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CYBERNETIC CONTROL OF MEMORY WHILE READING CONNECTED DISCOURSE.

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A STUDY WAS CONDUCTED TO DETERMINE HOW ADULTS ADAPT TO DIFFERENT PASSAGE ORGANIZATIONS AND STIMULI WHICH PLAY A CRITICAL ROLE IN GOVERNING READING BEHAVIOR. A MODEL OF READING IS DESCRIBED WHICH STATES THAT SUBJECTS ENTER A MINIMAL SET OF STIMULI INTO MEMORY WHICH GOVERNS SUBSEQUENT FEEDBACK CONTROL, AND THAT SUBJECTS ALLOW PASSAGE ORGANIZATION TO ACT AS A SURROGATE STORAGE FOR EASILY RETRIEVED VERBAL UNITS. THE MODEL WAS TESTED IN AN ANALYSIS OF VARIANCE USING 24 COLLEGE-AGE FEMALES. SUBJECTS WERE GIVEN THE ATTRIBUTES OF A VERBAL CONCEPT AND TOLD TO FIND ITS NAME IN A READING PASSAGE. THEY WERE NOT INSTRUCTED TO LEARN THE MATERIALS. THE GROUP WHICH READ THE SENTENCES ORGANIZED BY CONCEPT NAME RETAINED MORE ATTRIBUTES THAN THE GROUP WHICH READ THE SAME SENTENCES ORGANIZED BY ATTRIBUTE. THE LATTER GROUP RETAINED MORE NAMES. THERE WERE NO SIGNIFICANT DIFFERENCES BETWEEN TREATMENTS IN TERMS OF TIME. IT WAS POSSIBLE TO PROGRAM MEMORY INPUTS SIMPLY BY REARRANGING THE SENTENCES. TABLES, FIGURES, AND REFERENCES ARE INCLUDED. (BK)

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ABSTRACT

A model of reading is described which states that Ss enter a minimal set of stimuli into memory which govern subsequent feedback control, and that Ss allow passage organization to act as a surrogate storage for easily retrieved verbal units. The model was tested in an analysis of variance using 24 college-age females. Ss were given the attributes of a verbal concept and told to find its name in a reading passage, but they were not instructed to learn the materials. The group which read the sentences organized by concept name retained more attributes than the group which read the same sentences organized by attribute ($p < .005$). The latter group retained more names ($p < .005$). It was thus possible to program memory inputs simply by rearranging the sentences.

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Cybernetic Control of Memory While Reading Connected Discourse

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Educational materials store information. If this information can be retrieved easily students will let the organization of the printed material perform a storage function which they are capable of performing themselves -- they are adaptive. A well organized or "easy" passage might thus work against retention of important content.

The immediate goal of the present study was to arrange verbal materials in such a way that when allowed to read in an unrestricted situation, without knowledge of results or instructions to learn specific information, groups of Ss (subjects) would be constrained to enter different verbal units into memory. The ultimate objective of this study was to determine how Ss adapt to different passage organizations and which stimuli play a critical role in the internal feedback processes which govern reading behaviors.

Some preliminary definitions may be helpful to the reader. "Connected" refers to two separate characteristics of the verbal materials used in this study. First, the use of connectives to join subject and predicate terms of a sentence. Second, the predicate of one sentence does not completely define

its subject, hence other attributes predicated of that subject are located in other sentences. These sentences are connected in the sense that they describe characteristics of a common subject term (which is the name of a concept). "Organization" then, refers to the variable (subject or predicate) which changes least rapidly from sentence to sentence. For instance, the sentences "John was born in 1926. John is pugnacious.", are organized by name. The sentences "John was born in 1926. Bill was born in 1926." are organized by dates.

In the context of the present study, "cybernetic control" means that the reader responds discriminately to stimuli in a passage and that his responses to these stimuli are evaluated against an internalized criterion. The results of this comparison are used to select further stimulus inputs which most directly advance the reader toward his goal. "Adaptive" means that if the task changes, the reader can place available skills under the control of an entirely different class of stimuli which will lead to the attainment of the goal in the new situation.

