



<http://researchspace.auckland.ac.nz>

ResearchSpace@Auckland

Copyright Statement

The digital copy of this thesis is protected by the Copyright Act 1994 (New Zealand).

This thesis may be consulted by you, provided you comply with the provisions of the Act and the following conditions of use:

- Any use you make of these documents or images must be for research or private study purposes only, and you may not make them available to any other person.
- Authors control the copyright of their thesis. You will recognise the author's right to be identified as the author of this thesis, and due acknowledgement will be made to the author where appropriate.
- You will obtain the author's permission before publishing any material from their thesis.

To request permissions please use the Feedback form on our webpage.

<http://researchspace.auckland.ac.nz/feedback>

General copyright and disclaimer

In addition to the above conditions, authors give their consent for the digital copy of their work to be used subject to the conditions specified on the Library Thesis Consent Form.

MULTIPLE-SCHEDULE PERFORMANCE IN CLOSED ECONOMIES

DOUGLAS MARK ELLIFFE

A thesis submitted in partial fulfilment of the requirements
for the degree of Doctor of Philosophy in Psychology,
University of Auckland, 1990.

ABSTRACT

Experimental preparations may be divided into two categories, called open and closed economies. In an open economy, the extent to which the subject is deprived of the scheduled reinforcer, most commonly food, is controlled by the experimenter. This is usually done by manipulating the amount of free food given to the subject after each experimental session. Consumption of the reinforcer is thus independent of behaviour during the session. By contrast, in a closed economy, no alternative source of the reinforcer is available outside the session. Consumption of the reinforcer is thus completely determined by the subject's interaction with the experimental environment. This may be done by having the subject live permanently within the experiment and receive all its food as reinforcers for responding on continuously available schedules. Most research in the experimental analysis of behaviour has been carried out within open economies, but it can be argued that the natural environment, as a whole, is better represented by a closed economy. Several experimental findings obtained within open economies have been shown not to be replicable within closed economies.

In the present series of experiments, three pigeons received their total daily intake of food as reinforcers for responding on continuously available multiple variable-interval schedules. The relation between the allocation of responding between components of a multiple schedule and the distribution of reinforcers can be conveniently described by the generalised matching law, which states that the ratio of component response rates is a power function of the ratio of component reinforcer rates. In an open economy, the power, called sensitivity, is typically less than

1.0. This is called undermatching. Experiment 1 of the present series found sensitivity values substantially greater than 1.0. This is called overmatching.

One procedural variable known to control sensitivity in open economies is level of deprivation. Experiments 2 to 5 examined the effect of deprivation in a closed economy. In Experiments 2 and 3, increasing deprivation by means of decreasing session duration produced decreases in sensitivity. In Experiment 4, increasing deprivation by decreasing overall reinforcer rate in continuous sessions had no effect on sensitivity. In Experiment 5, deprivation was held constant by changing session duration and overall reinforcer rate in opposite directions. Sensitivity increased with increasing session duration and decreasing overall reinforcer rate.

Taken together, these results suggest that multiple-schedule sensitivity increases with decreasing deprivation, with decreasing overall reinforcer rate, and as the economy for reinforcers other than those arranged by the experimenter (extraneous reinforcers) becomes more closed. A quantitative model of multiple-schedule performance, elaborated from that of McLean and White (1983), was developed to account for these effects. In this model, response allocation is governed by the concurrent choice between scheduled- and extraneous-reinforcer rates within each component. The total rate of extraneous reinforcement is affected by both deprivation and economy, and the distribution of extraneous reinforcers between components depends inversely on the distribution of scheduled reinforcers. Unlike other published models, this model predicts overmatching in the present experiments. Quantitatively, the model accounts for both the present closed-economy data and

published data from open-economy multiple schedules as well as does the generalised matching law, and better than does its most influential competitor, Herrnstein's (1970) equation.

Finally, it is proposed that, while the economy for scheduled reinforcers is important to understanding total response output on multiple schedules, the economy for extraneous reinforcers has much more influence on the allocation of that responding between components.

ACKNOWLEDGEMENTS

Many people have contributed over the years to the production of this thesis. I thank the staff, students and technicians of the operant laboratory at the University of Auckland, particularly Brent Alsop, Dianne McCarthy and Philip Voss, for helping to run the experiments and look after the subjects. I thank Geoff White, Anthony McLean and Tony Nevin for many helpful discussions, Ivan Beale for the use of experimental equipment, and Frances McSweeney for supplying data for reanalysis.

I also thank Brenda Lobb and my parents, Ross and Elisabeth Elliffe, for their valued support and encouragement. Finally, I thank my supervisor, Michael Davison, for his knowledgeable and expert guidance. Without these four people, this thesis would never have been completed.

PREFATORY NOTE

The results of Experiment 1 of the present thesis, together with parts of those obtained in Experiments 3 and 4, were also reported by Elliffe and Davison (1985), in the Journal of the Experimental Analysis of Behavior.

