Significant Range
Means	0.76	0.78	0.80	1.27	1.33	1.39	1.48	1.65	1.65	1.68	1.94	2.61	.01 Level
(3) 0.76		0.02	0.04	0.51	0.57	0.63	0.72	0.89	0.89	0.92	1.18	1.85	R_2 = .459
(1) 0.78			0.02	0.49	0.55	0.61	0.70	0.87	0.87	0.90	1.16	1.83	R_3 = .479
(11) 0.80				0.47	0.53	0.59	0.68	0.85	0.85	0.88	1.14	1.81	R_4 = .469
(4) 1.27					0.06	0.12	0.21	0.38	0.38	0.41	0.67	1.34	R_5 = .502
(6) 1.33						0.06	0.15	0.32	0.32	0.35	0.61	1.28	R_6 = .509
(7) 1.39							0.09	0.26	0.26	0.29	0.55	1.22	R_7 = .516
(9) 1.48								0.17	0.17	0.20	0.46	1.13	R_8 = .521
(2) 1.65									0.00	0.03	0.29	0.96	R_9 = .526
(5) 1.66										0.02	0.28	0.95	R_{10} = .530
(8) 1.68											0.26	0.93	R_{11} = .534
(12) 1.94												0.76	R_{12} = .537
	(3)	(1)	(11)	(4)	(6)	(7)	(9)	(2)	(5)	(8)	(12)	(10)	

$$S_{\bar{x}} = \frac{S}{\sqrt{n}} = \frac{\sqrt{1.748}}{\sqrt{110}} = .126$$

syndrome. An automatic left turn response may have been instilled in these aviators from the fact that landing patterns at most airfields and all aircraft carriers require left turns as do most practice bombing target patterns. The fact that all pilots tested were fighter and attack carrier pilots, each having flown literally hundreds of simulated carrier landings and practice bomb runs may explain why left corrections were seemingly easier.

The lack of significant difference in performance between the two groups was surprising. It may relfect one of two things:

1. A 14 month period of nonflying is not as serious a detriment as had been hypothesized, or

2. This particular skill is lost rapidly; i.e., the first 4 weeks of nonflying is the period where most of the ability to recognize VGI indications is lost.

The high degree of interaction between trials and slides may be explained by examination of figures 1, 2, and 3. It will be noted that there are some slides with steep learning curves (slide 2) and some with shallow learning curves (slide 3). The very high mean value for the first trial of slide 10 may be because slide 10 happened to be the third slide in the sequence and it was the first "difficult" attitude presented. Almost all subjects were visibly surprised to see an attitude of this nature so early in the trial sequence. 18 of the 22 subjects did not respond correctly to this slide on the first trial within the 8 second time period. Subsequent trials of this slide yielded results similar to other difficult slides.

