Sponsoring Committee: Professor John G. Rockwell,
Professor Ernest R. Wood and Assistant
Professor Roscoe C. Brown

THE EFFECT OF SOCIAL ISOLATION ON THE BEHAVIOR

OF THE ALBINO RAT

- - - - -

GEORGE DOLGER

Submitted in partial fulfillment of the

requirements for the degree of Doctor of

Philosophy in the School of Education of

New York University

1954

Sponsoring Committee: Professor John G. Rockwell,
Professor Ernest R. Wood and Assistant
Professor Roscoe C. Brown

An Abstract of

THE EFFECT OF SOCIAL ISOLATION ON THE BEHAVIOR

OF THE ALBINO RAT

- - - - -

GEORGE DOLGER

Submitted in partial fulfillment of the

requirements for the degree of Doctor of

Philosophy in the School of Education of

New York University

1954

The Problem

The purpose in this experiment is to determine the effects of genetic social isolation on the behavior of the albino rat as measured by four variables—weight, emotionality, intelligence and dominance.

Method

The following procedure was used in the investigation. Forty newly-weaned litter mates, 20 males and 20 females, were equally divided into 4 groups and raised in isolation or communal cages. The 4 groups were identified by rearing condition and sex—communal male, communal female, isolate male, and isolate female.

At approximately 95 days of age, the rats were weighed to the nearest gram and a series of three tests was begun. The first was a measure of emotionality (timidity) based on time required for hungry animals to run and eat from a food container in a field situation. The Hebb-Williams closed-field test, a maze-type apparatus, was used to measure the problem-solving ability (intelligence) of the animals. The last test was a measure of intra- and inter-group dominance utilizing the method of paired comparisons and having matched, thirsty animals compete for water. Finally, the four variables of weight, emotionality, intelligence, and dominance were inter-correlated with each other for all four groups.

Results

The results of the experiment are as follows: The communal rats with a mean weight of 325.1 grams for the males and 206.4 grams for the females weigh significantly less than the isolated male and female animals with respective mean weights of 347.9 and 231.1 as determined by Fisher's t test for small samples. These findings are assumed to denote physical superiority for the communal groups since it has been established that thin rats are healthier than fat ones.

Similarly, the emotionality scores reveal that the communal populations required less time than the isolates to adjust to the test situation. Mean time for the communal male, communal female, isolate male, and isolate female groups is respectively 27.3, 79.1, 49.3, and 96.1 minutes. The raw data were transformed by the square root method to assure homogeneity of variance and then factorially analyzed. The calculations show that the means of the communals are significantly lower than the means of the isolates.

The closed-field test of intelligence indicated that the communal rats made fewer errors than the isolated rats. Mean error scores for the 4 groups—communal male, communal female, isolate male, and isolate female—are respectively 24.9, 33.0, 29.8, and 44.3. The reciprocally transformed raw data, subjected to an analysis of variance, demonstrates that the differences between the means are statistically significant.

The results of the competition at the water tube between rats matched for intra-group dominance and sex show that in the case of the 10 paired males, 8 communals were dominant over their isolated partners; with the females, 9 of the social rats dominated their isolated litter mates. Chi square tests of these frequencies yielded values of 2.5 for the males and 4.9 for the females, both of which are significant.

Conclusions

The foregoing test results and analyses permit the following conclusions to be drawn:

1. Albino rats raised in a social environment weigh significantly less than rats raised in isolation.

2. Albino rats reared in a social environment are significantly less emotional or timid than rats reared in isolation.

3. Albino rats raised in a communal milieu are significantly better in problem-solving ability than rats raised in isolation.

4. Albino rats reared communally are significantly dominant over rats reared in isolation.

5. The measured variables of weight, emotionality, intelligence, and dominance did not significantly intercorrelate.

31-69 32 Street

Long Island City 6, N.Y.

May 3, 1954

I hereby guarantee that no part of the dissertation
which I have submitted for publication has been heretofore
published and(or) copyrighted in the United States of America,
except in the case of passages quoted from other published
sources; that I am the sole author and proprietor of said
dissertation; that the dissertation contains no matter which,
if published, will be libelous or otherwise injurious, or
infringe in any way the copyright of any other party; and
that I will defend, indemnify and hold harmless New York
University against all suits and proceedings which may be
brought and against all claims which may be made against
New York University by reason of the publication of said
dissertation.

George Dolger
George Dolger

ACKNOWLEDGMENTS

It is with a great deal of pleasure that the writer acknowledges the assistance of the people who have contributed to the production of this thesis. To the members of the Committee, Professors John G. Rockwell, Ernest R. Wood, and Roscoe C. Brown, many thanks for their constructive criticizms and guidance.

I am particularly indebted to Mr. Alfred Plimack, who contributed considerable time and aid in the construction of the animal cages and testing equipment.

Finally, I would like to express my deepest gratitude to my wife, Barbara, who not only typed the entire manuscript, but more important provided encouragement and comfort throughout a difficult period.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

THE PROBLEM

General Statement

It is virtually a matter of common knowledge that for human beings social organization and interaction, both familial and cultural, are of the utmost importance for optimal physical and mental development. On the other hand, as one progresses down the evolutionary and phylogenetic scales, there is increasingly less dependence on the social matrix and more emphasis on the ontogenetic and endogenous processes of growth in the organism. It would be; therefore, of more than mere passing interest, in this connection, to select a species of lower animal and ask the question, "What effect, if any, does social development—or conversely, non-social development—have on the behavior of this animal?"

Consequently, the purpose in this investigation is to measure and compare certain aspects of the growth and behavior of male and female albino rats reared in experimental isolation with those reared in a communal milieu.

Specific Problems

1. To weigh and compare differences in weight between the groups.

2. To determine and test differences in emotionality between the groups.

3. To determine and test differences in learning abil-

ity between the groups.

4. To measure and compare dominance in and between the groups.

5. To discover the relationships between emotionality, weight, intelligence, and dominance in each group.

Definition of Terms

Learning Ability

Learning ability or intelligence (the words are used synonomously here) are operationally defined in this experiment as the rat's demonstrated problem-solving facility in a standardized situation. The performance score is viewed as an index of intelligence.

Emotionality

Emotionality is defined as the state of being emotional. This state involves a constellation of physiologic, experiential, and expressive reactions and denotes a general upset or excited condition of the organism. Since animals and men vary in intensity of emotional expression, emotionality can be considered a trait. It is not, however, a distinct entity or faculty, but rather a convenient concept for describing a complex of factors. Phenomenally, it is viewed as fearful or timid behavior in a novel situation.

Dominance

Dominance or dominant behavior occurs when one organism

satisfies its needs before or at the expense of others.

Communality

A communal or social milieu is defined as one which contains two or more occupying organisms and allows for their interaction and the formation of relationships.

Isolation

Isolation refers to the absence of social interactions and development of inter-organismic relationships as a result of solitary confinement.

Split-litter technique

The split-litter technique is a method whereby litter mates are evenly divided into two or more groups on the basis of one or more characteristics—sex, weight, etc., thereby minimizing hereditary differences.

Delimitations

As a study in animal psychology, the experimental population consists of mature, highly inbred, male and female albino rats of approximately the same age. The animals, by the split-litter technique, are divided into four groups—communal male, communal female, isolated male, and isolated female. A rat in any one group is represented by litter mates in the other groups. This type of selection makes for a relatively homogeneous sampling since hereditary differences tend to be minimized. Litter mates with obvious physical deficiencies

or deformities are excluded from the experiment.

Basic Assumptions

It is assumed for purposes of this investigation that the various tests to which the rats are subjected are sufficiently sensitive to reliably and validly measure differences in behavioral development and adjustment resulting from the experimental design. It is further assumed that hereditary differences between the animal subjects are minimal and non-significant.

Basic Hypothesis

The main hypothesis in this experiment is that the social rats, in comparison with the isolated rats, will evidence a superior type of adjustment and behavior as a result of their communality. Superiority has as its referent any modification of behavior which may be construed as being of greater survival benefit to the organism.

Sub-hypotheses

1. The communal groups will weigh significantly less than the isolated groups.

2. The communal groups will display significantly less emotionality than the isolated groups.

3. The communal groups will be significantly superior to the isolated groups on the basis of measured intelligence.

4. The communal groups will be significantly dominant

over the isolated groups.

5. The measured variables of intelligence, emotional-
ity, dominance, and weight will significantly intercorrelate.

The Need for the Study

In a recent discussion of conceptual trends in compara-
tive psychology, Schneirla[1] has noted that animal social in-
vestigations are as yet fairly uncommon and that psychology
is even less productive than biology in this area of research
activity.

Yet as early as 1937, A. H. Maslow[2] drew attention to
the need for a comparative social psychology. He stressed
the fact that since animals have minimal or no culture and
consequently lack repression, in the Freudian sense, truer
relations between social and psychological factors can be
established. The comparative method lends itself to dealing
with such problems as ascendence-dominance, social-emotional
expression, competition-cooperation, sexual behavior, etc.,
and seems to offer a prolific source of experimentation. In
this way, Maslow continues, a more valid understanding of
social behavior should be theoretically obtainable. It is
also probable that the comparative method offers the most

1. T. C. Schneirla, "A Consideration of Some Conceptual
    Trends in Comparative Psychology," Psychological
    Bulletin, 49, 1952, pp. 559-597.
2. "The Comparative Approach to Social Behavior," Social
    Forces, 15, 1937, pp. 487-490.

promising way of separating the biological from the purely cultural in social behavior. This opens wider the path to the understanding of man in general and not just man in particular.

E. R. Hilgard propounds much the same idea when he points out that few animal psychologists are concerned with animal behavior per se. "Rather," he states, "they are interested instead in the more general problems of comparative psychology, with the outlook of evolutionary theory in the background. Ultimately, the knowledge of animal behavior is to be placed on a continuum with human behavior."[1]

One of the best illustrations of the afore-mentioned viewpoints and the heuristic and epistemological value of comparative studies may be found in the recent work of Clellan S. Ford and Frank A. Beach on sexual behavior.[2] By utilizing an interdisciplinary approach which combined biology, psychology, and sociology, and exploring a range of mammalian sex life, these authors have placed human sexuality in a more correct evolutionary and comparative perspective, and thereby added significant increments to the fund of knowledge concerning this area of human behavior.

Another excellent example of a not entirely dissimilar kind of comparative colligation is contained in W. C. Allee's[3]

---

1. Theories of Learning, p. 328.
2. Patterns of Sexual Behavior.
3. Cooperation Among Animals.

book dealing with the social life of animals. His data and
exposition are particularly germane to the present investi-
gation. Allee cites a large number of experiments showing
that group living as against solitary or isolated living
under a variety of conditions is biologically valuable,
since it bestows greater survival benefits to the organ-
ismal aggregations. This interaction between organisms
leading to mutual support and aid, Allee defines as a pro-
cess of proto-cooperation or unconscious mutualism (Schneirla
prefers to speak of "bio-social facilitation")[1] and propounds
the theory that it is a fundamental life principle operating
at all phylogenetic levels of animal behavior.[2] Furthermore,
he feels that cooperation has played an equal, if not more
important, role than competition in the evolution of life.

Assuming Allee's thesis to be biologically true, the
question raised, then, is whether analogous <u>psychological</u>
values can be demonstrated in animal aggregations? More
specifically, will the process of proto-cooperation or bio-
social facilitation be reflected in the social development

1. T. C. Schneirla, "Problems in the Biopsychology of
   Social Organization," <u>Journal of Abnormal and Social
   Psychology</u>, 41, 1946, pp. 385-402.
2. Earlier exponents of this viewpoint include Petr Kropot-
   kin, <u>Mutual Aid: A Factor In Evolution</u> (1902); Lester
   Ward, <u>Dynamic Sociology</u> (1893); W. M. Wheeler, <u>The
   Social Life of Insects</u> (1922). Some of the most re-
   cent thinking on this subject is offered by M. F.
   Ashley Montagu in two books: <u>On Being Human</u> (1951)
   and <u>Darwin, Competition and Cooperation</u> (1952).

of the rat in contrast to solitary development?

The proposed investigation also holds definite impli-
cations for education and educational psychology. Dewey
and other progressive educators (the term is used generi-
cally) have long stressed the role of experience and social
interaction in the education and total growth of the child.
Learning is conceptualized in a dynamic and organismic
framework—it is based on experience, it necessitates res-
onse to situations, it is a growth process, and it involves
emotional concommitants. The importance that Dewey attaches
to his experiential theory is indicated in the following
quote—"...the fundamental unity of the newer philosophy
is found in the idea that there is an intimate and necessary
relationship between the processes of actual experience and
education."[1]

It should be noted that no attempt is being made to
equate the experiences and learning processes of a rat with
those of a human being, although some psychologists consider
learning in both organisms as highly analogous. However, if
it can be experimentally demonstrated that the development
of communal rats is superior to that of isolated litter-mates,
then, the theory of experience and the theory of cooperation,
psychologically, may be extended along the evolutionary scale,

---

1. John Dewey, Experience and Education, p. 7.

thereby becoming more generalized, valid and meaningful.

Finally, a behavioral analysis of the effects of the experimental experiences may be expected to provide insight into the more elemental forms of animal social interaction and reaction, particularly since heredity is controlled and cultural transmission is absent.

CHAPTER II

REVIEW OF THE LITERATURE

Effect of Genetic Isolation on Human Beings

Although interest in the question of the effects of social isolation on the development and behavior of human beings dates back considerable time, little experimental literature is available because of obvious ethical considerations. The first attempt, nevertheless, to answer the query was made several centuries B.C. by Psammetichus who reputedly had two children reared apart from speaking adults in order to determine whether or not they would develop language in the absence of adult example.[1] The answer, however, was not specifically forthcoming until the present century, when an illegitimate child reared in seclusion with her deaf-mute mother was discovered at the age of $6\frac{1}{2}$ years.[2] Communication with her mother was limited to gestures, the child having never learned to speak. After two years of speech training, albeit, she was able to talk with the verbal facility of a six-year old.