Figure 1 presents a simple model which includes the salient characteristics of the system. The figure states that

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Insert Figure 1 about here

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some requirement is imposed upon the reader from outside the system (open loop) -- these may be stated objectives or direct instructions, or a question. Objectives might also originate within the reader and be inconsistent with the nominal objectives. These objectives induce a goal in the reader which he stores in memory, and which governs the closed-loop operations shown below the solid line. From the range of possible stimuli the reader thus has a criterion for selecting stimuli for storage. The average reader also has appropriate verbal skills (verbal associates or chains) and a variety of problem solving skills. When the reader has gone through the relevant stimuli (achieved his goal), he stops. In short, reading a classroom assignment, for instance, is a form of self-directed problem solving which the teacher attempts to structure by imposing certain conditions.

Hypotheses suggested by this model were tested in the present study by constructing verbal concepts (planets) which had certain attributes (distance from earth, terrain, and atmospheric color). Subjects were instructed to find the name of the planet (goal) which was a certain distance, and had a particular terrain and atmospheric color (criteria). Unlike concept attainment tasks, Ss were given the attributes of the concept and asked to find its label. The present task attempted to preserve certain characteristics of ordinary reading. First, the reading materials should exhibit connectedness, in the sense

previously defined, and they should deal with meaningful verbal concepts. Second, Ss should be allowed to respond freely to the passage by taking notes, re-reading pages, etc. Third, Ss should be required to use the passage in some way, but should not be instructed to memorize a list of stimuli. Normally, students read a passage to find some general information and are not told precisely what they will be asked to recall at a later time.

For half of the Ss the materials were organized by planets, with the attributes varying most rapidly. For the other half of the Ss the materials were organized by attribute, with the name varying most rapidly. In the first case the attributes carry the most information and the materials "store" the name information which is easily retrieved if a match is made with the criterion. In the second case the names carry the most information. If a match is made with one criterion the name must be entered into storage and a search made for the same name. Figure 2 indicates that the reader

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Insert Figure 2 about here

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has the ability to look at the passage and to adapt his search procedure to the organization of the materials. The S begins by determining which stimuli he must deal with. Information from scanning the organization of the passage is then stored and used to determine which stimuli will be selected during

further reading. The stimuli which are to control further stimulus selection are entered into memory, and a search for criterion related information is begun. The goal and specific search behaviors have been eliminated to simplify Figure 2.

It was predicted that Ss who read the materials organized by concept name would recall more attributes, since these would be the stimuli most useful for making the necessary criterion comparisons. Subjects who read the materials organized by attribute should recall more names, for a similar reason. These words, which are entered into memory, are the stimuli which permit S to maintain the connectedness of the sentences regardless of the organization of the passage.

The materials were also presented in two formats, either as a vertical list of sentences or as a regular prose passage, with paragraph indentation to separate different name or attribute data. It is possible that the physical characteristics of prose -- sentences one after another and broken to conform to margins -- might significantly influence the ease of retrieving information and hence exert some control over learning. It was thus predicted that the prose condition would produce higher retention.

The model proposed here places special emphasis upon the stimulus selection strategies of readers which are mainly closed-loop operations, and which reflect the use of a variety of skills. Growing interest in these internal feedback

processes (Hunt, 1965; Rothkopf, 1965; Smith & Smith, 1966) has important theoretical and practical implications for instruction. The control of learning behaviors may yet be achieved in ways which satisfy the practical demands of the classroom and which attribute to the learner some of the higher cognitive skills we know him to be capable of, but which make rather elusive experimental variables.

Method

Subjects

Twenty-four college-age female clerical employees from the Bell Telephone Laboratories served as Ss. A coin was flipped twice for each S to determine which of four experimental groups S would be assigned to. Two heads meant one group, a head and a tail meant another group, etc.

Materials

The ten planet names were paralogs of medium meaningfulness, familiarity, and emotionality (Runquist, 1966). The three attributes were selected for distinctiveness both between attributes and between the four values each attribute took on. The attribute values were assigned so that each planet was unique, and only differed from the target planet on one attribute. This distribution of attributes was chosen to minimize the discriminability of the planets, thus requiring that Ss read the passage carefully. Table 1 presents a complete description of the planets.

