

The Maudsley Reactive and Nonreactive Strains of Rats: A Survey¹

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Experiments with two strains of rats, the Maudsley Reactive and Nonreactive, developed in London, England, and which were performed during 1964–1974 by a variety of investigators are summarized in a table. It is concluded that the results support the strains' standing as exemplars of differences in emotional reactivity.

KEY WORDS: rat; selective breeding; emotionality; Maudsley strains.

INTRODUCTION

A program of bidirectional selection for extremes of emotional elimination in the restandardized open-field test of Hall (1938) was started in 1954 (Broadhurst, 1957, 1958a) and led to the foundation of the Maudsley Reactive and Nonreactive strains of rats, MR and MNR, respectively, to use the now generally accepted nomenclature (Festing and Staats, 1973). It hardly needs reiterating that the strain designations "reactive" and "nonreactive" relate solely to defecation scores in the open field for which selection was practiced. The progress of this selection experiment was reported by Broadhurst (1958b, 1960, 1962) through the fifteenth generation of selection (S_{15}), and incidental presentation of results to S_{20} may be found in, for example, Broadhurst (1963, 1964, 1966, 1967, 1970),

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¹ This paper is dedicated on his sixty-fifth birthday to Calvin S. Hall, one of the pioneers of psychogenetics on whose foundations the next generation of workers has, typically, built.

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Broadhurst and Eysenck (1965), Eysenck (1965), Gray (1971), and Rick and Fulker (1972). Their main importance lies in the demonstration that relaxation of selection from S_{16} onward occasioned no reversion toward the parental values of the foundation population.

Ten years after the strains had been founded, the outcome was surveyed by Eysenck and Broadhurst (1964) in terms of the extent to which the phenotypic differences in open-field defecation and in the inversely correlated ambulation scores, now stable and reliable differentiating features of the MR and MNR strains (see Table I, items 1–31), underlie the many other differences, physiological as well as behavioral, which characterize them. Our earlier review of over 50 different measures of all sorts taken from the two strains led us to the conclusion that the manifold differences detected pointed to a very real differentiation in their general emotional responsiveness brought about by the selection for high and low defecation in the open-field test. Now, a further 10 years later, the strains have been exported to other laboratories in both Britain and North America and over 70 further studies using them had been reported up to early 1974.

The purpose of the present paper is to review this new body of evidence, again with the intention of assessing its bearing on the prediction that the reactive strain will behave in a more fearful, emotional manner, relative always to the nonreactive. Attention is drawn to other surveys of some of this material, not always arriving at similar conclusions (Robinson, 1965; Benešová and Beneš, 1968; Archer, 1973).

RESULTS

The main presentation of the relevant data is the tabular summary given in Table I, which is modeled closely on that published in 1964 (Eysenck and Broadhurst) in order to provide continuity and to facilitate comparison with the older work. Some notes on the principles governing the construction and interpretation of the table follow.

First, the survey is focused on strain comparisons only, so that studies which reported results from only one of the two strains are excluded, together with the few which did not separate the data or which used numbers too small to permit comparison. No emphasis is laid on the effect of other variables, either constitutional, especially sex differences, or experimental, that is, treatment variables. It has, however, not always been possible to avoid taking such results into account in evaluating the strain comparisons, noted in the column headed "Difference," since they sometimes determine outcomes in interaction with strain differences. Where such differences do not reach a conventionally accepted level of signifi-

cance, the letters "ns," indicating "no significant difference," are entered in column 5.

Second, it is obvious that any interpretation of the impact of the results on the general hypothesis under test will be a subjective matter. Policy here has been to adopt a conservative approach, so that the summary symbol + in the penultimate column of the table headed "Evaluation," meaning that the strain difference reported appears to support the notion that the strains represent a valid dichotomy with respect to general emotionality, is used rather sparingly, with recourse being had in case of doubt to the 0 symbol, which is otherwise generally reserved for outcomes which appear to have little or no bearing on the question. A minus sign (-) is used when the results go counter to what might be expected on the basis of an emotionality hypothesis. Apparent idiosyncrasies in these respects can often be related to experimental details in the published report which render dubious what might appear to be an obvious interpretation or to the crucial bearing the results have on some argument in the literature about the hypothesis in question. The outraged reader is invited to consult the reference concerned, but may still disagree!

Third, the table is subdivided somewhat arbitrarily into four rather broad topic areas, behavioral, psychophysiological, psychoendocrinological, and psychopharmacological. This separation was made in order to facilitate comparison between experiments, but, as before, it has necessarily resulted in multiple entries in cases where a single publication reports results bearing on several topic areas. The headings used in the table are also sometimes inappropriate to the detailed subject matter, so that "Test" in column 2 must sometimes be interpreted as "situation" or even "drug." Similarly, it has not always been possible, given the need for economy of wording in a table of this kind, to specify precisely the details of mensuration in column 3. A question mark (?) has been entered, especially in column 4, in cases where a necessary item of information is not available from the report, or was not supplied by the author of the present paper or by authors of the papers in question, many of whom have been kind enough to respond to these and other queries in correspondence.

Finally, the meshing of this survey with its predecessor (Eysenck and Broadhurst, 1964), which likewise sought to be as contemporary as possible in an expanding field and hence also referred to unpublished material, presented a problem which has been resolved as follows. While a few items previously missed have been included, none of the previous material is repeated, except in a case where it was accidentally misquoted (item No. 122) and a few other cases where a published reference is now available for what was previously attributed to a "personal communication."

Table I. Summary of Results Using MR and MNR Strains

| Item | Test | Measure | Generation | Difference | Evaluation | Reference |
|---------------|------------|-------------------------------|-------------------------|-----------------------|------------|---|
| A. Behavioral | | | | | | |
| 1 | Open field | Defecation | S ₁₆ | MR more | + | Broadhurst and Eysenck (1965) |
| 2 | | | S ₁₈ | MR more | + | Gray and Levine (1964) |
| 3 | | | S ₁₉ | MR more | + | Gray <i>et al.</i> (1965) |
| 4 | | | S ₂₀ | MR more | + | Broadhurst (1963) (see also text) |
| 5 | | | S ₂₂ | MR more | + | Sudak and Maas (1964) |
| 6 | | | S _{23, 24} | MR more | + | Joffe (1965b, 1969) |
| 7 | | | S ₂₇ | MR more | + | Harrington and Hanlon (1966) |
| 8 | | | S ₃₀ | MR more | + | Rick <i>et al.</i> (1971), Rick and Fulker (1972) |
| 9 | | | S ₃₁ | MR more | + | Blizard (1970) |
| 10 | | | S _{33, 34, 40} | MR more | + | Harrington (1972) |
| 11 | | | S ₃₆ | MR more | + | Imada (1970) |
| 12 | | | ? | MR more | + | Powell and North-Jones (1974) |
| 13 | | | S _{37, 43} | MR more | + | Satinder (1974c) |
| 14 | | | S _{34, 40, 45} | MR more | + | Satinder (1974c) |
| 15 | | | S ₄₆ | ns | - | Eller (1974) |
| 16 | | | ? | MR more | + | Chamove (1974) |
| 17 | | Defecation change | S ₂₇ | MR augmt, MNR decline | + | Harrington and Hanlon (1966) |
| 18 | | Defecation change, prepuberty | ? | MR more | + | Chamove (1974) |
| 19 | Ambulation | | S ₁₄ | MNR more | + | Wilcock and Broadhurst (1967) |
| 20 | | | S ₁₆ | ns | - | Broadhurst and Eysenck (1965) |
| 21 | | | S ₁₈ | MNR more | + | Gray and Levine (1964) |
| 22 | | | S ₁₉ | MNR more | + | Gray <i>et al.</i> (1965) |
| 23 | | | S ₂₀ | MNR more | + | Broadhurst (1963) (see also text) |
| 24 | | | S ₂₂ | MNR more | + | Sudak and Maas (1964) |
| 25 | | | S _{23, 24} | MNR more | + | Joffe (1965b, 1969) |