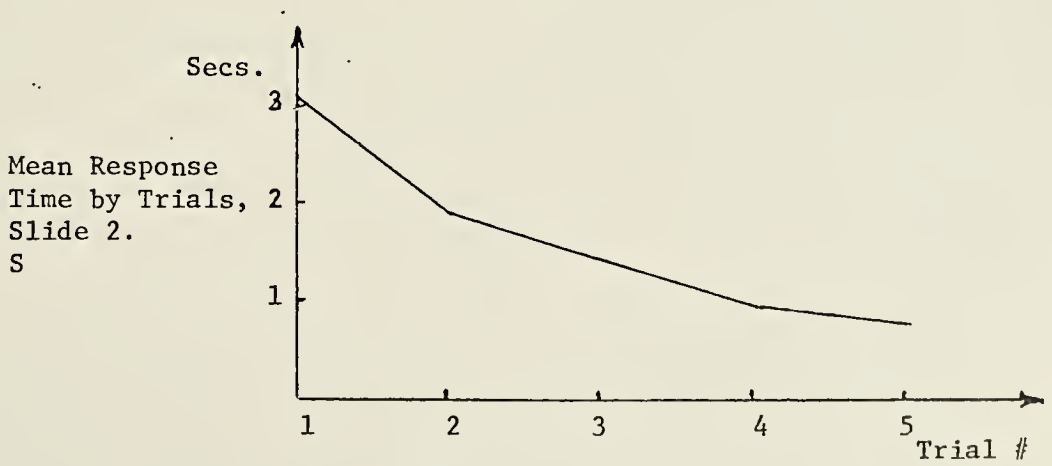


Figure 1

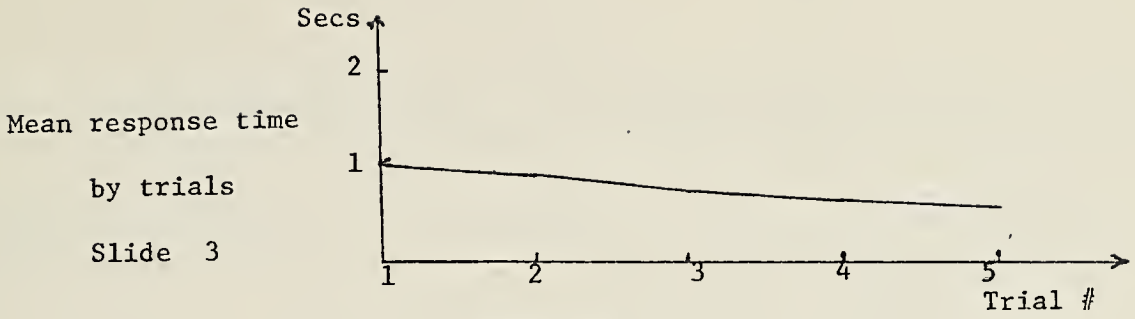


Figure 2

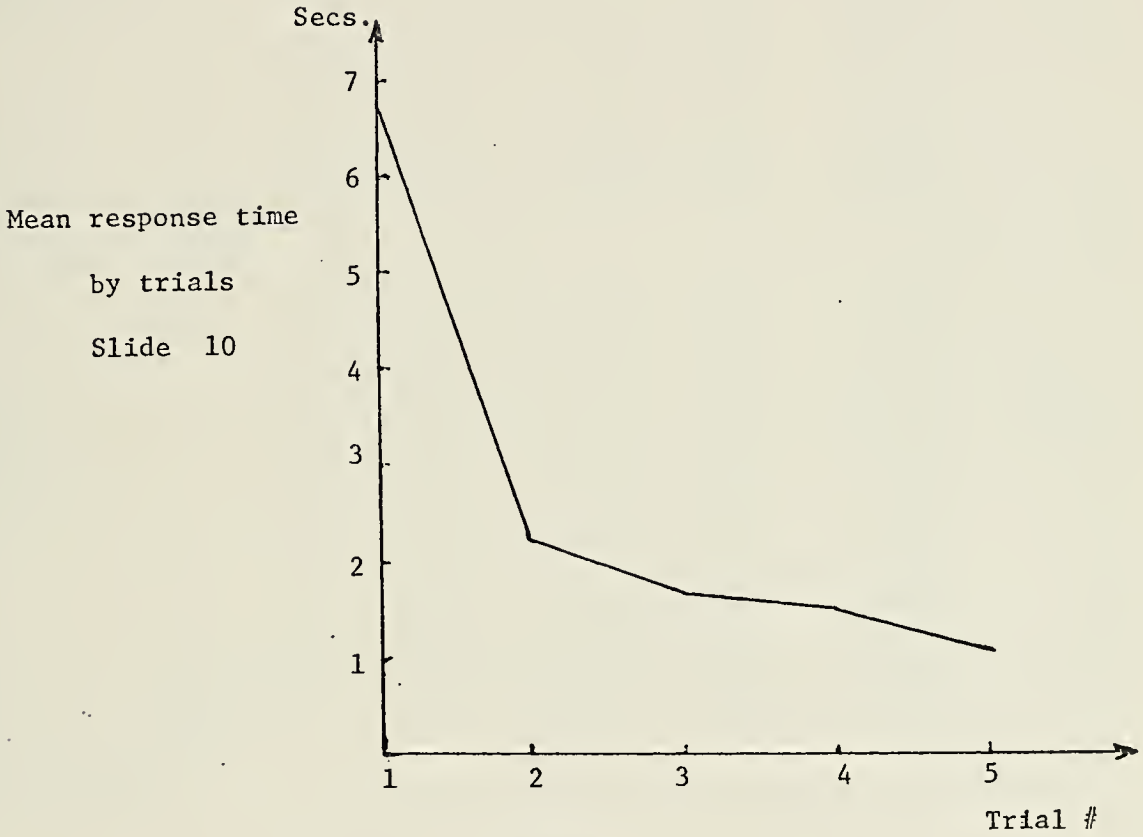


Figure 3

It was noted that two other groups could be formed from these same subjects with the criterion for group membership being total flight time. This was done forming one group composed of aviators having less than 1,700 hours and the other group having more than 1,700 total flight hours.

Table V shows the data from the new grouping.

TABLE V

Mean Response Times by Groups, Slides, and Trials and Over All Groups, Slides, and Trials; More Experienced vs Less Experienced

Groups	Slides	Trials					Over All Trials
		1	2	3	4	5	
More Experienced	1	1.30	0.67	0.77	0.56	0.42	0.75
	2	2.89	1.38	0.83	0.76	0.62	1.30
	3	0.83	0.84	0.67	0.54	0.48	0.67
	4	1.86	1.74	1.02	0.92	0.98	1.30
	5	1.79	1.45	0.80	1.31	0.98	1.27
	6	2.73	1.23	0.72	1.37	0.87	1.39
	7	1.22	2.23	1.01	0.70	0.95	1.22
	8	2.32	1.66	0.52	1.66	1.20	1.47
	9	1.88	1.36	0.76	1.19	1.33	1.30
	10	6.88	1.36	1.55	1.40	0.93	2.42
	11	1.13	0.75	0.38	0.68	0.54	0.69
	12	1.70	1.77	1.39	1.86	1.16	1.58
	Over All Slides	2.21	1.37	0.87	1.08	0.87	1.28
Less Experienced	1	1.44	0.71	0.79	0.50	0.53	0.82
	2	3.33	2.55	1.96	1.19	0.94	1.99
	3	1.17	0.94	0.82	0.69	0.66	0.86
	4	2.48	1.26	0.76	0.86	0.78	1.23
	5	3.10	2.36	1.52	1.67	1.47	2.03
	6	3.03	0.97	0.57	0.92	0.89	1.28
	7	2.75	1.86	1.13	1.05	0.99	1.56
	8	3.81	1.78	0.80	1.59	1.47	1.89
	9	2.40	2.36	1.10	1.13	1.30	1.66
	10	6.38	3.18	1.66	1.58	1.17	2.79
	11	1.02	0.94	0.81	0.92	0.80	0.90
	12	3.03	2.81	1.51	1.60	2.55	2.30
	Over All Slides	2.83	1.81	1.12	1.15	1.13	1.61
Over All Groups and Slides		2.52	1.59	0.99	1.12	1.00	1.45

An analysis of variance (Table VI) of the data from the new grouping showed that there was a significant difference in performance, with the pilots having more flight hours performing better. Similar results to Table I were obtained, reassuringly, about slide and trial differences and interactions.

TABLE VI

Analysis of Variance Comparing Groups of Less Than 1700 Hours and Greater Than 1700 Hours by Slides and Trials

SOURCE	df	SUM OF SQUARES	MEAN SQUARES	f	p
TOTAL	1319	2,947.389	---	---	---
BETWEEN SLIDES	21	159.112	---	---	---
GROUPS	1	35.384	35.384	5.719	.025
ERROR BETWEEN	20	123.728	6.186	---	---
WITHIN SUBJECTS	1298	2,788.277	---	---	---
SLIDES	11	342.156	31.105	18.461	<.001
TRIALS	4	445.269	111.317	101.408	<.001
GROUPS X SLIDES	11	26.046	2.368	1.405	n.s.
GROUPS X TRIALS	4	11.457	2.864	2.609	n.s.
SLIDES X TRIALS	44	365.562	8.308	6.742	<.001
SLIDES X TRIALS X GROUPS	44	54.827	1.246	1.011	n.s.
ERROR 1	220	370.683	1.683	---	---
ERROR 2	80	87.818	1.098	---	---
ERROR 3	880	1,084.459	1.232	---	---

These results suggest that, to a certain extent, experience is a greater factor in this particular flying skill than currency.