TABLE OF CONTENTS

	Page
List of Figures	xi
List of Tables	xiii
Introduction	1
Quantifying the Law of Effect	1
Herrnstein and the Matching Law	2
Undermatching and Bias	9
The Generalised Matching Law and Concurrent Schedules	12
The Generalised Matching Law and Multiple Schedules	15
Bias in Multiple Schedules	18
Herrnstein's Equation and Generalised Matching	20
Sensitivity in Multiple Schedules	22
Effects of Deprivation	22
Effects of a Common Schedule of Reinforcement	24
Effects of Component Duration	28
Effects of Stimulus Disparity	33
Conclusion	35
The Constant- k Assumption	36
The Linear Systems Approach	45
Formal and Quasi-Formal Versions of the Matching Law	48
An Alternative Model for Multiple Schedules	50
Extending Experimental Results Outside the Laboratory	59
Differences Between Natural and Experimental Economies	60
Supply and Demand Curves	64
Supply Curves and Feedback Functions	64
Demand Curves and Elasticity	68

	Page
Factors Affecting Demand Elasticity	71
Demand Interactions: Substitutability and Complementarity	74
Criticisms of Economic Interpretations	77
Behaviour Regulation	78
Conclusion	82
General Method	84
Subjects	84
Apparatus	84
Procedure	86
Experiment 1	87
Method	87
Results	88
Discussion	90
Experiment 2	95
Method	95
Results	97
Discussion	101
Experiment 3	103
Method	103
Results	104
Discussion	109
Experiment 4	112
Method	112
Results	114
Discussion	121
Within-Session Patterns of Behaviour	122
Overall Response Rates	126
Allocation of Responding Between Components	131
Experiment 5	134

	Page
Method	134
Results	136
Discussion	141
Summary of Results	142
Bias	142
Deprivation	144
Overall Response Rates	146
Sensitivity	148
General Discussion	151
Overall Response Rates	151
Herrnstein	152
Economic Interpretation	156
Conclusion	158
Overmatching and Multiple-Schedule Models	160
The Generalised Matching Law	160
Herrnstein	163
Williams	164
McLean and White	170
Conclusion	175
A Proposed New Model for Multiple Schedules	176
Assumptions	176
Predictions	185
Reanalysis of Existing Multiple-Schedule Data	195
Details of Curve-Fitting Method	195
Equations	196
Charman and Davison (1982)	198
Other Data Sets	204
Criticisms of the Proposed Model	209
Effects of Overall Reinforcer Rate	209

	Page
Substitutability of Scheduled and Extraneous Reinforcers	212
Reallocation of Extraneous Reinforcement	214
Other Criticisms	218
Comparison with McLean and White (1983)	219
Conclusions	221
Appendix A : Data from all experiments	224
Appendix B : List of Equations	234
Appendix C : Derivation of supply curve for Nevin and Baum's (1980) feedback function	243
Appendix D : Generalised trend test	244
Appendix E : Hypothetical response rates for varying reinforcer rates and magnitudes	247
Appendix F : Fits of the generalised matching law and of the proposed model to data from Experiments 1, 2 and 4	250
Appendix G : Reanalyses of Charman and Davison's (1982) data	253
Appendix H : Reanalyses of other existing data from conventional multiple-schedules	257
References	268

LIST OF FIGURES

	Facing page
<u>Figure 1</u> : Response rates on single VI schedules, from Catania and Reynolds (1968)	2
<u>Figure 2</u> : Consumption as determined by equilibrium between supply and demand	64
<u>Figure 3</u> : Demand curves of different elasticities and the equivalent response-rate functions	69
<u>Figure 4</u> : Four VI supply curves, and a demand curve derived from Herrnstein's (1970) hyperbola	71
<u>Figure 5</u> : Component response rates as functions of relative reinforcer rate in Experiment 1	89
<u>Figure 6</u> : Generalised-matching plots for Experiment 1	90
<u>Figure 7</u> : Component response rates in Experiment 2	97
<u>Figure 8</u> : Component reinforcer rates in Experiment 2	98
<u>Figure 9</u> : Generalised-matching plots for Experiment 2	99
<u>Figure 10</u> : Component response rates in Experiment 3	105
<u>Figure 11</u> : Component reinforcer rates in Experiment 3	106
<u>Figure 12</u> : Sensitivity as a function of session duration in Experiments 2 and 3	107
<u>Figure 13</u> : Sensitivity as a function of deprivation level in Experiments 2 and 3	108
<u>Figure 14</u> : Deprivation level as a function of arranged overall reinforcer rate in Experiment 4	114
<u>Figure 15</u> : Overall response and obtained reinforcer rates in Experiment 4	115
<u>Figure 16</u> : Overall response rates as functions of obtained reinforcer rates in Experiment 4	116
<u>Figure 17</u> : Generalised-matching plots for Experiment 4	117
<u>Figure 18</u> : Sensitivity as a function of arranged overall reinforcer rate in Experiment 4	118
<u>Figure 19</u> : Sensitivity as a function of deprivation level in Experiments 2, 3 and 4	119
<u>Figure 20</u> : Component response rates in blocks of 20 components in Condition 15 of Experiment 4	120
<u>Figure 21</u> : Sensitivity in blocks of 20 components in Condition 15 of Experiment 4	121