Insert Table 1 about here

The sentences describing each planet were formally the same across planets. Each sentence was eight words long, and the only words that varied between planets were those which identified that planet -- its name and distinctive attribute. The sentences describing the planets were then combined to make sentence lists or paragraphs which were organized according to the names or attributes. The following is the beginning of the first page of the sentence format organized by name (Group SN).

Forty light years away is the planet Capstan.
Mountains cover a vast area of Capstan's surface.
Orange sunsets and sunrises are seen on Capstan.

The first page of the sentence format organized by attribute (Group SA) began:

Forty light years away is the planet Capstan.
Twenty light years away is the planet Nimbus.
Sixty light years away is the planet Endive.

In the prose format the organization by name (Group PN) was:

> Forty light years away is the planet Capstan. Mountains cover a vast area of Capstan's surface. Orange sunsets and sunrises are seen on Capstan.

And finally, the prose format organized by attribute (Group PA) was:

Forty light years away is the planet Capstan. Twenty light years away is the planet Nimbus. Sixty light years away is the planet Endive.

For all groups the order of attribute presentation was, distance-terrain-atmospheric color. For Groups SN and PN these data were presented for the first planet, then the planet name was changed and the same order of attributes given for the next planet. For Groups SA and PA all planet names were given along with their distances from earth, then the attribute data was changed to terrain, and finally to atmospheric color. For Groups SN and PN the attribute data thus varied most rapidly, for SA and PA the names varied most rapidly.

The order of planet names presented to Groups SN and PN was maintained in presenting the distance data for Groups SA and PA. The target planet "Lichens" was placed last to insure that if Ss tested each name sequentially all groups would have to read every sentence in order to find the target name.

The passage was divided into three pages. For groups SN and PN the first four planets were given on page one, and the next two pages contained the data from three planets each. For Groups SA and PA the distance data was given on page one, terrain data on page two, and the last page contained the atmospheric colors.

Procedure

Subjects were run individually. Upon reporting, S was immediately ushered into a small room and seated at a table upon which an instruction sheet had been placed. There was a television camera mounted unobtrusively above and to the right of S which allowed E to remain outside the room during reading and testing, and yet be able to monitor performance continuously. The following are the instructions which S read.

"Recently a new solar system was discovered which has ten planets. We know the distance of these planets from earth, their terrain, and what colors their atmospheres take on during sunrise and sunset.

I will give you the astronomer's complete report on this solar system to read. As fast as possible, find the name of the planet which is twenty light years away, mountains cover a vast area of its surface, and orange sunsets and sunrises are seen on it.

When you are sure that you have found the correct planet, turn the report face down and shout 'Stop'. Then immediately tell me the name of the planet. After that, do not look back at the report until I tell you.

You may take notes and write anything down you wish to on the paper provided. Do not write on the report. You may keep these instructions to refer to during reading, if necessary.

- remember -

<u>As fast as possible</u> find the planet which is

twenty light years away

mountains cover a vast area of its surface

orange sunsets and sunrises are seen on it

If you have no questions, ask me for the report. If you have questions ask them now."

When ready to begin <u>S</u> asked for the reading materials. These consisted of the three pages of sentences, and a cover sheet which instructed <u>S</u> to say "Start" when turning the page to begin. At that time <u>E</u> began timing the session. The clock was stopped when <u>S</u> turned over the materials and said "Stop". If <u>S</u> had identified the wrong name <u>E</u> said, "Wrong. Continue.", and the clock was again started. Only two <u>S</u>s (one from the name and one from the attribute groups) made such a mistake.

Immediately after the reading task <u>E</u> removed the reading materials and any notes that <u>S</u> had made, and handed out the test booklet. On separate pages <u>S</u> was required to list the names of the planets, and the attributes which had been mentioned in the text. The <u>S</u> was not permitted to turn back after completing a page. There was also a recognition test which required that <u>S</u> circle the names of the planets recognized from a list of 20 (the distractors were drawn from the same list of experimental paralogs as the planet names).

