AD-A058 940 NEW MEXICO STATE UNIV LAS CRUCES HUMAN PERFORMANCE LAB F/G 5/10

HUMAN PERFORMANCE SIMULATION.(U)

AUG 77 E WILLIAMS, W H TEICHNER F44620-76-C-0013

UNCLASSIFIED NMSU-AFOSR-TR-77-4 AFOSR-TR-78-1231 NL

1 OF 1

AD A058940

END

DATE FILMED

11-78

DDC

DDC FILE COPY AD A058940

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

(2)

| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
|---|---|---|
| 1. REPORT NUMBER AFOSR-TR- 78-1231 | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle) Human Performance Simulation | | 5. TYPE OF REPORT & PERIOD COVERED Interim 1976-1977 |
| | | 6. PERFORMING ORG. REPORT NUMBER NMSU-AFOSR-TR-77-4 |
| 7. AUTHOR(s) Evelyn Williams | | 8. CONTRACT OR GRANT NUMBER(s) F44620-76-C-0013 |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS Human Performance Laboratory (Dept. of Psychology) New Mexico State University Las Cruces, New Mexico 88003 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 61102F 2313A4 |
| 11. CONTROLLING OFFICE NAME AND ADDRESS Air Force Office of Scientific Research (NL) Bolling Air Force Base Washington, D.C. 20332 | | 12. REPORT DATE 31 August 1977 |
| | | 13. NUMBER OF PAGES 22 |
| 14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) | | 15. SECURITY CLASS. (of this report) Unclassified |
| | | 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE |

LEVEL II

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)

Human Performance Theory, Task Analysis, Short Term Memory

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

This study provides a summary of the work done in the fiscal year 1976-1977 on the grant entitled Human Performance Simulation, Number AFSOR F44620-76-C-0013. The report emphasizes the progress which has been made on Teichner's Human Performance Theory of acquisition, memory, and task analysis.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

(18) AFOSR (19) TR-78-1231

(6) HUMAN PERFORMANCE SIMULATION.

AFSOR Contract No. (15) F44620-76-C-0013

Principal Investigator: Warren H. Teichner

(16) 2313 (17) A4

(9) ANNUAL REPORT. 1 Sep 76 - 31 Aug 77

compiled by

(10) Evelyn Williams, Warren H. Teichner

Acting Principal Investigator

(11) 31 Aug 77 (12) 23p.

(14) NMSU-AFOSR-TR-77-4

1 September 1976 - 31 August 1977

The views and conclusions contained in this document are those of the authors and should not be interpretted as necessarily representing the official policies or endorsements, either expressed or implied, of the Air Force Office of Scientific Research or the U.S. Government.



78 09 05 068

410 343

JOB

Cumulative Chronological List of Written Publications in Technical Journals

Companion, M. A. & Teichner, W. H. Application of task theory to task analysis: Evaluation of validity and reliability using simple tasks. (Tech. Report 77-3), Las Cruces, New Mexico: New Mexico State University, Department of Psychology, January 1977.

Teichner, W. H. Input, output, and response blocking in immediate recall. (Tech. Report 77-2), Las Cruces, New Mexico: New Mexico State University, Department of Psychology, October 1977.

Williams, E. The effects of amount of information in the Stroop color word test. Perception and Psychonomics, 1977, 22, 463-470.

Professional Personnel Associated with the Research Effort

Warren H. Teichner - Principal Investigator

Ben Fairbank - Research Associate

Evelyn Williams - Research Associate

Michael Companion - Graduate Student

Greg Corso - Graduate Student

Novita Ward - Graduate Student

Interactions (Coupling Activities)

Williams, E. Encoding and retrieval in the Stroop phenomenon. Psychonomic Society, Washington, D.C., 1977.

Teichner, W. H. Encoding and retrieval in short term memory. Psychonomic Society, Washington, D.C., 1977.