The study, and mostly anecdotal reporting, of the behavior of so-called wild children, i.e., children lost or abandoned in uninhabited regions and left to their own

---

1. Herodotus, The History of Herodotus, pp. 110-111.
2. M. K. Mason, "Learning to Speak After Six and One-Half Years of Silence," Journal of Speech Disorders, 7, 1942, pp. 295-304.

devices, provides additional information on this subject.
The most famous of these feral children was Victor, the
wild boy of Aveyron, who was intensively studied and
trained by the physician, Itard.[1] The boy had been found
in some woods at the age of ten, and after having been
placed on public exhibition was put in Itard's care. At
this time, Victor was described as a dirty, scarred, and
inarticulate being, who trotted and grunted like a beast
of the field, ate the most filthy refuse, and was incap-
able of attention, and generally apathetic. After two
years of diligent instruction, there was to be seen an al-
most normal child who could not speak, but who lived like
a human being; clean, affectionate, even able to read a
few words and to understand much that was said to him.
Apparently the boy never developed much beyond this stage
because three years later his total vocabulary consisted
of two words. He died at the age of forty, much improved
but still sub-normal.

An even more dramatic illustration of the need for
social interaction in human development is seen in the
case of Anna,[2] an illegitimate girl born in a nursery and
noted at the time as normal. She was discovered at the age of
five, confined in the attic storage room of a farmhouse.

------

1. J. M. G. Itard, The Wild Boy of Aveyron.
2. K. Davis, "Extreme Isolation of a Child," American
        Journal of Sociology, 45, 1940, pp. 554-565; and
        52, 1947, pp. 432-435.

The child had been given no solid food, fed milk and oatmeal gruel by spoon, and had not been allowed to walk or talk. She was described as "just skin and bones;" unable to stand or walk, talk, chew, or drink. She had never been bathed nor had toilet training. The child was removed to a county home, where given proper feeding, massage and care, she sat up within three days. Soon after she began to make rudimentary responses: looked up when the door opened, frowned, scowled, and revealed temper when restrained. At six years of age, after five months of treatment, she attained the performance score on a standard test of a one year old child. At ten years of age, when she died, Anna had developed speech to about the two year level and was rated at about the $2\frac{1}{2}$ year level of intelligence. The author of the report concluded that this case "...like others, seems to demonstrate the Cooley-Mead-Dewey-Farris theory of personality—namely, that human nature is determined by the child's communicative social contacts as much as by his organic equipment and that the system of communicative symbols is a highly complex business acquired early in life as the result of long and intimate training."[1]

Although the previously described cases are quite helpful in understanding the effects of social isolation, they were fortuitous and unplanned. The only experimental study,

---

1. _Ibid._, p. 564.

to date—not without limitations, however—is that made by Wayne Dennis.[1] He and his wife raised a set of fraternal twins from the age of one lunar month to 15 lunar months for the purpose of determining the responses which a child would develop if he were removed as far as is possible from the influence of adults and of other children. The care of the children was consequently reduced to the minimum attention required to insure their physical comfort and well-being. At the end of the experiment it was reported that the twins were model babies—healthy, happy and active. The author concluded that practically all the common responses of the first year of life may be developed autogenously. That is, infants will develop these responses without encouragement or instruction, reward or punishment. Sociogenic factors would, then, seem to be most important after the first year of life. Dennis' results tend to contradict the position taken by such people as Spitz,[2] Ribble,[3] and Bakwin,[4] who contend that the absence of a mother or mother-figure during the first year of life severely limits the child's emotional, intellectual, and neuro-muscular development.

In conclusion, mention must also be made of the depress-

---

1. "Infant Development Under Conditions of Restricted Practice and of Minimum Social Stimulation," Genetic Psychology Monographs, 23, 1941, pp. 143-190.
2. R. A. Spitz, Grief: A Peril in Infancy. Cited in Ruch, F. L., Psychology and Life, p. 444.
3. M. A. Ribble, The Rights of Infants.
4. H. Bakwin, "Loneliness In Infants," American Journal of Diseases of Children, 63, 1942, pp. 30-40.

ing and debilitating effects of isolated group living on the
personality development of human beings. Colvin Hollow, a
secluded hamlet in the Appalachian Mountains, epitomizes
such a state. The inhabitants of this village were character-
ized as having little anxiety, their emotions dulled and apa-
thetic, their intelligence retarded, and their way of life
stereotyped and static.[1]

Effect of Genetic Isolation on Infrahuman Primates

Infant primates have been reared in isolation from kind
for the chief purpose of observing the maturation of innate
behavior patterns and physical growth. Jacobsen, et al.,[2]
reared a chimpanzee from birth to nine months and described
her development and the first responses of the infant to
another at the end of isolation. Aggression by the young ape
was replaced by dependence on her companion after a few weeks.
Two studies, reported by Foley,[3] [4] focused on the physical
development of a male rhesus monkey reared in isolation for
two years. No detailed account of the initial adaptation
to other monkeys after the isolated period was given beyond

1. M. Sherman and J. Henry, Hollow Folk.
2. C. F. Jacobsen, M. N. Jacobsen and J. G. Yoshioka,
   "Development of an Infant Chimpanzee During Her First
   Year," Comparative Psychological Monographs, 9,
   1932, No. 41.
3. J. P. Foley, Jr., "First Year Development of a Rhesus
   Monkey (Macaca Mulatta) Reared in Isolation," Journal
   of Genetic Psychology, 45, 1934, pp. 39-105.
4. J. P. Foley, Jr., "Second Year Development of a Rhesus
   Monkey (Macaca Mulatta) Reared in Isolation During
   the First Eighteen Months," Journal of Genetic
   Psychology, 47, 1935, pp. 73-97.

a general statement—about genital exploration and preference

for females by the experimental male.

Effect of Genetic Isolation on Infra-primate Mammals

As with nonhuman primates, infra-primate mammals (in par-

ticular, the rat) have also been experimentally isolated for

purposes of studying the development of innate behavior.

Stone's observations that male[1] and female[2] rats reared in

isolation until the age of puberty mate in typical adult fash-

ion have been verified and amplified by Beach,[3] who was par-

ticularly interested in discovering whether isolation weakens

the sex drive and whether isolation alters the normal copula-

tory pattern. Beach found that the isolated group copulated

more frequently than the cohabitating group. The greater in-

cidence of copulation in the isolated rats was attributed to

(1) greater excitability resulting from the novelty of contact

with another animal and (2) greater weight, since copulators

in either group weighed more on the average than non-copula-

tors, and the isolated rats, as a group, weighed more than

the cohabitating animals.

---

1. C. P. Stone, "Congenital Sexual Behavior of Young Male
   Albino Rats," Journal of Comparative and Physiological
   Psychology," 2, 1922, pp. 95-153.
2. C. P. Stone, "The Initial Copulatory Response of Female
   Rats Reared in Isolation from the Age of 20 Days to
   Puberty," Journal of Comparative Psychology, 6, 1926,
   pp. 73-83.
3. F. A. Beach, "Comparison of Copulatory Behavior of Male
   Rats Raised in Isolation, Cohabitation, and Segregation,"
   Journal of Genetic Psychology, 60, 1942, pp. 121-136.

Bayroff,[1] on the other hand, has utilized the isolation technique to test for gregariousness in rats. The aim of his research was to determine if rats reared in isolation would show a greater preference for rats and food, as against food alone, than rats reared under normal conditions. Two groups, divided by the split-litter method, were weaned at 19 days, after which the individuals of one group were isolated and those of the other reared together. Beginning at puberty, all animals were given preliminary training in a two-choice apparatus and then offered 60 daily opportunities to choose between compartments containing two other rats and food, and only food. A second experimental series employed only stimulus animals versus an empty compartment. In neither series were consistent differences found between the social preferences of isolated rats or rats reared in a group. In a later investigation, Bayroff[2] again failed to demonstrate the influence of early isolation on later social behavior. He paired previously isolated and normal rats and had them compete for a quick means of escape from water. Only one rat could escape at a time, hence the tardy animal was temporarily trapped under water. Winners of this contest were as frequently from one group as

———

1. A. G. Bayroff, "The Experimental Social Behavior of Animals. I. The Effect of Early Isolation of White Rats as Measured by Two Periods of Free Choice," Journal of Comparative Psychology, 21, 1936, pp. 67-81.
2. A. G. Bayroff, "The Experimental Social Behavior of Animals. II. The Effect of Early Isolation of White Rats on Their Competition in Swimming," Journal of Comparative Psychology, 29, 1940, pp. 293-306.

from the other; therefore, a social or non-social history apparently had no influence. Bayroff warns, however, that his conclusions are limited to his methodological approach and do not strictly deny the presence of a gregarious tendency in rats. Perhaps the rather disappointing results of such careful experimentation on this topic came from an over-eagerness for quantification to the neglect of systemic qualitative observation which might have indicated striking peculiarities in interactive behavior of socially naive subjects.

Effect of Genetic Isolation on Birds

Pattie,[1] in an experiment similar to that of Bayroff's,[2] explored the effect of early isolation on the social responsiveness (gregariousness) of chickens. He arranged a pen with two stimulus compartments, one containing two chicks and the other, two white mice. Beginning with the fourth day of life, 42 isolated chicks and 42 normals were placed one at a time, daily, for 30 minute periods in the test pen. The period of time spent in front of each stimulus compartment was automatically recorded. Testing was continued for six days. Social preferences measured in this way showed no significant differences between isolated and control animals, but when the first

---

1. F. A. Pattie, Jr., "The Gregarious Behavior of Normal Chicks and Chicks Hatched in Isolation," Journal of Comparative Psychology, 21, 1936, pp. 161-178.
2. A. G. Bayroff, "The Experimental Social Behavior of Animals. I. The Effect of Early Isolation of White Rats on Their Later Reactions to Other White Rats as Measured by Two Periods of Free Choice," Journal of Comparative Psychology, 21, 1936, pp. 66-81.

three days were considered, a preference of the isolated chicks for other chicks was displayed which waned in favor of a preference for mice on the last three days.

Judging from the Bayroff[1] and Pattie[2] research, it would appear that the naturally observed propensity of rats and chicks to associate with their own kind is more a function of learned or acquired factors than any innate or instinctive type of response.

Bruckner[3] investigated social responsiveness of chicks in a somewhat different manner. He reared two domestic chicks in a brooder with translucent windows, which allowed them to see the shadows of other chicks and to hear them. While alone they developed various types of play and tossed worms and other food about as if other chicks were present and competing for them. After seven weeks each isolated chick was paired with another. Fighting, as well as pecking at a mirror image of itself, occurred. Upon being released into a group of 250 chicks, the isolated animals showed bewilderment and retreated to secluded nesting places as soon as possible to avoid pecking by the others.

W. Craig, in one of the earliest experiments of this

---

1. Loc. cit.
2. Pattie, op. cit.
3. G. H. Bruckner, "Untersuchungen zur Tiersoziologie, insbesondere zur Auflosung der Familie," Z. Psychologie, 128, 1933, pp. 1-110. Cited in M. P. Crawford, "The Psychology of the Vertebrates, "Psychological Bulletin, 36, 1939, p. 430.

kind, reared three male doves in isolation for periods of from one to three years and observed their initial responses to females. Two of the three birds made sexual responses to his hand, which fed them. In contrast to the rats previously mentioned, all the doves displayed maladaption to mating when paired with a female, but became proficient after some time. The symbolic function of the experimenter's hand as a stimulus for all sorts of social and sexual responses is perhaps the most interesting result of the study.[1]

Finally, in an investigation of communication in chickens, it was found that crowing by young males was the only vocalization—of 13 types of vocalizations—which appeared earlier in chicks within sight and sound of adults than in isolated individuals.[2]

Biological Effect of Isolation

The biological value of group living as opposed to isolation has been intensively studied and summarized by Warder C. Allee.[3] In a number of experiments he found, that varying with the nature of the environment, the isolated organism will, in general, evidence retardation of growth, be irremed-

1. "Male Doves Reared in Isolation," Journal of Animal Behavior, 4, 1914, pp. 121-133.
2. T. Schjelderup-Ebbe, "Weitere Beitrage zur Sozial-und Individual-Psychologie des Haushuhns, "Z. Psychologie, 92, 1923, pp. 60-87. Cited in M. P. Crawford, "The Psychology of the Vertebrates," Psychological Bulletin, 36, 1939, p. 432.
3. Cooperation Among Animals.

iably damaged, or die; where the organism living in a group constellation will increase in size and in speed of its physiological reactions, tend to recover more quickly from body damage, and survive more often.

Thus planarian worms[1] which had been exposed to ultra-violet radiation disintegrated more rapidly when isolated than when they were associated together. In another experiment, goldfish[2] introduced together in groups of ten into a lethal suspension of colloidal silver survived much longer than those which were placed in similar suspensions alone. The explanation lay in the fact that the group fish, when exposed to the toxic solution, shared between them a dose easily fatal for any one of them. The slime they secreted changed much of the silver into a less toxic form, thereby extending their survival period. This experiment illustrates in the case of goldfish—and presumably holds true for other aquatic life—the physicochemical basis of the advantage which lies in numbers.

