An electronic aid for presenting equivalent information in concept identification

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An electronic aid to assist in administering concept-identification problems with floating solutions is described. Digital circuitry generates all combination pairs from four selection switches, presents a particular comparison of these pairs, and, on command of the E, eliminates selected pairs from future comparisons. Each comparison is designed to minimize the information fed back to the S. The apparatus is used to administer and evaluate performance on conjunctive and disjunctive problems that are matched for information gain.

A special-purpose computer was designed to assist in administering conjunctive and disjunctive problems in concept identification when Ss select examples and the concept is not fixed. In problems of this kind, the task of the S is to identify the relevant attributes that define the concept. Positive examples include the attributes that define the concept; negative examples do not. Ss select examples, and each is designated positive or negative by the E. The problem solver continues to select examples until he extracts sufficient information to identify the concept.

When Ss select examples, it is often desirable to avoid fortuitous selections and to provide equal amounts of information for logically equivalent selections. Problems with no fixed solution fulfill these requirements. Solutions depend upon the examples a S selects and the type of problem.

When the solution is permitted to float, it is necessary for the E to know how many concepts are viable prior to each selection, how many viable concepts would be eliminated if a particular selection were designated an example of the concept (positive example), and how many would be eliminated if that same selection were designated not an example of the concept (negative example). With this knowledge, the E can minimize or maximize information gain for each selection by choosing the appropriate designation. The number of possible concepts in these problems depends upon the number of dimensions, the number of attributes (states) in each dimension, and the number of relevant dimensions. This instrument was designed for problems with four binary dimensions, two of which are relevant. The instrument serves three functions: (1) storage, (2) comparator, and (3) updating of storage.

The storage function consists initially of the 24 pairs of attributes possible with four binary dimensions. Each of the 24 pairs represents a concept that could be the correct solution in the conjunctive and disjunctive problems used by Arenberg (1969, in press). A flip-flop is associated with each possible concept. The storage maintains an inventory of the viable concepts (flip-flops still on) prior to selection (Fig. 1). (The sequence of selections is currently recorded by the E and is not stored by the instrument.) All 24 flip-flops are set (on) at the beginning of each problem.

The comparator function divides all viable concepts into two subsets: those concepts that would be eliminated if a particular selection were designated as a positive example and those that would be eliminated if that selection were designated as a negative example. Previously eliminated concepts are not considered by the comparator; only concepts in current storage, i.e., those that are consistent with all information available to the S, enter into this division. Two analog adders summate these two subsets. A meter compares the two sums and indicates the amount and direction of their difference. The meter indicates to the E which feedback (designation of positive or negative) will minimize gain in information available to the S as a result of that particular selection.

Storage is updated by resetting flip-flops for all concepts (pairs of attributes) eliminated by a particular example. The E updates storage by activating the appropriate switch (positive or negative) to eliminate one of the two subsets of concepts. Current storage consists of all concepts still viable after those eliminated by all previous examples have been withdrawn from the initial 24.

The display panel of the instrument includes the meter, a labeled light indicating the state of the flip-flop for each of the 24 possible concepts, four selection switches, A, B, C, and D, and control switches. A selection is represented by a combination of positions of the four selection switches, A, B, C, and D. Two of the control switches modify storage; one is for selections designated positive, the other for negative. Control switches reset flip-flops of all concepts eliminated by the particular setting of the A, B, C, and D switches and whether that selection was designated positive or negative; and the appropriate lights also go off. Two switches select the type of problem; one is conjunctive, the other disjunctive. Also, there is an on-off switch and a switch that sets all flip-flops to begin a new problem. The entire display is for the E and is not seen by the S.

The functions performed within the instrument depend on the type of problem. The types of problems for which this instrument can be used are described more fully by Arenberg (1969, in press). Briefly, the conjunctive problems require the S to identify the two specific attributes (among the eight attributes in four binary dimensions) that, when present together (conjunction), make an example positive. There are 24 possible concepts and the S's task is to eliminate all but one with as few selections as he can. The disjunctive problems require the S to identify the two specific attributes that alone or together (inclusive disjunction) make an example positive. The same 24 concepts possible in