A study by Fitts and Jones (1947) determined that the VGI contributed to pilot errors in two categories, reversal errors and errors due to illusions. Reversal errors are the result of misinterpretation of the VGI, thereby making a control movement that aggravates rather than corrects an undesirable condition. A statement typical of those recorded by Fitts and Jones was:

> "I glanced away from the instruments.... Upon glancing back at the artificial horizon, I was confused as to the direction of turn shown by the little pointer which indicates degree of bank. Upon beginning to roll out, I used exactly opposite aileron control from what I should...."

The first phrase of that statement is crucial. A pilot who is able to continually scan his VGI is not apt to misinterpret it. As stated earlier, however, a pilot does not usually have that luxury. The degree of discontinuity in this experiment did exaggerate the problem because a good instrument pilot can regulate his scan to provide bits of attitude information regularly to enable him to interpret the situation in a continuous manner.

IV. SUMMARY

An attempt was made to determine if a prolonged period of no flying is detrimental to one of the basic piloting skills: the ability to recover an aircraft from an unusual attitude. Current and stagnant groups of jet Naval Aviators were tasked with responding to a sequence of sixty slides of an aircraft attitude indicator. The slides depicted twelve different aircraft attitudes. No significant difference was found between groups. The subjects were reassigned into more experienced and less experienced groups. The more experienced group performed significantly better.

The author believes that follow-on work in this area is definitely warranted. It is believed that comparisons made between a stagnant group composed as this one and a current group composed of aviators that had flown within a day or two of testing would yield different results; i.e., there would be a significant difference in performance.

The experiment does suggest that, to a certain extent, experience is a greater factor in this phase of flying skill than currency. It is recommended that strong consideration be given prior to assigning pilots with low flight hours to billets with prolonged periods of no flying.

APPENDIX A

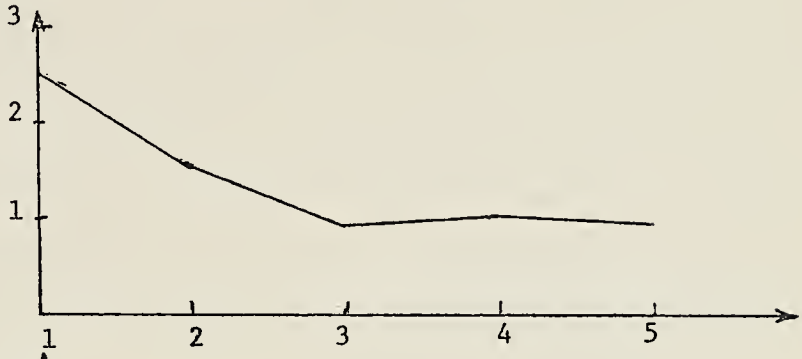
SUBJECTS TESTED

SUBJECT NUMBER	STAGNANT OR CURRENT	TOTAL FLIGHT TIME	MEAN RESPONSE TIME: ALL SLIDES ALL TRIALS
1	C	1900	1.568
2	"	1500	1.411
3	"	2600	0.966
4	"	2800	1.704
5	"	4500	1.113
6	"	3900	0.947
7	"	2300	1.415
8	"	6000	1.003
9	"	1800	1.693
10	"	4000	1.112
11	"	1600	2.112
12	S	1000	1.569
13	"	1050	1.323
14	"	1200	1.993
15	"	2150	1.246
16	"	750	1.173
17	"	1100	1.598
18	"	3600	1.397
19	"	1000	1.023
20	"	1000	1.789
21	"	1300	2.070
22	"	900	1.641

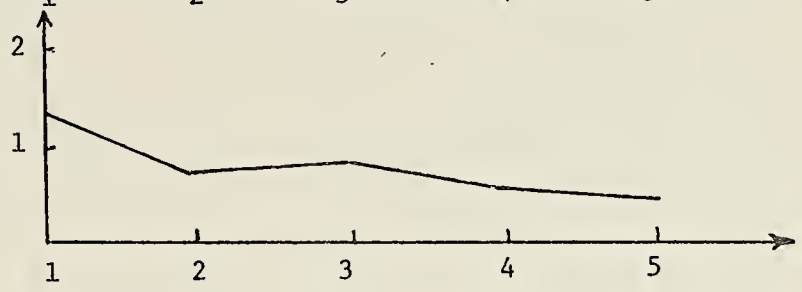
APPENDIX B

All Subjects' Mean Performance by Trials
ORDINATE: Seconds ABSCISSA: Trial Number

Mean of All Slides



Slide 1



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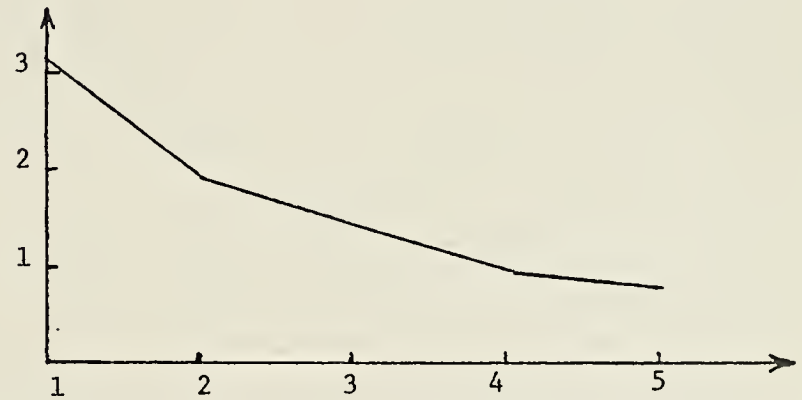