The long range goal of the project is the development of a comprehensive theory to represent the human operator in system design. Achievement of this long range goal is seen as requiring a theory of human performance which is also a theory of tasks. This model should provide a quantitative framework within which empirical data can be entered and accurate predictions can be made of the parameters of human performance. This quantitative framework should be amenable to measures of human capacity so that the effects of task loading on the operator may be determined and overloads avoided.

Theory and Progress

The basic theory has been described by Teichner (1974). The theory will be reviewed, therefore, in a limited way with particular emphasis on those translational aspects which are most pertinent to the analyses to follow.

The theory in its simplest terms may be expressed as the following development of Donder's law:

$$P = f_1(a) + f_2(S\text{-}S) + f_3(S\text{-}R) + f_4(R_I) \qquad (1)$$

where: $a = a_s + a_k$ = RT and $a_k$ is that portion of the response measure, P, associated with neural transmission, while $a_s$ is stimulus encoding time; S-S = the portion of P due to translations between stimulus codes; S-R the portion due to translation from the final stimulus code to the response code, and $R_I$ is the portion due to response initiation, i.e., that portion associated with the selection of a motor program to carry out the action specified by the S-R translation. Performance, P, is expressed as a measure of speed or error, or a combination such as amount or rate of information processing.

The human processing system represented as Equation 1 is a serial system. Whether, in fact, the system is serial, parallel, or some combination of serial and parallel processing probably depends upon the level of analysis employed. That is, if the stages (subtasks, functions) of Equation 1 were refined into still more detailed stages, parallel sub-systems might (or might not) emerge. At the indicated level of analysis we are assuming serial transmission.

We define a task as a transfer of information. Accordingly, Equation 1 is a task with an information transfer from a stimulus input to a response. The four stages of the process are subtasks or task functions since each involves a transfer of information. Then, those operations which occur within functions are the processes or operations which act upon the information and determine the amount or rate of transfer.

For reasons explained in the basic paper, the operations of interest in establishing a task taxonomy are those which occur within the S-S and S-R *functions. Those processes are:* Compression (symbol reduction), conservation (one-to-one mapping), classification (many-to-few mapping), and creation (few-to-many-mapping). Accordingly, tasks are defined as combinations of functions and processes.

Equation 1 may be expressed with P in the domain of time, error information transmission, etc. The specific functions will be different for each. Thus, each variant of Equation 1 represents a transfer function for that task and dependent measure.

We have identified Equation 1 as Type 1 task regardless of the dependent measure involved. Given certain tentative constraints, two other functional classes of tasks can be identified. A Type 2 task is expressed as Equation 2 and a Type 3 as Equation 3:

$$P = f_1(a) + f_3(S\text{-}R) + f_4(R_I) \qquad (2)$$

and

$$P = f_1(a) + f_4(R_I) \tag{3}$$

Given these three types, the four processes, and the constraints of the theory, a task classification system evolves which contains a large number of uniquely defined basic tasks. These tasks are abstract representations of actual task activities. Thus, if they can be used to describe a task of interest, and if they are described in appropriate empirically-based mathematical form, they can be used to represent the human operator. We have a limited number of such equations developed. Research along this line is still developing.

In order to understand what constraints should be imposed on the terms of Equation 1, as well as to develop a more advanced understanding of the number and kinds of stages to be used in the equation, it is necessary to develop models within the stages which predict the subtask transfers and which describe and quantify the four processes within the S-S and S-R stages. We shall discuss this more below and indicate the present status of model development and its advancement within the proposed research.

Figure 1, modified from Teichner (1974) provides a general outline of the theoretical approach proposed to deal with Equation 1. Current experimental work and model development are suggesting modifications and ways to fill in some of the stages with quantitative expressions. Although we are not ready to do that at this writing, we shall indicate the nature of those ways as we go along.

Viewing the figure with Equation 1 in mind, it can be seen that

1. a comprises a sensory register and scanner and a criterion established by the long-term based active memory of the stimulus.