Finally, S had to indicate how interesting the task was and how interesting the task would have been if the goal had been to learn the names of the planets from the same passage. Subjects had to circle one of seven alternatives from "very boring" through "neutral" to "very interesting". Numbers from 1-7 were assigned to these responses.

After the experiment, S was given a complete description of the purpose of the study, and was cautioned not to discuss the experiment with anyone. The entire session took about 15 minutes.

Design

A 2x2 factorial design was used with six Ss in each cell. The factors were organization (name - attribute) and format (sentence - paragraph).

Results

Table 2 summarizes the results on the retention and time measures. Recognition test scores are given for the names because of heterogeneous variances on the recall measure (the Mann-Whitney non-parametric test comparing Groups SN-PN with SA-PA on recall of names yielded $U = 21$; $.001 < p < .01$).

Insert Table 2 about here

Groups SN and PN had significantly lower means than Groups SA and PA on the recognition of names ($F = 13.6$, $df = 1/20$, $p < .005$), but they scored higher on recall of the attributes ($F = 13.5$, $df = 1/20$, $p < .005$).

The prose format did not influence any retention measure, nor did it interact with the organization of the material. Combining the names and attributes recalled yielded a non-significant F, i.e., Ss in the various groups did not differ in amount learned. They learned different things.

There were no significant differences between any of the conditions in terms of time taken to complete the task, nor were there any differences in attitude toward the task. Subjects' estimate of how interesting the task would have been if they had been asked to learn the names of the planets was significantly lower ($\overline{X} = 4.29$) than their ratings of the present task ($\overline{X} = 5.29$); $t = 3.12$, $df = 23$, $p < .01$.

A number of unobtrusive measures were also recorded. None of the Ss skipped to the end of the passage in Groups SN and PN, finding the target name exposed as the last planet to be given. This is an important consideration because it indicates that every S "read" each page.

Subjects in the SA and PA groups relied heavily upon paper and pencil to reduce the memory strain of their task. Ten of these Ss took notes, while only two of the SN and PN Ss did ($p < .005$ using Fisher's exact probability test). The SA and PA groups, in general, listed the names of the planets then systematically checked off the names each time one of the attributes matched the target planet's attribute.

All Ss in Groups SN and PN voiced objections when they encountered the recall test. This was surprising, especially since E had usually left the room and could only hear the noises issuing from within. All the Ss in Groups SA and PA, however, accepted the task without comment. The SN and PN Ss volunteered the information (before E asked) that they hadn't bothered to look at the names. Most Ss, it would seem, were aware of the strategies they had employed.

Discussion

The present study reveals something about the organization of passages and also about the processes involved in adjusting to different organizations.

The grouping of related information has important consequences for the behaviors which the reader performs. In the present study, changing the organization of the material resulted in learning different words. These learning differences did not result from the immediate discriminative properties of the passage. Grouping the passage by attributes places the different names together (which should increase the distinctiveness of the names), but such grouping also places the different values of a particular attribute together. The important consequence of changing the organization is that different verbal units must be entered into storage in order to perform the criterion tests required by the objective. Hence, the activities

of Ss must be viewed, not only in terms of the organization of the material, but also in terms of the objectives which govern and integrate higher level skills.

One of these skills, note-taking, involves the generation of surrogate storage and hence the construction or composition of important verbal stimuli. The attribute organization of the materials succeeded in getting most SA and PA Ss to write out the names of planets. In this respect, specific written responses were under the control of the general organizational pattern of the passage. It would have been possible to increase the differences between the groups in the present study merely by prohibiting note-taking. These differences would probably be reflected in both retention and time scores.

The large variability in scores worked against finding time differences, but the means in Table 2 suggest that such an effect might be found. The Ss in this study were rather heterogeneous; some had attended college and some were relatively recent high-school graduates. The population to which these results can be generalized is probably broader than one would obtain, for instance, with a particular class of psychology students. Preliminary trials of the present material with a more homogeneous sample (Ph.D.'s and graduate students) yielded much more pronounced effects of the organization factor. The fact that each group (SN-PN vs. SA-PA) scored

higher on one set of stimuli and did not differ in total number of words retained suggests that the random assignment did not result in any bias in favor of one group.