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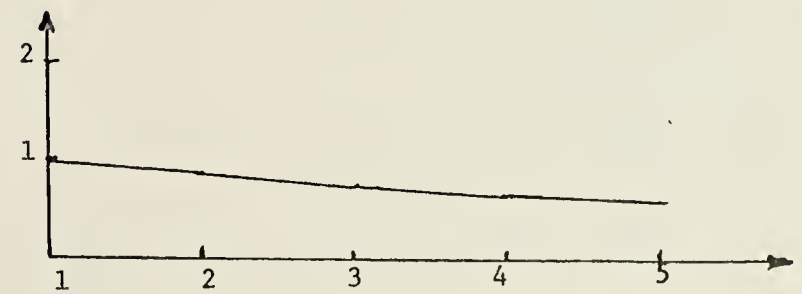
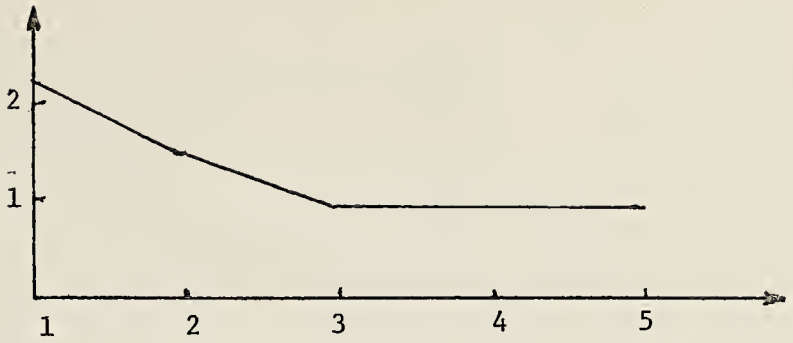
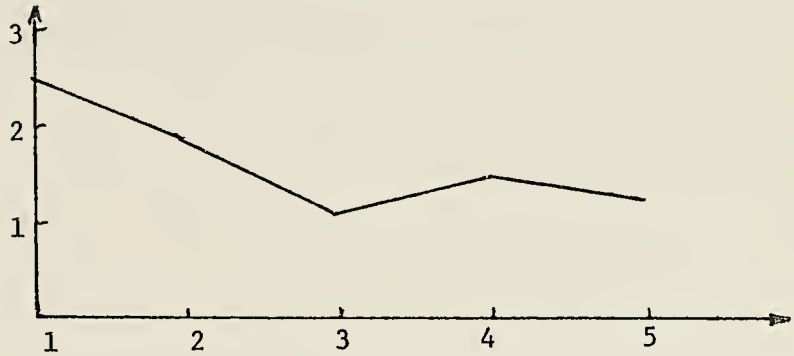


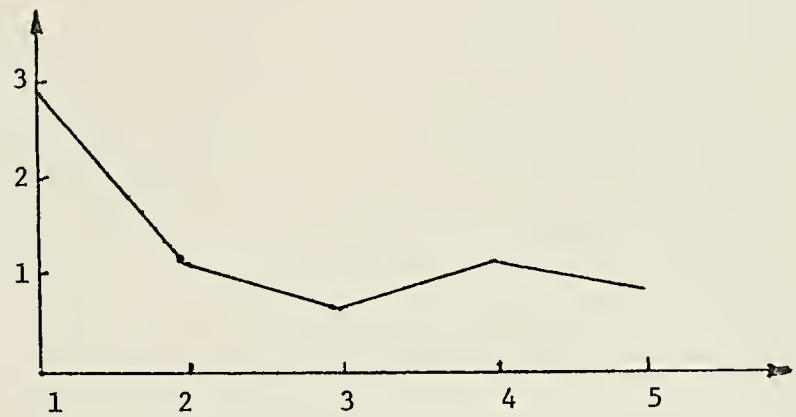
Slide 4



Slide 5



Slide 6



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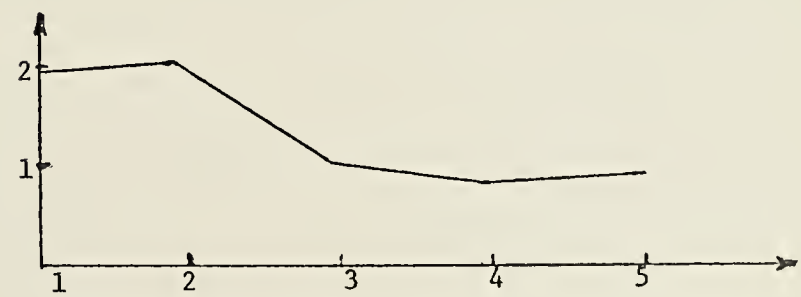