2. The S-S translation (Stage 2 in Eq. 1) results from a comparison process between the material in short-term memory (provided by the a-component)

and the active memory of the stimulus.

3. The S-R translation results from a comparison between the S-S translation and a long-term storage based active memory of stimulus response relationships.

4. Response initiation and the ensuing motor activity is a direct consequence of the S-R translation.

The dashed lines in the figure indicate that with practice first S-S and later S-R translations are bypassed allowing a more direct signal-to-response flow from primary memory to response initiation. To do that requires that the data in primary memory be coded somehow. That is done by a more or less passive encoding process which is achieved through a response-criterion recognizing mechanism with LTM establishing the criterion from expectations (i.e., probabilities) of what the stimulus will be.

a-Component

A fundamental stage in the theory is the a-component for which a two-step model has been proposed. One aspect of the model is a response criterion submodel which determines the amount of evidence, and consequently the time, required to make a decision about the presence of a signal. The second is a model of scanning mechanism which determines the timing of and between signals. We have been doing pilot work and some more extensive studies for some time which are intended to develop a better understanding, and improved models, of these two jointly operating processes. These studies have been accelerated in the visual domain and are being extended to the auditory domain in a dissertation by Gregory Corso, which is at the point of being written up in dissertation form.

Within the auditory domain the central problem being investigated is how the temporal order of two signals should be modeled. This modeling is necessary to understand which of several signals closely spaced in time are preceived. A further intent of this investigation is to determine if the scanning mechanism involves different criterions and/or psychological moments for different tasks, i.e., detection and temporal order judgments. The preliminary analyses of these data indicate that the relationship of response criterion and psychological moment (rate of scanning) is very complex and is dependent on task, interstimulus interval and stimulus intensity.

In the visual realm experimental work on the response criterion model concerns an evaluation of signal detection vs. signal identification vs. signal classification. The technique presents block-type alphanumerics, and other symbolic forms, monocularly and dichoptically. We have just completed the data collection stage of an extensive monocular study and have a comparable dichoptic experiment under way. One very important question associated with these experiments is whether it is necessary first to detect a signal and then to identify it, or whether detection and identification are one and the same process at different criterial levels. If the former is true, and that has been the general assumption for a very long time, the theory and its applied extensions will need a detection stage followed by an identification stage in all tasks. If they are the same process, as implied by the present postulates of the theory, only one stage will be required.

At the same time these experiments have been concerned with the relationship between the amount of perceptual information in the stimulus and detection, identification and classification. This is being done through comparisons with signals to which different amounts of information must be added from memory to the signal. For example, one kind of symbol presented briefly to the subject is a square with one side missing. Depending on the experimental conditions, the subject (a) reports that something is missing (detection),

(b) reports which side is missing (identification), or (c) reports whether the missing side was north-south or east-west (classification). Under another experimental condition only one of the four sides is presented and the subject detects, identifies, or classifies with respect to which side of the square it is. In one case reporting is of what is there in the visual scene, but in the other reporting is of what is not there. As a result, for the first case, more information must be supplied by the subject. Note for reference below that this is a few-to-many translation.

Finally, in a third set of comparisons the subject does the same thing except that the stimuli are from a set of alphanumeric symbols. In all three cases the signal is presented both monocularly and dichoptically. The signal is followed by another which prevents the subject from further perceptual processing of the first signal, and the time between the two signals is an independent variable. For alphanumerics, the second symbol is the block digit, 8; for squares, it is the rest of the square.

This type of experiment bears on certain fundamental questions: 1. Can detection, identification and classification be represented as different criterion levels of the same process? The evidence so far suggests that classification may always require two processing steps, of which one is identification. It also suggests that detection and identification may be treated as one process. This is critical to the question of whether it is necessary to have a first detection stage in the model followed by an identification stage even when the S-S translation has become "automatic."

