A STIMULUS--DRIVEN MODEL OF CONCEPT IDENTIFICATION

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ABSTRACT

The discrete events assumed to occur in problem solving behavior (where an unpracticed person is trying to identify the rule being used in the binary classification of objects) have been modeled using SNOBOL4. The main assumption of this cognitive simulation is that attention given to unexpected characteristics of succeeding objects drive the behavior of the S (subject). Specifically, the simulated Ss with smaller short-term memories indicated a strong recency effect: rules represented by values occurring in the last positions in the instance were significantly easier to identify. For the largest memory size used, a significant primacy effect was seen.

I. CONCEPT IDENTIFICATION

The nature of the CI (concept identification) task is quite basic. An S is presented with an object or a description of an object and is told to classify it as either an example or non-example of some unknown concept. After his attempt, he is told if he is correct. By using this feedback after each presentation of another object or instance, he tries to solve the problem of identifying the unknown concept.

This CI task is quite versatile as a wide range of concepts can be used. A simple concept might involve the presence of a single value (e.g. red) or a complex one might entail the joint presence and/or absence of several characteristics (e.g. the preflight profile of a "skyjacker": carry-on luggage, no advance reservations, no credit card).

Unfortunately most CI investigations come nowhere near real-world problem solving. Most CI experiments involve elaborate instructions and practice problems. The S is no longer naive to the task. His problem space has been carefully specified. Real-world problems seldom come so neatly defined.

CI simulations have had some success matching behavior once the S has become practiced and stable (3,4), but no attempt has been made to simulate an S as he gets to this practiced stable state. Initial behavior is likely to be less logical and more stimulus-driven than later cognitive processing. Hence a model which considers the attention aspects of cognitive processing would be appropriate. In Falmagne's terms, it would be less isolated from the "chaos" of the real world (1).

II. A STIMULUS-DRIVEN MODEL

The following is a description of such a model--designed to identify concepts which are single values. In this model an STM (short-term memory) work area perceives values from presented instances. Specifically, STM is assumed to contain several different things including one place keeper, one rule designator (i.e. a process) and a variable number of values (depending on the setting of the STM.CAPACITY parameter and on whether the rule designator is present or not). Unexpected values--which are added to STM--are those from the current instance which are not already in STM. Addition of each new value bumps out the oldest value when STM.CAPACITY is reached. At no time are any logical or "focusing" processes assumed to occur. The value selected to become the rule is the value which has been most recently added to STM.

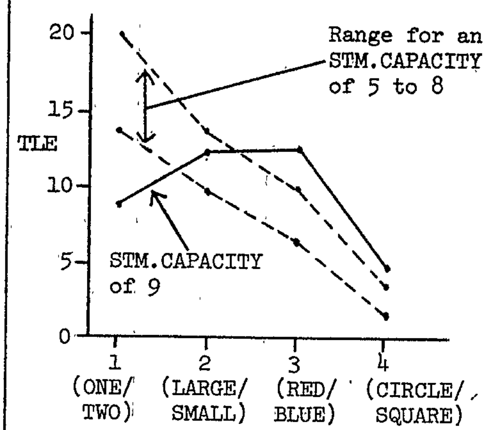
The simulation runs with this model using objects which were described on four two-valued dimensions (e.g. ONE LARGE RED SQUARE, TWO SMALL RED SQUARES, ONE LARGE BLUE CIRCLE, etc.) had as a result the generation of two unexpected predictions--which likely would have been missed from just a verbal description of the model. The main prediction is the occurrence of a strong recency effect in the processing of values from an instance. Those values at the end of the instance (CIRCLE or SQUARE) stand the best chance of being considered as rules, and hence problems using these rules are solved more quickly (as indicated by the trial of the last error (TLE)). Though it might have been supposed from the storage and retrieval procedures used with STM (last in/first out) that this prediction is obvious, it should not be forgotten that a new object will only be added at the beginning of STM if it is not already there.

The second prediction of the model is a primacy effect with memory size (i.e. STM.CAPACITY) increased to 9, the limit of the 7 ± 2 range over which it is commonly assumed to vary. Concepts represented by values in the first position (ONE or TWO) are found to be significantly easier than those in the second and third positions (but still not as easy as fourth position ones). Illustration 1 shows the nature of these two predictions. Tests for the difference between TLE means using Duncan's procedure showed not only the reality of the primacy effect, but also that the means for different rule positions for the other settings of STM.CAPACITY differed significantly from one another ($p < 0.05$).

A further increase in STM.CAPACITY would have rendered the model inoperable as no solutions would be reached because all eight values, the place keeper, and the rule designator could have been in memory simultaneously (and changes would never be made by new instances). Hence there is a need for runs using 4 3-valued dimensions (or the like) where the number of possible rules is increased from 8 to 12.

ILLUSTRATION 1

TLE as a Function of Rule Position



III. MODEL VERIFICATION

PAST WORK

Investigation of the literature indicated little work on the ease or difficulty with which CI rules with different values are solved. This was not unexpected because of the practiced nature of the Ss used in these experiments. Most Ss had learned to reason logically and process each value individually--irrespective of the attention-generating qualities of its position. Even the work of Trabasso and Bower (5), where they specifically considered attention, indicates only that experimentally predetermined value saliency can affect the selection of tentative rules.

Some support comes from Heidbreder's pioneer work on saliency (2). She notes that concrete concepts are easier to identify than abstract ones. The present model provides an alternate explanation of this finding. In that an object is usually described with the concrete name coming last (ONE LARGE RED SQUARE), it may be that recency is really the cause for an easier solution here.

Further support for this model comes from a common phenomenon in verbal learning: the serial position effect (6). Simply stated this effect says that initial and terminal list members are easier to learn than middle ones. Clearly that is seen in these simulations when STM.CAPACITY is set to 9. The rules represented by values in the first (as well as the last) positions become significantly easier than second and third position rules.

EXPERIMENTATION

Experiments are needed to investigate the validity of this model. One possibility would be a CI task using descriptions written in a Romance language where the adjective/noun order is reversed (e.g. in Spanish ONE LARGE RED SQUARE would be UNO CUADRO GRANDE Y ROJO). Here rules whose values were colors would be predicted to be easier.

A more extensive experimental program would consider the model's ability to predict in a variety of different CI paradigms involving the rule "presence of one value"--particularly in those situations where large memory size predicts both a primacy and a recency effect. Results from experiments using 5 2-valued dimensions, 6 2-valued dimensions, 4 3-valued dimensions, etc. can all be predicted as well as the 4 2-valued dimensions which have been simulated here.

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