CURRENT RESEARCH ON CHOICE BEHAVIOUR AT THE UNIVERSITY OF AUCKLAND

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A review of recent work in operant psychology in the University of Auckland.

I first developed a strong interest in the study of operant choice behaviour while doing my doctoral research at Otago University in 1967. In the course of teaching ourselves about the area known as the experimental analysis of behaviour, Dr Ray Over (my supervisor) and I came across two papers by Herrnstein (1964 a, b) which apparently showed that when pigeons chose between two stimuli which were associated with different reinforcement rates, the choice behaviour was directly controlled by the number of reinforcements per hour provided in each stimulus. The experiments used the concurrent chain procedure. Briefly, the animal commences the experiment with two white response keys which are generally associated with two independent variable-interval schedules. This part of the procedure is known as the 'initial links'. Pecks to the two keys in the white initial links are occasionally followed, according to the variable-interval schedules, by the pecked key changing colour. The left key may, for example, go green and provide the animal with another schedule under which pecks are occasionally followed by food reinforcement. While this key is green, the other key is blacked out and inoperative. After one or more food reinforcements in green, the schedules revert to the two white initial link keys. Parallel events occur on the second key, which may go red when pecked, and be associated with a different schedule of food reinforcement. The red and green conditions are known as the terminal links. Herrnstein showed that the ratio of responses emitted to the two white keys equalled the ratio of the reinforcement rates obtained in the green and red terminal links, at least when the terminal link schedules were variable-interval schedules.

Dr Over and I, still bearing the mark of Hull and various philosophers of science, determined to disprove this finding. By programming two food reinforcements to occur in a time of two minutes in each terminal link, but varying the time of the first food presentation after the start of the terminal links, we showed that the immediacy of the first food presentation controlled preference as measured by the initial link performance. While these data were not at all counter-intuitive, it proved impossible to account for them with any simple mathematical model. As a result, the paper (Davison, 1968) was turned down by the most illustrious operant behaviour journal, but with great exhortations to carry on the work. This reinforcement was sufficient to maintain my behaviour for the next year while I carried out another experiment, this time on the choice between a fixed-interval terminal link *versus* a mixed-interval (two randomised fixed-intervals with no correlated stimuli) terminal link. The analysis of this was easy. Killeen (1968) had just published a paper on the choice between fixed-interval and variable-interval schedules. His data

revealed that preference in that situation was not controlled by the simple number of reinforcements per hour on each terminal link key. The average interval to reinforcement in the variable-interval terminal link was effectively not the arithmetic mean interval, but the harmonic mean interval (which is of smaller value than the arithmetic mean). In other words, like our original study, small intervals to reinforcement were weighted more heavily in the choice than long intervals. Stated quantitatively, the ratio of responses in the initial links equalled the ratio of the moments of the terminal link intervals with a power of -1. (The moment is the mean of the scheduled intervals raised to some power). Analysed in the same way, my data showed that choice between fixed-interval and mixed-interval schedules could be explained by the generalised moment equation, but with a power of -3, showing an even stronger weighting of small intervals to reinforcement (Davison, 1969).

Why this rather marked difference between Killeen's and my result? I believed that the number of intervals in the mixed or variable-interval schedules might be the answer. A mixed-interval schedule has two intervals, Killeen's variable-interval schedule has 10 or 12. But a paper now in press (Davison, 1972), in which this variable was expressly manipulated, shows this is not the case.

Another reason for the difference is suggested by some research reported by Duncan and Fantino (1970). They studied choice between two fixed-interval schedules, and reported that there was a curvilinear relation between the value of the exponent in the generalised moment equation and the shortest programmed interval to reinforcement in the terminal link. The exponent becomes larger, weighting smaller intervals more heavily, when the shortest interval becomes greater in absolute value. The difference between my original results and Killeen's results can very roughly be accounted for by the value of the shortest interval—Killeen used two or three seconds, I had used 15 seconds.