| | | | | | | |
|----|-------------------------------|-------------------|-----------------------|------------|---|---|
| 26 | Open field | Ambulation | S ₃₀ | MNR more | + | Rick <i>et al.</i> (1971), Rick and Fulker (1972) |
| 27 | | | S _{33,34,40} | MNR more | + | Harrington (1972) |
| 28 | | | S ₃₅ | MNR more | + | Imada (1970) |
| 29 | | | ? | ns | - | Powell and North-Jones (1974) |
| 30 | | | S _{35,40} | MNR more | + | Satinder (1974a) |
| 31 | | | S ₃₆ | MNR more | + | Eller (1974) |
| 32 | Light and noise as open field | Defecation | S ₃₁ | MR more | + | Blizard (1971) |
| 33 | | Ambulation | S ₃₁ | ns | - | Blizard (1971) |
| 34 | Drinking | Defecation | S ₃₆ | MR more | + | Imada (1972) |
| 35 | Handling | Defecation | S ₂₇ | MNR more | - | Harrington and Hamlon (1966) |
| 36 | Time sampling | Rearing amount | S ₁₇ | ns | - | Gray (1965) |
| 37 | | | S ₁₉ | MNR more | + | Gray <i>et al.</i> (1965) |
| 38 | Light as open field | Rearing frequency | S ₃₁ | ns | - | Blizard (1971) |
| 39 | Noise as open field | | S ₃₁ | MNR more | + | Blizard (1971) |
| 40 | Light and noise as open field | | S ₃₁ | ns | - | Blizard (1971) |
| 41 | Rearing cage | | S _{36,27} | MNR more | + | Garg (1969a, b) |
| 42 | | | S ₃₃ | ns | - | Gupta and Gregory (1967) |
| 43 | | | S ₃₃ | ns | - | Holland and Gupta (1967) |
| 44 | | | S ₃₃ | ns | - | Gregory and Liebelt (1967) |
| 45 | | | S ₃₀ | MNR more | + | Weldon (1968b) |
| 46 | | | ? | MNR more | + | Gregory (1967a) |
| 47 | | | S ₃₁ | MNR more | + | Groves (1971) |
| 48 | | | S _{36,27} | MNR longer | + | Garg (1969a, b) |
| 49 | | Rearing duration | S ₃₀ | ns | - | Gregory and Liebelt (1967) |
| 50 | | | S ₃₁ | MNR longer | - | Weldon (1968b) |
| 51 | | | ? | ns | - | Gregory (1967a) |
| 52 | | | S ₄₁ | ns | 0 | Groves (1971) |
| 53 | Alley | Ambulation | S ₃₃ | ns | - | Gregory <i>et al.</i> (1967) |
| 54 | Activity wheel | Revolutions | ? | MNR more | 0 | Harrington (1971b) |
| 55 | Emergence, familiar | Latency | ? | MR longer | + | Harrington (1971a) |
| 56 | Emergence, novel | | ? | ns | - | Harrington (1971a) |
| 57 | Rearing cage, after shock | Activity | S ₃₀ | ns | - | Gregory (1967b) |

Table I. Continued

| Item | Test | Measure | Generation | Difference | Evaluation | Reference |
|------|------------------------------------|---------------------|-------------------------|-------------|------------|---|
| 58 | Time sampling | Grooming | S ₁₇ | ns | 0 | Gray (1965) |
| 59 | | | S ₁₉ | MR more | 0 | Gray <i>et al.</i> (1965) |
| 60 | | Various others | S ₁₇ | ns | 0 | Gray (1965) |
| 61 | Avoidance conditioning | First avoidance | S ₃₁ | ns | - | Broadhurst and Wallgren (1964) |
| 62 | | Intertrial crossing | S ₁₆ | MNR more | + | Broadhurst (1966) |
| 63 | | | S ₂₁ | ns | - | Broadhurst and Wallgren (1964) |
| 64 | | | S _{26, 27} | ns | - | Gupta and Holland (1969b) |
| 65 | | | S ₃₀ | MNR more | + | Rick <i>et al.</i> (1971), Rick and Fulker (1972) |
| 66 | | | S _{36, 37} | ns | - | Satinder (1971) |
| 67 | | Avoidances | S ₃₀ | ns | 0 | Broadhurst (1964) |
| 68 | | | S ₃₁ | ns | 0 | Broadhurst and Wallgren (1964) |
| 69 | | | S _{23, 24} | MNR more | + | Joffe (1964) |
| 70 | | | S _{36, 37} | MNR more | + | Gupta and Holland (1969a) |
| 71 | | | ? | MNR more | + | Martin and Powell (1970) |
| 72 | | | S ₃₀ | MNR more | + | Rick <i>et al.</i> (1971), Rick and Fulker (1972) |
| 73 | | | S _{31, 36, 37} | ns | - | Satinder (1971) |
| 74 | | | ? | ns | - | Powell and North-Jones (1974) |
| 75 | Effects of preschool | | S _{25, 26} | MR improved | 0 | Wilcock (1966) |
| 76 | Failures to avoid | | S _{23, 24} | MR more | + | Joffe (1964) |
| 77 | Avoidance latency | | S ₁₁ | MR longer | + | Savage (1965) |
| 78 | | | S ₁₇ | MR longer | + | Broadhurst (1966) |
| 79 | | | S ₂₁ | MR longer | + | Broadhurst and Wallgren (1964) |
| 80 | | | S _{31, 36, 37} | ns | - | Satinder (1971) |
| 81 | Escape latency | | S ₁₇ | MNR longer | + | Broadhurst (1966) |
| 82 | | | S _{31, 36, 37} | ns | - | Satinder (1971) |
| 83 | | | ? | MNR longer | + | Powell and North-Jones (1974) |
| 84 | Multivariate "conditionability" | | S _{26, 27} | MNR higher | 0 | Gupta and Holland (1972a) |