Further study by Allee and Evans[3] on the rate of clea-

---

1. W. C. Allee, "Group Protection for Euplanaria Doroto-cephela from Ultra-Violet Radiation," Physiological Zoology, 12, 1938, pp. 110-135.
2. W. C. Allee, and E. Bowen, "Studies in Animal Aggre-gations: Mass Protection Against Colloidal Silver Among Goldfishes," Journal of Experimental Zoology, 61, 1932, pp. 185-207.
3. W. C. Allee and G. Evans, "Some Effects of Numbers Present on the Rate of Cleavage and Early Development in Arbacia," Biological Bulletin, 72, 1937, pp. 217-232.

vage of the fertilized egg of the common sea urchin, arbacia,

showed that the rate was more rapid in the denser clusters

of eggs than in unclustered or isolated fellow eggs. Another

investigation has indicated that protozoans[1] grew faster

when placed in large numbers into a sterile medium of simple

salts than if the cultures were started with only a few or-

ganisms. Again, in the bacteria, Escherichia,[2] it has been

demonstrated that they did not thrive if inoculated in small

numbers, but with larger numbers the culture survived. In

this connection, it has been established that 30 bacteria

neutralize at least 200 times the amount of poison that can

be neutralized by an isolated bacterium.

The biological advantages seem to be primarily in the

crowding—not overcrowding—while separation or isolation

would appear to be inimical to the proper development and

growth of the organism. What constitutes an optimal popula-

tion size for different groups in nature will depend upon the

group and its environment, but present evidence strongly

suggests that optimal numbers present in a given situation

have certain positive survival values and exert stimulating

effects on the growth of individuals and the increase of

populations.

1. W. H. Johnson, "Experimental Populations of Microscopic
   Organisms," American Naturalist, 71, 1937, pp. 5-20.
2. J. Churchman and M. Kahn, "Communal Activity of Bacteria,"
   Journal of Experimental Medicine, 33, 1921, pp. 583-
   591.

In summary, the technique of experimental isolation has been applied to a fairly large variety of organisms for purposes of studying both psychogenic and biogenic processes. These investigations have been concerned with problems of physical growth, sexual maturation, social interaction, gregariousness, symbolic behavior, and mass protection.

CHAPTER III

PROCEDURE IN COLLECTING DATA

Description of Subjects and Experimental Conditions

The animal population used in this investigation consisted of 20 male and 20 female albino rats. Half of each sex was raised under conditions of partial isolation and the remaining half in a social environment, making a total of four groups—male isolated, female isolated, male communal, and female communal—with 10 animals to each group. The subjects were bred from the Wistar-strain colony maintained by the School of Education, New York University.

Thirteen females and only two males were used for breeding, thus still further reducing hereditary differences. The male and female pups of 10 litters, all born within 6 days of each other, were weaned at 21 days and assigned randomly to each of the 4 experimental groups on the basis of the split-litter method. Thus a rat in one group was represented by its litter-mates in the other three groups. That is to say that all the animals from litter 1 were designated as rat number 1 in each of the four groups. The rats from litter 2 were designated as rat number 2 and so on through litter 10.

Immediately after weaning the male and female pups, which constituted the isolated groups, were placed in individual cages. These isolation cages were 12 inches long, 6 inches wide and 8 inches high, constructed of pine wood on the four sides with a wire mesh floor and a removable wire

mesh top. Under this procedure, tactual contacts and social relationships were completely excluded. As previously stated, however, the isolation was only partial or incomplete, since auditory and olfactory stimulation from other rats was uncontrolled, the animals all having lived in the same room.

The communal or social rats, on the other hand, were divided into two groups, the females occupied one cage and the males another. The communal cages were identical in construction with the isolation cages except that they were much larger, measuring 25 inches long, 12 inches wide, and 9 inches high. Here the rats were in intimate contact and actively interacting with one another. In this sense, they may be thought of as having lived in a social environment.

As with the isolated animals, all the social rats were weaned at 21 days old. However, since the various litters were not born at the same time, those born earlier and consequently weaned earlier, remained in their post-natal cages until such time as all litters had been weaned. Thereupon, the two groups, which made up the social population, were introduced into their cages simultaneously. To do otherwise would have distorted the development of intra-group relations, since late-comers to the communal cage would have been at a disadvantage. Personal observation had indicated to the experimenter that rats already acclimated to a particular environment are in a better position to dominate new-comers entering the environment.

The diet for all animals consisted of unlimited amounts of Purina Laboratory Food Pellets and water supplemented with green vegetables.

Methods and Materials

Ninety-five days after weaning, testing was begun. Through this three month period, the rats were confined to their cages and underwent virtually no handling.

Measurement of Weight

Prior to the actual testing each animal was weighed and its weight recorded to the nearest gram.

Test of Emotionality

The first test which the subjects received was concerned with determining intra- and inter-group differences in emotionality (timidity). It was originally anticipated that the simple and expeditious technique for investigating emotionality in the rat introduced and utilized by Calvin Hall[1] in 1934 would be adopted in this experiment. Hall's study was designed to establish that defecation and urination constitute valid measures of emotionality in the rat by comparing elimination with failure to eat when hungry.

His experiment employed the following procedure. Hungry

---

1. C. S. Hall, "Emotional Behavior in the Rat. I. Defecation and Urination as Measures of Individual Differences in Emotionality," Journal of Comparative Psychology, 18, 1934, pp. 385-403.

rats were individually placed at the edge of a circular enclosure, eight feet in diameter, with a receptacle in the center containing wet mash. Each animal remained in the field for a period of three minutes a day for twenty days. While in the field the animals were observed and record kept of the number of trials in which the rats defecated, urinated, and ate food.

When Hall correlated the number of trials in which the animals failed to eat with the number of trials they defecated, he found a correlation coefficient of .82 with a probable error of .04. Urination yielded a corresponding correlation of .70 plus or minus .06. These correlations suggested that the test was actually measuring what it purported to measure—namely, individual differences in emotionality.

Additional data contributed by Hall,[1] and Tryon, Tryon, and Kuznets[2] appeared to support Hall's contention that defecation and urination in the rat provide valid information on differences in emotionality.

O'Kelley's[3] findings, published in 1940, alone cast

1. C. S. Hall, "Drive and Emotionality: Factors Associated with Adjustment in the Rat," Journal of Comparative Psychology, 17, 1934, pp. 80-108.
2. R. C. Tryon, C. M. Tryon, and G. Kuznets, "Studies in Individual Differences in Maze Ability. X. Ratings and Other Measures of Initial Emotional Responses of Rats to Novel Inanimate Objects," Journal of Comparative Psychology, 32, 1941, pp. 447-473.
3. L. I. O'Kelley, The Validity of Defecation as a Measure of Emotionality in the Rat," Journal of General Psychology, 23, 1940, pp. 75-87.

some doubt on the validity of Hall's test. He failed to
discover significant differences in speed of locomotion
between defecating and non-defecating rats. Furthermore,
differences in average time scores in a water maze were only
slightly significant, the defecating group being the more
rapid instead of the slower, as was anticipated. The latest
experimentation on this problem, reported in 1953, by Bindra
and Thompson[1] reaffirmed O'Kelley's results. Their experi-
ment was patterned somewhat after Hall's original validating
study and tested his proposition that elimination and defeca-
tion constituted valid indices of emotionality or fearfulness.
They correlated emotional elimination scores with fearfulness
as measured by failure to eat when hungry. A correlation co-
efficient of -.06 between these 2 measures was obtained. The
authors concluded, therefore, that emotional elimination was
not a generally valid test of emotionality or fearfulness.

It was apparent after reviewing the literature that
Hall's defecation-urination test would be unsuitable for ex-
perimental purposes. Consequently, the tentative procedure
was revised and a different technique for measuring individual
differences in emotionality was substituted. This was done by
utilizing a modification of Hall's[2] original validating method;

_____

1. D. Bindra and W. R. Thompson, "An Evaluation of Defeca-
   tion and Urination as Measures of Fearfulness," Jour-
   nal of Comparative and Physiological Psychology, 46,
   1953, pp. 43-45.
2. Hall, op. cit.

namely, inhibited eating of hungry rats as a function of timidity.

The use of the inhibited-eating method was accepted on a priori rather than experimental grounds. It seemed obvious— to paraphrase Hall's[1] argument—that if a hungry rat fails to eat in a situation in which it has already learned the location of food, the failure to do so can only be attributed to the emotionality or upset condition of the animal which vitiates against the satisfaction of the hunger drive. Certainly intellectual factors—defined as problem-solving ability— must be deemed of minimal import in such a situation.

To date, no one has seriously questioned the rationale of this viewpoint. In fact, Munn,[2] in his comprehensive review of rat psychology indicates that failure to eat under these conditions is..."generally regarded as a sign of emotionality..."

The problem of completely isolating emotional from intellectual functioning is a very difficult one and probably can never be achieved. The method of inhibited eating in the rat, as adapted in this experiment, however, probably came as close to separating these two factors as is currently possible.

------

1. C. S. Hall, "Emotional Behavior in the Rat. I. Defecation and Urination as Measures of Individual Differences in Emotionality," Journal of Comparative Psychology, 18, 1934, pp. 385-403.
2. N. L. Munn, Handbook of Psychological Research on the Rat, p. 99.

Under this technique the rats were deprived of food for 23 hours and then individually placed in the field situation— an enclosure 30 inches square and 4 inches high with a wire mesh roof—through an entrance in one corner. Diagonally across, in the opposite corner, a permanent goal box was attached which contained wet Purina mash in a fixed glass container. After a short while, the animal discovered the food and was allowed to eat for five minutes. The animal was then removed and another rat replaced it. Upon removal from the field, each animal was put in a special feeding cage and given a large food pellet, about five grams in weight, to eat.

This training was continued for four days, once a day, in order to familiarize the rats with the location of the food box; thereby minimizing intellectual factors involved in finding the food. By the end of the fourth day, it was apparent that this objective had been attained since the animals were running quickly and easily to the food, thus indicating that they were familiar with the position of the food container.

At this point the actual measure of emotionality began. Into the field apparatus were placed wooden barriers, whose function will be explained later, but suffice to say that they required little, if any, problem-solving ability to circumvent on the part of the rat in its run to the food box. A total of six patterns of barriers were used, a different pattern being set up each day, but all quite simple for the rat to navigate in its run to food. When the barriers were in position, the

animal was placed in the entrance alley and allowed to go to
the food box. Time was recorded from the moment the rat en-
tered until he took his first bite of food from the wet mash
provided in the goal box. Upon taking a few bites from the
mash, he was replaced in the entrance alley and run again.
This process was repeated nine times in a row, once a day,
for each rat until all animals reached the same criterion—
nine runs to food in 60 seconds repeated twice in succession.[1]
When the nine runs had been completed, the animal was put in
a special feeding cage and given a food pellet of uniform size.
For those animals which reached the criterion earlier, reduced
and untimed runs, three or four, were continued until all the
rats had met the same time criterion. The total amount of
time required to complete the nine runs to food—not including
time spent in the food box, after the first bite and the time
it took to replace the rat in the entrance alley—was recorded.
The sum of all time scores to the nearest second for each set
of nine runs until the criterion was reached constituted the
final score for the rat. This score was then viewed as an
index of emotionality with the assumption that the greater

---

1. Observation of the animals revealed that intellectual
   factors were negligible in determining how soon a
   rat would complete its runs. In any series of nine
   runs, the initial run was generally the fastest, while
   later runs were much slower. Furthermore, the greatest
   amount of time was spent in the area between the en-
   trance to the food box and the food container itself—
   a distance of about six inches—which was well beyond
   the barriers set up in the field.

the time score, the more emotional the rat.

The order of testing, both for the groups as a whole and the individual members within the groups, was randomized for all testing situations. This was done in order to control for serial effects as well as differences in time of testing, since the maximum time required for complete runs or trials of all 40 animals at the beginning was approximately eight hours per day, minimum time later on was about four hours.

Test of Intelligence

This particular test of learning ability departed from the more orthodox type of cul-de-sac maze learning and represented a relatively new innovation in measuring animal intelligence. It was devised and introduced by Hebb and Williams in 1946.[1] In discussing their new technique, the authors noted that a typical maze score may be either a measure of timidity, or need for food, of the exploratory drive, or a complex of these with intellectual factors—but not a clearly interpretable index of either learning ability in general nor of intelligence. Furthermore, the most valid and meaningful ratings of intelligence are not based strictly on learning scores, but on an analysis of the quality of performance in a large number of trials. They proposed, therefore, an analogous attack on the problem of estimating the mental ability

---

1. D. O. Hebb and K. Williams, "A Method of Rating Animal Intelligence," _Journal_ _of_ _General_ _Psychology_, 34, 1946, pp. 59-65.

of animals. Their method was designed to minimize variations
of motivation (either of timidity or of eagerness for food),
based its quantitative score on a large number of qualitative
analyses of performance, and was economical of time.

The results were achieved mainly by the use of a con-
stant setting for the problems and a constant goal, to which
the animal was first accustomed. The technique had the fur-
ther advantage that it approximated in this respect the human
intelligence test, which is distinguished from the more typi-
cal animal test by its use of familiar problems in a familiar
setting. The method, however, lacked in the wide variety of
tasks to be found in such a test as the Wechsler-Bellevue
Scale, but resembled the Porteus Maze, which uses the same
kind of tasks, varying only in difficulty.

Reliability coefficients obtained under various condi-
tions of testing with this test were quite respectable, rang-
ing from .66 to .85.

Although no direct evidence of validity was cited in this
report, the investigators revealed that there was some basis
for considering the test valid. Two groups of rats were tested
three times. Correlations of scores on second and third test-
ing were not lower than those obtained from the first testing.
This indicated that the differences between the rats were not
easily erased by the test experience. If high scores were due
to more rapid learning, differences should tend to disappear
with repetition of the test; and the same thing is true if

early differences in performance were to any great extent a product of timidity.

Additional experimentation by Hebb's students utilizing the "closed field intelligence test," as it is referred to, indicated that it was an efficient and valuable instrument with a high degree of reliability and validity. Rabinovitch,[1] in working through a standardization of the test, reported test-retest reliability coefficients of .84 and .80 with respective rat populations of 28 and 18. He also found that the test significantly discriminated between cortically extirpated rats, normal rats raised in small individual cages, and free environment rats raised in an extremely large cage allowing considerable freedom and movement.

