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VERBAL PRESCRIPTIVE RULES IN COGNITIVE PRETRAINING FOR THE VERTICAL S-A TRAINING MANEUVER

William V. Hagin
Robert C. Haygood
Scott S. Herrington

USAF Office of Scientific Research

Grant No. 76-2900

ARIZONA STATE UNIVERSITY
EDUCATIONAL TECHNOLOGY

Technical Report #70615

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REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER: AFOSR-TR-78-0210	2. GOVT ACCESSION NO. / 3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle): Verbal Prescriptive Rules in Cognitive Pretraining for the Vertical S-A Training Maneuver.	5. TYPE OF REPORT & PERIOD COVERED: INTERIM rept.
	6. PERFORMING ORG. REPORT NUMBER: TR-70615
7. AUTHOR(s): William V. Hagin, Robert C. Haygood, Scott S. Herrington	8. CONTRACT OR GRANT NUMBER(s): AFOSR-76-2900
9. PERFORMING ORGANIZATION NAME AND ADDRESS: College of Education, Arizona State University, Tempe, AZ 85281	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 61102F, 2313/A2, A2
11. CONTROLLING OFFICE NAME AND ADDRESS: A. F. Office of Scientific Research (NL), Bolling AFB, D.C. 20332	12. REPORT DATE: July 1977
	13. NUMBER OF PAGES: 34 (42 p.)
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report): Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Verbal prescriptive rules
Cognitive pretraining
Instructional cues
Simulator
Pilot Training

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A study was conducted to determine the effectiveness of verbal prescriptive rules in cognitive pretraining for an instrument flight maneuver. Thirty male pilot trainees participated in the study. Each subject had acquired simple aircraft control skills, but was naive with respect to the experimental maneuver. The subjects were assigned to one of three treatment groups. The first group received systematically-developed rule sets covering the entire maneuver. The second was given only the simple maneuver

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20. definition, but was asked to generate and record a set of rules for the maneuver. The third group was given only the maneuver definition. The effects of cognitive pretraining were assessed by having the subjects perform the maneuver in an instrument flight trainer immediately following pretraining. All three groups showed comparable achievement in learning the motor task. The results indicate that subjects who already know the component elements of a task do as well when given a simple definition of the maneuver and performance criteria as do subjects who are drilled on sets of rules for performance.

ARIZONA STATE
UNIVERSITY TEMPE, ARIZONA 85281

OFFICE OF RESEARCH GRANTS AND CONTRACTS

October 1, 1976

Alfred R. Fregly, Ph.D.
Program Manager
Life Sciences Directorate
Air Force Office of Scientific Research
Department of the Air Force
BOLLING AIR FORCE BASE
Washington, D.C. 20332

Dear Dr. Fregly:

RE: Technical Reports--U.S. Air Force Office of Scientific Research Grants AFOSR-71-2128 and AFOSR-76-2900

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VERBAL PRESCRIPTIVE RULES IN COGNITIVE PRETRAINING FOR THE VERTICAL S-A TRAINING MANEUVER

Rule Learning and Systematic Instruction in
Undergraduate Pilot Training

Vernon S. Gerlach, Principal Investigator

VERBAL PRESCRIPTIVE RULES IN COGNITIVE PRETRAINING FOR THE VERTICAL S-A TRAINING MANEUVER

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Research sponsored by the Air Force Office of Scientific Research, Air Force Systems Command, USAF, under Grant No. AFOSR 76-2900

College of Education
Arizona State University
Tempe, Arizona

July, 1977

Contents

I. Problem

Flying training typically includes substantial ground instruction on procedures and techniques leading to skilled performance followed by, and intermixed with, airborne practice. A significant amount of student time is devoted to the mastery of verbal prescriptive rules--statements of procedure which when followed assure the proper motor response. Such student time is well spent only if all the information learned is truly prerequisite and functionally relevant to skill development.

Brecke, Gerlach, and Schmid (1976) demonstrated the superiority of systematically developed and 100% functional instructional rules over conventional and less functional rules in cognitive pretraining for the Vertical S-A, an instrument flight training maneuver.

They also found that simpler instructional materials in the form of definitive statements of maneuver goals, conditions, and criteria were, for all practical purposes, equally effective. In fact, in terms of instructional efficiency, they concluded that this simpler type of instruction was the most economical, yielding a high level of maneuver performance for a minimal cognitive pre-training effort. They observed:

> An instructional procedure which merely supplies the learner with an objective or with a precise idea of the desired performance goal and enlists the ingenuity of the learner in finding ways to attain this performance goal thus appears to be a more economical way to raise the instructional efficiency of pilot training than supplying the learner with explicit "how to" cues which are costly to develop.(page 25)

They further addressed the issue of training goals:

> If the learner is supplied with an explicit set of instructional cues for each flight maneuver, he is faced with the task of learning sets of procedures, i.e., lists of carefully sequenced sentences or sentence fragments. . . this kind of instructional procedure is hardly conducive to the development of judgment, the ability to analyze flying tasks, and the ability to make autonomous decisions.(page 25)

In essence, the work of Brecke et al. suggests that, if students are moderately well along in the flying training program, simple task definitions will lead to performance as good as that obtained with elaborate cognitive pretraining using systematically developed rules.