The time constants involved in processing to the three responses are critical to the development of the scanning mechanism being modeled. So far, our data suggest that the time between signal onsets (SOA) is the most critical variable for monocular resolution of the non-simultaniety of two signals, whereas for dichoptic processing, signal duration is the most important variable. The situation appears to be different in the auditory mode, however, since an SOA of about 2.0 milliseconds can be resolved dichotically. This should be compared to 35 milliseconds monocularly and even longer SOA dichoptically for very short signals.

The resolution of temporal order appears to require about 20 milliseconds in the auditory mode according to the literature. We have no certainty yet about the comparable visual resolution although the same time constant has been claimed and, therefore, the same central control processor. These are issues to be resolved to decide on the generality of the scanner, i.e., whether it should be modeled as a single processor of all incoming signals or whether each modality will require a separate model.

Another problem of the response criterion model is the need for a generalizable, empirical measure of the criterion. From the experimental data just described we shall be looking at signal detection measures for this purpose, but it will also be valuable to establish a scale which is more descriptive in terms of the manner in which the information is coded for short-term memory. If we can do that, we shall have a clear path numerically through the entire theoretical system. Otherwise, it will be necessary to develop transformations. The experiments in progress should provide data which can be thought of as pilot data for a further, very specific study with that question in mind.

A specific intensity function for the response criterion model was derived in our simple reaction study (Teichner and Krebs, 1972). The derivation was based on the demonstration that the total energy received by the eye can be used to represent the theoretical neural pulsing rate for which the response criterion stands. However, the data also imposed the requirement that the criterion as well as the pulsing rate increase with signal intensity. Therefore, it was necessary to assume that the pulsing rate must increase faster than the criterion. Accordingly,

$$PR = kL^m \qquad (4)$$

where PR is pulsing rate, L is luminance, and m and k are constants. And,

$$RC = aL^n \quad m \quad n \qquad (5)$$

where RC is the response criterion and a and n are constants. Therefore,

$$RT = cL^{n-m} \quad C = a/k \qquad (6)$$

here RT is reaction time, c a constant, and the constants of Equation 6 are already known empirically.

It is important now to determine how non-intensive features of stimuli should be handled in the model. That can be done using Equation 6 as a baseline for signals which vary in both intensity and features.

S-S Translations

A very important assumption of the theory is that with extended practice S-S translations developed during training drop out of the processing sequence. The result is an automatic reaction to a signal which bypasses the translation stages. We have been trying to instrument a simple situation which will permit us to test this assumption. If the assumption is supported, the theory need not be altered in this regard. Instead questions can then be raised about the conditions which facilitate and which impede the S-S drop-out and methods for identifying when dropouts have occurred. The latter has immediate implications for training criteria.

If the assumption is only partially supported, i.e., if only certain kinds of S-S translations become automatic, those that do can be studied in the context of the a-component. For those that do not, or if the assumption is not supported at all, it will have to be assumed that translations become faster, but are always required, and therefore, always subject to interference or loss from short-term memory. In addition to tests of these possibilities which are about to be described, the detection-identification-classification experiments described above are relevant. Tentatively, they are suggesting so far that one-to-one translations may drop out, but that many-to-few and few-to-many translations may not.

Apparatus which is now almost completed is intended to provide tests of the automaticity of S-S translations with sufficient practice. The basic arrangement is of four matrices of contact points (pennies) and a slide projector. The slides will be used to present novel images (e.g., Vanderplas figures) which must be coded on a one-to-one basis (identification S-S) by the cells of the first matrix. In turn the remaining three matrices will be used to make translations of the item coded in the first matrix. Going from the first to the second, and thence to the third and fourth matrices will be a succession of further encodings. Some will be one-to-one; some will be few-to-many mappings (creations), and some will be many-to-few mappings (classifications). In all cases the relation between the first and last matrix will be constant so that if the intermediate encodings had not been required, the subject could actually have learned to go from Matrix 1 to Matrix 4.