Lansdell[2] in a study of the effects of brain damage on rat intelligence revealed that the test differentiated between normal and brain-damaged rats and between rats with varied amounts of cortical extirpation. His reliability coefficients for the various groups ranged from .60 to .97, when corrected by the Spearman-Brown formula.

Finally, Hymovitch,[3] in an investigation of the effects of variations of early experience on the problem-solving ability of mature rats, found that the closed-field test

_____

1. M. S. Rabinovitch, Standardization of a Closed-field Intelligence Test for Rats.
2. H. C. Lansdell, The Effect of Brain Damage on Rat Intelligence.
3. B. Hymovitch, The Effects of Experimental Variations on Problem Solving in the Rat.

successfully discriminated between his experimental groups.
Particularly noteworthy is the fact that these same groups
when run in a conventional 10-alley maze showed no signifi-
cant differences in mean scores. The Spearman- Brown estim-
ates of reliability for the total test ranged between .81 and
.94.

In light of the literature and results cited, it would
appear that the closed-field test provides a reliable and
valid measure of rat intelligence.

The technique used in testing the intelligence of rats
in this investigation followed that described in the Rabino-
vitch standardization experiment,[1] with a slight modification.

The basic apparatus in this method was a 30 inch square
enclosure, 4 inches high and covered with a movable, framed
wire screen. Outlined in black on the floor were 36 five
inch squares; these defined error zones. Various barriers,
ranging in length from 5 to 25 inches and all 4 inches high
and $\frac{1}{2}$ inch wide, were used in setting up the different prob-
lems, which gradually increased in difficulty. The starting
box and goal (food box) were permanently fixed diagonally
across from each other on the square. The barriers were inter-
posed between the starting point and the goal, preventing the
rat from making a straight, diagonal run to the goal. As
noted previously, the barriers were set up in increasingly

—————

1. Rabinovitch, op. cit.

complex patterns, making each run somewhat more tortuous than the preceeding one. There were 12 patterns in all, with 6 additional patterns of a comparatively simple nature for preliminary training. For each particular problem pattern, the most direct route to the goal box was defined. Any large deviations from the direct path into one or more error zones taken by the rat constituted one or more errors, depending on the number of error zones entered.

Before the actual intelligence testing begins, the Rabinovitch method requires that the rats be familiarized with the field situation and become accustomed to handling for the purpose of minimizing emotional variability in the animals. This is done by placing the naive animals in the apparatus in groups of four, after 12 hours of food deprivation, for a period of a half hour, twice a day. Then as soon as the animals are eating well and give the impression of being adjusted to the situation, they are given individual preliminary runs with the training barriers in place so that they will become accustomed to them.

It was this preliminary training with the barriers in place,[1] as outlined by Rabinovitch, which was adapted to the experimental procedure for measuring emotionality. Since the preliminary training series was designed to minimize or negate differences in emotionality, it was well suited to the purpose

---

1. Cf., pp. 29f.

of testing emotionality in the experimental population. Thus the training served a dual purpose: it simultaneously provided a measure of emotionality and prepared the animals for the actual test of learning ability.

The actual measurement of intelligence involved eight runs in each problem situation early in the morning. Eight hours later the same procedure was repeated with the next problem. At the end of the second problem each day, every rat was given a five gram pellet of food. The process continued for 6 days until all 12 test items had been completed.

The performance score was a function of the error zones entered. Time did not count. An error was scored on each occasion that the rat's forefeet crossed a line marking an error zone. Where there were two error zones, two errors were scored. The sum of all error scores for all items constituted the final score for each rat.

Measure of Dominance

The final test was a measure of dominance-submission, which utilized the method of paired comparisons. The reviews of Allee,[1] Collias,[2] and Smith and Ross[3] have all pointed up the presence and relative stability of dominance hierarchies

---

1. W. C. Allee, Cooperation Among Animals, pp. 129-153.
2. N. E. Collias, "Aggressive Behavior Among Vertebrate Animals," Physiological Zoology, 17, 1944, pp. 83-123.
3. W. I. Smith and S. Ross, "The Social Behavior of the Vertebrates: A Review of the Literature (1939-1950)," Psychological Bulletin, 49, 1952, pp. 598-627.

in vertebrate animals.

Referring to rodent behavior in particular, Hall and Klein[1] have found aggressiveness—a correlate of dominance—to be a comparatively stable characteristic in the rat. Independent ratings of aggressiveness in individual rats obtained at different times by the two experimenters correlated to the order of .85.

In a more direct fashion, R. H. Bruce[2] studied dominance in water and food situations. Following water deprivation, paired rats were allowed access to a single water tube. Dominance was inferred in terms of control of the tube. A rat was scored dominant if it forced the other rat from the tube and maintained control for the greater length of a specified period of time. In the food situation where two hungry rats had access to a single piece of food, dominance was determined by how often a rat took the piece of food from its partner and how long it was retained. It was discovered that in 12 of the 14 pairs of animals tested under both types of motivation, the same rats were dominant. The conclusion of chief importance here is that dominant rats were rather consistently dominant and submissive rats rather

_____

1. C. S. Hall and S. J. Klein, "Individual Differences in Aggressiveness in Rats," _Journal of Comparative Psychology_, 33, 1942, pp. 371-383.
2. "An Experimental Analysis of Social Factors Affecting the Performance of White Rats. III. Dominance and Cooperation Motivated by Water and Food Deprivation," _Journal of Comparative Psychology_, 31, 1941, pp. 395-412.

consistently submissive. The results also suggested that Bruce's method is a fairly reliable one—the water-food trials revealing a high test-retest correlation.

Seward,[1] on the other hand, in an investigation of aggressiveness, fighting, and dominance-subordination, failed to experimentally establish a dominance hierarchy. His data disclosed wide individual differences in aggressiveness but no stable social order. He explained his failure to develop a dominance hierarchy in terms of the proneness of rats to develop "strong and highly generalized conditioned fear responses as a result of battle."[2]

The technique followed in establishing dominance hierarchies in this investigation was largely adapted from that used by Bruce.[3] Following a 23 hour period of water deprivation, paired rats from the same group were placed in a special "drinking" cage and permitted access to a single water tube. A cone extending outward from around the mouth of the water tube precluded the possibility of both rats sharing the drinking tube simultaneously. A rat was scored dominant if it maintained control of the tube for the greater part of a two minute period. Upon return to its home cage, the rat was provided with additional water for one hour. Dry food pellets were

1. J. P. Seward, "Aggressive Behavior in the Rat. II An Attempt to Establish a Dominance Hierarchy," Journal of Comparative Psychology, 38, 1945, pp. 213-224.
2. Ibid., p. 223.
3. Bruce, op. cit.

available to the animals at all times.[1]

As mentioned previously, the method of paired comparisons was used in the assessment of dominance-submission. This method involved the pairing of each animal in a group with every other. Thus, in the case of N subjects, the total number of paired comparisons would equal $N(N-1)/2$. In the present investigation, this amounted to 45 trials for each of the 4 groups.

The first series of pairs were selected by the use of random numbers. Thereafter, in order to minimize the effects of victory at the drinking tube, winners were paired with winners and losers with losers. Matched rats were equated as closely as possible in terms of previous wins and losses. This procedure was made necessary in light of Seward's[2] results concerning aggressive behavior in the rat. He found that the day after a fight, the loser was usually less belligerent than before. Although Seward's data involved fighting rather than control of a water tube, the situations showed partial identity and therefore it was required that some control be exercised over the effects, if any, of the competition

1. Preliminary investigation by the experimenter had established that, under the deprivation conditions outlined above, approximately two minutes were required for an adult rat to sufficiently satiate its thirst so that it would start eating dry food.
2. J. P. Seward, "Aggressive Behavior in the Rat. IV. Submission as Determined by Conditioning, Extinction, and Disuse," Journal of Comparative Psychology, 39, 1946, pp. 51-75.

at the water tube.

After all paired comparisons had been completed, each of the four groups, isolated and communal of each sex, were ranked in serial order on the basis of the total number of wins. The rat with the highest number of wins in each particular group was ranked the highest, i.e., rank position 1; the rat with the least number of wins was ranked the lowest, i.e., rank position 10, and the remaining rats occupied intermediate rank positions. Where ties occurred in the ranking, the tied rats were paired for an additional matching, thereby breaking the ties.

Having established dominance hierarchies within each group, it was then possible to determine which groups were more dominant—the isolated or communal. This was done by modifying the method of paired comparisons. Instead of pairing each rat with every other, rats were paired according to their sex and rank order. The rats were therefore equated, since the most dominant rat of the communal group was paired off with the most dominant rat of the isolated group, and so forth in descending serial order. The same experimental procedure and criteria, as outlined previously, were followed in determining inter-group dominance.

The complete testing of the experimental population was accomplished in a nine week period; thus the whole experiment, beginning with the breeding of the animals, required seven months for its culmination.

CHAPTER IV

RESULTS

Analysis of Results

Weight

The weights in grams of the entire experimental population are presented in Table I. The mean weights, ranges, and standard deviations for the four groups are recorded in Table II. Fisher's t test for correlated small samples[1] was used to estimate the significance of the differences between the means of the isolated and communal males and the isolated and communal females. The formula is as follows:

$$t = \frac{M_d}{\sqrt{\dfrac{\text{Sum } x_d^2}{N(N-1)}}}$$

A one-tailed rather than a two-tailed test of significance was applied to the statistical treatment of all the data with the exception of the correlations because the experimental hypotheses were uni-directional. That is, it was hypothesized that the communal groups would prove superior to the isolates on the measured variables.

Since a t of 1.83 or higher is required for a one-tailed test of significance at the 5 per cent point of confidence

---

1. J. P. Guilford, Fundamental Statistics in Psychology and Education, p. 228.

for 9 degrees of freedom, the obtained t's of 2.51 for the males and 2.67 for the females are both statistically significant. Thus it may be concluded that the communal groups weigh significantly _less_ than the isolated groups.

TABLE I

Weight in Grams of the Four Experimental Groups

Subjects	Communal Males	Communal Females	Isolate Males	Isolate Females
1.	296	201	302	213
2.	298	205	314	196
3.	322	201	281	235
4.	331	238	391	254
5.	298	217	355	234
6.	319	188	371	229
7.	332	181	351	277
8.	372	213	394	206
9.	340	215	355	256
10.	343	202	365	211
	3251	2061	3479	2311

TABLE II

The Means, Ranges, and Standard Deviations
of Weights in Grams for the Four
Experimental Groups

	Male Groups		
	Mean	Range	S. D.
Communals	325.1	296-372	22.8
Isolates	347.9	281-394	35.6

	Female Groups		
	Mean	Range	S. D.
Communals	206.1	181-238	16.0
Isolates	231.1	196-277	24.3

Emotionality

The raw data of the emotionality time test (time required to run and eat from food box) for the communal male, communal female, isolate male and isolate female groups can be found respectively in Tables III, IV, V, and VI in the appendix. For **ready** reference, Table VII lists the total time in minutes required for each animal in the four groups to meet the emotionality test criterion.

TABLE VII

Total Time In Minutes Required for the Subjects of the Four
Experimental Groups to Meet the Emotionality Test Criterion

Subjects	Communal Males	Communal Females	Isolate Males	Isolate Females
1.	47	11	112	26
2.	23	58	25	32
3.	22	12	152	101
4.	63	130	122	116
5.	65	2	25	64
6.	21	18	22	112
7.	6	15	11	177
8.	12	49	153	115
9.	5	172	17	108
10.	10	26	151	110
	274	493	790	961

A complete summary of means, ranges, and standard deviations of the emotionality test scores in minutes is provided in Table VIII. Upon perusal of this table, it will be noted that the communal groups required less mean time than the isolated groups to adjust to the test situation and meet the required criterion.

In order to determine the significance of the differences

between these four means, the data were factorially analyzed.[1]
This particular statistical treatment was applied because it
yielded the greatest amount of information about the data.

TABLE VIII

The Means, Ranges, and Standard Deviations of Emotionality
Scores in Minutes for the Four Experimental Groups

	Mean	Male Groups Range	S. D.
Communals	27.3	5-65	21.6
Isolates	79.1	11-154	60.4
	Mean	Female Groups Range	S. D.
Communals	49.3	2-172	54.3
Isolates	96.1	26-177	45.8

Not only was it possible to ascertain the significance of the
differences between the means of the communal and isolate
groups, but, in addition, the significance of sex differences
and interaction (the effect derived from having a particular
sex raised under a particular condition) could be evaluated.
The analysis of variance design also helped meet the limitations
of the relatively small experimental population. If a t test
had been employed to evaluate the significance of the differ-
ences between the means on the variables of emotionality and

---

1. A. L. Edwards, Experimental Design in Psychological
     Research, pp. 208-236.

and intelligence, then each group of 10 rats would have been compared with every other group of ten rats. On each occasion, therefore, only 10 animals would have been tested against 10 other animals. The factorial design, on the other hand, permitted combining the entire communal population, male and female, and the entire isolate population, male and female, so that the test of significance was based on two samples of 20 animals each—double the size which would have been used in a t test.

Before the analysis of variance could be done, it was necessary to transform the raw scores by the square root method in order to assure homogeneity of variance.[1] Bartlett's test of homogeneity as applied to the raw emotionality scores yielded a chi square of 8.85. With 3 degrees of freedom, a chi square of 7.82 is significant at the 5 per cent level of confidence. The obtained value thus showed that the variances of the four groups were significantly heterogeneous. When the raw data were transformed by the square root method and again subjected to Bartlett's test, a chi square of 4.29 was obtained. Since this obtained value was not significant, the transformed data offered no evidence against the hypothesis of random samling from a population with a common variance. Under these conditions, a significant F can legitimately be ascribed to

---

1. Ibid., pp. 195-207.

the differences between the means.