The experiment described below was designed to explore this suggestion further, both to provide additional empirical clarification and to explore conditions that influence the utilization of simple task-definition information. Another major purpose of the study was to investigate the effects of requiring the subject to analyze the task and generate his own rules.

II. Method

Subjects and Design

Thirty male undergraduate pilot trainees from Williams AFB participated in the study as part of their regular training. All had completed the basic phase of ground training in the T-4 instrument procedures trainer, but none had flown the actual T-37 training aircraft. This initial phase of T-4 training acquaints the student with fundamental procedures for aircraft

control--pitch, bank and power--but does not introduce him to the more complex maneuvers. Thus each subject had the generic aircraft control skills required, but was naive with respect to the Vertical S-A maneuver used as the experimental task. All were U.S. nationals, graduates of either Air Force ROTC or the Air Force Academy. Their previous flight experience was limited to Air Force indoctrination programs using light planes and gliders.

The experiment was conducted as a simple randomized groups design with three experimental treatment groups. The first group received systematically-developed rule sets covering the entire maneuver. The second group was given only the simple maneuver definition, but was asked to generate and record a set of rules for the maneuver. The third group received the simple maneuver definition without the requirement to generate and record rules. Each subject was assigned to one of the three treatment conditions by a stratified random procedure that insured filling the groups uniformly. The effects of cognitive pretraining were assessed by having the subject perform the maneuver in the T-4 trainer immediately following the pretraining.

Materials and Apparatus

The cognitive pretraining materials used by Group I consisted of the linear self-instructional program for the Vertical S-A given the low-practice, systematic rules group in the Brecke et al. (1976) study. It consisted of an introductory section describing the maneuver and defining the conditions of performance, followed by sets of rules for each maneuver segment. Each rule set was accompanied by practice frames leading to a mastery frame in which the learner named in order the set of rules appropriate for the

segment. Appendix A contains the complete introductory section, a sample of the rules for one maneuver segment (transition to climb), one of the practice frames, and the mastery test frame for this segment.

The treatment for Group II provided the same introductory description of the Vertical S-A given Group I, followed by blank frames on which the subject was required to write down his own rules for successful performance of each maneuver segment. This treatment and the Brecke et al. control group treatment were the same.

Group III was also given the introductory section to read. These subjects received no supplementary information about the maneuver, nor were they asked to generate or record their own rules.

The T-4 instrument flight trainer for the T-37A was used for the performance of the motor task. This trainer is the operational version of the T-4G used in the Brecke et al. study. The T-4 does not have a motion base while the T-4G has a limited pitch, roll, and heave motion system. Its flight and handling characteristics are superior to the T-4G in most other respects. Of the 39 subjects in the Brecke et al. study, 32 reported that the T-4G was unstable and "harder to fly" than either the T-4 or the T-37 aircraft.

Task and Procedure

The experiment was conducted during the period between the time each subject completed his final ride in the Basic Phase of T-4 training and the time he reported to the flight line for his first T-37 flight. Each subject was advised of the nature of the experiment and asked to sign a subject participation release form (Appendix B).

The first step in the procedure was to provide each subject the set of cognitive pretraining materials appropriate to his treatment group, along with oral instructions describing the experiment. Subjects were allowed as much time as needed to complete these materials.

Following completion of the pretraining materials, each subject was assigned to one of two trained instructor-pilot observers for his criterion ride in the T-4 trainer. The instructor gave the following instructions to the subject:

> "I will start you out at 15000 ft., 160 knots on a heading of 180°. You will have a few minutes to warm up by flying straight and level and then I will ask you to perform a Vertical S-A. You then may start when you are ready. I will record how well you do on this form (showed recording instrument). When you finish the trial, I will give you time to stabilize straight and level on heading, altitude and airspeed before telling you to start another trial. There will be six in all."

The criterion maneuver was a typical Vertical S-A. Beginning in straight and level flight at 15,000 ft., airspeed 160 knots, heading 180°, the subject was required to climb to 16,000 ft. at a constant rate of 1,000 ft. per min., descend again to 15,000 ft. at the same constant rate, and level out at 15,000 ft.--maintaining a constant airspeed and heading throughout. The procedure for the data-recording flight was conducted as described in the instructions above. After the data recording flight, each subject completed a brief questionnaire and was excused. The total time for the complete procedure did not exceed 90 minutes.