| | | | | | | |
|-----|----------------------------------|---|---------------------------------|-------------------|---|---|
| 85 | Avoidance conditioning | Multivariate "non-irrelevant activity", ²⁷ | S ₂₆ , ²⁷ | MR higher | 0 | Gupta and Holland (1972a) |
| 86 | Avoidance conditioning, modified | Avoidances | S ₃₅ , ⁴⁰ | MNR more affected | 0 | Satinder (1972b) |
| 87 | Skinner box | Intertrial crossing | ? | ns | 0 | Satinder (1972b) |
| 88 | | Lever press rate | S ₃₉ | MNR faster | + | Ferraro and York (1968) |
| 89 | | Lever press duration | ? | MNR faster | 0 | Keehn (1972a) |
| 90 | | Lever press duration for light | | MNR longer | 0 | Ferraro and York (1968) |
| 91 | | Lever press duration | | MNR longer | + | Weldon (1969) |
| 92 | | Shocked lever press duration | | MNR longer | + | Ferraro and York (1968) |
| 93 | | Response decrement to shock | | MR more | + | Ferraro and York (1968) |
| 94 | | Schedule-induced lick rate | S ₃₉ | MNR more | 0 | Keehn (1972a, 1974) |
| 95 | | Schedule-induced lick rate for alcohol | | MNR more | 0 | Keehn (1972b) |
| 96 | | Schedule-induced alcohol drunk | | ns | 0 | Keehn (1972b) |
| 97 | | Schedule-induced water drunk | | MNR more | 0 | Keehn (1972b) |
| 98 | | Lever biting | | ns | 0 | Keehn (1972a, 1974) |
| 99 | | Lever press for light | S ₃₀ , ³¹ | MNR more | + | Weldon (1968c) |
| 100 | | Lever press for dark preference | | MR more | + | Weldon (1968c) |
| 101 | | Lever press for change | | MNR more | + | Weldon (1968c) |
| 102 | Hebb-Williams maze | Running time | S ₂₈ , ²⁷ | MR faster | 0 | Garg and Holland (1967, 1968a, 1969), Garg (1970) |
| 103 | | Change after pain | | MNR faster | 0 | Garg and Holland (1968b) |
| 104 | | Errors | | ns | 0 | Garg and Holland (1967) |
| 105 | | | | MR more | - | Garg and Holland (1967, 1968a, b, c, 1969) |
| 106 | | Change after pain | | MNR more | 0 | Garg and Holland (1967) |

Table I. Continued

| Item | Test | Measure | Generation | Difference | Evaluation | Reference |
|------|---------------------------|---------------------------------------|-------------------------|------------------|------------|-------------------------------|
| 107 | T-maze | Running time | S ₂₂ | MR longer | + | Weldon (1967) |
| 108 | | Alternations | | MNR more | + | Weldon (1967) |
| 109 | | Errors | ? | ns | + | Powell (1970) |
| 110 | | Errors after reversal | | MNR more | 0 | Powell (1970) |
| 111 | Underwater Y-maze | Swimming time | S ₂₂ | ns | - | Wright <i>et al.</i> (1967) |
| 112 | | Reminiscence | | MNR more | 0 | Wright <i>et al.</i> (1967) |
| 113 | Mowrer box | Eating, buzzer, and shock | | ns | 0 | Weldon (1967) |
| 114 | | Eating after buzzer | | ns | 0 | Weldon (1967) |
| 115 | | Eating under threat | | MNR more | + | Weldon (1967) |
| 116 | Response to shock | Running | S ₂₆ | MR more | 0 | Wilcock (1968) |
| 117 | | Backing | | MNR more | 0 | Wilcock (1968) |
| 118 | | Various others | | ns | 0 | Wilcock (1968) |
| 119 | Water escape | Swimming speed | S ₂₁ | MR faster | + | Wampler (1964) |
| 120 | Interspecific aggression | Muricide | ? | MR more | + | Lonowski <i>et al.</i> (1974) |
| 121 | | Mouse carrying | | MNR more | 0 | Lonowski <i>et al.</i> (1974) |
| 122 | Mild stress | Water intake | S ₁₆ | ns | 0 | Broadhurst and Eysenck (1965) |
| 123 | | | S ₃₆ | ns | 0 | Imada (1972) |
| 124 | | Water intake, under brighter light | | MNR more | + | Imada (1972) |
| 125 | | Water intake, with shock | | MR more affected | + | Imada (1972) |
| 126 | Naturalistic stress (cat) | Various measures | S _{39, 40, 46} | MNR difference | 0 | Satinder (1974c) |
| 127 | Stress applied to mothers | Offspring defecation and conditioning | S ₂₃ | ns | 0 | Joffe (1965b, 1969) |
| 128 | | Offspring defecation | S ₁₆ | MR decrease | + | Eller (1974) |
| 129 | | Offspring ambulation | S ₂₃ | ns | 0 | Joffe (1969), Fulker (1970) |

| | | | | | | |
|------------------------|---------------------------------|--------------------------------------|--------------------|-------------|---|-------------------------------|
| 130 | Stress applied to mother | Offspring ambulation | S ₁₆ | MR increase | + | Eller (1974) |
| 131 | Stress applied to foster mother | Various | S ₂₃ | ns | 0 | Joffe (1965a) |
| B. Psychophysiological | | | | | | |
| 132 | Body size | Birth weight of offspring | S ₂₃ | ns | 0 | Joffe (1969) |
| 133 | | Weaning weight of offspring | | ns | 0 | Joffe (1969) |
| 134 | | Adult weight | S ₁₆ | MR heavier | 0 | Broadhurst and Eysenck (1965) |
| 135 | | | S ₁₇ | MR heavier | 0 | Broadhurst (1966) |
| 136 | | | S ₃₆ | MR heavier | 0 | Imada (1970) |
| 137 | | | ? | MNR heavier | 0 | Powell and North-Jones (1970) |
| 138 | | | S _{35,40} | MR heavier | 0 | Satinder (1974a) |
| 139 | | | | MR heavier | 0 | Satinder (1974a) |
| 140 | | Weight loss after stress | S ₁₆ | MNR more | - | Broadhurst and Eysenck (1965) |
| 141 | Litter size | Number born | S ₂₃ | MNR larger | 0 | Joffe (1969) |
| 142 | Stress applied to mother | Litter size | | ns | 0 | Joffe (1969) |
| 143 | Stress applied to foster mother | Pup weight | | ns | 0 | Joffe (1969) |
| 144 | Home cage | Food intake | S ₃₆ | MNR more | 0 | Imada (1970) |
| 145 | | Water intake | | ns | 0 | Imada (1970) |
| 146 | | Defecation boluses | S ₃₁ | MNR more | 0 | Blizard (1970) |
| 147 | | | S ₃₆ | ns | 0 | Imada (1970) |
| 148 | | Defecation boluses, corrected weight | | MNR higher | 0 | Imada (1970) |
| 149 | | Digestive transit time | S ₃₁ | ns | + | Blizard (1970) |
| 150 | | Heart rate | S ₂₇ | MNR higher | 0 | Harrington and Hanlon (1966) |
| 151 | | Heart rate, handling | | MNR more | 0 | Harrington and Hanlon (1966) |
| 152 | Open field | Heart rate | | MNR higher | 0 | Harrington and Hanlon (1966) |
| 153 | | Heart rate, decrease | | MR greater | 0 | Harrington and Hanlon (1966) |
| 154 | Light and noise as open field | Heart rate variability | S ₃₁ | MR greater | + | Blizard (1971) |
| 155 | | Colonic pressure | ? | MR more | + | Blizard (1975) |