The results of the analysis of variance of correlated groups based on a 2 x 2 factorial design are given in Table IX. Since an F value of at least 7.68, for 1 and 27 degrees of freedom, is required for significance at the 1 per cent point of confidence, the obtained F of 11.86 for condition of rearing may be considered as highly significant. Sex differences, interaction, and the amount of correlation between the four equated groups are all statistically non-significant.

TABLE IX

Complete Analysis of Variance of Transformed Emotionality
Scores

Source of Variation	Sum of Squares	df	Mean Square	F
Exp. Condition	112.28	1	112.28	11.86*
Sex	17.65	1	17.65	1.86
Interaction	.17	1	.17	.02
Residual	255.51	27	9.47	-----

*Significant at the 1 per cent point of confidence.

The statistical analysis of the data permits the conclusion that the means of the two communal groups are significantly lower than the means of the two isolated groups. The communals are therefore less emotional or timid in strange situations and are distinctly superior to the isolates on the measured variable.

In support of the significance of the emotionality

findings, it should be noted that the experimental procedure used in this study actually made it more difficult than necessary to discover significant differences. This occurred because the preliminary training—without the barriers in place and designed to familiarize the animals with the location of the food box in order to minimize intellectual factors—also served to decrease emotional variability. The more often an animal is introduced into the same basically innocuous situation, the more accustomed it becomes to it and so manifests less variability and intensity of emotional response when it comes under observation.

Intelligence

The complete results of the closed-field intelligence test in terms of error scores are presented in Table X for the communal male and female groups and Table XI for the isolate male and female groups. These tables appear in the appendix. For convenience, the total number of errors committed by the animals in all four groups on the intelligence test are listed in Table XII and included below. Table XIII contains the means, ranges, and standard deviations of the error scores for the four groups.

Examination of this table indicates that the communal groups made fewer errors than the isolate groups and that the males committed fewer errors than the females. To test the null hypothesis that the means were not significantly different from each other but were due to chance, an analysis

of variance was performed.[1] It was necessary, however, to reciprocally transform the raw scores in order to meet the requirement of homogeneous variance in the four groups.[2]

TABLE XII

Total Number of Errors Commited by the Subjects of the Four Experimental Groups on the Closed-field Intelligence Test

Subjects	Communal Males	Communal Females	Isolate Males	Isolate Females
1.	17	35	31	43
2.	24	30	29	44
3.	25	35	25	40
4.	42	38	31	44
5.	26	28	37	64
6.	37	22	39	29
7.	13	49	26	94
8.	19	25	25	26
9.	26	35	25	31
10.	20	33	30	28
	249	330	298	443

Bartlett's test of homogeneity as applied to the raw intelligence scores yielded a chi square of 8.68. With 3 degrees of freedom, a chi square of 7.82 is significant at the 5 per cent level of confidence. The obtained value thus showed that the variances of the four groups were significantly heterogeneous. When the raw data were reciprocally transformed and again subjected to Bartlett's test, a chi square of 6.16 was obtained. Since this obtained value was not significant, the transformed data offered no evidence against

---

1. Ibid., pp. 208-236.
2. Ibid., pp. 195-207.

the hypothesis of random sampling from a population with a common variance. Under these conditions, a significant F could legitimately be ascribed to the differences between the means.

The outcome of the analysis of variance of the transformed error scores is offered in Table XIV. For 1 and 27 degrees of freedom, an F of 4.21 is required for significance

TABLE XIII

The Means, Ranges, Standard Deviations, and t Values of the
Error Scores on the Closed-field Intelligence Test for
the Four Experimental Groups

	Mean	Range	S.D.	t
		Male Groups		
Communals	24.9	13-42	8.4	
				2.05
Isolates	29.8	25-39	4.7	
		Female Groups		
	Mean	Range	S.D.	t
Communals	33.0	22-49	7.2	
				2.19
Isolates	44.3	26-94	19.8	

at the 5 per cent point of confidence. Thus the obtained F of 5.91 for condition (isolation vs. communality) and the F of 12.38 for sex are respectively significant at the 5 and 1 per cent points of confidence and allow for the rejection of the null hypothesis.

Since the difference between the means of the isolate and communal females was twice as great as the difference between the means of the isolate and communal females, it was

decided that t tests for these two sets of groups would be calculated in order to determine whether the significant F for condition was due to the larger mean difference between the female isolate and communal groups.

TABLE XIV

Complete Analysis of Variance of Transformed Intelligence
Test Error Scores

Source of Variation	Sum of Squares	df	Mean Square	F
Exp. Condition	.0006455	1	.0006455	5.91**
Sex	.0011355	1	.0011355	12.38*
Interaction	.0000576	1	.0000576	.53
Correlation	.0006890	9	.0000766	.70
Residual	.0029477	27	.0001092	

**Significant at the 5 per cent point of confidence.
*Significant at the 10 per cent point of confidence.

Fisher's t test for correlated small samples was performed and yielded values of 2.05 for the males and 2.19 for the females. Based on a one-tailed test of significance, for 9 degrees of freedom, a t value of 1.83 is required for significance at the 5 per cent point of confidence. Thus the obtained t values reported above are both statistically significant and preclude the possibility of a spuriously high F for the experimental rearing condition.

Since the statistical analysis reveals that the communal groups made significantly fewer errors than the isolate groups, it may be concluded that the former are intellectually supe-

rior to the isolates. As with the emotionality measure, interaction and correlation variances are non-significant.

Dominance

The results of the intra-group test of dominance in rank scores of the four groups are presented in Table XV.

TABLE XV

Rank Orders of the Four Experimental Groups as Determined by the Intra-group Test of Dominance

Subjects	Communal Males	Communal Females	Isolate Males	Isolate Females
1.	3	3	3	2
2.	2	2	2	1
3.	7	5	8	5
4.	10	6	1	10
5.	9	1	5	9
6.	8	7	6	8
7.	6	10	4	7
8.	1	4	10	6
9.	5	9	7	3
10.	4	8	9	4

This table may be interpreted in the following way. The rat that received a rank of 1, scored only 1 loss in its various pairings with the other animals of its group, the rat with a rank of 2, scored 2 losses, and so on.

The findings revealed by the test of inter-group dominance are reported in Table XVI. Inspection of this table indicates that in the case of the 10 paired males—matched according to their rank-dominance position—8 communals were dominant over their isolated partners; while only 2 isolates were dominant over their communal partners. The competition between

the females revealed an even stronger trend—9 of the 10 communal rats dominated their isolated mates—and conversely only 1 of the 10 isolates dominated its communal mate.

TABLE XVI

Results of the Inter-group Dominance Water Test in
Terms of Wins and Losses

	Males		Females	
	Won	Lost	Won	Lost
Communals	8	2	9	1
Isolates	2	8	1	9

In order to determine whether these frequencies occurred by chance, the probabilities were computed by the use of the binomial expansion. Assuming that wins and losses were equally possible, the probability of the 9 communal females winning over their isolate partners by chance is only 12 in 1,000. The probability of the 8 communal males winning out over their isolate mates is somewhat more—54 chances in 1000. Both values may be considered statistically significant and permit the conclusion that, regardless of sex, rats raised in a social environment are significantly dominant over rats raised in isolation.

Correlations of the Dependent Variables

The four measured variables of weight, emotionality, intelligence, and dominance were correlated with each other for each of the four groups of animals. The total of 24

correlation coefficients are presented in Table XVII. All

are Pearsonian r's with the exception of the coefficients com-

puted between dominance and the other three variables, which

are rank-difference coefficients. It was not possible to

calculate product-moment correlations in these cases, since

the data on dominance were originally obtained in terms of

rank scores.

TABLE XVII

Inter-correlations of the Four Dependent Variables—Emotionality, Weight, Intelligence, and Dominance—for each of the Four Experimental Groups—Communal Male, Communal Female, Isolate Male, and Isolate Female

	Communal Males				Communal Females		
	Wgt.	Int.	Dom.		Wgt.	Int.	Dom.
Emo.	-.49	.46	.35	Emo.	.61	.13	.37
Wgt.	—	-.09	.21	Wgt.	—	-.20	.14
Int.	—	—	.70*	Int.	—	—	.46
	Isolate Males				Isolate Females		
	Wgt.	Int.	Dom.		Wgt.	Int.	Dom.
Emo.	.02	.32	.43	Emo.	.69*	.30	.62
Wgt.	—	.20	-.26	Wgt.	—	.55	-.37
Int.	—	—	-.44	Int.	—	—	.22

*Significant at the 5 per cent level of confidence.

For 8 degrees of freedom, a minimum r of .62 is required

for significance at the 5 per cent point of confidence. In

case of rho, the obtained value must equal or exceed .65,

i.e., about 4 per cent higher. An examination of Table XVII

discloses that only 2 of the 24 coefficients of correlation
are sufficiently high to be considered significant. Thus
the hypothesis that the four dependent variables would sig-
nificantly inter-relate is not borne out.

The lack of significant inter-correlation between the
three psychological variables suggests that the tests of emo-
tionality, intelligence, and dominance were measuring fairly
discrete aspects of the experimental rats' behavior. This is
to say that the overlap to be expected when the same organism
is tested in a variety of situations was not sufficiently
great to involve significant inter-correlation between the
various measures in this experiment.

Some very definite trends, nevertheless, are observable
in the present data which favor the inter-correlation hypothe-
sis. It may be noted, for example, that of the 24 coefficients
only 6 are negative and the remaining 18 are positive in sign.
The trend becomes even more pronounced if the weight correla-
tions are delineated—then, of the remaining 12 psychological
correlations, i.e., between emotionality, intelligence and
dominance, only 1 is negative. In other words, the data
suggest that the more intelligent animal (committed fewer test
errors) within any group is likely to rank higher in dominance
(scored fewer water-test losses) and evidence less emotional-
ity (required less time to meet test criterion) than his fellow
members. There was, however, no consistent trend in the weight
correlations among the various groups which indicates that this

particular factor was a negligible one, even in terms of the dominance variable.

In conclusion, it should be noted that the positive trend revealed in the correlational data might have attained statistical significance if the population had been larger.

Reliability of the Tests

To determine the reliability of the emotionality and intelligence tests, odd-even product-moment correlations were computed for each group and then corrected by the Spearman-Brown prophecy formula. Table XVIII contains the reliability coefficients calculated for the test of emotionality. The magnitude and consistency of these numerical values indicate that the measure of emotionality is a highly reliable one.

TABLE XVIII

Reliability Coefficients of the Emotionality Test
for Each of the Four Groups

	Communal Male	Communal Female	Isolate Male	Isolate Female
Reliability Coefficients	.95	.89	.91	.81

The reliability coefficients for the intelligence test, although not quite as high as those calculated above, also demonstrate the reliability of this instrument. The reliabilities are reported in Table XIX.

TABLE XIX

Reliability Coefficients of the Intelligence Test for Each of the Four Groups

	Communal Male	Communal Female	Isolate Male	Isolate Female
Reliability Coefficients	.79	.79	.75	.88

Evaluation of Results

In order to properly evaluate the results of the experiment reported above, it is necessary that additional relevant and supplementary findings be presented. Furthermore, these findings, for the most part, will serve to substantiate the results established in the present investigation.

Weight

The fact that the communal animals weighed less than the isolates means very little of itself. A number of studies, however, have shown that thin rats are healthier than fat rats.

In a review of the influence of nutrition on longevity in the rat, Clive M. McCay[1] has pointed out that of such variables as the level of protein, the degree of body fatness, or the amount of exercise—the fatness of the body appeared to have the most profound influence upon the length of life. Animals kept from becoming excessively fat either by means

------

1. "Nutrition, Ageing and Longevity," Transactions and Studies of the College of Physicians of Philadelphia, 10, No. 3, 1942, 10 pp.

of exercise or the restriction of calories were consistently the long-lived group. Furthermore, fat rats showed a greater incidence of disease, the most common of which appeared in the following order of frequency: chronic pneumonia, chronic nephrosis, and various types of tumors including lymphosarcoma.

In summary, to quote from a recent publication, "Demographers assure us that, for man also 'the thin rats bury the fat ones;' and barring some accident, a lean and hungry Cassius is pretty certain to outlive a fat Falstaff. Not only do overweight animals enjoy a shorter life-span (sic), but they are also more prone to a number of diseases—especially the degenerative ones, including cancer."[1]

Unfortunately, what constitutes excessive fatness in the rat has not been specifically defined. It is difficult, therefore, to properly evaluate the small differences in weight between the communal and isolate groups, which averaged 18 grams. The fact that thin rats are healthier than fat rats tells very little about these small weight differences found in the experimental sample. Nevertheless it would not be unwarranted to say in light of what information is available that the significant differences in weight between the communal and isolate animals may reflect a slight biological superiority.

————

1. Ralph W. Gerard, Ed., et. al., Food For Life, pp. 4-5.

Emotionality

The present findings indicating that rats raised communally are less emotional than rats raised in isolation are partially and indirectly confirmed in a study by Clark, et al.,[1] dealing with temperamental and intellectual differences among a litter of six dogs as a result of developmental environment. After weaning, three pups were raised as pets and had considerable handling; the remaining three were raised together in a cage—3 feet by 6 feet, covered with translucent glass. The first group, for obvious reasons, was identified as the free-environment group, the second as the restricted group. At $7\frac{1}{2}$ months of age, the restricted animals were released into a large room and there joined by the free-environment group.

No differences in weight or health between the two groups were found. Decided variation in temperament, however, was discovered. The restricted animals displayed a great deal of "freezing" behavior when placed in unfamiliar surroundings or when handled by an experimenter. The animals would hug the floor and stare forward. Restricted dogs avoided human contact, but free-environment dogs welcomed it. These peculiarities of behavior, for the most part, diminished after about a week, but could still be elicited in vestigial form under certain conditions after six months.