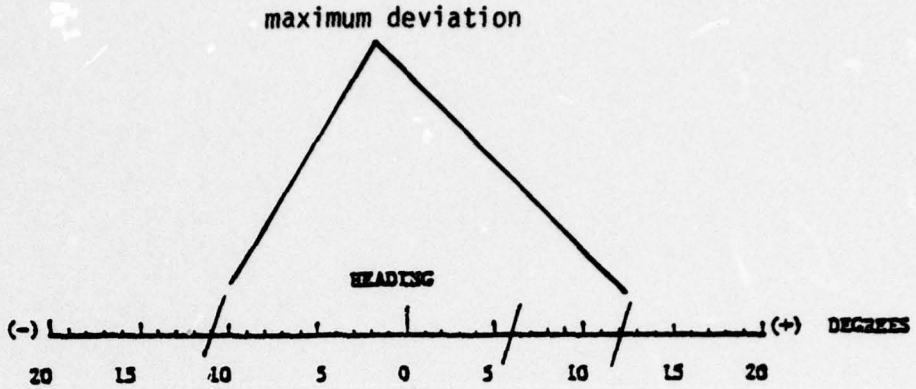
Data Collection and Analysis

During the flight, the instructor pilot observed and recorded performance using a specially developed recording form (Appendix C) that provided appropriate spaces for recording the relevant parameters for each segment of the maneuver.[1] These included heading, airspeed, vertical velocity during climb and descent, maximum altitude attained, lead points for transitions, use of power, and elapsed time. The instructors had been trained extensively in the use of the recording form.

Continuous linear scales were used for recording deviations in heading, airspeed, and vertical velocity. Each scale was centered on the required value (e.g., 160 knots) with gradations out to an arbitrary maximum deviation above and below the required value. When a deviation occurred, the instructor would track it to its maximum excursion, then make a pencil mark at that point. A later deviation exceeding this would result in another pencil mark even more extreme. For the purposes of scoring, the range between the two most extreme marks (above and below the required value) in any segment was taken as the performance measure for that parameter in that segment. When deviations occurred on only one side, the range between the required value and the maximum deviation was used as the measure. Scoring examples are shown in Figure 1.

A stopwatch was used to measure maneuver time. To overcome difficulty in determining exactly when the maneuver begins and ends, timing was started as the altimeter passed 15,2000 ft. on the ascent and stopped as the

[1]The specifics of how this instrument was developed and how the observers were trained are covered in "Measuring Pilot Proficiency on an Instrument Training Maneuver" by William V. Hagin, Robert C. Haygood, and Scott S. Herrington (Tempe: Arizona State University. 1977).



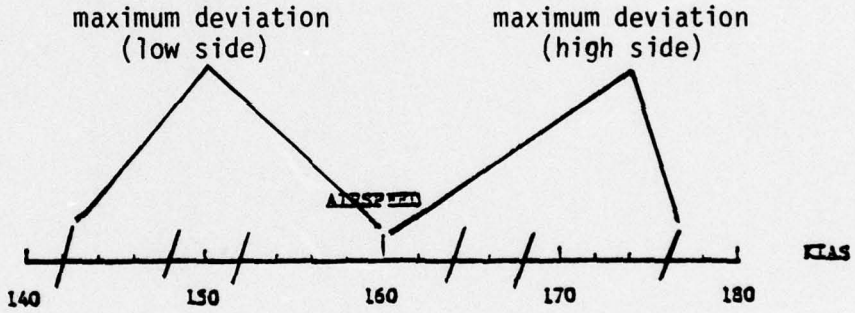


Figure 1. Determining maximum deviation range scores.

altimeter again passed through 15,200 ft. on the descent. This procedure gave the instructors an observable, operational definition of maneuver time without loss of any of the most critical segments of the maneuver.

For purposes of analysis, the range of deviations within segments for heading, airspeed, and vertical velocity were averaged across segments to generate a mean range for the entire maneuver trial. For the remaining parameters--maximum altitude, lead point for transition from climb to descent, lead point for level out, and elapsed time--a single value was obtained for each trial. For all but time, the value used in the analyses was the absolute value of the difference between the desired value (e.g., 16,000 ft. for maximum altitude, 15,900 ft. for first lead point) and the obtained value. For elapsed time, a nominal value was established by measuring the times of skilled instructor pilots in ASPT maneuver recordings judged to be Good or Excellent; this value was 1:22 minutes. The subject's time was subtracted from the nominal value, and the signed difference was used in all analyses. In the absence of a rational basis for combination, no attempt was made to combine the various parameters into an overall figure of merit.