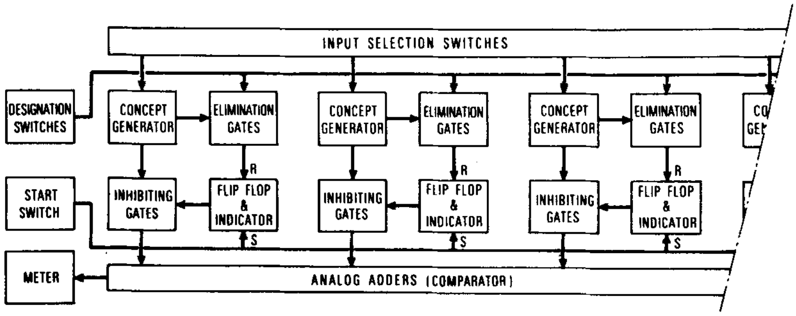

Fig. 1. Block diagram. Three of the 24 circuits are shown.

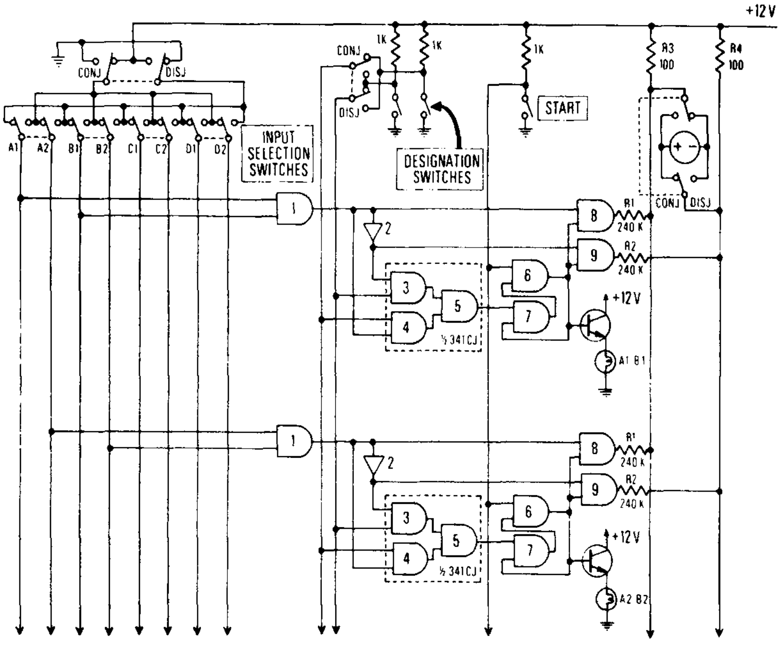

Fig. 2. Schematic diagram. Inputs of Gate 1 are connected to create all of the 24 possible concepts.

1. 22 ADDITIONAL CIRCUITS IDENTICAL TO THOSE SHOWN EXCEPT FOR INPUT CONNECTIONS.
2. ALL GATES AND INVERTERS ARE ¼ 321CJ AMELCO UNLESS SPECIFIED.
3. ALL TRANSISTORS ARE 2N1304 OR EQUIVALENT.
4. METER IS WESTON MODEL PMS 1209, 50-0-50 μa.
5. ALL LAMPS ARE G.E. 344 OR EQUIVALENT.

the conjunctive problems are also possible in the disjunctive problems. Conjunctive and disjunctive problems can be logically matched in terms of formal information properties. Relative effectiveness in identifying matched concepts under a variety of experimental conditions is a set of empirical questions investigated in Arenberg's problem-solving research.

A conjunctive problem requires that the solutions be the results of "ANDing" pairs of attributes in the selection while "ORing" generates solutions in the disjunctive problem. De Morgan's theorem allows the same hardware to be used for both problems by merely switching from positive to negative logic,[2] i.e., designating a positive signal as on or true for the conjunctive function and as off or false for the disjunctive function. Therefore, only the conjunctive operation is described below.

The 24 possible concepts are generated by NAND gates (Fig. 2, Gate 1) wired directly to the selection switches. Following each gate is circuitry concerned only with a particular concept; therefore, 24 identical circuits make up a substantial part of the instrument (Fig. 1).[3] In a conjunctive problem, a negative (off) output at a concept-generating gate assigns that concept to the subset that will be eliminated if the selection is designated negative; a positive output at a gate assigns that concept to the subset that will be eliminated if that selection is designated positive.