————

1. R. S. Clark, W. Heron, M. L. Fetherstonhaugh, D. G. Forgays, and D. O. Hebb, "Individual Differences in Dogs; Preliminary Report on the Effects of Early Experience," Canadian Journal of Psychology, 5, 1951, pp. 150-156.

A study by Bingham and Griffiths,[1] on the other hand, concerned with the effect of different environments during infancy on the behavior of rats, failed to elicit dissimilarities in emotionality. This study is highly comparable to the present one since the rats were raised in what were, in effect, isolated and communal environments, but which were characterized by the authors as narrow and wide environments. The subjects were divided into three groups—one group was raised individually in regular laboratory cages, the second group in extremely small individual "squeeze" boxes, and the third group communally in the freedom of a room and given access to tunnels, inclined planes, and swinging doors.

Emotionality results, based on Hall's defecation-urination test, did not disclose significant differences between the three groups. The authors concluded, therefore, that emotionality in the adult rat was not measurably affected by the differential early environments used in their study. It is not unlikely, however, in light of the literature reviewed earlier, that if Bingham and Griffiths had used a more sensitive measure of emotionality instead of Hall's technique, which has been shown to be invalid, their conclusions regarding emotionality in the adult rat may have been considerably altered.

---

1. W. E. Bingham and W. J. Griffiths, Jr., "The Effect of Different Environments During Infancy on Adult Behavior in the Rat," Journal of Comparative and Physiological Psychology, 45, 1952, pp. 307-312.

Intelligence

The results showing that the communal animals are superior in problem-solving ability to the isolates have been substantiated in a number of studies. Probably the most directly related investigation is that by Bingham and Griffiths[1] cited earlier. It will be recalled that rats were raised individually in small laboratory cages and even smaller "squeeze" boxes and were compared with rats raised together in a room. The room-raised animals were significantly superior to the individually-raised groups in maze performance. The two individually-raised groups, however, did not differ significantly on the maze test.

An earlier study by Hymovitch,[2] also concerned with the effects of wide and restricted environments on the problem-solving ability of rats, disclosed similar findings. He raised four groups of rats under the following conditions: a) free-environment box—which allowed extensive visual and motor experience because of the size of the living space and the simple "play" structures in it, b) small mesh cages—which allowed extensive visual experience but very limited motor activity (these cages were placed in the free-environment box and shifted from time to time therein), c) enclosed activity wheels—which restricted both the area of free movement and the visual experience of the animals but allowed them ample opportunity

---

1. Ibid.
2. B. Hymovitch, The Effects of Experimental Variations on Problem Solving in the Rat.

for muscular exercise, and d) cylindrical stove-pipe cages—
which severely restricted both the motor and visual experiences
of the animals.

After the rearing period, the closed-field test of animal
intelligence was administered. Both the free-environment and
mesh cage groups were clearly superior on the closed-field test
to the stove-pipe cage and activity wheel groups. There was,
however, no significant difference between the mean error
scores of the mesh-cage and free-environment rats. In order to
determine the stability of these results, a group of rats were
permitted the free-environment experience during early life
(30-75 days of age) and were restricted to the stove-pipe cages
for an equal amount of time (85-130 days of age) in later life.
Conversely, another group for equal amounts of time was reared
in the restricted environment of the stove-pipe cages and then
switched to the free-environment condition. The results showed
a conclusive superiority in problem-solving of the early free-
environment rats over the late free-environment group.

Finally, to establish how dependent the animals were on
distance cues in running the closed-field, the apparatus was
rotated and the original four groups were retested. Almost
every animal was disturbed by the rotation of the apparatus.
The groups that were superior on the field test, moreover,
were disturbed to a much greater degree than the groups that
were inferior.

In discussing his findings, Hymovitch felt that the

results of his experiment could not be attributed either to motivation, specific S-R habits, or purely motor factors. It would appear, rather, that the differential opportunities afforded the various experimental groups for perceptual learning may be deemed responsible for the differences in performance. This perceptual learning he considered to be of the incidental or latent type. Furthermore, he demonstrated that to elicit these effects it was necessary that the "broad" experience occur during early life. The effects also were seemingly permanent and possibly irreversible. He concluded that in the rat it is likely that the wider the experiential background the more highly developed the perceptual and conceptual organization will be.

In an enquiry into the nature of the effect of the free-environment experience, Forgays and Forgays[1] arrived at similar conclusions explaining the phenomenon of superior problem-solving ability of rats raised in "wide" environments. Rats raised in free-environments with and without playthings (simple wooden and metal structures) were compared with rats raised in restricted and "normal" environments. The results showed that the problem-solving performance of the adults, as measured by the closed-field test, favored the free-environment groups with a high degree of statistical significance. Further-

---

1. D. G. Forgays and J. W. Forgays, "The Nature of the Effect of the Free-environmental Experience in the Rat," Journal of Comparative and Physiological Psychology, 45, 1952, pp. 322-328.

more, the free-environment group with playthings was signifi-
cantly better in test performance than the free-environment
group without playthings. Since these two groups were raised
in enclosures of the same size, the physical dimensions of
the living space, as such could be discounted as a factor
affecting the differences between them.

Finally, the foregoing experiment by Clark, et al.,[1] on
temperamental and intellectual differences among dogs as a
consequence of free and restricted infant environment pro-
vides additional confirmation and extension of the findings
reported above. The animals were tested on a modified version
of the closed-field apparatus and the free-environment dogs
were noted to be highly superior to the restricted dogs.

It will be recalled that in addition to the significant
differences in learning ability between the communal and iso-
lated rats, Table XIV attests to the fact that sex differences
are even more significant—to be precise, at well over the
one per cent point of confidence. Although the superiority
of the male populations over the females under both conditions
of rearing is clear-cut, the literature is far from being un-
equivocal on this point. The studies of Sadovnikova-Koltzova,[2]

1. R. S. Clark, W. Heron, M. L. Fetherstonhaugh, D. G. For-
    gays, and D. O. Hebb, "Individual Differences in Dogs:
    Preliminary Report on the Effects of Early Experience,"
    Canadian Journal of Psychology, 5, 1951, pp. 150-156.
2. M. P. Sadovnikova-Koltzova, "Genetic Analysis of Tempera-
    ment in Rats," Journal of Experimental Zoology, 45,
    1925, pp. 301-318.

Tryon,[1] and McNemar and Stone[2] have shown maze learning to be better in males, but Corey[3] found females superior. In the latest investigation of this problem in 1933, Tomilin and Stone[4] attempted to correct some possible inadequacies of the earlier studies and used both maze and discrimination equipment. They discovered no sex differences in variability.

In evaluating the present findings that the male rats are superior to the female rats in learning ability, it must be kept in mind that the performance of the animals discussed in the literature was measured by the usual blind-alley maze apparatus; whereas, in this experiment problem-solving performance was tested by the new closed-field apparatus. Consequently the results of the experiment are not directly comparable with the results found in the literature, particularly since Hymovitch[5] has demonstrated that the closed-field test is a much more sensitive and discriminating instrument than the older maze test. Because no general confirmation of the presence or absence of sex differences in the rat is available,

1. R. C. Tryon, "Studies in Individual Differences in Maze Ability. II. The Determination of Individual Differences by Age, Weight, Sex, and Pigmentation," Journal of Comparative Psychology, 12, 1931, pp. 1-22.
2. Q. McNemar and C. P. Stone, "The Sex Difference in Rats on Three Learning Tasks," Journal of Comparative Psychology, 14, 1932, pp. 171-180.
3. S. M. Corey, "Sex Differences in Maze Learning by White Rats," Journal of Comparative Psychology, 10, 1930, pp. 333-338.
4. M. I. Tomilin and C. P. Stone, "Sex Differences in Learning Abilities of Albino Rats," Journal of Comparative Psychology, 16, 1933, pp. 207-209.
5. Hymovitch, op. cit.

it can only be left to future research with the same kind of closed-field measure to confirm or invalidate the differences found in this experiment.

Dominance

The only study to date which complements the finding that social rats are dominant over isolate animals is that by Clark, et al.,[1] referred to earlier. These investigators studied dogs raised under wide and restricted environments and determined the relative dominance of one group over the other. Two and one-half months after removal from their restricted environment, this group was tested against the free-environment animals in a competitive situation (fighting for a bone). All the restricted dogs were markedly subordinate to the free-environment dogs.

---

1. Clark, et al., op. cit.

CHAPTER V

SUMMARY AND CONCLUSIONS

The purpose in this experiment was to determine the effects of genetic social isolation on the behavior of the albino rat as measured by four variables—weight, intelligence, emotionality, and dominance.

Since previous research had established that group living in contrast to solitary living bestowed definite biological values on organisms, this experiment was undertaken to determine whether social development in comparison to isolated development would result in psychological benefit to the social animals.

The following procedure was used in the investigation. Forty newly-weaned rats were divided into 2 groups of 20 males and 20 females. These two groups were again equally divided and randomly placed in individual isolation cages or in large communal cages—one for the females and another for the males. The 4 experimental groups, of 10 animals each, were identified by rearing condition and sex—communal male, communal female, isolate male, and isolate female. The groups were equated and hereditary differences controlled by having each animal in any group represented by its litter mates, male and female, in the other three groups. The subjects were fed unlimited amounts of water and Purina Laboratory Food Pellets, supplemented with leafy vegetables.

At approximately 95 days of age, the animals were weighed to the nearest gram and a series of three tests was begun. The first was a measure of emotionality (timidity). Hungry rats were placed in a field apparatus, which measured 30 inches by 30 inches by 4 inches in height covered with a removable wire-mesh top. Diagonally across from the entrance, a stationary food container was located with wet Purina mash in it. After being acclimated to the field and the location of the food goal, the animals were given daily trials. Each trial consisted of nine consecutive runs to the goal box. The series ended for an animal when it was able to make the 9 runs to food in 60 seconds on 2 successive occasions. Since intellectual factors were minimal, the total time required to meet this criterion was viewed as an index of emotionality.

A modified version of the Hebb-Williams closed-field test was used to measure the problem-solving ability (intelligence) of the animals. The results were achieved by the use of a constant setting for the problems and a constant goal. The same apparatus described previously was used with problem barriers interposed between the entrance alley and the food box preventing the animal from making a direct run to the goal. The test consisted of 12 trials with a different barrier-pattern set up for each trial. For each particular problem pattern, the most direct route to the goal box was delineated. Any defined deviations from the direct path constituted one or more errors depending on the extent of

the deviation. The performance score was a function of the total number of errors made by an animal.

The final test was a measure of dominance-submission utilizing the method of paired comparisons. Following a period of water deprivation, paired rats from the same group were placed in a "drinking" cage and permitted access to a single water tube. A rat was scored dominant if it maintained control of the tube for the greater part of a two-minute period. At the end of the test it was possible to rank each member of a particular group in serial order, on the basis of wins and losses, in a dominance hierarchy. Having established intra-group dominance standing, inter-group dominance was determined by pairing like-sexed members of the communal and isolated groups according to their rank and having them compete for water as outlined above.

The results of the experiment are as follows: The communal rats with a mean weight of 325.1 grams for the males and 206.4 grams for the females weigh significantly less than the isolated male and female animals with respective mean weights of 347.9 and 231.1 as determined by Fisher's t test for small samples. These findings are assumed to denote physical superiority for the communal groups since it has been established that thin rats are healthier than fat ones.

Similarly, the emotionality scores reveal that the communal populations required less time than the isolates to adjust to the test situation. Mean time for the communal male,

communal female, isolate male, and isolate female groups is respectively 27.3, 79.1, 49.3, and 96.1 minutes. The raw data were transformed by the square root method to assure homogeneity of variance and then factorially analyzed. The calculations show that the means of the communals are significantly lower than the means of the isolates.

The closed-field test of intelligence indicated that the communal rats made fewer errors than the isolated rats. Mean error scores for the 4 groups—communal male, communal female, isolate male, and isolate female—are respectively 24.9, 33.0, 29.8, and 44.3. The reciprocally transformed raw data, subjected to an analysis of variance, demonstrates that the differences between the means are statistically significant.

The results of the competition at the water tube between rats matched for intra-group dominance and sex show that in the case of the 10 paired males, 8 communals were dominant over their isolated partners; with the females, 9 of the social rats dominated their isolated litter mates. Chi square tests of these frequencies yielded values of 2.5 for the males and 4.9 for the females, both of which are significant.

Conclusions

The foregoing test results and analyses permit the following conclusions to be drawn:

1. Albino rats raised in a social environment weigh

significantly less than rats raised in isolation.

2. Albino rats reared in a social environment are significantly less emotional or timid than rats reared in isolation.

3. Albino rats raised in a communal milieu are significantly better in problem-solving ability than rats raised in isolation.

4. Albino rats reared communally are significantly dominant over rats reared in isolation.

5. The measured variables of weight, emotionality, intelligence, and dominance did not significantly inter-correlate.

CHAPTER VI

DISCUSSION

Having demonstrated significant differences on the variables of weight, emotionality, intelligence, and dominance between rats raised socially and in isolation, it now remains to examine and offer possible explanations for these results.

The differences in weight between the communal and isolated groups, which favor the former, may best be accounted for on the basis of physical exercise. Since the diet was the same and unlimited for all groups, this factor may be immediately removed from consideration. Observation of the animals during the three-month rearing period disclosed that the social rats were far more active than their isolated litter-mates. This activity seems to have been more related to the stimulation provided by members of the group than to the difference in size between the communal and isolate cages, which afforded the communal animals much more room to move around in.