III. Results

As in Brecke et al., it was hypothesized that performance on the Vertical S-A would be differentially affected by the presence or absence of verbal prescriptive rules during cognitive pretraining. Since the Vertical S-A is defined by climbing at a constant rate to achieve a required altitude, and descending again to the original altitude, holding airspeed and heading constant, these variables were taken as the principal indicators of performance. Maneuver time provided an index of a consistent

error in vertical velocity control--too fast or too slow a maneuver time reflects too much or too little in pitch change during climb, transition, and descent. The other variables (lead points and power handling) were intended to be diagnostic in nature.

Heading Analysis

The mean deviation range scores for heading for the three treatment conditions over the six trials are shown in Table 1. Heading control was quite satisfactory from Trial 1 on. Analysis of variance revealed no significant treatment effects, $F(2,27) < 1$. There was, however, a significant improvement over trials, $F(5,135) = 3.34$, $p < .01$ (Tables for this and the following ANOVA's are provided in Appendix D).

Airspeed Analysis

The mean deviation range scores for airspeed for the three treatment conditions over six trials are shown in Table 2. Again, the absolute scores indicate good control. There were no significant group differences in airspeed control, $F(2,27) < 1$. There was, however, significant improvement over trials, $F(5,155) = 11.53$ $p < 01$.

Vertical Velocity and Time Analyses

The mean deviation range scores for vertical velocity and time are shown in Tables 3 and 4. The analysis of variance for vertical velocity showed significant treatment effects, $F(2,227) = 11.23$, $p < .01$. Group I subjects performed substantially poorer in vertical velocity control than did subjects in the two other groups. There was a significant improvement in control of vertical velocity over trials, $F(5,135) = 3.60$, $p < .01$,

Table 1

Mean Heading Deviation Ranges in Degrees

Group:	n	Trial 1	2	3	4	5	6
I	10	2.2	2.1	1.4	1.7	1.5	1.1
II	10	3.0	2.6	1.0	1.7	1.7	2.2
III	10	3.0	2.2	1.7	2.1	1.4	1.7

Table 2

Mean Airspeed Deviation Ranges in Knots

Group:	n	Trial 1	2	3	4	5	6
I	10	4.4	3.6	3.1	2.9	2.4	2.6
II	10	4.6	2.5	2.3	2.6	2.2	2.4
III	10	5.4	4.3	4.0	3.3	2.5	2.4

Table 3

Mean Vertical Velocity Deviation Ranges in Feet

Group:		Trial					
	n	1	2	3	4	5	6
I	10	529	535	489	497	525	587
II	10	414	350	269	283	343	335
III	10	425	413	398	411	380	314

Table 4

Mean Time Maximum Deviation Score in Seconds

Group:		Trial					
	n	1	2	3	4	5	6
I	10	21.2	21.3	18.7	17.3	19.6	17.6
II	10	12.3	8.8	5.4	3.9	5.2	6.5
III	10	12.9	4.9	6.6	13.2	7.0	7.3

and the interaction of trials and treatment conditions was also significant, $F(10,135) = 3.43$, $p < .01$.

In the analysis of time scores, the main effect of treatment was not significant, but the improvement over trials was similar to that of vertical velocity, $F(5,135) = 2.34$, $p < .05$. The interaction of treatments and trials was similarly significant, $F(10,135) = 5.44$, $p < .01$.

Inspection of Tables 3 and 4 sheds some light on the nature of the interaction. Group I subjects had trouble over all six trials in controlling vertical velocity. As can be seen from Table 3, their performance on trials 5 and 6 was no better than for trials 1 and 2. Their time deviation scores, as summarized in Table 4, show also that they were using a larger pitch-up and pitch-down control action than were the other two groups.

Maximum Altitude Analysis

Analysis of maximum altitude scores showed no significant treatment effects and no improvement over trials. Attainment of the proper altitude was quite good throughout all trials, with a standard deviation for maximum altitude of 16.3 ft. This indicates that approximately 95 per cent of attained altitudes were within ± 35 ft. of the desired value of 16,000 ft.

Other Analyses

Examination of power handling revealed only a few instances of failure to lead with power, and the instructors noted only one or two instances of radically wrong power settings. Analysis of variance for the first lead point (transition from climb to descent) showed a significant effect of treatment, $F(2,27) = 3.87$, $p < .01$, with Group I showing the best performance (mean deviation 34.2 ft.), Group II intermediate (mean deviation 49.7 ft.),

and Group III the worst (mean deviation 59.0 ft.). However, this difference in performance was not reflected in attainment of the correct maximum altitude.

Analysis of variance of second lead point scores showed no significant differences.

Questionnaires

Responses to the questionnaire were either too varied to be summarized meaningfully or they were an obvious reflection of the treatment given. For example, all Group I subjects identified ± 5° as a critical pitch rule when asked to list important rules for doing the maneuver, while the other two subject groups listed the conventional ± 1-1/4 bar-widths.

All the groups expressed a strong preference for IP briefings as a part of any instruction they received. Self-study or programmed text presentations were equally acceptable if accompanied by an IP briefing.