After the subject learns the succession of coding steps, the intermediate matrices will be eliminated and he will code directly from Matrix 1 to Matrix 4. Initially, he should go through the intermediate translations mentally, but once a reasonable level of performance is established, the intermediate translations should drop out according to our postulate. Thus, after practice, with Matrices 1 and 4, the intermediate matrices will be put back in the system, but their codes will be altered. After practice with this arrangement, the subject will return again to the two-matrix task. Note that the relationship between these two will be as before. Thus, if there is a decrement in performance on the two-matrix encoding at this point, it can be interpreted as indicating that the first intermediate S-S translations never dropped out. If they had, the altered code could not have interferred with the second two-matrix performance.

Experiments using this basic paradigm will be done with both one and two intermediate steps and with different kinds of S-S translations for the various inter-matrix relations, and between the slide and each matrix. As these data are collected, distribution functions both within and over subjects will also be accumulated for the purpose indicated next.

Regardless of the outcome of these experiments, S-S translations are not automatic initially, and in fact, they require a considerable amount of practice before the dropping out issue is relevant. The theory needs distribution functions for them and these functions will be obtained systematically using the basic arrangement (penny-board) just described. The number of translating steps will be varied as will be the nature of the codes, the amount of information, and of compression, and the level of practice.

All of the S-S work described should be ongoing in the near future. This research has been delayed due to apparatus problems. We were previously trying to couple the apparatus with a new microprocessor-based microcomputer which was found to have problems in its circuits. We just finished interfacing the apparatus with the PSP/8 and data collection is currently underway.

Short-Term Memory (STM)

As shown in Figure 1, the theoretical system includes a STM to store data encoded by the a-component or first stage of the model before a stage S-S translation can occur. The nature, the speed, and the accuracy of encoding into STM and of retrieval (including re-coding) from STM, is central to all other considerations of theory and practice. Of course the Sternberg recognition memory model is available. But we also need a method for evaluating recall or reproduction. For maximum value the method should provide a description of the processing and encoding into STM and, separately, of retrieval from it.

Such a method was developed and it has been described before. Basically, a display of symbols is presented to the subject; and he makes pushbutton identifications on a one-to-one basis. The duration of the display is so short that rehearsal is not possible. The data available are in errors and time to each successive button-press.

Input and output are extracted from the data as follows. The average time between each successive button-press following the first button response made provides an estimate of the retrieval rate (plus response execution). This is subtracted from the time to the first button-press. The remainder is a measure of input time through encoding time into a nonsensory STM since the time required to retrieve and press the first button is now removed. Then by subtracting input time from the total time, the actual output time is obtained.

Using this method, we have completed five STM experiments in the present year. The experiments have been analyzed and have been used to support the basic empirical model for the separation of input and output. Support for the usefulness of the measures is partially based on evidence that the separation of input and output time leads to findings in which the effect of independent variables upon total input and output time is different. The research also demonstrates the flexibility of the separation procedure and its applicability to different theoretical models if additional assumptions of the nature of processing input and output (serial vs. parallel) and assumptions as to where information is lost from memory.

These experiments have been described elsewhere in detail, (Teichner, 1977) however, a summary of the experiments and their results are given below.

Experiment 1.

This experiment varied the number of alphanumeric symbols displayed (density) and the display duration factorially. Each combination was presented as a constant over a block of trials. Subjects were well-practiced. Both duration and density were found to have significant and interacting effects on encoding time, but no effects on retrieval rate.

Experiment 2.

This experiment was a replication of the first except that only the two shortest durations were used and density (1, 2, 4 or 8 symbols per display) was randomly varied within the blocks. Thus, the subject could not anticipate how many stimuli were to be reported. The results indicated that none of the independent variables had a significant effect on output time per response (t/r). Total time as well as input time was only affected by density. Duration of the stimulus had no effect on any of the measures.

Experiment 3.