One major difficulty about Duncan and Fantino's results was that they used a number of experimental conditions which controlled very strong preference for one terminal link. In the concurrent chain procedure, if preference is excessive, animals come to enter one terminal link more often than the other. When this does occur, a positive feedback develops. The animal is now not only chosing between two different terminal links, but also between two different probabilities of being exposed to the two terminal links. Such unequal entries increase the already strong preference, and thus again increase the imbalance in entries. We carried out an experiment in which we investigated choice between fixed-interval schedules, but used schedule values which were designed to produce only mild preference, and hence equal entries into the terminal links. From this, we found a simple straight-line relation between the value of the exponent and the value of the smallest interval to reinforcement. However, this was only half the story: as a check, we held the smallest interval constant and varied the larger interval. We expected that we would get a constant exponent until the point at which unequal entries occurred. What we got was an apparently unbroken curve on a log-log plot relating exponent value to the value of the larger interval. The exponent was not constant with smallest interval. Plotting the log of the response ratio in the initial links against the reinforcement rate ratio in the terminal links gives a very clear straight line, implicating an exponential

relation between choice and reinforcement rate. This new outcome appears to be a most profitable development, and suggests an entirely new way of accounting for performance in these schedules. Our biggest worry now is that the research is beginning to take on a tinge of Hull again!

We are, of course, following up this latest finding. One of our concerns is to find out whether the terminal link schedule values can be traded off against the intitial link values, and this experiment is being done by Mr Grant Wardlaw, an M.A. student. Miss Mary Foster, an M.Sc. student, is re-investigating preference for fixed *versus* mixed-interval schedule performance in the light of these new findings.

A different departure has been taken by Mr William Temple, a doctoral student, who is investigating the effect of deprivation on choice in concurrent chain schedules. The interesting result of these experiments seems to be that, while decreasing deprivation lowers response rates in the various part of the schedules, it has no effect on the choice behaviour whatsoever. This result would be very useful in allowing a wider comparison of results coming from different laboratories.

We are also examining choice behaviour in the more simple concurrent schedule situation, in which reinforcements are programmed for two schedules operating simultaneously (like the concurrent chain procedure, but without the terminal links). For her Ph.D., Miss Valerie Hollard, a lecturer in this Department, has made an extensive investigation of the choice between food reinforcement and intracranial stimulation (Hollard and Davison, 1971). She was able to demonstrate a constant proportional preference for food over brain stimulation which was unaffected by the rates of occurrence of either reinforcer. This finding allows us to quantify choice behaviour between qualitatively different reinforcers. Following this, Miss Hollard and I are investigating the effects of a variety of commonly prescribed drugs on preference between food and brain stimulation. As a baseline for this study, we are presently looking at the effects of these drugs on concurrent schedules of food reinforcement, again finding that while the rate of responding is easily changed, the choice behaviour is, as yet, completely insensitive to drugs.

A similar technique was used by Mr Archie Davis in his MSc. thesis. Instead of looking at the choice between brain stimulation and food, Mr Davis investigated the choice between different intensities and frequencies of stimulation at different sites of the brain (Davis, Davison and Webster, in press).

Again using the concurrent schedule procedure, we previously investigated programming a variable-interval schedule concurrently with a fixed-interval schedule (Trevett, Davison and Williams, in press). Unlike some recent work by Nevin (1971), we found a constant proportional preference for the variable-interval schedule, which is very easily explained by Schneider's research showing that fixed-interval performance consists of a period of 'dead time' followed by a period which is rather equivalent to a variable-interval schedule. The constant preference derives from this period of dead time, in which animals are responding only on the concurrent variable interval schedule. Mrs Brenda Lobb is now investigating the duration of this

period of dead time according to the reinforcement rate provided by the concurrent variable-interval schedule, and I am extending the research to concurrent fixed-interval mixed-interval schedules. We should shortly be able to provide a coherent account of concurrent interval schedule performance.

Apart from experiments using concurrent and concurrent chain schedules, we are studying the maintenance of choice behaviour in pairs of animals whose behaviour is reinforced as agreement occurs, and is not reinforced as disagreement occurs. Many will remember Verhave's (1966) paper in the *American Psychologist* which suggested that a discrimination could be maintained through mutual reinforcement for agreement. We are attempting to extend this finding to many of the possible ways in which correct and incorrect agreements, and disagreements can be reinforced. The experiments are being carried out by Miss Louise Dickinson and Miss Deryn Cooper, both M.A. students. At the moment we have to confess that we can only maintain correct discrimination performance through reinforcement for correct agreements — but the study is still in its very early stages. We hope in the end to extend our findings to human behaviour, and possibly derive a new technology of teaching from these results.

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