IV. Discussion and Conclusions

That Groups II and III maintained air speed and heading and achieved correct maximum altitude as well as well as did Group I, confirms the finding of Brecke et al.: Detailed presentation and rote learning of verbal prescriptive rules as a form of cognitive pretraining is of little benefit to the student--at least under the conditions of this experiment. These conditions require special comment, however, before any attempt is made to generalize to other training exercises.

Just prior to the experiment, the subjects had received basic instruction on all of the control operations required in performing the Vertical S-A. They had practiced pitch, bank, yaw, power, and trim techniques required for

maintaining straight and level flight and constant rate climbs and descents. None had been exposed to the Vertical S-A as such, but they had acquired the basic component skills. The task given them in the experiment, therefore, demanded only that they put these elementary skills together in the sequence required for successful maneuver performance. The principal novel feature of the maneuver was the transition from climb to descent, a requirement that seemingly provided little challenge for the subjects.

It thus appears that subjects who already know the component elements of a task do as well when given a simple definition of the maneuver and performance criteria as do subjects who are drilled on sets of rules for performance. It is not clear, however, that this finding can be generalized to more complex types of training maneuvers in which there may be a greater number of novel elements, including requirements for visual judgments (as in landing, aerobatics,and formation).

Unlike the subjects of Brecke et al., who showed no improvement over trials, the subjects in the present study improved. This may be a result of the different training levels of the two sets of subjects. The subjects in this experiment had received only simulator training whereas the Brecke et al. subjects had had several hours in the simulator and had flown nine to twelve hours in the T-37 airplane.

Failure to find a difference in performance--on any variable--between Groups II and III indicates that the requirement to generate and record rules (as was imposed on the control group in Brecke et al.) contributes little to performance. This finding contradicts a Brecke et al. suggestion that the requirement to analyze the task and to generate rules explicitly accounts for the good performance of subjects who are not drilled on detailed prescriptive rules.

The difficulties with vertical velocity and maneuver time experienced by Group I also require comment. The correct pitch for 1000 ft./min. climb or descent in the T-37 and T-4 is approximately ± 3°. Since this value is not marked on the attitude indicator, instructor pilots have had to formulate cues for students, the most typical being a displacement of the horizontal bar by 1-1/4 bar widths above or below the horizontal reference line. Because the judgment of 1-1/4 bar widths is rather difficult to make precisely, Brecke et al. devised an equivalent alternative, namely, to place the dot just below the +5° mark for climb and just above the -5° mark for descent.

In the training materials used both by Brecke et al. and in the present experiment, this cue was given correctly in its initial presentation. However, subsequent prompts to the subject stressed the 5° mark and apparently many subjects came to believe that the correct pitch was ± 5° rather than ± 3°. Spontaneous comments to the observers and in the questionnaire indicated that subjects were confused on this point. The IP observers also commented that Group I subjects seemed to be having unusual difficulty with pitch. Although these subjects had received the correct pitch value of ± 3° during training immediately preceding the experiment, they seem to have accepted the ± 5° cue as one of the "rules of the game," and apparently spent all six trials in a problem-solving state trying to accomplish the Vertical S-A using the impossible combination of 1000 ft./min., 160 knots airspeed, and ± 5° pitch. This probably accounts for their failure to show improvement in vertical velocity control over the six trials.

The question arises as to why the Brecke et al. subjects did not similarly suffer from the cue as stated. The answer seems to lie in the greater experience and sophistication of these subjects, who had approximately 10

hours in the T-37 in addition to T-4 training. Thus they were considerably less likely to be confused by the ± 5° prompts, prompts that they were perhaps able to see as equivalent to other cues previously provided (1-1/4 bar widths) for the required ± 3° pitch for 1000 ft./min vertical velocity.

The results reaffirm in a striking way the insistence of Brecke et al. that rules provided as cues to students must be functional;[2] a single non-functional prompt can have relatively serious and persistent degrading effects on performance, and a rule that can be functional or neutral for students in one stage of training can be seriously non-functional at an earlier stage of training. The possibility that the problems with pitch may have interfered with performance on other variables such as airspeed and heading was also examined. To evaluate this possibility, performance on these variables at Trial 6 was compared with the average performance of a skilled instructor pilot flying four trials rated as "Good" or better in the usual USAF grading scheme: The mean airspeed deviation range for this IP was 1.8 knots and his mean heading deviation range was 1.3°.

It is clear that by Trial 6 performance of the Group I subjects is approaching that of the instructor pilot, and it does not appear that variables other than vertical velocity and time have suffered any substantial decrement. It is anticipated that it will be possible to confirm this conclusion at some point in the future when suitable subjects become available for pretraining using the conventional cue (1-1/4 bar width) and with the potentially misleading prompts removed from the training materials.