In the previous two experiments, the symbols were in random positions on the display. This experiment used only the density 8 condition and arranged the characters in an array of two rows and four columns (2 x 4), located in the central area of the screen. Exposure durations of 100, 200, 300, and 400 milliseconds were blocked with 24-trial sequences, eight sequences per day for two days to provide four replications of the experiment. The total time was dependent upon both replications and stimulus duration. Neither input time nor the output measure, time per response (t/r) were significantly affected by duration. Both input time and t/r decreased with practice, but in different ways, i.e., t/r linearly and input time non-linearly.

In comparison with the results of previous experiments (all experiments were done with the same subjects) t/r and output time appeared to be unaffected by the change in the nature of the display, and continued to improve from its last measured bases, input time started with an initial large loss from which it recovered. It seems that changing the organization of the display had a strong initial effect on the input and none on the output. Since display organization would be expected to be an input variable, this is reasonable.

Experiment 4.

This experiment was an exact replicate of Experiment 3 except that partial reports were involved as soon as the symbols were removed from the display. The subject was given an instruction to report either the whole top or bottom row of four items (constant probe) or to report the content of randomly selected single matrix cells. The varied probe condition apparently placed an overload on subjects and their performance was very poor in terms of accuracy and number of responses. In the constant probe conditions, the probe density significantly affected all three temporal measures: Total time, Input time and t/r.

Experiment 5.

In this final experiment subjects received trials in which the response panel was labeled followed by trials in which no label was present. As in the previous experiments stimulus density varied. The effects of removing the labels on input time was to add a constant time to the input processing. The effect of removing the labels on the output time was a marked increase in that time. The overall effect was an even more rapidly increasing output time curve than for the labeled condition so that as density increased, the difference between the two density functions increased.

In addition to measuring output rate as the mean time between button presses, we also looked at the first such time (time between the first and second button responses) as an estimate of the output rate. There are two purposes in this. First, for cases where output rate changes with each successive button-press, the estimate provides a measure with the least contamination by the operating variable. Secondly, to study S-R translations, we would like to interfere with the response sequence in a systematic way that depends on the ongoing performance. For this purpose a good estimate of the average output rate obtained early would permit on-line feedback control. So far over several sets of data the single difference measure between the first and second response has been an excellent numerical estimate of the average value.

S-R Translations.

This is an area of great importance because situations requiring computations and varied solutions to incomplete information and risky decisions will probably always involve S-R translations. We have not previously brought the theoretical system to the point of handling decision-making because until very recently we did not have an experimental method to study it as a separate stage.

Of some bearing to the question of S-R translations is the problem of providing a means by which responses can be made selectively. What if two signals are present, but only one is "correct"? This is the old problem of selective attention. One of the frequent ways by which it has been studied is with the Stroop phenomenon. The subject sees a word which is the name of a color, but it is printed in a different color. He is asked to report the actual color, and to ignore the word. Generally, he has considerable difficulty responding selectively compared with responding to the color alone.

This task, along with some others, has led to two classes of theories of selective attention. One depends on perceptual selection (e.g., a filter); the other depends on response inhibition. If the latter kind of theory is right, our general model will need some way of checking or verifying the S-R translation, or of suppressing a response. If the perceptual theory is right, the response criterion model may be able to handle the matter as we make the model more complex.

To investigate this problem, the Stroop literature was reviewed and an experiment conducted by Professor E. Williams with assistance from this project. The experiment manipulated the amount of color and of word information factorially. The main reason for doing that was to manipulate the processing times of the colors and of the words so that the interference of the words could be localized on the stimulus or response side, or so that if there were an interaction, it could be identified. The data suggest that the interference is localized on the stimulus side. This can be handled as a response criterion problem in the a-component. However, it still raises the issue of a possible need for a stimulus or response verifier before the response initiation stage to suppress already started S-R translations.