The data of Table 2 also suggest that, in the long run, there may be a slight retention advantage for the paragraph structure. The fact that such a difference was not found in the present study indicates that the magnitude of retrieval difficulty introduced by the ordinary paragraph format is not large, and that Ss lack of attention to certain stimuli does not depend critically upon the physical distinctiveness of the sentences.

The focus of the present study has been upon memory, however, it should be possible to achieve control over other important learning skills. In this study, E's strategy was to interpose a barrier between S and the attainment of a goal by reorganizing the material, thereby forcing S to use his memory. If Ss had been asked to find the name of the farthest planet, however, Ss would also have been forced to make direct comparisons between attributes. This would most likely have benefited the SA and PA groups most. Similar effects might be achieved with carefully worded questions or instructions. These events, just as the instructions given to Ss in the present study, would not have direct instructive effects, but they would set a goal which Ss could only attain by manipulating the content in specific ways.

This paper has viewed the reading of an organized passage as involving several factors, including goals or objectives, Ss' skill repertoire, and the nature of the verbal material. These elements interact in a complex manner to produce various response outcomes, such as the use of appropriate strategies which Ss seem to be able to verbalize, retention of different words, and written response production.

The experimental results shed light upon the importance of goal related criteria for the selection and storage of verbal stimuli which modify further reading in precise ways. In this respect, reading is seen as adaptive symbolic behavior which channels information according to an organized series of plans (Miller, Galanter, & Pribram, 1960). By changing the organization of the stimulus material it is possible to modify critical events involved in the feedback control of reading behaviors and thus to manipulate differences in learning outcomes.

Subjects in the present study clearly demonstrated some of the adaptive reading behaviors required by the cybernetic model described.

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TABLE 1

Summary of Distinctive Characteristics
of the Planets

Name	Distance	Terrain	Atmosphere
Lichens[a]	twenty	mountains	orange
Percept	twenty	mountains	yellow
Vertex	twenty	mountains	blue
Tartan	twenty	mountains	red
Nimbus	twenty	craters	orange
Rostrum	twenty	lakes	orange
Lemur	twenty	deserts	orange
Capstan	forty	mountains	orange
Endive	sixty	mountains	orange
Jetsam	eighty	mountains	orange

[a] Note.- This was the target name.

TABLE 2

Means and Standard Deviations of Major Dependent Variables

Organization	Names[a]		Attributes[b]		Time in Sec.	
	M	SD	M	SD	M	SD
SN	3.83	1.68	9.50	1.50	75.67	53.87
PN	4.67	1.70	9.17	2.12	93.17	79.79
SA	6.83	2.27	5.67	2.13	103.50	64.98
PA	7.83	1.77	6.83	1.68	119.17	53.02

Note.- N = 6 for each group.

[a]Recognition test scores.

[b]Recall test scores.

FIGURE CAPTIONS

Fig. 1. Directed reading as a problem solving process.

Fig. 2. System model for the present experiment.