The analog adders (Fig. 2, R_1-R_4) accept only negative inputs; therefore, the outputs of the concept-generating gates are fed directly to one adder but inverted (Fig. 2, Gate 2) before they are fed to the other. The flip-flop (Fig. 2, Gates 6 and 7) associated with each possible concept disallows (Fig. 2, Gates 8 and 9) the contribution of a previously eliminated concept to either adder. A gating configuration (Fig. 2, Gates 3, 4, and 5) resets a concept's flip-flop whenever that concept is eliminated by a particular selection. The 24 panel lights indicate the state of the 24 flip-flops; lights that are on represent concepts currently viable at any point during the problem. The cost of parts for this instrument was approximately $300. A photograph of the printed circuit board is shown in Fig. 3. The majority of the circuitry is made up of 12 of these boards.

For a disjunctive problem the polarity of the power to the selection switches, the meter inputs, and the function of the negative and positive switches are reversed (Fig. 2).

In summary, simple digital and analog elements were assembled to assist in administering concept-identification problems with no fixed solutions. The instrument: (1) indicates which concepts are viable at any time during a problem, (2) indicates which designation of a selection would minimize gain in available information, and (3) modifies the storage appropriately for each selection. The instrument can also be used in scoring to determine the maximum number of possible concepts that could be eliminated prior to each selection and the number actually eliminated by a particular selection. In this way, throughout the scoring of the problem, each selection can be compared with an optimal selection.

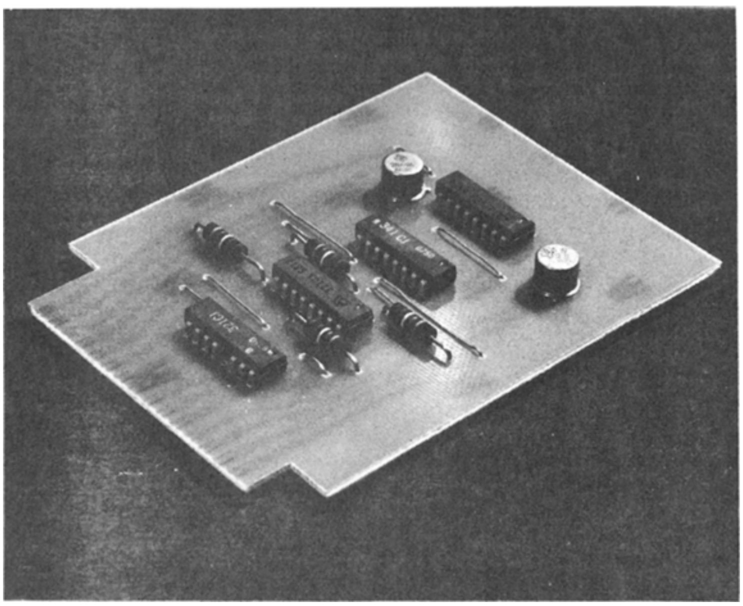

Fig. 3. Photograph of printed circuit board. Twelve of these boards (all identical) make up the majority of the circuitry.

REFERENCES

ARENBERG, D. Concept identification and age. Proceedings of the 8th International Congress of Gerontology. Vol. 2, Washington, 1969. P. 59. (Abstract)

ARENBERG, D. Equivalence of information in concept identification. Psychological Bulletin, in press.

NOTES

1. Reprint requests should be sent to Phillip R. Thorne, Gerontology Research Center, Baltimore City Hospitals, Baltimore, Maryland 2124.

2. De Morgan's theorem can be expressed as $\overline{A} + \overline{B} = \overline{AB}$. Hence, a NAND gate will yield an AND function if followed by an inverter or an OR function if preceded by inverters. This is accomplished by reversing the polarity of power applied to the selection switches.

3. These circuits were constructed on 12 (2 to a card) single-sided 3¼ x 4¼ in. printed circuit cards. A negative is available from the authors. (See Fig. 3.)

4. Art and photographic contributions of Rowland Schnick are gratefully acknowledged.

A simple and inexpensive method to measure urinary excretion in nonhuman primates

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A simple and inexpensive automated method is described for simultaneous recording of time of day and frequency of urinary excretion. A 24-h event record for eight rhesus monkeys illustrates possible usefulness of the method in determining individual differences, response to environmental factors, and diurnal patterns.