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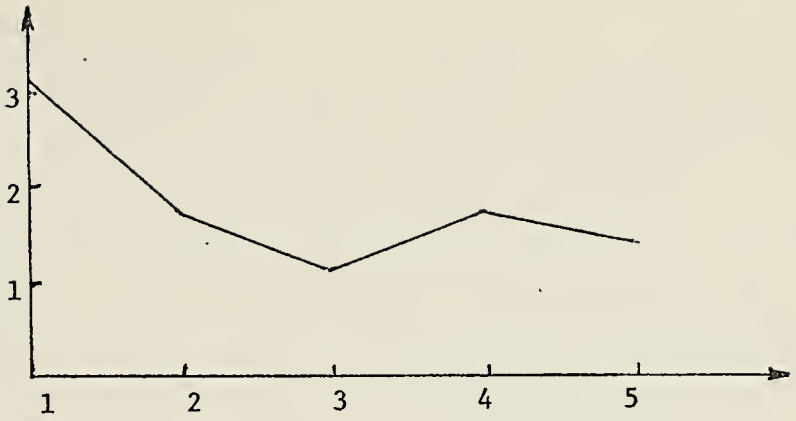
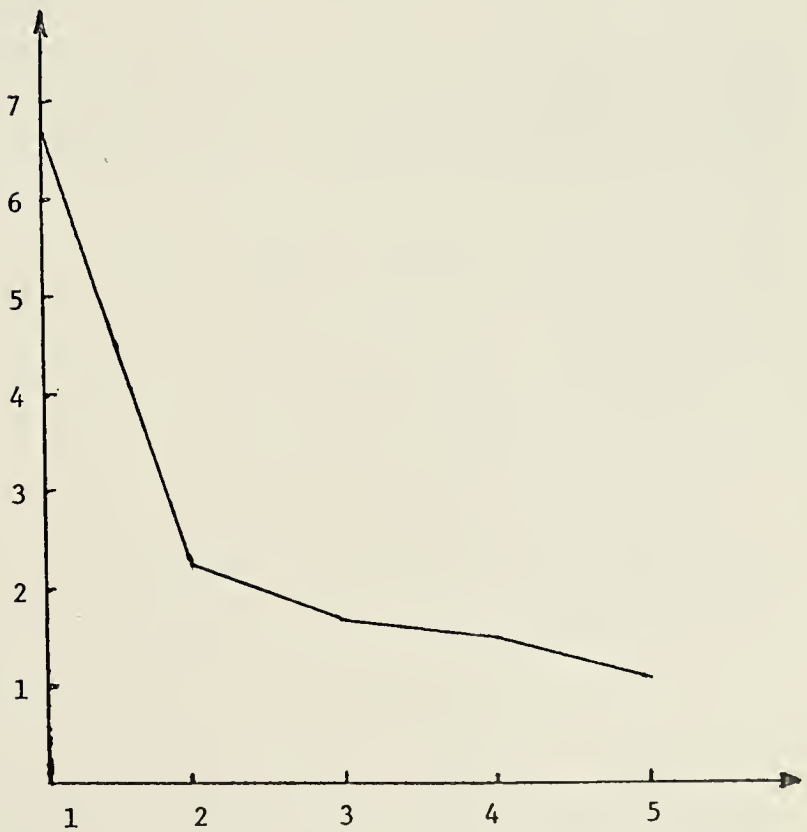


Slide 9

Slide 10



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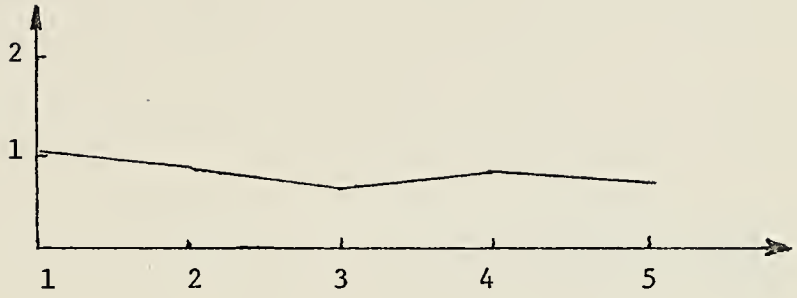
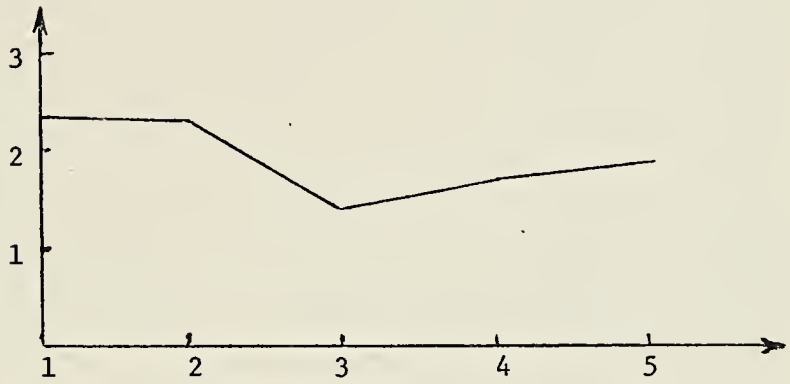