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[2]A functional rule is one that is precise, unambiguous, relevant, and timely. For more detailed differentiation between functional and non-functional rules, see Brecke, Gerlach, and Shipley (1974).

Brecke et al. hypothesized that the apparent interference by non-functional rules resulted from an added information-processing load. The subject has the added task of separating essential rules from those which are not helpful. If an authority figure presents these rules as important to task performance, the subject of necessity must rely on a trial-and-error search to identify that which works and that which does not. Support for this conclusion was provided by one subject who observed, "The hardest part of the maneuver was figuring out that $\pm$ 5° $\neq$ $\pm$ 1000 ft./min. climb or descent." The problem-solving set thus created distracts the subject from the main task at hand until he has discovered for himself which rules are relevant and work.

The most important conclusion of these studies is that drill on detailed sets of verbal prescriptive rules--for motor tasks of this type--does not enhance transfer sufficiently to warrant a large investment in materials preparation and training time, provided that students have previously acquired the component task skills. Furthermore, the potential interference of rule sets which are less than 100 percent functional represents an unwarranted risk that may undo any possible benefits.

Both studies suggest that these conclusions apply also to oral instructions provided by instructor pilots in the conventional training context. Non-functional cues may cause the student to enter a problem-solving or trial-and-error mode that delays improvement until the student sorts out which rules are functional and which are not. This concern becomes even more important when it is recalled that instructional content of an IP briefing is typically 70% functional and 30% non-functional (Brecke, Gerlach, and Shipley, 1974). Thus it would appear that research directed toward improvement of instructor-delivered verbal rules would be highly productive, particularly

since students were nearly unanimous in expressing a strong desire that all flight-line instruction include IP briefings.

References

Brecke, F. H., Gerlach, V. S., and Shipley, B. D. Effects of instructional cues on complex skill learning (Technical Report No. 40829, Project No. AFOSR 71-2128, Arlington, VA: U. S. Air Force Office of Scientific Research, 1974).

Brecke, F. H., Gerlach, V. S., and Schmid, R. F. The role of verbal prescriptive rules in cognitive pretraining for a flying task (Technical Report No. 60201, Project No. AFOSR 75-2900, Arlington, VA: U. S. Air Force Office of Scientific Research, 1976).

Appendix A

Mark your starting time here: _____

This programmed learning booklet is designed to teach you as much as possible about flying the instrument maneuver "Vertical S-A" before you actually touch a stick or throttle. In order to derive the maximum possible benefit from this program, follow these ground rules to the letter:

- Read each page carefully
- Complete all assignments on a page before you go on
- Do not peek ahead for the answers - you won't learn a thing if you do!
- Do the best you can but don't be afraid to make mistakes. Your performance on this program will not become part of your record.

Why the Vertical S-A

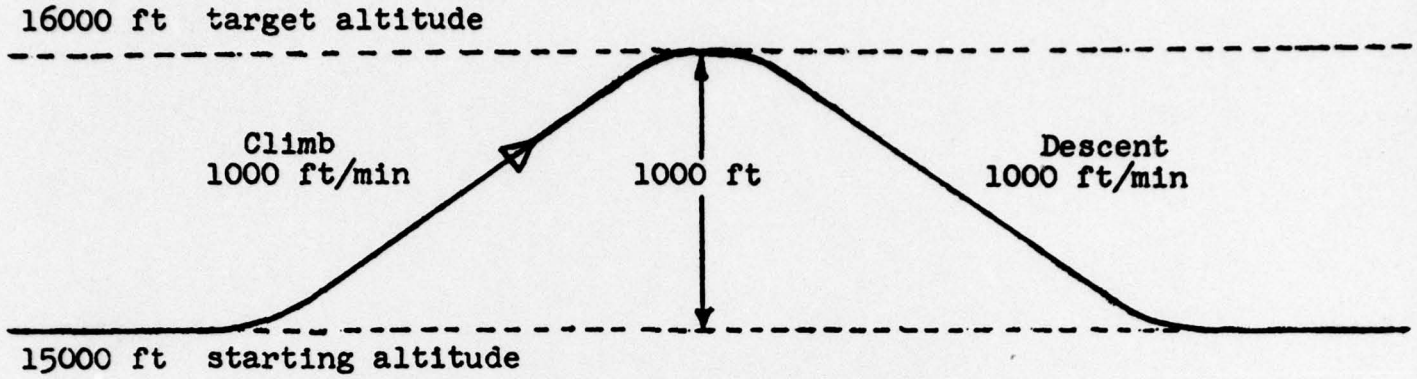
You have previously learned basic T-37 aircraft control techniques and have practiced pitch and power changes, but you have not yet been introduced to the Vertical S-A.