While time, frequency, and amount of urinary excretion have been used in studies of water balance, circadian rhythms, and conditioning, few researchers have devised automated ways of obtaining the data. Most frequently, the amount of urine is recorded either in 24-h samples or within smaller periods of time (Dykman et al, 1962; Hoshizaki et al, 1969; Rohles & Osbaldiston, 1969). Recently, Nicholson and Warwick (1969) used circuits employing either temperature- or light-sensitive transistors to measure the time at which urination occurred. They could record the "amount" of urine if a drop tube and counter were also used. Another method to automatically record amount and time of urine flow used an aneroid manometer in a water-filled system (Feldmahn et al, 1960). This method is expensive and space consuming.

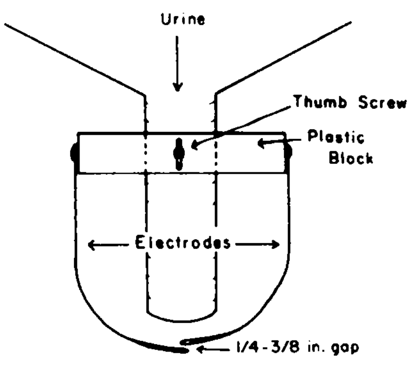

Fig. 1. Electrode placement on urine drain spout.

The apparatus to be reported here records the time of day and frequency of urination and can be adapted to record "volume" by adding a drop tube and counter similar to that used by Nicholson and Warwick. The basic apparatus consists of two electrodes affixed to the drain spout of the urine collection pan and a current-sensitive relay circuit. The output of the relay can be connected to any event recorder. Eight of these units are currently being used simultaneously to measure the urination patterns of eight rhesus monkeys. The unit cost for electrodes and relay circuit is under $6.

The electrode assembly and method of mount is shown in Fig. 1. The electrodes are constructed from 30-ga stainless steel sheets cut into ½ x 3 in. pieces. These are attached to a Plexiglas block of sufficient width to prevent a short between the spout and electrodes and are of sufficient length so that they can extend below the spout before being bent inward. One electrode is bent so that it is slightly higher and extends inward over the other so that the vertical fall of the urine will not miss the electrodes. A gap of approximately 1/4 to 3/8 in. is set between the tips of the electrodes so that occasional drops of urine that may lodge and be delayed on a feces separation screen do not record as urination. The electrodes are cleaned every 2 to 3 weeks to prevent an increase in electrode resistance from corrosion. They are inspected twice daily on the cages to remove animal hair that may collect on the electrodes and cause a temporary short.

The current-sensitive relay circuit (Fig. 2) is a modification of those commonly used to measure contact (see, e.g., Jarvik & Carley, 1964). The transistor, 2N1415, is used to drive the Type 11F-550 Ohm Sigma relay. In addition, a 100K resistor is added to provide transistor turn-off current and a 1-meg potentiometer is used to vary the bias turn on current. The potentiometer is adjusted by setting it at maximum resistance, applying a direct short across the electrodes, and then decreasing the resistance until the relay pulls in. The potentiometer is then adjusted slightly, with the short removed, to make consistent relay closures when urine is poured into the pan.

A 24-h record for eight rhesus monkeys (Fig. 3) illustrates the patterns and frequency of urination as recorded on an Esterline Angus event recorder. Each group of eight lines reads from right to left for time of day and includes a 4-h period. The lower line in each set represents Animal 1 and the top line is Animal 8. The top eight lines begin at midnight (M) and end at 4 a.m. The next set begins at 4 a.m. and ends at 8 a.m. This is the pattern for each set. One pattern of malfunction that occurs is seen from noon (N) until 4 p.m. for Animal 3. It appears that urination lasts for several minutes during each of several times followed by repeated voidings every few minutes. This pattern occurs when one or two hairs effectively decrease the electrode distance so that the last drops of urine after urination travel down the hairs and make a sufficient short for the contact sensor to operate.

While the first author is interested in a detailed analysis of urinary excretion over long periods of time and in comparing

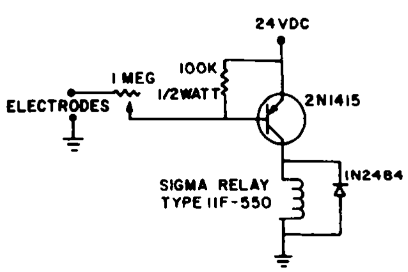

Fig. 2. Schematic diagram of current-sensitive relay circuit.