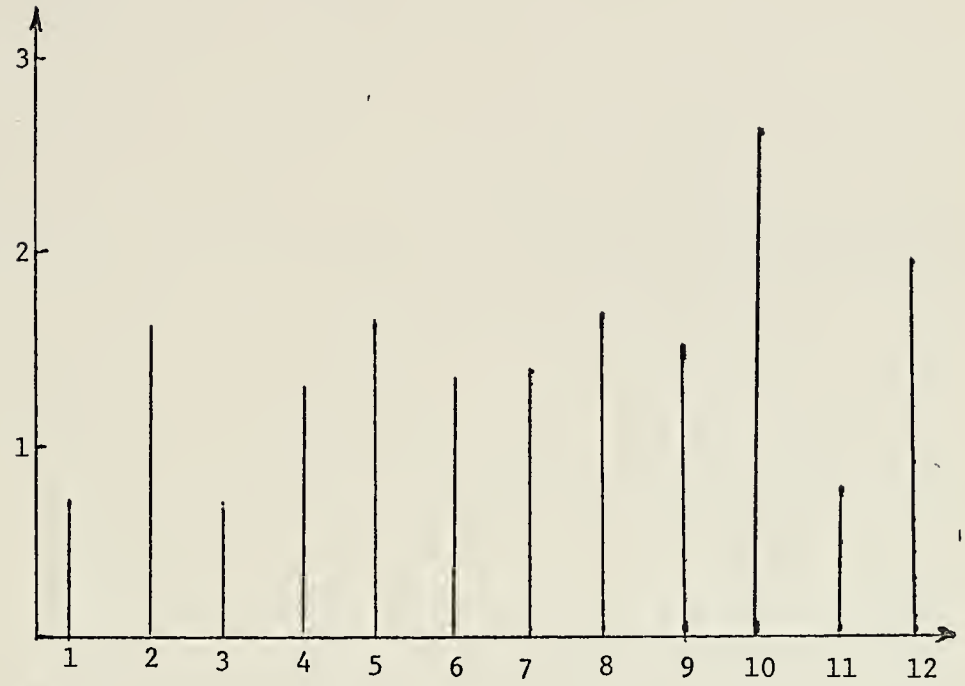
Slide 12



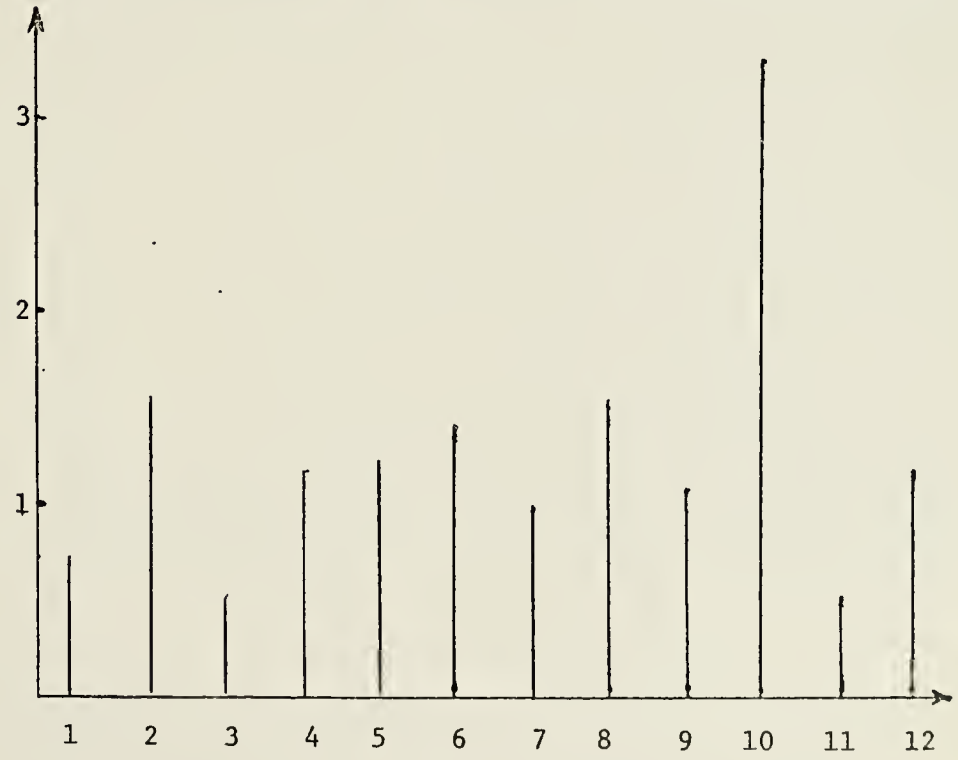
APPENDIX C

All Subjects' Mean Performance by Slides
ORDINATE: Seconds ABSCISSA: Slide Number