The Vertical S-A is a training maneuver which simulates flight conditions as they might occur during instrument flying. It is designed to provide pilots with an opportunity to improve two things:

-Speed and efficiency of crosscheck

-Aircraft control

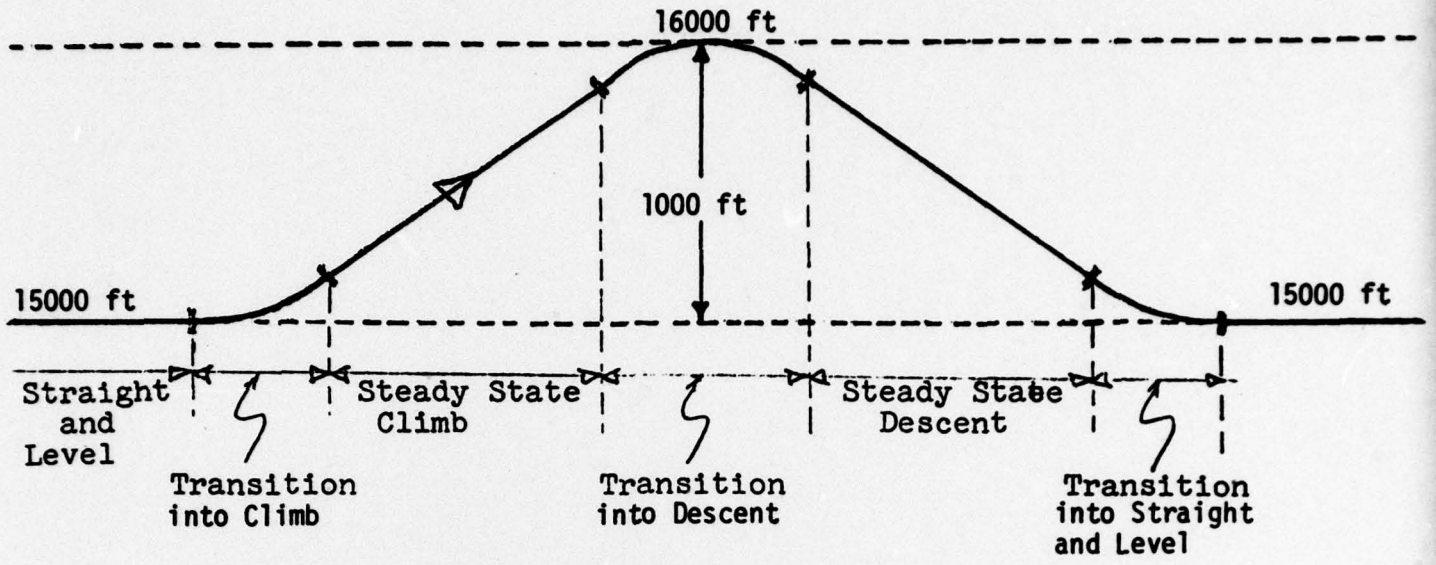
What is the Vertical S-A



Constant airspeed: 160 KIAS
Constant heading : as desired

The Vertical S-A consists of a series of alternating climbs and descents. From straight and level flight you can start either with a climb or a descent. During the mission you are about to fly you will always start with a climb. Each climb and descent covers 1000 ft of altitude change - from 15000 ft to 16000 ft and back down to 15000 ft. Each climb and descent is to be flown at a constant rate: 1000 ft/min. Heading and airspeed (160 KIAS) remain constant throughout the maneuver.

Maneuver Segments



The maneuver can be divided into several segments. These segments are of two kinds: steady states and transitions. The maneuver starts out with a steady state, straight and level flight. Then comes a transition into the climb. The climb itself is again a steady state. After the climb comes the transition over the top from the climb into a descent. The descent itself is again a steady state. The maneuver ends with another transition, the level-off to straight and level flight at starting altitude.

See whether you can remember the figures:

1. Airspeed: _____ KIAS
2. Rate of climb or descent: _____ ft/min
3. Starting altitude: _____ft
4. Target altitude: _____ft
5. Heading: Variable or constant? (Circle one)

Go to the next page and compare your answers.

1. Airspeed: 160 KIAS
2. Rate of climb or descent: 1000 ft/min
3. Starting altitude: 15000 ft
4. Target altitude: 16000 ft
5. Heading: Variable or constant

Appendix B

STATEMENT OF CONSENT

Project: Rule Learning and Systematic Instruction in Pilot Training*

Researchers: W.V. Hagin, D. Wigand and S. Herrington

In return for the opportunity of participating as a subject in a scientific research investigation and for other considerations, I hereby authorize the performance upon me of the following procedure:

1. Verbal textual instruction on a specific flight maneuver
2. Performance of the maneuver in an instrument trainer
3. Filling out a questionnaire designed to elicit my opinion on the instruction received

This consent I give voluntarily and after the nature of the experimental procedure, the known dangers, and the possible risks and complications have been fully explained to me. I knowingly assume the risks involved and I am aware that I may withdraw my consent and discontinue participation at any time without penalty to myself.

