

Table 2. Confirmations and disconfirmations of rules for move and episode generation. The units counted here are again episodes. However, since we are presenting data for the five rules for move and episode generation combined there will in many cases be more than one confirmation or disconfirmation per episode. Hence, the total instances recorded here for Newell and Simon's subject (34) exceeds the total recorded in the previous table (25).

	Positions					
	Middle	End	Real game	End	Middle	Reverse
<i>Newell and Simon subject</i>						
Primary confirmations	28					
Secondary confirmations*	1					
Disconfirmations	5					
<i>Scurrah and Wagner subject</i>						
Primary confirmations	85	20	15	37	21	11
Secondary confirmations*	5	1	0	1	1	0
Disconfirmations	1	0	3	5	2	0

*These represent those cases in which the second-to-last move, rather than the last one, was replaced (see rule 2 for move and episode generation).

all plausible line moves have been considered, the new move generated will be a new base move.

4) If the evaluation is positive and the subject has made an early tentative decision on the best or most favored base move, he may switch to a new base move.

5) If the evaluation is positive and all plausible line moves have been considered, the present base move will be chosen by the subject.

Rule 2 is disconfirmed if a generated new move replaces neither the last nor the second-to-last move. In rules 3 and 5 all plausible line moves have been considered when the subject makes some statement which indicates exhaustion of plausible line moves as he sees them. Again, in rule 4 a judgment that the subject has made an early tentative decision on the best or most favored move is made on the basis of some statement of his to that effect.

As Table 2 shows, these rules have a larger number of applications in the protocols of both subjects, and, while the percentage of confirmations declines slightly from 90 to 85 for the Newell and Simon subject, it rises sharply from 57 to 95 for our subject when we compare Newell and Simon's rule 3 with our four more detailed rules.

If one combines Newell and Simon's rules 1 and 2 with our move and episode generation rules and if one assumes that a system of situation-response moves along the lines of the 19 rules suggested by Newell and Simon in their Table II brings the subject along his tree of exploration to the point where he evaluates the base move he is considering, a flow chart of the move and episode generation process can be drawn up (see Fig. 1). This seems to

be a fairly close representation of part of the decision process of these two subjects. The "black box," which needs further analysis, is the system of situation-response moves which brings the subject from his initial choice of a base move to be analyzed through a series of hypothetical responses by himself and his opponent to the point in the exploration tree where he considers an evaluation is in order. We suspect that the responses are made to situational clues that trigger countermoves that are stored in the memory on the basis

Denver Earthquakes

The recent exchange between Karp and Simon (1) prompts us to comment on the results of short-period seismograph observations at the University of Colorado at Boulder, some 40 km west-northwest of the Rocky Mountain Arsenal well. This station was operated from April 1954 to November 1959; it was reactivated in November 1965 and has been kept in operation to the present. The instruments used since May 1966 are the same as those that were in operation during the 1950's.

Observations made since 1965 show that events at Derby of magnitude 1.5 on Major and Simon's listings (2) can often be detected at Boulder but would not be distinguished from background noise in the absence of these listings. Events of magnitude 1.8 usually stand out well from the background noise, and events of magnitude 2.0 or greater give clear and distinctive traces. A systematic search through records from the earlier period of observation has failed to reveal a single event showing the characteristics of modern Derby earth-

of previous chess games or reading of chess literature. Thus, for example, the situational clue, "man attacked," might call forth the response, "counter-attack of equal value." The addition of rules for these two parts of the decision-making process in chess—the initial choice of a base move and the system of moves to the evaluation point—are a logical next step in research and would result in a complete cognitive model of the chess decision process.

While the cognitive model proposed is not a complete one, it does seem to explain significant proportions of the decision process and may well indicate heuristics that could be used in writing computer programs for chess play.

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References and Notes

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2. R. Fine, *The Middle Game in Chess* (McKay, New York, 1952), p. 439; A. D. De Groot, *Thought and Choice in Chess* (Mouton, The Hague, 1965), positions A, B, and PB-6.
3. M. J. Scurrah and D. A. Wagner in preparation.

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quakes. Events thought by Krivoy and Lane (3) possibly to be Derby earthquakes have been definitely identified as artificial explosions.

The average frequency of Derby earthquakes of magnitude greater than 2.0 was about four per month between 1962 and 1968. Hence, we conclude that earthquake activity at the Arsenal during the 1950's, if there was any, must have been nearly two orders of magnitude less than during, and immediately after, the pumping of the disposal well.

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