The hypothesis that differences in weight are primarily due to social stimulation and activity rather than to differences in cage size is lent credence by the results of the Hymovitch[1] experiment cited earlier. It will be recalled that Hymovitch raised rats in restricted and wide environments

---

1. B. Hymovitch, The Effects of Experimental Variations on Problem Solving in the Rat.

in order to test for the effects of these developmental situations on problem-solving ability. Two of his groups were raised in a free-environment cage. One group was allowed complete freedom of this extremely large cage, while the other group was placed in small cages within the larger cage. No significant differences in weight were found between the two groups despite the fact that the small cage group had considerably less spatial freedom than the large cage group. Thus the amount of living space afforded the two groups had no appreciable effect on their weight.

The superiority of the social animals over their isolated litter mates on the psychological variables of emotionality, intelligence, and dominance is best understood if these measures of behavior are viewed as inter-related aspects of the total organism functioning in and adjusting to different experiential situations. Within this holistic framework, the primary referent will be the perceptual and conceptual processes of the organism and their development.

Earlier it was shown in a number of experiments[1] that animals raised in environments characterized as wide were superior in problem-solving ability to animals raised in narrow or constricted environments. This superiority was assumed to be causally related to the richer and more complex experiences permitted the wide-environment animals during their maturation. Furthermore, it was indicated that the

---

1. Cf., pp. 60-63.

greater ability of the wide-environment animals could be, in part, specifically attributed to the increased utilization of distance cues in the environment when confronted with a novel problem-solving task.

Of particular interest in this connection is Forgay's[1] study because it revealed that this greater utilization of distance cues was not necessarily related to the physical dimensions of the rearing cages, but rather to the complexity of the environment in terms of the presence or absence of "playthings."

The relevance of these research findings to the present work are obvious. Although the developmental environments of the rats in this investigation were defined as communal and isolated, they could have just as easily been referred to as wide and narrow. By virtue of their communality, the social rats lived in a far more complex milieu, which involved organismic interaction and adjustment; whereas, the isolated rats led a relatively circumscribed and bland existence.

Thus it may be seen, for example, that the superior intellectual performance of the social animals is a function of their more extended and heterogeneous developmental experiences. The question remains, however, how does this genetic experience work? The answer must needs be a highly theoretical one. A fruitful orientation is offered in the behavioral

---

1. Supra, pp. 51 f.

schema of D. O. Hebb.[1] The explanation, in terms of this theory,
would be that experience in its initial stages operates to es-
tablish basic perceptual and neurological elements in the or-
ganism. These are the entities that make up more complex per-
ceptions. The organization of such elements in the various
sense modes lays the foundation of later responses to external
and internal stimulation. This is followed by a period wherein
simple associations are established and with them conceptual
sequences—the period in which meaning first begins to appear.
Eventually the learning characteristic of the mature animal
emerges. This later learning is essentially conceptual. Even
in the rat, maze learning requires the idea of the stimulus as
acting to arouse conceptual activities which in turn control
motor-responses. What is being said, essentially, is that
perceptual systems, under appropriate conditions, may lead to
conceptual systems. In addition, perception at any stage is
regarded as involving an expectancy which is selective in func-
tion, and which thereby influences situational adjustments and
future learning. What is learned at any stage depends on what
can then be perceived, i.e., it is a function of how far the
perceptual systems have advanced.

Keeping Hebb's schema in mind and the experimental condi-
tions under which the rats were raised, it further becomes pos-
sible to hypothesize concerning the reasons for the greater

------

1. The Organization of Behavior.

emotionality or timidity exhibited by the isolated subjects. First, however, it must be noted that emotion should not necessarily be construed as an awareness, i.e., a distinctive conscious process that is quite separate from intellectual processes. Emotion is a neural process that is inferred from and causes emotional behavior. It can then be postulated that up to a certain point, lack of correspondence between expectancy and perception may simply have a stimulating (or pleasurable) effect; beyond this point a disruptive (or unpleasant) effect. Thus with varied experience, the animal will become increasingly less dependent on any particular stimulation that is not a constant feature of his environment.

The behavior of the experimental rats conforms to this postulation. Apparently the variegated stimuli of the testing situation impinging on the isolated animals were more disruptive for them than for the social animals, since expectancy and perception were at greater variance. In consequence, it required a greater amount of time for these animals to adjust and cope with the unfamiliar testing situation than was required by the communal groups. These results illustrate the inter-relation of learning and emotion.

In light of the foregoing discussion of the association existing between emotion and learning, it becomes possible to explicate concerning the superiority of the social animals over the isolates in the dominance test. It seems apparent that the same combination of factors operating in the other

testing situations is responsible for the results in the test
of dominance. In this case, furthermore, transfer of training
of two kinds is involved. For one thing, the social rats were
more accustomed to the presence of other rats; for another,
they had a background of "playful fighting." The isolates,
on the other hand, were deficient in both these kinds of ex-
perience. Thus when the social and isolated rats were paired
off in a competitive situation, the former were able to make
a quicker adjustment and more successfully defend their stand
at the water-tube than the latter.

Theoretical Implications

The results of this investigation permit an extension of
Allee's biological concept of unconscious organismic coopera-
tion into the psychological realm. It has been experimentally
verified that group development as opposed to solitary devel-
opment bestows psychological and possibly physiological values
on the albino rat which are of definite survival benefit, since,
under most conditions, the healthier, more intelligent, less
timid, and dominant animal stands a better chance for reach-
ing old age than one less ably equipped. Thus it may be said
that social maturation plays an important and salubrious role
in determining this sub-primate's total ability to cope with
and adjust to the environment.

The presence of egoistic and competitive forces in animal
life, which lead to self-preservation and personal advancement,
have long been recognized, particularly since the promulgation

of the Darwinian concepts of evolution. Unfortunately, despite
a respectable history, the idea of group-centered forces of
natural cooperation, which lead to the preservation of the
group or part of it, is not as well recognized. It can only
be hoped that wider dissemination of the increasing scientific
and empirical knowledge concerning the vital role of basic
cooperative processes among living beings will lead to even-
tual acceptance of cooperation as a guiding tenet both in
educational and social theory and as a much needed basis for
human behavior.

Finally, the research has adduced information which allows
for the comparative understanding of the function of exper-
iential factors in the development and adjustive capacities of
sub-primate life, in this case the albino rat. The experiment
has demonstrated that endogenous processes in isolation are
not sufficient for optimal maturation of the organism. These
processes are influenced and mediated by experience, such that
the richer and wider the experiential background, the better
the animal can adjust to its dynamic environment. Thus al-
though experience, and in particular social experience, does
not play the crucial part in life for the rat that it does in
the human being, yet, the conclusion is unavoidable that it
is not insignificant. The study properly serves to emphasize
the role of experience in human development by placing it in
phylogenetic perspective with its role in infra-human life.

Suggestions for Further Research

The results of this investigation, as is entirely proper, have raised more questions than have been answered. Listed below are some of the research areas which may be fruitfully explored.

1. Since it has been experimentally verified that rats raised communally are superior to rats raised in isolation, a question of immediate interest is what constitutes an optimal population? Is a communal group of 2 rats, for example, equivalent to a group of 5, 10, or 20 rats? In other words, is there a functional relationship between what has been defined as superior behavior and density of population? The assumption might be made that as group size increases, superiority becomes more pronounced. However, if the physical space were kept constant, obvious overcrowding would result and the functional curve would be expected to drop beyond a certain population size.

2. Although Hymovitch's findings (see pp. 49-50) indicate that intellectual superiority in the rat as a result of growth in a free-environment is irreversible, it would be well to retest this outcome and also extend it to the variables of emotionality, dominance, and weight. This would be done by raising one group of equated animals in a communal milieu and another in isolation. At maturity, the experimental conditions would be reversed for an equal amount of time, i.e., the communal group would be isolated while the isolated animals would

be grouped together. After this period, the animals would be tested to determine whether the effects of these early experiences on the two groups are stable and irreversible.

3. The significant superiority of the male rats in problem-solving ability (see pp. 52-54) as measured by the closed-field test deserves to be further investigated in light of the conflicting and equivocal findings reported in the literature.

4. Finally, it will be recalled that the experimental animals were raised in partial social isolation, since auditory and olfactory stimulation from other animals were not excluded. It would be of more than passing interest, then, to investigate whether complete isolation would exacerbate the established vitiating effects of development under conditions of partial social isolation. This complete isolation would also severely restrict environmental stimulation and would require that the animals be raised in small, vision-restricting cages out of sound and odor of other animals.

BIBLIOGRAPHY

Allee, Warder C., Cooperation Among Animals. New York:
    Henry Schuman, Inc., 1951. 233 pp.

------- and Bowen, E., "Studies in Animal Aggregations:
    Mass Protection Against Colloidal Silver Among Gold-
    fishes," Journal of Experimental Zoology, 61, 1932,
    pp. 185-207.

------- and Evans, G., "Some Effects of Numbers Present
    on the Rate of Cleavage and Early Development in Arbacia,"
    Biological Bulletin, 72, 1937, pp. 217-232.

------- and Wilder, J., "Group Protection for Euplanaria
    Dorotocephela from Ultra-violet Radiation," Physiologi-
    cal Zoology, 12, 1938, pp. 110-135.

Bakwin, H., "Loneliness in Infants," American Journal of
    Diseases of Children, 63, 1942, pp. 30-40.

Bayroff, A. G., "The Experimental Social Behavior of Ani-
    mals. I. The Effect of Early Isolation of White Rats on
    Their Later Reactions to Other White Rats as Measured by
    Two Periods of Free Choice." Journal of Comparative
    Psychology, 21, 1936, pp. 67-81.

--------, "The Experimental Social Behavior of Animals.
    II. The Effect of Early Isolation of White Rats on Their
    Competition in Swimming," Journal of Comparative Psych-
    ology, 29, 1940, pp. 293-306.

Beach, F. A., "Comparison of Copulatory Behavior of Male
    Rats Raised in Isolation, Cohabitation, and Segregation,"
    Journal of Genetic Psychology, 60, 1942, pp. 121-136.

Bindra, D. and Thompson, W. R., "An Evaluation of Defecation
    and Urination as Measures of Fearfulness," Journal of
    Comparative and Physiological Psychology, 46, 1953,
    pp. 43-45.

Bingham, W. E. and Griffiths, W. J., Jr., "The Effect of
    Different Environments During Infancy on Adult Behavior
    in the Rat," Journal of Comparative and Physiological
    Psychology, 45, 1952, pp. 307-312.

Bruce, R. H., "An Experimental Analysis of Social Factors
    Affecting the Performance of White Rats. III. Dominance
    and Cooperation Motivated by Water and Food Deprivation,"
    Journal of Comparative Psychology, 31, 1941, pp. 395-412.

Bruckner, G. H., "Untersuchungen zur Tiersoziologie, insbesondere zur Auflosung der Familie," Z. Psychologie, 128, 1933, pp. 1-110. Cited in Crawford, M. P., "The Psychology of the Vertebrates," Psychological Bulletin, 36, 1939, p. 430.

Churchman, J. and Kahn, M., "Communal Activity of Bacteria," Journal of Experimental Medicine, 33, 1921, pp. 583-591.

Clark, R. S., Heron, W., Fetherstonhaugh, M. L., Forgays, D. G., and Hebb, D. O., "Individual Differences in Dogs: Preliminary Report on the Effects of Early Experience," Canadian Journal of Psychology, 5, 1951, pp. 150-156.

Collias, N. E., "Aggressive Behavior Among Vertebrate Animals," Physiological Zoology, 17, 1944, pp. 83-123.

Corey, S. M., "Sex Differences in Maze Learning by White Rats," Journal of Comparative Psychology, 10, 1930, pp. 333-338.

Craig, W., "Male Doves Reared in Isolation," Journal of Animal Behavior, 4, 1914, pp. 121-133.

Crawford, M. P., "The Psychology of the Vertebrates," Psychological Bulletin, 36, 1939, pp. 407-446.

Davis, Kingsley, "Extreme Isolation of a Child," American Journal of Sociology, 45, 1940, pp. 554-565; and 52, 1947, pp. 432-435.

Dennis, W., "Infant Development Under Conditions of Restricted Practice and of Minimum Social Stimulation," Genetic Psychology Monographs, 23, 1941, pp. 143-190.

Dewey, John, Experience and Education. New York: The MacMillan Co., 1951. 116 pp.

Edwards, Allen E., Experimental Design in Psychological Research. New York: Rinehart and Co., 1951. 446 pp.

Foley, J. P., Jr., "First Year Development of a Rhesus Monkey (Macaca Mulatta) Reared in Isolation," Journal of Genetic Psychology, 45, 1934, pp. 39-105.

--------, "Second Year Development of a Rhesus Monkey (Macaca Mulatta) Reared in Isolation During the First Eighteen Months," Journal of Genetic Psychology, 47, 1935, pp. 73-97.

Ford, Clellan S. and Beach, Frank A., Patterns of Sexual

<u>Behavior</u>. Scranton, Pa.: Harper Bros., 1951. 307 pp.

Forgays, D. G. and Forgays, J. W., "The Nature of the Effect of the Free-environmental Experience in the Rat," <u>Journal of Comparative and Physiological Psychology</u>, 45, 1952, pp. 322-328.

Geier, F. M., Levin, M., and Tolman, E. C., "Individual Differences in Emotionality, Hypothesis Formation, Vicarious Trial and Error, and Visual Discrimination Learning in Rats," <u>Comparative Psychology Monographs</u>, 17, No. 3, 1941, 20 pp.

Gerard, Ralph W., Ed., et al., <u>Food for Life</u>. Chicago: University of Chicago Press, 1952, 233 pp.

Guilford, J. P., <u>Fundamental Statistics in Psychology and Education</u>. New York: McGraw-Hill Book Co., 1950. 663 pp.

Hall, C. S., "Drive and Emotionality: Factors Associated with Adjustment in the Rat," <u>Journal of Comparative Psychology</u>, 17, 1934, pp. 89-108.