_____ Name

_____ Date

_____ Signature

_____ Witness

* Research conducted by Arizona State University under USAF Grant #OSR 76-2900, Vernon S. Gerlach, Principal Investigator.

Appendix C

TRANSITION TO CLIMB

① AIRSPEED — KIAS
140 150 160 170 180

② HEADING — (-) (+) DEGREES
20 15 10 5 0 5 10 15 20

③ START TIME (START THE STOPWATCH).

CLIMB

④ AIRSPEED — KIAS
140 150 160 170 180

⑤ HEADING — (-) (+) DEGREES
20 15 10 5 0 5 10 15 20

⑥ VVI — FT/MIN
200 400 600 800 1000 1200 1400 1600 1800

TRANSITION TO DESCENT

⑦ LEAD POINT — FEET
15700 15800 15900 16000 16100

⑧ POWER/PITCH — TOGETHER YES NO; SMOOTH YES NO

⑨ ALTITUDE — FEET
15800 15900 16000 16100 16200

⑩ AIRSPEED — KIAS
140 150 160 170 180

⑪ HEADING — (-) (+) DEGREES
20 15 10 5 0 5 10 15 20

DESCENT

⑫ AIRSPEED — KIAS
140 150 160 170 180

⑬ HEADING — (-) (+) DEGREES
20 15 10 5 0 5 10 15 20

⑭ VVI — FT/MIN
200 400 600 800 1000 1200 1400 1600 1800

TRANSITION TO STRAIGHT & LEVEL

⑮ TIME AT 15300 ft. _____

⑯ LEAD POINT — FEET
14900 15000 15100 15200 15300

⑰ LEAD WITH POWER? YES NO

⑱ AIRSPEED — KIAS
140 150 160 170 180

⑲ HEADING — (-) (+) DEGREES
20 15 10 5 0 5 10 15 20

Appendix D

Table D-1

Analysis of Variance: Heading Deviation Range

Source of Variance	Sum of Squares	df	Mean Square	F	p
Group (G)	5.14	2	2.57	< 1	ns
Ss: G	152.75	27	5.66	-	-
Trials (T)	39.96	5	7.99	3.34	< .01
T x G	10.59	10	1.06	< 1	ns
Ss x T	322.95	135	2.39	< 1	ns

Table D-2

Analysis of Variance: Airspeed Deviation Range

Source of Variance	Sum of Squares	df	Mean Square	F	p
Groups (G)	23.57	2	11.74	< 1	ns
Ss: G	362.55	27	13.43	-	-
Trials (T)	118.16	5	23.63	11.53	< .01
T x G	23.26	10	2.33	1.14	ns
Ss x T	276.75	135	2.05	-	-

Table D-3

Analysis of Variance: Vertical Velocity Deviation Range

Source of Variance	Sum of Squares	df	Mean Square	F	p
Groups (G)	120.46	2	60.23	11.23	<.01
Ss: G	144.71	27	5.36	-	-
Trials (T)	9.54	5	1.91	3.60	<.01
T x G	18.17	10	1.82	3.43	<.01
Ss x T	70.89	135	0.53	-	-

Table D-4

Analysis of Variance: Time Maximum Deviation

Source of Variance	Sum of Squares	df	Mean Square	F	p
Groups (G)	5324.13	2	2662.06	7.74	<.01
Ss: G	9139.15	27	338.49	-	-
Trials (T)	573.32	5	114.66	2.34	<.05
T x G	2661.80	10	266.18	5.44	<.01
Ss x T	6611.55	135	49.97	-	-

Table D-5

Analysis of Variance: Maximum Altitude Deviation

Source of Variance	Sum of Squares	df	Mean Square	F	p
Groups (G)	8.72	2	4.36	< 1	ns
Ss x G	118.53	27	4.39	-	-
Trials (T)	8.99	5	1.80	< 1	ns
T x G	28.61	10	2.86	1.24	ns
Ss x T	312.07	135	2.31	-	-

Table D-6

Analysis of Variance: First Lead Point Maximum Deviation

Source of Variance	Sum of Squares	df	Mean Square	F	p
Groups (G)	188.81	2	94.41	3.87	
Ss: G	658.75	27	24.40	-	-
Trials (T)	54.89	5	10.98	1.89	-
T x G	90.13	10	9.01	1.55	
Ss x t	783.15	135	5.80	-	-

Table D-7

Analysis of Variance: Second Lead Point Maximum Deviation

Source of Variance	Sum of Squares	df	Mean Square	F	p
Groups (G)	79.64	2	39.82	2.97	< .10
Ss: G	362.52	27	13.43		
Trials (T)	16.56	5	3.31	< 1	
T x G	44.76	10	4.48	1.2	
Ss x T	518.18	135	3.84		