Table I. Continued

| Item | Test | Measure | Generation | Difference | Evaluation | Reference |
|------|---|----------------------------------|--------------------|-------------|------------|--|
| 156 | Response to shock | Colonic pressure | S ₂₆ | MR more | + | Blizard (1975) |
| 157 | Response to shock | Electrical resistance | S ₂₆ | MNR higher | + | Wilcock (1968) |
| 158 | Response to shock, plus carcinogen | Growth index | ? | ns | 0 | Holland (1974) |
| 159 | Immobilization restraint | Gastric ulcers | S ₂₀₋₂₂ | ns | 0 | Mikhail and Broadhurst (1965) |
| 160 | Immobilization re- straint, plus shock | | S ₂₆ | MR more | + | Mikhail (1969) |
| 161 | Brain protein | | S ₂₆ | ns | 0 | Mikhail (1972) |
| 162 | Brain metabolism | Electrophoresis | ? | ns | 0 | Bailey and Heald (1961) |
| 163 | | Cholinesterase | S ₆ | ns | 0 | Broadhurst and Watson (1964) |
| 164 | | Serotonin | S ₂₂ | MR more | + | Sudak and Mass (1964) |
| 165 | | GABA, cerebral hemispheres | S ₂₀₊ | MNR more | - | Riek <i>et al.</i> (1967) |
| 166 | | | S ₃₀ | MR higher | + | Riek <i>et al.</i> (1971), Riek and Fulker (1972), Fulker and Riek (1973) |
| 167 | | GABA, elsewhere | S ₁₈₋₂₀ | ns | 0 | Riek <i>et al.</i> (1967) |
| 168 | Cholesterol content | Brain | S ₁₈₋₂₀ | ns | 0 | Feuer (1963a, 1969) |
| 169 | | Liver | S ₂₆ | MR more | 0 | Feuer (1963a, 1969) |
| 170 | | Blood serum | S ₂₀₊ | MR more | 0 | Feuer (1963a, b, 1969) |
| 171 | C. Psychoendocrinological | | | | | |
| 172 | Pituitary | Gland weight | S ₁₆ | ns | 0 | Broadhurst and Eysenck (1965) |
| 173 | | Serum eosinophils | S ₁₈₋₂₀ | MR more | + | Feuer (1969) |
| | | Serum eosinophils, after ACTH | S ₁₈₋₂₀ | ns | 0 | Feuer (1963b, 1969) |
| 174 | Gonads, testes | Gland weight | S ₁₆ | MR heavier | 0 | Broadhurst and Eysenck (1965) |
| 175 | | | S ₁₈₋₂₀ | ns | 0 | Feuer (1969) |
| 176 | | Plasma testosterone | S ₄₆ | ns | 0 | Broadhurst (1973) |
| 177 | Gonads, ovaries | Gland weight | S ₁₆ | MNR heavier | 0 | Broadhurst and Eysenck (1965) |
| 178 | | | S ₁₈₋₂₀ | MNR heavier | 0 | Feuer (1969) |

| | | | | | | |
|-----|--------------------------|------------------------------------|--------------------|--------------------|---|--------------------------------------|
| 179 | Gonads, ovaries | Defecation, induced estrus | S ₁₈ | MR more | 0 | Gray and Levine (1964) |
| 180 | | Ambulation, induced estrus | | ns | 0 | Gray and Levine (1964) |
| 181 | Thyroid function | Gland weight | S ₁₆ | MR heavier | + | Broadhurst and Eysenck (1965) |
| 182 | | Serum thyroxine | S ₁₈₋₂₀ | MNR more | + | Feuer (1969) |
| 183 | | Response to thyroxine | | MR more | + | Feuer (1963b, 1969) |
| 184 | | Metabolism | S ₄₆ | ns | 0 | Bernet (1974) |
| 185 | Adrenal function | Gland weight | S ₁₆ | ns | - | Broadhurst and Eysenck (1965) |
| 186 | | | S ₁₈ | MR heavier | + | Feuer (1969) |
| 187 | | Gland corticosteroid | | MR more | + | Feuer (1969) |
| 188 | | Serum corticosteroid | | MNR more | 0 | Feuer (1969) |
| 189 | | | S ₃₀ | ns | - | Fulker (1972) |
| 190 | | Serum cholesterol | S ₁₈ | MR more | 0 | Feuer (1969) |
| 191 | | Urine catecholamines | S _{46,47} | MNR more | - | Bernet (1974) |
| 192 | | Avoidances decline, epinephrine | S _{26,27} | MNR more | + | Gupta and Holland (1969a) |
| 193 | | Activity, epinephrine | | ns | 0 | Gupta and Holland (1969b) |
| 194 | | Ambulation, epinephrine | S ₂₃ | ns | 0 | Gregory <i>et al.</i> (1967) |
| 195 | | Rearing, epinephrine | | ns | 0 | Gupta and Gregory (1967), Holland |
| 196 | EEG theta driving | Sex difference | ? | MNR none | 0 | and Gupta (1967) |
| 197 | | Exogenous testosterone | | MNR no response | 0 | Gray (1974) |
| 198 | D. Psychopharmacological | Activity cage | S ₂₃ | ns | 0 | Gregory <i>et al.</i> (1967) |
| 199 | Amphetamine | Open-field ambulation | S ₃₀ | MNR augment | 0 | Gupta and Holland (1972b) |
| 200 | Amphetamine | Rearing | S ₂₃ | ns | 0 | Gupta and Gregory (1967), Holland |
| 201 | | | | | | and Gupta (1967) |
| 202 | | Avoidance | S ₃₀ | MNR augment | + | Gupta and Holland (1972b) |
| 203 | | conditioning | S _{26,27} | MNR augment | + | Gupta and Holland (1969a) |
| 204 | | | S ₃₀ | MNR augment | + | Gupta and Holland (1972b) |
| | | | S _{26,37} | MR augment | - | Satinder (1971) |