<u>Figure 22</u> :	Overall response rates as functions of VI schedule for Experiment 4 and Hursh (1978)	126
<u>Figure 23</u> :	Overall response rates and hypothetical hyperbolae for Bird 250 in Experiment 4	129
<u>Figure 24</u> :	Overall response rates in Experiment 5	137
<u>Figure 25</u> :	Overall reinforcer rates in Experiment 5	138
<u>Figure 26</u> :	Overall response rates as functions of overall reinforcer rates in Experiment 5	139
<u>Figure 27</u> :	Sensitivity as a function of session duration in Experiments 2, 3 and 5	140
<u>Figure 28</u> :	Sensitivity as a function of deprivation level in Experiments 2, 3, 4 and 5	141
<u>Figure 29</u> :	Mean sensitivity as a function of session duration in all experiments	149
<u>Figure 30</u> :	Mean sensitivity as a function of deprivation level in all experiments	150
<u>Figure 31</u> :	Overall response rates as functions of overall reinforcer rates in Experiments 3, 4 and 5	152
<u>Figure 32</u> :	Effect of generalised-matching bias correlated with reinforcer ratio	173
<u>Figure 33</u> :	Predictions of the proposed model at various extraneous-reinforcer rates	186
<u>Figure 34</u> :	Correlation between sensitivity and overall extraneous-reinforcer rate	199
<u>Figure 35</u> :	Correlations between sensitivity and both extraneous-reinforcer rate and Herrnstein's interaction parameter	202
<u>Figure 36</u> :	Correlation between percentages of variance accounted for by the generalised matching law and by the proposed model	206
<u>Figure 37</u> :	Correlation between values of the Akaike criterion for the generalised matching law and for the proposed model	207
<u>Figure 38</u> :	Correlation between estimates of bias produced by the generalised matching law and by the proposed model	208
<u>Figure 39</u> :	Predictions of the proposed model for two different experimental designs	210

LIST OF TABLES

	Page
<u>Table 1:</u> Fits of Herrnstein's (1970) single-schedule equation for each hypothetical data set in Appendix E	40
<u>Table 2:</u> Sequence of conditions in Experiment 1	88
<u>Table 3:</u> Fits of the generalised matching law for Experiment 1	89
<u>Table 4:</u> Sequence of conditions in Experiment 2	96
<u>Table 5:</u> Fits of the generalised matching law for Experiment 2	99
<u>Table 6:</u> Summary of conditions and results for Experiment 2	101
<u>Table 7:</u> Sequence of conditions in Experiment 3	104
<u>Table 8:</u> Summary of conditions and results for Experiment 3	106
<u>Table 9:</u> Sequence of conditions in Experiment 4	113
<u>Table 10:</u> Fits of the generalised matching law for Experiment 4	117
<u>Table 11:</u> Individual-component data for Bird 251 in Condition 20 of Experiment 4	121
<u>Table 12:</u> Sequence of conditions in Experiment 5	135
<u>Table 13:</u> Fits of the generalised matching law for Experiment 5	139
<u>Table 14:</u> Bias values in Experiments 1, 2 and 4	142
<u>Table 15:</u> Deprivation levels in all experiments	145
<u>Table 16:</u> Overall response rates in all experiments	147
<u>Table 17:</u> Sensitivity values in all experiments	149
<u>Table 18:</u> Directional changes in deprivation, session duration and overall response and reinforcer rates in Experiments 3, 4 and 5	152
<u>Table 19:</u> Fits of Equations 56, 57 and 58 to data from Experiments 1 and 4	180
<u>Table 20:</u> Fits of Equations 9, 60 and 61 to data from Experiments 1 and 4	184
<u>Table 21:</u> Mean fits of Equations 9 and 61 to data from Experiments 1, 2 and 4	185

	Page
<u>Table 22</u> : Mean fits of Equations 9, 61 and 68 to data from Charman and Davison (1982)	198
<u>Table 23</u> : Fits of Equations 9, 61 and 68 to data from two subjects from Charman and Davison (1982)	200
<u>Table 24</u> : The effect of changing parameter values on the fits shown in Table 23	201
<u>Table 25</u> : Mean fits of Equations 9 and 61 to 173 existing multiple-schedule data sets	205
<u>Table D1</u> : Frequency distributions of Ferguson's (1965) trend statistic	245
<u>Table D2</u> : Frequency, probability, and cumulative probability distributions of the generalised trend statistic	246
<u>Table E1</u> : Hypothetical response rates and fits of Herrnstein's (1970) single-schedule equation	248