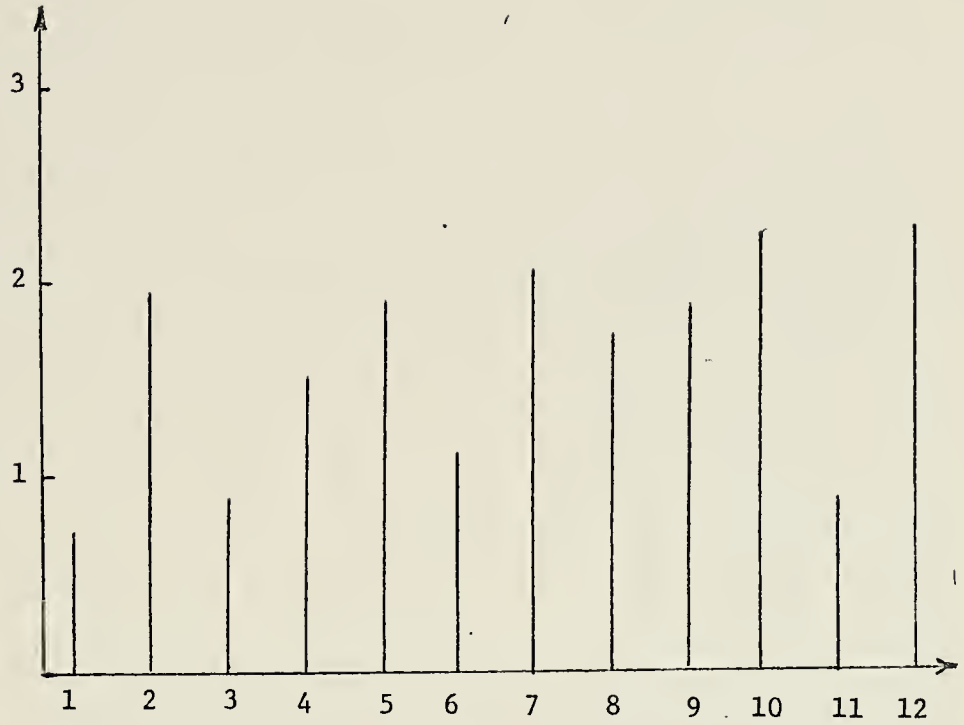
Mean of All Trials



Trial One

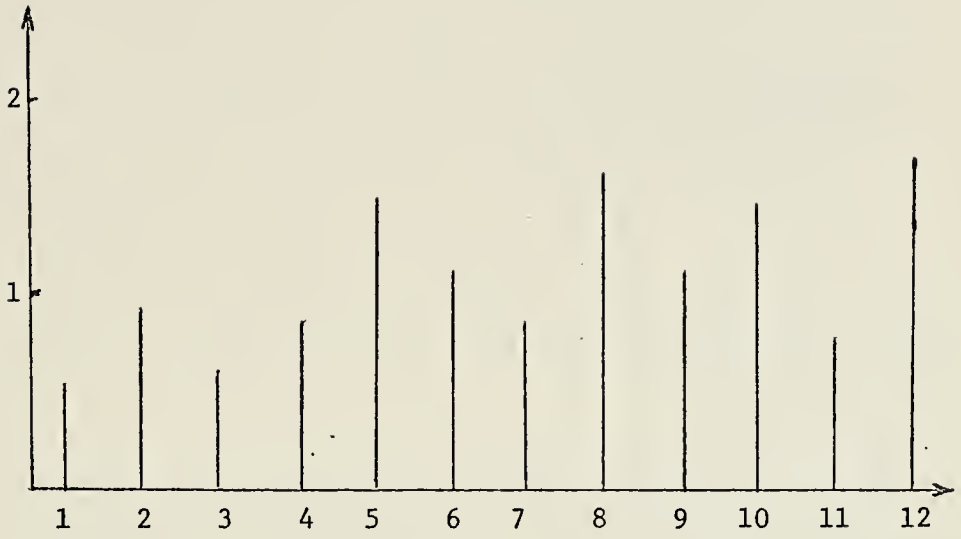


Trial Two

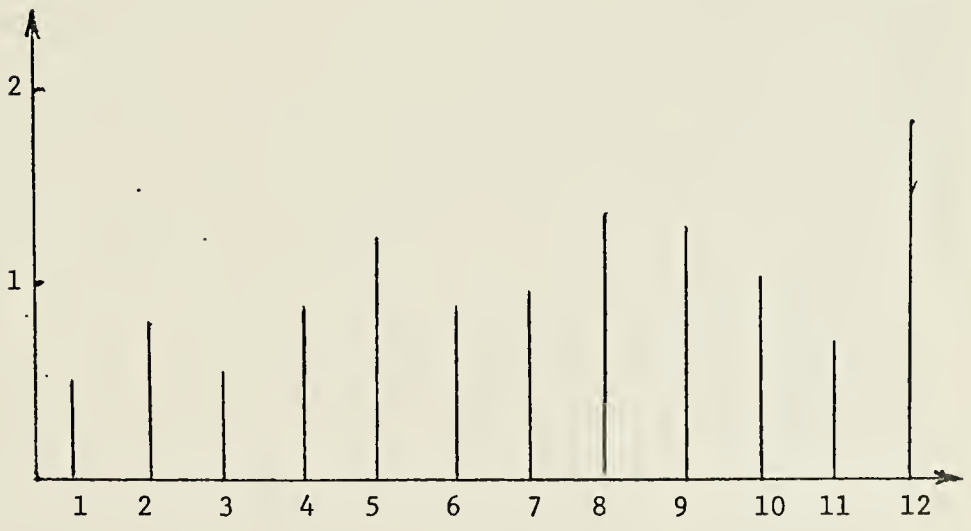


Trial Three

Trial Four



Trial Five



APPENDIX D

INSTRUCTIONS TO SUBJECTS

This is an experiment to attempt to determine if a prolonged period of no flying is detrimental to one of the basic piloting skills: The ability to recover an aircraft from an unusual attitude.

You will be shown a random sequence of slides of an attitude gyro depicting an aircraft in various attitudes. You should respond to the slides with the correct initial control input to recover an aircraft from that attitude. Please use standard instrument RAG procedures:

1. If nose high; lower nose then level wings
2. If nose low; level wings then raise nose

Assume you have about 250 knots indicated airspeed. (Any questions were discussed here.)

Unfortunately, there is no feedback to a wrong response. If you make a wrong response and do not correct it yourself, I will say "that's not right". Please make the correct response as soon as you realize what it should be. If you have not made the correct response by the time the slide goes off (about 8 seconds), I will describe what the situation was and what the response should have been.

To establish a basic movement time, I will ask you to move the stick five times in each direction in response to a series of "neutral" slides (it happens to have a '5' on it). These twenty trials will also let you get the feel of the stick and of the sequencing of the test. I will tell you which direction to move the stick prior to each slide during this portion of the test.

When you move the stick, move it like you would in an aircraft, try to resist the temptation to "slap" the stick in reaction to the slides.

After this basic movement time portion there will be five more slides that require no specific response. This time can be used to clear up any last minute questions you may have before the sequence of VGI slides begins.

Now, before the test begins, you will be shown a slide of the VGI in normal flight. Study it, noting its peculiarities, as long as you like. Tell me when you have seen it enough.

APPENDIX E

Sequence of Slides Used in Test

trial set 1	trial set 2	trial set 3	trial set 4	trial set 5
8	2	11	12	2
3	7	7	3	10
10	4	8	5	5
7	1	12	10	7
6	6	2	6	6
11	8	4	4	3
5	3	6	9	9
2	5	5	8	4
9	10	10	2	8
4	12	9	11	12
12	9	1	1	11
1	11	3	7	1