Table I. Continued

| Item | Test | Measure | Generation | Difference | Evaluation | Reference |
|------|-------------|---|--------------------|-------------|------------|---------------------------|
| 205 | Amphetamine | Avoidance conditioning | ? | ns | 0 | Powell and Hopper (1971) |
| 206 | | Avoidance conditioning, modified | S _{35,40} | MR augment | + | Saunders (1972b) |
| 207 | | Avoidance conditioning, latency | | MR augment | 0 | Saunders (1972b) |
| 208 | | Avoidance conditioning, escape latency | S _{36,37} | MR decline | + | Saunders (1971) |
| 209 | | Avoidance conditioning, intertrial crossing | ? | ns | 0 | Powell and Hopper (1971) |
| 210 | | Avoidance conditioning, intertrial crossing | S _{36,37} | MNR augment | 0 | Saunders (1971) |
| 211 | | Avoidance conditioning, intertrial crossing | S _{36,27} | MNR augment | + | Gupta and Holland (1969b) |
| 212 | | Avoidance conditioning | S ₃₀ | MNR augment | + | Gupta and Holland (1972b) |
| 213 | | Avoidance conditioning, latency | S _{36,37} | MR augment | - | Saunders (1971) |
| 214 | | Avoidance conditioning, escape latency | S _{35,40} | ns | 0 | Saunders (1972b) |
| 215 | Caffeine | Avoidance conditioning | S _{36,27} | MR augment | - | Saunders (1971) |
| 216 | | Avoidance conditioning, latency | | MR decline | - | Saunders (1971) |
| 217 | | Avoidance conditioning, escape latency | | MNR augment | 0 | Saunders (1971) |
| 218 | | Avoidance conditioning, intertrial crossing | | MNR augment | + | Saunders (1971) |
| 219 | Nicotine | Rearing, frequency | S _{36,27} | MNR augment | + | Garg (1969a, b) |
| 220 | | Rearing, duration | | ns | 0 | Garg (1969a, b) |

| | | | | | | |
|-----|----------------|---|--------------------|-------------|---|--|
| 221 | Nicotine | Hebb-Williams maze, errors | S _{26,27} | MNR decline | + | Garg and Holland (1967) |
| 222 | | Hebb-Williams maze, time | | ns | 0 | Garg and Holland (1967, 1968a, 1969) |
| 223 | | Y-maze, underwater swimming time | S ₂₂ | ns | 0 | Wraight <i>et al.</i> (1967) |
| 224 | | Y-maze, reminiscence | | ns | 0 | Wraight <i>et al.</i> (1967) |
| 225 | Picrotoxin | Hebb-Williams maze, errors | S _{26,27} | MNR decline | 0 | Garg (1969a), Garg and Holland (1967, 1968c) |
| 226 | | | | ns | 0 | Garg (1970) |
| 227 | Amylobarbitone | Open-field ambulation | S ₂₈ | ns | 0 | Gregory <i>et al.</i> (1967) |
| 228 | | Rearing | | ns | 0 | Gupta and Gregory (1967), Holland and Gupta (1967) |
| 229 | | Avoidance conditioning | S _{26,27} | MNR decline | + | Gupta and Holland (1969a) |
| 230 | | Avoidance conditioning, intertrial crossing | ? | ns | 0 | Martin and Powell (1970) |
| 231 | | | | ns | 0 | Martin and Powell (1970) |
| 232 | | Avoidance conditioning, freezing | | MNR augment | - | Martin and Powell (1970) |
| 233 | | Hebb-Williams maze, errors | | MNR more | 0 | Martin and Powell (1970) |
| 234 | Pentobarbital | Hebb-Williams maze, time | S _{26,27} | MNR augment | 0 | Garg (1969a), Garg and Holland (1967, 1968b) |
| 235 | | Hebb-Williams maze, time | | ns | 0 | Garg and Holland (1967, 1968b) |
| 236 | Methylpentynol | Open-field ambulation | S ₂₈ | ns | 0 | Gregory <i>et al.</i> (1967) |
| 237 | | Rearing | S ₂₀ | ns | 0 | Gupta and Holland (1972b) |
| 238 | | | S ₂₈ | ns | 0 | Gupta and Gregory (1967), Holland and Gupta (1967) |
| 239 | | Avoidance conditioning | S ₂₀ | ns | 0 | Gupta and Holland (1972b) |
| 240 | | | S _{26,27} | MR augment | + | Gupta and Holland (1969a) |
| 241 | | | S ₂₈ | MR augment | + | Holland and Gupta (1966) |

Table I. Continued

| Item | Test | Measure | Generation | Difference | Evaluation | Reference |
|------|----------------------------------|---|-------------------------|-------------|------------|--------------------------------|
| 242 | Methylpentynol | Avoidance conditioning | S ₃₀ | ns | 0 | Gupta and Holland (1972b) |
| 243 | | Avoidance conditioning, intertrial crossing | S _{28, 27} | MNR augment | - | Gupta and Holland (1969b) |
| 244 | Methylpentynol, plus amphetamine | Open-field ambulation | S ₃₀ | MNR augment | 0 | Gupta and Holland (1972b) |
| 245 | | Rearing | | ns | 0 | Gupta and Holland (1972b) |
| 246 | | Avoidance conditioning | | ns | 0 | Gupta and Holland (1972b) |
| 247 | | Avoidance conditioning, intertrial crossing | | MNR augment | 0 | Gupta and Holland (1972b) |
| 248 | Prenylamine | Open-field ambulation | | ns | 0 | Gregory (1968) |
| 249 | | Rearing | | ns | 0 | Gregory (1968) |
| 250 | Reserpine | Avoidance conditioning | S ₃₀ | MR augment | + | Broadhurst (1964) |
| 251 | Trihexyphenidyl | Licking for alcohol | S ₃₉ | ns | 0 | Keehn (1972b) |
| 252 | Alcohol | Avoidance conditioning | S ₃₁ | ns | - | Broadhurst and Wallgren (1964) |
| 253 | | T-maze reversal | ? | ns | 0 | Powell (1970) |
| 254 | Alcohol preference, 0.01% | Preference ratio | S _{25, 26} | ns | 0 | Brewster (1969) |
| 255 | Alcohol preference, 0.1% | | | MR higher | + | Brewster (1969) |
| 256 | Alcohol preference, 5 and 10% | | | MR higher | + | Brewster (1969) |
| 257 | | | S _{33, 38} | MR higher | + | Satinder (1972a) |
| 258 | Alcohol preference, 5% only | | S _{26, 27, 29} | MNR higher | - | Brewster (1968, 1969, 1972) |