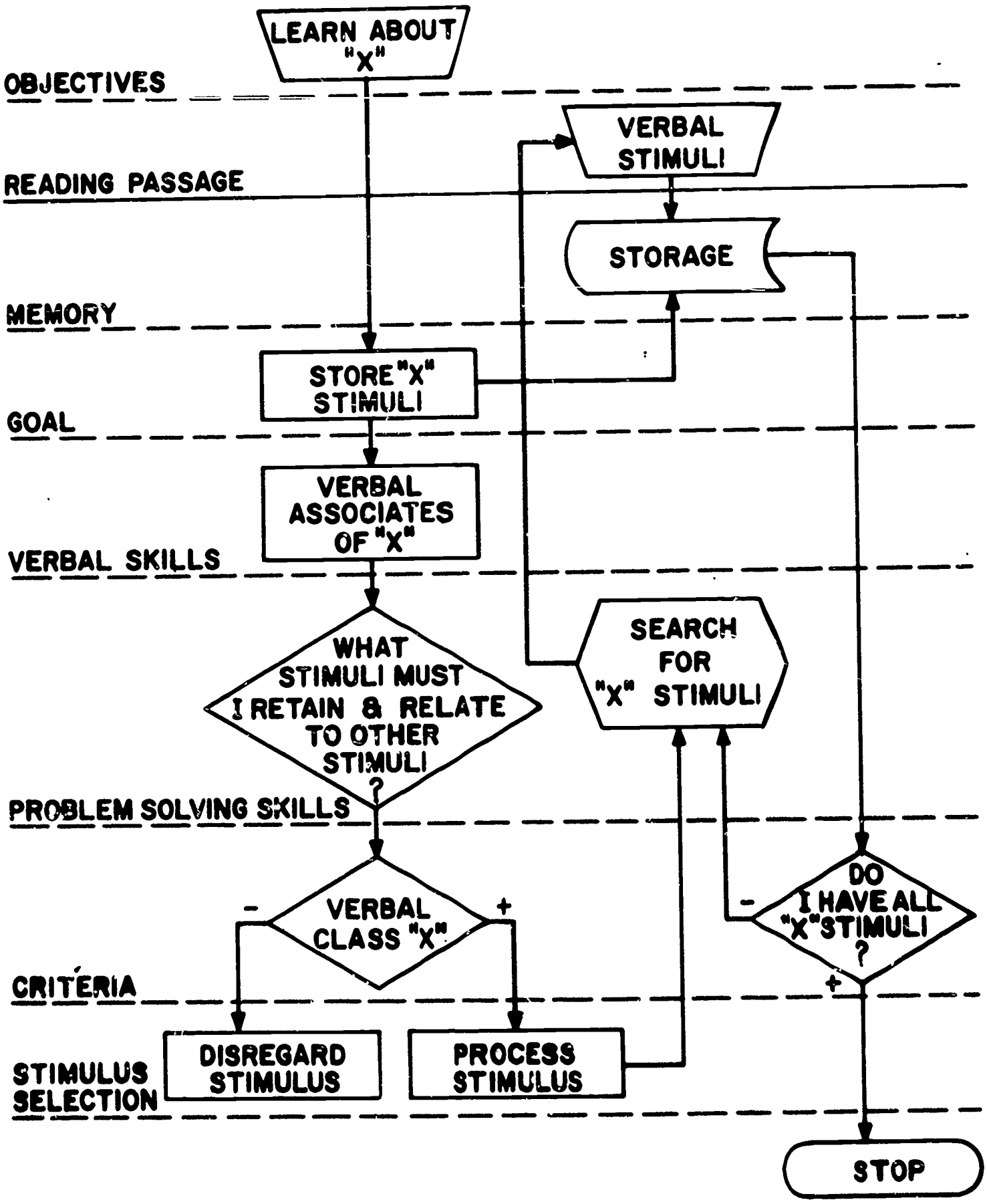
LEARN ABOUT "X"
OBJECTIVES
VERBAL STIMULI
READING PASSAGE
STORAGE
MEMORY
STORE "X" STIMULI
GOAL
VERBAL ASSOCIATES OF "X"
VERBAL SKILLS
WHAT STIMULI MUST I RETAIN & RELATE TO OTHER STIMULI ?
SEARCH FOR "X" STIMULI
PROBLEM SOLVING SKILLS
VERBAL CLASS "X"
-
+
DO I HAVE ALL "X" STIMULI ?
-
+
CRITERIA
DISREGARD STIMULUS
PROCESS STIMULUS
STIMULUS SELECTION
STOP