APPENDIX F

Figures

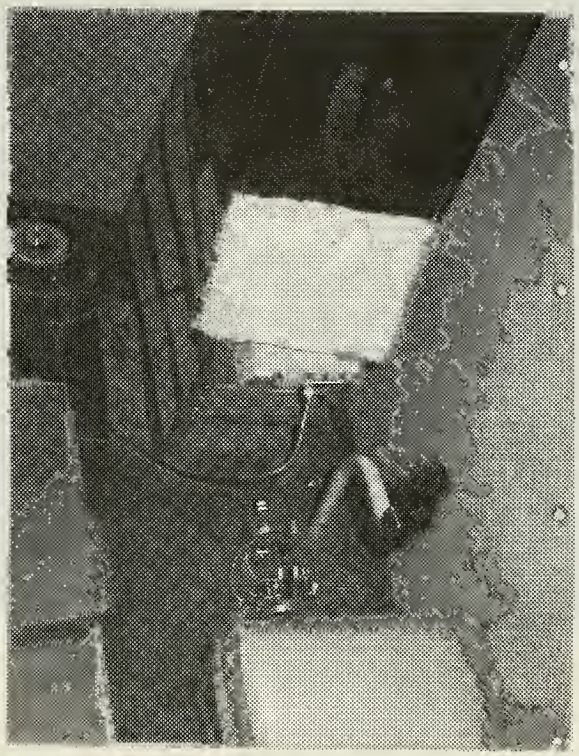


Figure 4

Testing Setup: Rear Projection Screen, Control Stick, and Subjects' Chair

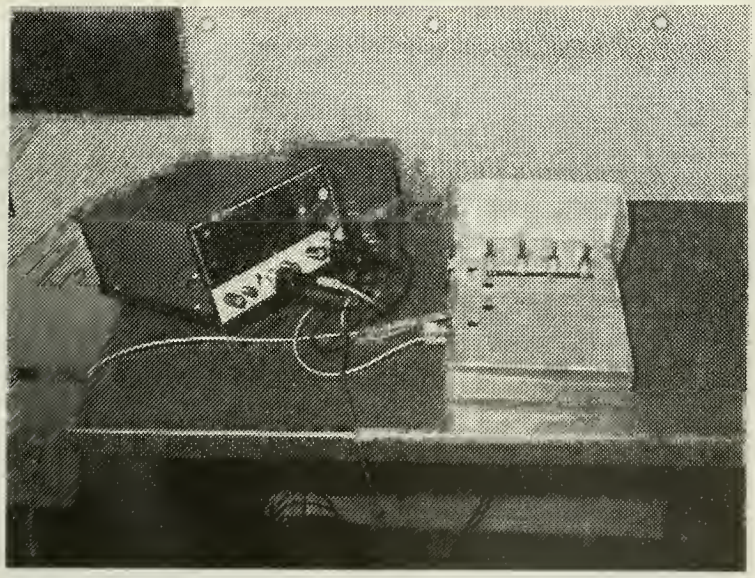


Figure 5

Experimenter's Station: Selection Box and Timer

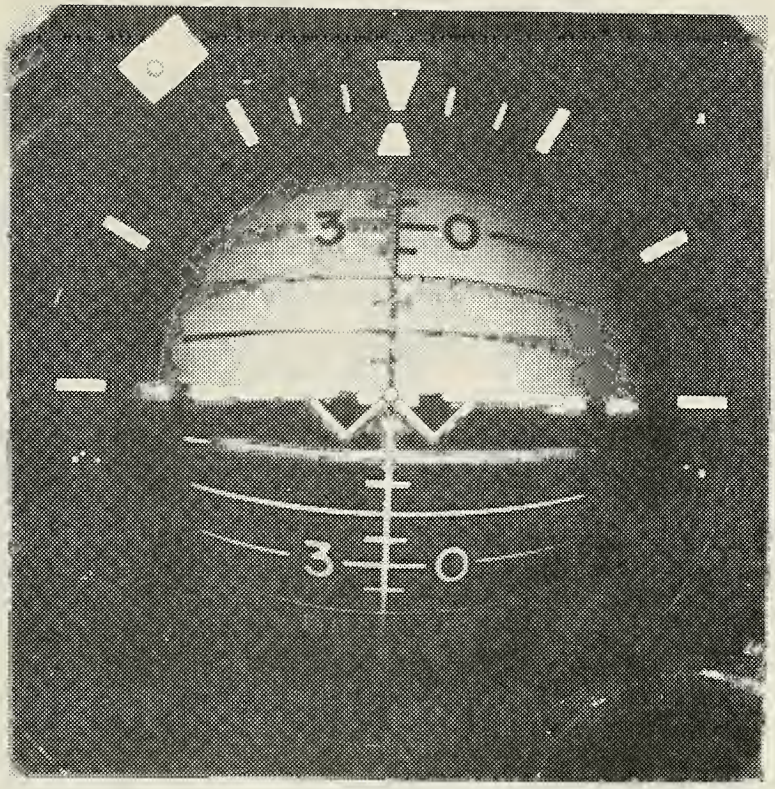


Figure 6

VCI in Normal Flight

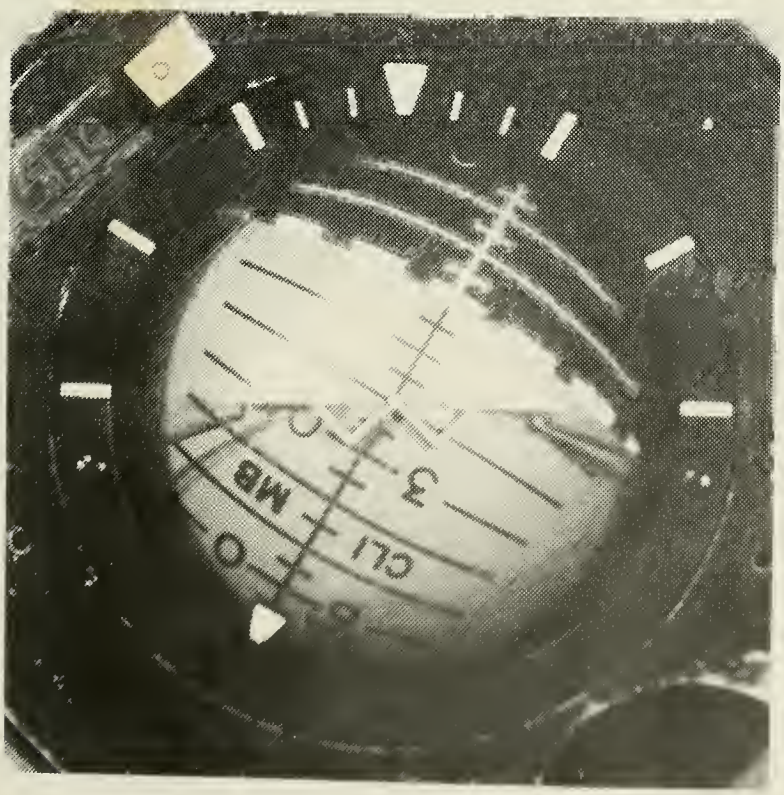


Figure 7

VCI in 30° Nose High, Inverted Attitude

(slide #9)

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13. ABSTRACT

An attempt was made to determine if one of the basic piloting skills was lost during prolonged periods of nonflying. "Current" and "stagnant" groups of jet Naval aviators were tasked with responding to a sequence of sixty slides of an aircraft attitude indicator. The Subjects' response times were measured. The slides depicted twelve different aircraft attitudes. No significant difference was found between groups but a difinite learning trend was established. The subjects were reassigned into "more experienced" and "less experienced" groups. The more experienced group performed significantly better.

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4. KEY WORDS	LINK A		LINK B		LINK C	
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Aviator Attitude Response						
Aviator Aircraft Attitude						
Unusual Attitude Recovery						
Aircraft Attitude Recovery						
Gyro Interpretation						

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Thesis
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