| | | | | | | |
|-----|---|-----------------------------|-----------------------|-------------------|---|-----------------------------|
| 259 | Alcohol preference, 0.25-32% | Preference ratio | S _{33,40} | ns | 0 | Satinder (1974a) |
| 260 | Alcohol preference, 20% | | S _{33,38} | ns | 0 | Satinder (1972a) |
| 261 | Alcohol preference, 64% | | S _{35,40} | MR higher | + | Satinder (1974a) |
| 262 | | Preference ratio, retest | | ns | 0 | Satinder (1974a) |
| 263 | Alcohol preference, 0.25-32% | | | MR more | + | Satinder (1974a) |
| 264 | Alcohol preference, 0.01% | Intake | S _{35,26} | MNR more | - | Brewster (1969) |
| 265 | Alcohol preference, 0.1% | | | ns | 0 | Brewster (1969) |
| 266 | Alcohol preference, 0.5 and 2% | | S _{35,40} | MNR more | - | Satinder (1974a) |
| 267 | Alcohol preference, 5 and 10% | | S _{35,26} | MR more | + | Brewster (1969) |
| 268 | Alcohol preference, 5% only | | S _{33,38} | MR more | + | Satinder (1972a) |
| 269 | | | S _{26,27,29} | MNR more | - | Brewster (1968, 1969, 1972) |
| 270 | Alcohol preference, 20% | | S _{33,38} | ns | 0 | Satinder (1972a) |
| 271 | Alcohol preference, 0.25, 1, 4-64% | | S _{35,40} | ns | 0 | Satinder (1974a) |
| 272 | Alcohol preference, 1, 4, 8, 16% | Intake, retest | | MR more | + | Satinder (1974a) |
| 273 | Alcohol preference, 0.25, .5, 2, 32, 64% | | | ns | 0 | Satinder (1974a) |
| 274 | Forced alcohol consumption | Various measures | S _{33,33} | MR mostly more | + | Satinder (1972a) |
| 275 | Forced alcohol choice | Relative intakes | S _{37,43} | MR mostly more | + | Satinder (1974a) |
| 276 | Preference after alcohol choice | | | MR higher | + | Satinder (1974a) |

Table I. Continued

| Item | Test | Measure | Generation | Difference | Evaluation | Reference |
|------|---------------------------------------|------------------|--------------------|------------|------------|------------------|
| 277 | Preference for morphine | Various measures | S _{39,44} | ns | 0 | Satinder (1974b) |
| 278 | Forced morphine consumption | | | ns | 0 | Satinder (1974b) |
| 279 | Preference after morphine consumption | | ? | ns | 0 | Katz (1973) |
| 280 | | | S _{39,44} | ns | 0 | Satinder (1974b) |

CONCLUSIONS

The conclusions arrived at as a result of this survey are briefly stated. They echo those Eysenck and Broadhurst expressed in 1964 and point to the massive support the many findings lend to the status of the two Maudsley strains as representing extremes of expression of a behavioral phenotype arrived at as a result of artificial selection. Despite a fair number of instances where differences which might reasonably be expected to correlate with the bidirectional selection have not appeared, there continues to be considerable evidence that the strains differ in several fundamental ways relating not only to behavior but also to associated functions which are putative substrates of it.

Differences are one thing, but interpretation is another, and the evidence in this respect is perhaps less conclusive, though still strong. A construct of emotionality still seems to be supported by the differences noted, despite exceptions for which in many cases, though not all, certain extenuating circumstances can be found. It is concluded therefore that the strains continue to be characterized by relatively stable differences in a generalized trait of emotional reactivity which expresses itself in many and various ways.

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REFERENCES

- Archer, J. (1973). Tests for emotionality in rats and mice: A review. *Anim. Behav.* **21**:205-235.
- Bailey, B. F. S., and Heald, P. J. (1961). The separation of the cytoplasmic proteins of brain by electrophoresis in a starch gel medium. *J. Neurochem.* **6**:342-349.
- Benešová, O., and Beneš, V. (1968). The relation between the type of higher nervous activity, some biochemical parameters and the reactivity to drugs. *Act. Nerv. Super.* **10**:223-231.
- Bernet, F. (1974). Personal communication.
- Blizard, D. A. (1970). The Maudsley strains: The evaluation of a possible artifact. *Psychon. Sci.* **19**:145-146.
- Blizard, D. A. (1971). Autonomic activity in the rat: Effects of genetic selection for emotionality. *J. Comp. Physiol. Psychol.* **76**:282-289.
- Blizard, D. A. (1975). Colonic reactivity in curarized rats of the MR and MNR strains: Differential response to novel stimuli and classical conditioning procedures. *Behav. Genet.* **5**:90 (abst.).

- Brewster, D. J. (1968). Genetic analysis of ethanol preferences in rats selected for emotional reactivity. *J. Hered.* 5:283-286.
- Brewster, D. J. (1969). Ethanol preference in strains of rats selectively bred for behavioral characteristics. *J. Genet. Psychol.* 115:217-227.
- Brewster, D. J. (1972). Ethanol preference in strains of rats selectively bred for behavioral characteristics. *Ann. N.Y. Acad. Sci.* 197:49-53.
- Broadhurst, P. L. (1957). Determinants of emotionality in the rat. I. Situational factors. *Brit. J. Psychol.* 48:1-12.
- Broadhurst, P. L. (1958a). Determinants of emotionality in the rat. II. Antecedent factors. *Brit. J. Psychol.* 49:12-20.
- Broadhurst, P. L. (1958b). Studies in psychogenetics: The quantitative inheritance of behaviour in rats investigated by selective and cross-breeding. *Bull. Brit. Psychol. Soc.* 34:2A (abst.).
- Broadhurst, P. L. (1960). Experiments in psychogenetics: Applications of biometrical genetics to the inheritance of behaviour. In Eysenck, H. J. (ed.) *Experiments in Personality*, Vol. I: *Psychogenetics and Psychopharmacology*, Routledge and Kegan Paul, London, pp. 1-102.
- Broadhurst, P. L. (1962). A note on further progress in a psychogenetic selection experiment. *Psychol. Rep.* 10:65-66.
- Broadhurst, P. L. (1963). The choice of animal for behaviour studies. *L.A.C. Coll. Papers* 12:65-80.
- Broadhurst, P. L. (1964). The hereditary base for action of drugs on animal behaviour. In Steinberg, H., de Reuck, A. V. S., and Knight, J. (eds.), *Animal Behaviour and Drug Action*, Ciba Foundation Symposium jointly with Co-ordinating Committee for Symposia on Drug Action, Churchill, London, pp. 224-236.
- Broadhurst, P. L. (1966). Behavioral inheritance: Past and present. *Cond. Reflex* 1:3-15.
- Broadhurst, P. L. (1967). The biometrical analysis of behavioural inheritance. *Sci. Progr.* 55:123-139.
- Broadhurst, P. L. (1970). Psikhogenetika i biometricheskii analiz nasledovaniya u krysy. *Genetika* 6:91-99.
- Broadhurst, P. L. (1973). Unpublished data.
- Broadhurst, P. L., and Eysenck, H. J. (1965). Emotionality in the rat: A problem of response specificity. In Banks, C. and Broadhurst, P. L. (eds.), *Stephanos: Studies in Psychology Presented to Cyril Burt*, University of London Press, London, pp. 202-221.
- Broadhurst, P. L., and Wallgren, H. (1964). Ethanol and the acquisition of a conditioned response in selected strains of rats. *Quart. J. Stud. Alcohol* 25:476-489.
- Broadhurst, P. L., and Watson, R. H. J. (1964). Brain cholinesterase, body build and emotionality in different strains of rats. *Anim. Behav.* 12:42-51.
- Chamove, A. (1974). Personal communication.
- Eller, G. (1974). Personal communication.
- Eysenck, H. J. (1965). *Smoking, Health and Personality*, Weidenfeld and Nicholson, London.
- Eysenck, H. J., and Broadhurst, P. L. (1964). Experiments with animals: Introduction. In Eysenck, H. J. (ed.), *Experiments in Motivation*, Pergamon, Oxford, pp. 285-291.
- Ferraro, D. P., and York, K. M. (1968). Punishment effects in rats selectively bred for emotional elimination. *Psychon. Sci.* 10:177-178.
- Festing, M., and Staats, J. (1973). Standardized nomenclature for inbred strains of rats: Fourth listing. *Transplantation* 16:221-245.
- Feuer, G. (1963a). Adrenal cortical activity and stress response in rats selectively bred for differences in behaviour. *J. Physiol.* 169:43P-44P.
- Feuer, G. (1963b). Influence of thyroid and adrenocorticotrophic hormones and of genetic factors on cholesterol metabolism in the rat. In Grant, J. K. (ed.), *The Control of Lipid Metabolism*, Academic Press, London, pp. 99-100.
- Feuer, G. (1969). Difference in emotional behaviour and in function of the endocrine system in genetically-different strains of albino rats. In Bajusz, E. (ed.), *Physiology and Pathology of Adaptation Mechanisms*, Pergamon, Oxford, pp. 214-233.