The response measure used in the above study and that of most Stroop studies is that of total time. The measure by necessity confounds all of processes of input with output. Experiments such as the above can only infer where the locus of interference is occurring - in the response criterion of the a-component or in the S-R translation stage. Therefore, Dr. Williams has been undertaking a series of experiments using the input-output methodology described above in order to more clearly separate out the locus of interference in a dual stimulation task. Data has been collected in these experiments and is currently being analyzed.

Systems and Application Studies

In the previous year, we showed that a complex task (DAIS) can be analyzed in the terms of the theory and that using those terms reasonable prediction can be made to operational performance. More work needs to be conducted along this line. Accompanying it, however, there has been a need to estimate the reliability and validity of the theory when it is used with actual tasks by persons not connected with the development of the theory.

Toward this end (Companion & Teichner, 1977) conducted an experiment to evaluate Teichner's theoretical task concepts when applied to simple operational tasks. Problems performed on desk and pocket calculators were developed so as to represent selected theoretical tasks. Subjects were instructed in the theoretical concept, then provided a partial operational analysis of the task problems, and were then required to complete the operational task analysis, and to transform it to a theoretical task analysis. Using the built-in operational and theoretical steps as references, the validity of the subject's procedures was evaluated in terms of how closely his analyses agreed with the references. The mean percentage of correct responses for the theoretical analyses was 81 percent; the mean percentage of correct responses for the operational analyses was 88 percent. When the theoretical analysis was adjusted to accomodate errors in the operational analysis, the percentage of correct theoretical responses was 88 percent. It appears, therefore, that with very little training people can comprehend the concepts and be at least as proficient in the theoretical analysis as they are in describing actual operations. Considering that and the general level of performance, it is concluded that the practicality of the approach is supported, i.e., operational task descriptions or task analyses can be translated correctly into the tasks of the theory by minimally trained observers.

Estimates of the reliability of the procedures, both within and between the 10 subjects, provided only moderate correlation coefficients. This suggests a need to improve some aspect of the training in order to increase reliability. On the other hand, reliability was high enough to allow the level of validity observed. Thus, it would appear that an increase in reliability should increase validity further.

A second objective of this effort was to establish a formal set of procedures for training personnel in the use of the theoretical task concept. A first set of procedures, subject to later improvement, is provided in the Companion and & Teichner (1977) report.

All in all the results are very encouraging. They support the idea that the theory can be applied meaningfully to "real" tasks. It is now important to extend the evaluation to more complex tasks.