FIG. 1

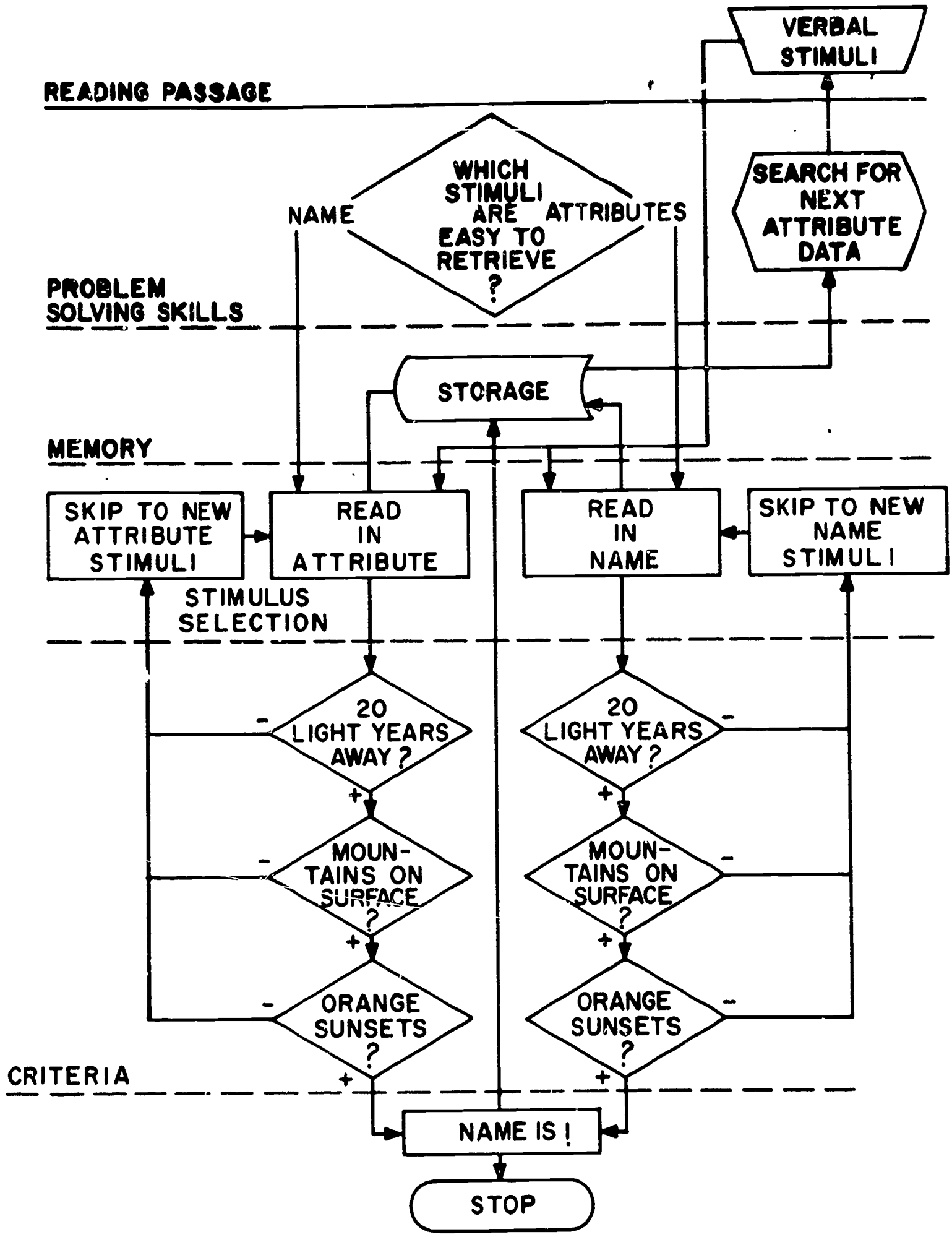
READING PASSAGE
VERBAL STIMULI
WHICH STIMULI ARE EASY TO RETRIEVE ?
NAME
ATTRIBUTES
SEARCH FOR NEXT ATTRIBUTE DATA
PROBLEM SOLVING SKILLS
STORAGE
MEMORY
SKIP TO NEW ATTRIBUTE STIMULI
READ IN ATTRIBUTE
READ IN NAME
SKIP TO NEW NAME STIMULI
STIMULUS SELECTION
20 LIGHT YEARS AWAY ?
MOUN-TAINS ON SURFACE ?
ORANGE SUNSETS ?
CRITERIA
NAME IS !
STOP

FIG. 2