- Fulker, D. W. (1970). Maternal buffering of rodent genotype responses to stress: A complex genotype-environment interaction. *Behav. Genet.* **1**:119-124.
- Fulker, D. W. (1972). Personal communication.
- Fulker, D. W., and Rick, J. T. (1973). Effects of preweaning stimulation on the GABA production in rat cortex. *Develop. Psychobiol.* **6**:349-356.
- Garg, M. (1969a). The effects of some central nervous system stimulant and depressant drugs on rearing activity in rats. *Psychopharmacologia* **14**:150-156.
- Garg, M. (1969b). Variations in effects of nicotine in four strains of rats. *Psychopharmacologia* **14**:432-438.
- Garg, M. (1970). Combined effect of drug and drive on the consolidation process. *Psychopharmacologia* **18**:172-179.
- Garg, M., and Holland, H. C. (1967). Consolidation and maze learning: A comparison of several post-trial treatments. *Life Sci.* **6**:1987-1997.
- Garg, M., and Holland, H. C. (1968a). Consolidation and maze learning: A further study of post-trial injections of a stimulant drug (nicotine). *Int. J. Neuropharmacol.* **7**:55-59.
- Garg, M., and Holland, H. C. (1968b). Consolidation and maze learning: The effects of post-trial injections of a depressant drug (pentobarbital sodium). *Psychopharmacologia* **12**:127-132.
- Garg, M., and Holland, H. C. (1968c). Consolidation and maze learning: The effects of post-trial injections of a stimulant drug (picrotoxin). *Psychopharmacologia* **12**:96-103.
- Garg, M., and Holland, H. C. (1969). Consolidation and maze learning: A study of some strain/drug interactions. *Psychopharmacologia* **14**:426-431.
- Gray, J. A. (1965). A time-sample study of the components of general activity in selected strains of rats. *Can. J. Psychol.* **19**:74-82.
- Gray, J. A. (1971). *The Psychology of Fear and Stress*, Weidenfeld and Nicholson, London.
- Gray, J. A. (1974). Personal communication.
- Gray, J. A., and Levine, S. (1964). The effect of induced oestrus on emotional behaviour in selected strains of rats. *Nature* **201**:1198-1200.
- Gray, J. A., Levine, S., and Broadhurst, P. L. (1965). Gonadal hormone injections in infancy and adult emotional behaviour. *Anim. Behav.* **13**:33-45.
- Gregory, K. (1967a). A note on strain differences in exploratory activity (rearing). *Life Sci.* **6**:1253-1256.
- Gregory, K. (1967b). Stress and strain—The suppression of activity in two strains of rats after exposure to electric shock. *Act. Nerv. Super.* **9**:140-144.
- Gregory, K. (1968). The action of the drug prenylamine (Segontin) on exploratory activity in strains of rats selectively bred for differences in emotionality. *Psychopharmacologia* **13**:29-34.
- Gregory, K., and Liebelt, E. (1967). An examination of sex and strain differences in the rearing response to a novel environment. *Act. Nerv. Super.* **9**:137-139.
- Gregory, K., Gupta, B. D., and Holland, H. C. (1967). The effects of drugs on activity in two strains of rats selectively bred for high and low emotionality. *Life Sci.* **6**:981-988.
- Groves, J. R. (1971). Some determinants of individual differences in rats: Behavioural arousal and learning. Unpublished doctoral dissertation, University of London.
- Gupta, B. C., and Gregory, K. (1967). The effects of drugs and their combinations on the rearing response in two strains of rats. *Psychopharmacologia* **11**:365-371.
- Gupta, B. D., and Holland, H. C. (1969a). An examination of the effects of stimulant and depressant drugs on escape/avoidance conditioning in strains of rats selectively bred for emotionality/non-emotionality. *Psychopharmacologia* **14**:95-105.
- Gupta, B. D., and Holland, H. C. (1969b). An examination of the effects of stimulant and depressant drugs on escape/avoidance conditioning in strains of rats selectively bred for emotionality/non-emotionality: Intertrial activity. *Int. J. Neuropharmacol.* **8**:227-234.
- Gupta, B. D., and Holland, H. C. (1972a). An examination of the effects of stimulant and depressant drugs on escape/avoidance conditioning in strains of rats selectively bred for emotionality/non-emotionality: A multivariate analysis of the effects of drugs on conditioned avoidance responses and intertrial activity. *Neuropharmacology* **11**:23-30.