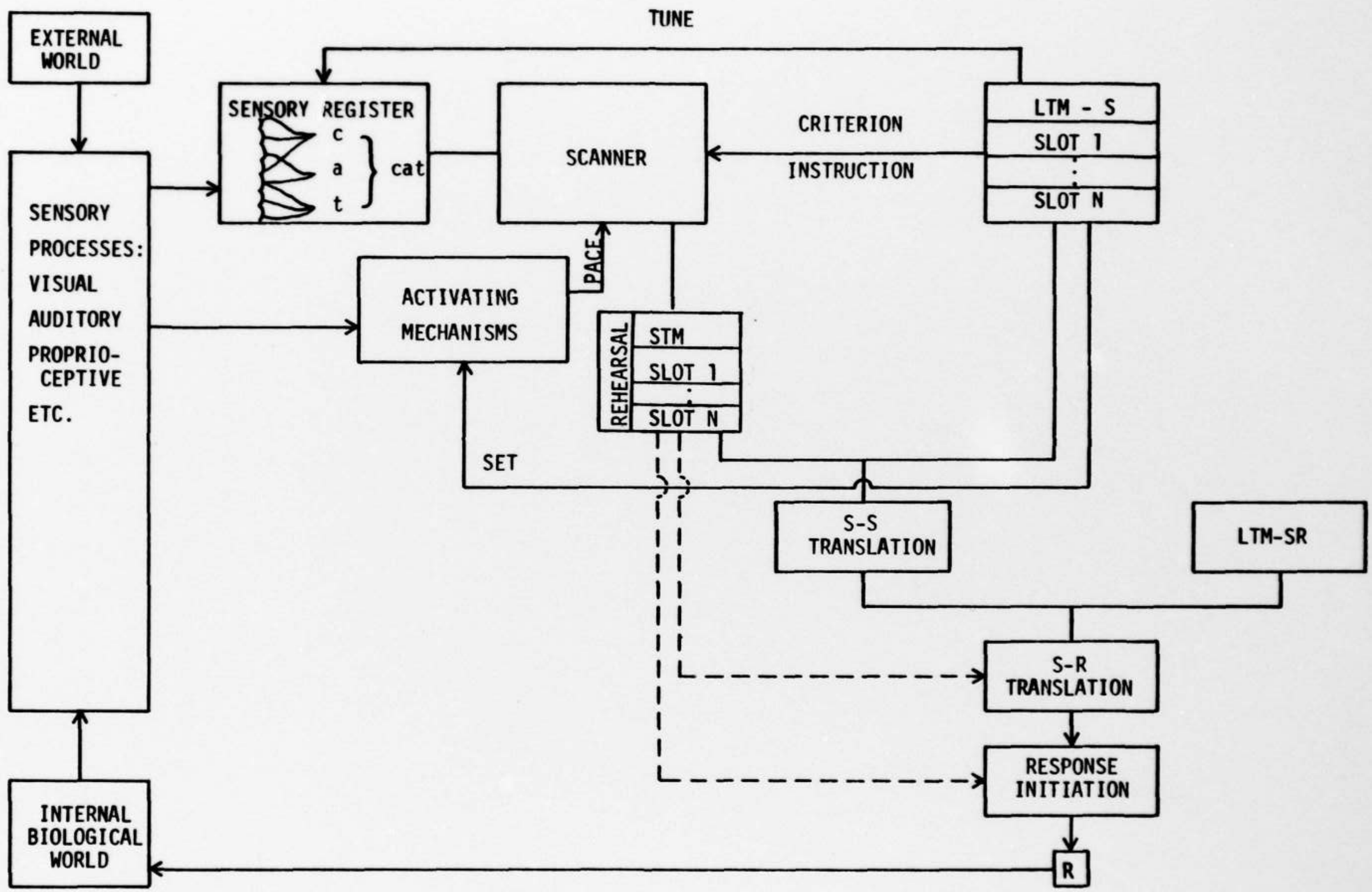
TUNE
EXTERNAL WORLD
SENSORY REGISTER
c
a
t
cat
SCANNER
CRITERION
INSTRUCTION
LTM - S
SLOT 1
SLOT N
SENSORY PROCESSES:
VISUAL
AUDITORY
PROPRIO-CEPTIVE
ETC.
PACE
ACTIVATING MECHANISMS
REHEARSAL
STM
SLOT 1
SLOT N
SET
S-S TRANSLATION
LTM-SR
S-R TRANSLATION
RESPONSE INITIATION
INTERNAL BIOLOGICAL WORLD
R

Figure 1.

# REFERENCES


Companion, M. A., & Teichner, W. H. Application of task theory to task analysis: Evaluation of validity and reliability using simple tasks (NMSU-AFOSR-TR-77-1). Las Cruces, New Mexico: New Mexico State University, Department of Psychology, January 1977.

Teichner, W. H. Quantitative models for predicting human visual/perceptual/motor performance (NMSU-ONR-TR-74-3). Las Cruces, New Mexico: New Mexico State University, Department of Psychology, October 1974.

Teichner, W. H. Input, output, and response blocking in immediate recall (NMSU-AFOSR-TR-77-2). Las Cruces, New Mexico: New Mexico State University, Department of Psychology, October 1977.

Teichner, W. H., & Krebs, M. J. Laws of the simple visual reaction time. Psychological Review, 1972, 79(4), 344-358.

Williams, E. The effects of amount of information in the Stroop color word test. Perception & Psychophysics, 1977, 22(5), 463-470.