--------, "Emotional Behavior in the Rat. I. Defecation and Urination as Measures of Individual Differences in Emotionality," <u>Journal of Comparative Psychology</u>, 18, 1934, pp. 385-403.

------- and Klein, S. J., "Individual Differences in Aggressiveness in Rats," <u>Journal of Comparative Psychology</u>, 33, 1942, pp. 371-383.

Hebb, D. O., <u>The Organization of Behavior</u>. New York: John Wiley and Sons, Inc., 1949. 335 pp.

--------, and Williams, K., "A Method of Rating Animal Intelligence," <u>Journal of General Psychology</u>, 34, 1946, pp. 59-65.

Herodotus, <u>The History of Herodotus</u>. (trans. by George Rawlinson). New York: Dutton Press, 1910. Vol. I. 410 pp.

Hilgard, Ernest, R., <u>Theories of Learning</u>. New York: Appleton-Century-Crofts, Inc., 1948. 409 pp.

Hymovitch, B., <u>The Effects of Experimental Variations on Problem Solving in the Rat</u>. Unpublished Ph. D. Thesis. McGill University, 1949. 68 pp.

Itard, Jean M. G. <u>The Wild Boy of Aveyron</u>. (trans. by George and Muriel Humphrey). New York: The Century Co., 1932. 210 pp.

Jacobsen, C. F., Jacobsen, M. M., and Yoshioka, J. G., "Development of an Infant Chimpanzee During Her First Year," Comparative Psychological Monographs, 9, 1932, No. 41.

Johnson, W. H., "Experimental Populations of Microscopic Organisms," American Naturalist, 71, 1937, pp. 5-20.

Lansdell, H. C., The Effect of Brain Damage on Rat Intelligence. Unpublished Ph. D. Thesis. McGill University, 1950. 67 pp.

McCay, C. M., "Nutrition, Ageing and Longevity," Transactions and Studies of the College of Physicians of Philadelphia, 10, No. 3, 1942, 10 pp.

McNemar, Q. and Stone, C. P., "The Sex Difference in Rats on Three Learning Tasks," Journal of Comparative Psychology, 14, 1932, pp. 171-180.

Maslow, A. H., "The Comparative Approach to Social Behavior," Social Forces, 15, 1937, pp. 487-490.

Mason, M. K., "Learning to Speak After Six and One-Half Years of Silence," Journal of Speech Disorders, 7, 1942, pp. 295-304.

Munn, N. L., Handbook of Psychological Research on the Rat. New York: Houghton Mifflin Co., 1950, 598 pp.

O'Kelley, L. I., "The Validity of Defecation as a Measure of Emotionality in the Rat," Journal of General Psychology, 23, 1940, pp. 75-87.

Pattie, F. A., Jr., "The Gregarious Behavior of Normal Chicks and Chicks Hatched in Isolation," Journal of Comparative Psychology, 21, 1936, pp. 161-178.

Rabinovitch, M. S., Standardization of a Closed-field Intelligence Test for Rats. Unpublished M. A. Thesis. McGill University, 1949. 35 pp.

Ribble, M. A., The Rights of Infants. New York: Columbia University Press, 1943. 118 pp.

Sadovnikova-Koltzova, M. P., "Genetic Analysis of Temperament in Rats," Journal of Experimental Zoology, 45, 1925, pp. 301-318.

Schjelderup-Ebbe, T., "Weitere Beitrage zur Sozial-und Individual-Psychologie des Haushuhns," Z. Psychologie,

92, 1923, pp. 60-87. Cited in Crawford, M. P., "The Psychology of the Vertebrates," Psychological Bulletin, 36, 1939, pp. 407-446.

Schneirla, T. C., "Problems in the Biopsychology of Social Organization," Journal of Abnormal and Social Psychology, 41, 1946, pp. 385-402.

--------, "A Consideration of Some Conceptual Trends in Comparative Psychology," Psychological Bulletin, 49, 1952, pp. 559-597.

Seward, J. P., "Aggressive Behavior in the Rat. II. An Attempt to Establish a Dominance Hierarchy," Journal of Comparative Psychology, 38, 1945, pp. 213-224.

--------, "Aggressive Behavior in the Rat. IV. Submission as Determined by Conditioning, Extinction, and Disuse," Journal of Comparative Psychology, 39, 1946, pp. 51-75.

Sherman, M., and Henry, J., Hollow Folk. New York: Thomas Y. Crowell Co., 1933. 220 pp.

Smith, W. I. and Ross, S., "The Social Behavior of the Vertebrates: A Review of the Literature (1939-1950)," Psychological Bulletin, 49, 1952, pp. 598-627.

Spitz, R. A., Grief: A Peril in Infancy. Cited in Ruch, F. L., Psychology and Life. New York: Scott, Foresman and Co., 1948, p. 444.

Stone, C. P., "Congenital Sexual Behavior of Young Male Albino Rats," Journal of Comparative and Physiological Psychology, 2, 1922, pp. 95-153.

--------, "The Initial Copulatory Response of Female Rats Reared in Isolation from the Age of 20 Days to Puberty," Journal of Comparative Psychology, 6, 1926, pp. 73-83.

Thorndike, R. L., "Organization of Behavior in the Albino Rat," Genetic Psychology Monographs, 17, 1935, pp. 1-70.

Tomilin, M. I. and Stone, C. P., "Sex Differences in Learning Abilities of Albino Rats," Journal of Comparative Psychology, 16, 1933, pp. 207-229.

Tryon, R. C., "Studies in Individual Differences in Maze Ability. II. The Determination of Individual Differences by Age, Weight, Sex, and Pigmentation," Journal of Comparative Psychology, 12, 1931, pp. 1-22.

Vaughn, C. L., "Factors in Rat Learning, An Analysis of the Inter-correlations Between 34 Variables," _Comparative Psychology Monographs_, 14, No. 3, 1937, 41 pp.

APPENDIX

TABLE III

Emotionality Test Time Scores in Seconds—Totals in Minutes— of the Communal Male Group

Subjects	Trials						
	1	2	3	4	5	6	7
1.	547	736	497	918	77	30	26
2.	255	131	194	363	147	55	45
3.	337	363	149	107	104	68	116
4.	679	1076	1083	427	121	203	64
5.	438	544	733	1063	308	429	81
6.	244	236	195	364	74	84	39
7.	92	64	48	73	37	18	
8.	196	136	46	67	79	118	16
9.	119	67	45	48			
10.	102	90	135	38	69	105	33

Subjects	Trials						Total
	8	9	10	11	12	13	
1.							47
2.							23
3.	22	19					22
4.	81	24	48				63
5.	102	126	33	30			65
6.	42						21
7.							6
8.	49						12
9.							5
10.	42						10
							274

Unequal number of trials occurred because some animals reached the test criterion—2 consecutive series of runs to food in less than 60 seconds—sooner than others.

TABLE IV

Emotionality Test Time Scores in Seconds—Totals in Minutes—
of the Communal Female Group

Subjects	Trials								
	1	2	3	4	5	6	7	8	9
1.	283	181	90	39	59				
2.	452	637	1091	308	196	722	47	30	
3.	293	167	42	119	37	58			
4.	1351	917	1243	430	388	637	249	1036	202
5.	53	42							
6.	380	211	135	68	84	144	36	29	
7.	307	233	121	107	76	58	18		
8.	677	718	452	625	133	91	86	60	65
9.	2652	2169	1219	2295	901	2049	567	1878	844
10.	291	789	148	72	105	111	24	45	

(continued)

Subjects	10	11	12	13	14	15	16	17	18	Total
1.										11
2.										58
3.										12
4.	701	327	121	32	49					130
5.										2
6.										18
7.										15
8.	38	33								49
9.	1086	227	320	87	91	81	59	33		172
10.	.									26
										493

Unequal number of trials occurred because some animals
reached the test criterion—2consecutive series of runs
to food in less than 60 seconds—sooner than others.

TABLE V.

Emotionality Test Time Scores in Seconds—Totals in Minutes—
of the Isolate Male Group

					Trials				
Subjects	1	2	3	4	5	6	7	8	9
1.	1225	2076	479	725	637	430	803	160	44
2.	450	309	240	210	105	76	47	44	
3.	675	1814	1066	1751	2569	533	247	168	67
4.	582	668	450	1522	2804	433	267	164	75
5.	337	212	158	245	175	131	122	59	53
6.	285	213	190	191	126	134	116	52	47
7.	288	64	90	65	77	83	49	51	
8.	2202	2548	1235	2154	308	431	241	47	60
9.	382	182	52	172	98	41	48		
10.	673	1812	2508	2583	897	715	241	144	42

(continued)

					Trials				
Subjects	10	11	12	13	14	15	16	17	Total
1.	78	33	37						112
2.									25
3.	170	59	24						152
4.	117	90	89	59	32				122
5.									25
6.									22
7.									11
8.									153
9.									17
10.									151
									790

Unequal number of trials occurred because some animals
reached the test criterion—2 consecutive series of runs
to food in less than 60 seconds—sooner than others.

TABLE VI

Emotionality Test Time Scores in Seconds—Totals in Minutes—
of the Isolate Female Group

Subjects	Trials									
	1	2	3	4	5	6	7	8	9	10
1.	487	413	222	308	92	41	18			
2.	677	538	197	238	163	70	21	19		
3.	813	1167	441	409	314	586	582	858	221	430
4.	690	1034	585	428	652	994	516	546	203	230
5.	677	718	284	346	254	736	187	99	208	88
6.	335	686	1036	474	731	293	641	509	271	119
7.	438	1809	1431	1757	1483	1032	283	201	154	363
8.	917	692	791	544	1059	737	1159	981	121	25
9.	1051	2285	1104	857	1342	1085	736	175	63	41
10.	2791	2346	967	1216	2102	1149	2081	848	62	60

(continued)

Subjects	Trials									Total
	11	12	13	14	15	16	17	18	19	
1.										26
2.										32
3.	53	67	73	33	19					101
4.	436	184	89	122	83	74	49	13		116
5.	109	101	24	20						64
6.	512	228	164	47	32					112
7.	247	185	364	37	228	252	248	58	52	177
8.	22									115
9.										108
10.	45									110
										961

Unequal number of trials occurred because some animals
reached the test criterion—2 consecutive series of runs
to food in less than 60 seconds—sooner than others.

TABLE X

Raw Error Scores on the Closed-field Intelligence Test for
the Communal Male and Communal Female Groups

Communal Males

Subjects	1	2	3	4	5	6	7	8	9	10	11	12	Total
1.	3	2	1	5	0	1	0	0	2	0	2	1	17
2.	4	1	2	2	0	2	0	2	2	4	4	1	24
3.	2	2	2	4	1	4	0	2	3	3	1	1	25
4.	3	4	5	8	0	4	2	3	2	3	5	3	42
5.	3	3	4	2	0	4	1	3	0	0	6	0	26
6.	7	2	4	2	0	3	3	3	2	3	4	4	37
7.	0	1	2	1	0	1	1	2	2	1	0	2	13
8.	2	3	1	0	0	1	1	3	0	0	7	1	19
9.	1	1	2	2	0	1	3	3	3	2	4	4	26
10.	1	0	2	1	0	0	2	4	6	2	1	1	20
													249

Communal Females

Subjects	1	2	3	4	5	6	7	8	9	10	11	12	Total
1.	4	1	3	2	0	2	2	6	4	3	2	6	35
2.	4	3	1	1	0	3	2	5	4	3	2	2	30
3.	6	4	2	1	0	0	1	6	5	2	3	5	35
4.	4	6	4	3	0	3	0	6	3	5	3	1	38
5.	1	3	2	1	0	2	2	5	5	2	2	3	28
6.	1	3	2	4	0	5	1	1	3	0	2	0	22
7.	5	2	4	3	0	5	3	6	6	7	6	2	49
8.	2	2	3	2	0	5	1	1	3	1	3	2	25
9.	2	4	6	4	0	3	2	9	1	2	1	1	35
10.	2	2	4	2	0	2	3	6	3	1	2	6	33
													330

TABLE XII

Raw Error Scores on the Closed-field Intelligence Test for
the Isolate Male and Isolate Female Groups

Isolate Males

Subjects	1	2	3	4	5	Trials 6	7	8	9	10	11	12	Total
1.	3	1	2	3	1	3	2	4	3	3	3	3	31
2.	1	4	1	2	0	3	4	4	1	4	1	4	29
3.	3	1	2	2	0	2	2	2	1	2	3	5	25
4.	6	2	4	3	0	1	2	5	2	3	2	1	31
5.	5	3	3	4	0	2	1	5	2	3	8	1	37
6.	4	4	4	2	0	2	3	7	3	4	2	4	39
7.	0	2	2	1	0	2	4	6	3	2	2	2	26
8.	3	1	1	1	0	2	2	2	1	4	7	1	25
9.	1	1	3	1	0	2	3	2	3	3	4	2	25
10.	3	2	2	3	0	1	2	3	7	3	1	3	30
													298

Isolate Females

Subjects	1	2	3	4	5	Trials 6	7	8	9	10	11	12	Total
1.	2	4	3	4	0	3	4	7	3	5	4	4	43
2.	5	3	2	2	0	5	5	5	5	3	6	3	44
3.	1	2	10	1	0	4	4	5	5	4	2	2	40
4.	5	8	2	3	2	6	3	5	3	1	3	3	44
5.	4	4	8	2	0	4	6	6	6	5	15	4	64
6.	3	5	2	2	0	3	4	3	4	0	1	2	29
7.	7	7	8	6	3	9	18	9	6	14	15	2	94
8.	2	3	1	5	0	2	4	3	2	1	1	2	26
9.	7	2	2	2	0	2	3	3	0	8	1	1	31
10.	3	2	2	1	0	4	2	3	2	3	0	6	28
													443