- Gupta, B. D., and Holland, H. C. (1972*b*). Emotion as a determinant of the effects of drugs and their combination on different components of behaviour in rats. *Neuropharmacology* **11**:31-38.
- Hall, C. S. (1938). The inheritance of emotionality. *Sigma Xi Quart.* **26**:17-27, 37. Also in Martin, W. F., and Stendler, C. B. (eds.) (1954). *Readings in Child Development*, Harcourt Brace, New York, pp. 58-68.
- Harrington, G. M. (1971*a*). Strain differences among rats initiating exploration of different environments. *Psychon. Sci.* **23**:348-349.
- Harrington, G. M. (1971*b*). Strain differences in rotating wheel activity of the rat. *Psychon. Sci.* **27**:363-364.
- Harrington, G. M. (1972). Strain differences in open-field behavior of the rat. *Psychon. Sci.* **27**:51-53.
- Harrington, G. M., and Hanlon, J. R. (1966). Heart rate, defecation and genetic differences in rats. *Psychon. Sci.* **6**:425-426.
- Holland, H. C. (1974). Temperament and tumour: A note on the growth index in two strains of rats following the implantation of a carcinogenic agent. *Act. Nerv. Super.* **16**:17-19.
- Holland, H. C., and Gupta, B. D. (1966). The effects of different doses of methylpentynol on escape/avoidance conditioning in two strains of rats selectively bred for high and low "emotionality." *Psychopharmacologia* **9**:419-425.
- Holland, H. C., and Gupta, B. D. (1967). Effects of drugs on the rearing response in emotionally reactive and non-reactive rats. *Act. Nerv. Super.* **9**:134-136.
- Imada, H. (1970). Amount of open-field defecation, home cage defecation and food and water intake in Maudsley reactive and non-reactive strains of rats. *Ann. Anim. Psychol.* **20**:1-6.
- Imada, H. (1972). Emotional reactivity and conditionability in four strains of rats. *J. Comp. Physiol. Psychol.* **79**:474-480.
- Joffe, J. M. (1964). Avoidance learning and failure to learn in two strains of rats selectively bred for emotionality. *Psychon. Sci.* **1**:185-186.
- Joffe, J. M. (1965*a*). Effect of foster-mothers' strain and pre-natal experience on adult behaviour in rats. *Nature* **208**:815-816.
- Joffe, J. M. (1965*b*). Genotype and prenatal and premating stress interact to affect adult behavior in rats. *Science* **150**:1844-1845.
- Joffe, J. M. (1969). *Prenatal Determinants of Behaviour*, Pergamon Press, Oxford.
- Katz, D. M. (1973). Personal communication. In Kumar, R., and Stolerman, I. P., Morphine dependent behaviour in rats: Some clinical implications. *Psychol. Med.* **3**:225-237.
- Keehn, J. D. (1972*a*). Schedule-induced drinking and biting by the Maudsley strains of rats. Unpublished manuscript.
- Keehn, J. D. (1972*b*). Effects of trihexyphenidyl on schedule-induced alcohol drinking by rats. *Psychon. Sci.* **29**:20-22.
- Keehn, J. D. (1974). Agresión dependiente de programas. In Bandura, A., and Ribes, E. (eds.), *Modificación de Conducta: Análisis Experimental de la Delincuencia y la Agresión Social*, Trillas, México.
- Lonowski, D. J., Levitt, R. A., and Larson, S. D. (1974). Mouse killing and carrying by Maudsley and Long-Evans strain rats. Unpublished manuscript.
- Martin, L. K., and Powell, B. J. (1970). Role of drug effects and UCS intensity in avoidance acquisition of the Maudsley MNR and MR strains. *Psychon. Sci.* **18**:44-45.
- Mikhail, A. A. (1969). Genetic predisposition to stomach ulceration in emotionally reactive strains of rats. *Psychon. Sci.* **15**:245-247.
- Mikhail, A. A. (1972). The effects of conditioned anxiety on the recovery from experimental ulceration. *J. Psychosom. Res.* **16**:115-122.
- Mikhail, A. A., and Broadhurst, P. L. (1965). Stomach ulceration and emotionality in selected strains of rats. *J. Psychosom. Res.* **8**:477-479.
- Powell, B. J. (1970). Alcohol effects on reversal learning in the Maudsley MR and MNR strains. *Proc. 78th Ann. Convention APA*, pp. 825-826.
- Powell, B. J., and Hopper, D. J. (1971). Effect of strain differences and D-amphetamine sulfate on avoidance performance. *Psychon. Sci.* **22**:167-168.
- Powell, B. J., and North-Jones, M. (1974). Effects of early handling on avoidance performance of Maudsley MR and MNR strains. *Develop. Psychobiol.* **7**:145-148.

- Rick, J. T., and Fulker, D. W. (1972). Some biochemical correlates of inherited behavioural differences. In Bradley, P. B., and Brimblecombe, R. W. (eds.), *Biochemical and Pharmacological Mechanisms Underlying Behaviour, Progress in Brain Research*, Vol. 36, Elsevier, Amsterdam, pp. 105-113.
- Rick, J. T., Huggins, A. K., and Kerkut, G. A. (1967). The comparative production of γ -amino butyric acid in the Maudsley reactive and non-reactive strains of rat. *Comp. Biochem. Physiol.* **20**:1009-1012.
- Rick, J. T., Tunnicliff, G., Kerkut, G. A., Fulker, D. W., Wilcock, J., and Broadhurst, P. L. (1971). GABA production in brain cortex related to activity and avoidance in eight strains of rat. *Brain Res.* **32**:234-238.
- Robinson, R. (1965). *Genetics of the Norway Rat*, Pergamon, Oxford.
- Satinder, K. P. (1971). Genotype-dependent effects of D-amphetamine sulphate and caffeine on escape-avoidance behavior of rats. *J. Comp. Physiol. Psychol.* **76**:359-364.
- Satinder, K. P. (1972a). Behavior-genetic-dependent self-selection of alcohol in rats. *J. Comp. Physiol. Psychol.* **80**:422-434.
- Satinder, K. P. (1972b). Effects of intertrial crossing punishment and *d*-amphetamine sulfate on avoidance and activity in selectively bred rat strains. *Psychon. Sci.* **29**:291-293.
- Satinder, K. P. (1974a). Genetic analysis of chronic alcohol intake in rats: Behavioral model. Unpublished manuscript.
- Satinder, K. P. (1974b). Genetic analysis of oral self-administration of morphine in rats. Unpublished manuscript.
- Satinder, K. P. (1974c). Genotype-specific reactions of rats to a cat. Unpublished manuscript.
- Savage, R. D. (1965). An analysis of learning curves: Inherited strain and environmental determinants. *Behav. Res. Ther.* **2**:281-283.
- Sudak, H. S., and Maas, J. W. (1964). Behavioral-neurochemical correlation in reactive and nonreactive strains of rats. *Science* **146**:418-420.
- Wampler, R. S. (1964). Summation of water aversion and hunger drives in two strains of rats selectively bred for emotionality. Paper presented at meeting of Midwestern Psychological Association.
- Weldon, E. (1967). An analogue of extraversion as a determinant of individual differences in behaviour in the rat. *Brit. J. Psychol.* **58**:253-259.
- Weldon, E. (1968a). Stimulus or stimulation: Relevant cues in a learning situation involving differences in light reinforcement. *Psychon. Sci.* **10**:239-240.
- Weldon, E. (1968b). To see, or not to see: Rearing activity as a function of changes in the visual field. *Psychon. Sci.* **12**:83-84.
- Weldon, E. (1969). Rearing activity as a measure of sensory reinforcement. *Bull. Brit. Psychol. Soc.* **22**:148 (abst.).
- Wilcock, J. (1966). The role of interfering and facilitatory responses in avoidance conditioning in rats. *Bull. Brit. Psychol. Soc.* **19**:A28 (abst.).
- Wilcock, J. (1968). Strain differences in response to shock in rats selectively bred for emotional elimination. *Anim. Behav.* **16**:294-297.
- Wilcock, J., and Broadhurst, P. L. (1967). Strain differences in emotionality: Open-field and conditioned avoidance behavior in the rat. *J. Comp. Physiol. Psychol.* **63**:335-338.
- Wraight, K. B., Weldon, E., Gupta, B. D., and Holland, H. C. (1967). The effects of post-trial injections of nicotine on the learning of an underwater discrimination task by rats. *Anim. Behav.* **15**:287-290.