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Affiliative Behaviour in Male and Female Rats

Until recently little was known of the social behaviour of rats; an oddity indeed given the long association between rats and researchers. When given the opportunity, however, laboratory rats are extremely sociable. Indeed, rats show affiliative behaviours that appear to be independent of mating and of aggressive behavioural patterns. Latane (1974) has noted that:

> "The contact that rats engage in is predominantly friendly and playful, rather than aggressive and hostile. Rarely do you see behaviour that can be coded as aggressive and we have seen virtually no instances of direct fighting between rats in pairs." (p. 288)

Steinger (1950) has observed that within a wild rat colony there is no real fighting between members: There is at most, slight friction usually confined to boxing with the forepaws or kicking with the hindpaws, but rarely biting. Moreover, although rats establish and vigorously defend nesting sites, there is no maintained individual distance - rats are, apparently, contact animals.

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In early work on the topic, both Seward (1945) and Barnett (1958) noted, while conducting investigations focused primarily on aggressive behaviour, that there was a tendency on the part of their animals to remain in contact while not

engaging in aggression. Barnett states that this tendency is present even in an animal who has just been beaten. Based on these observations, and those of his own, Grant (1963) postulated that there may be an independent approach component other than aggression or mating which he referred to as a "social drive". It is this approach contact or affiliative behaviour with which this thesis is concerned.

It should be noted that the terms affiliative behaviour and social behaviour are not meant to be synonomous. Rather, affiliative behaviours are considered as one sub-class of social behaviours. Other sub-classes would be those of aggressive behaviours and of sexual behaviours. These three sub-classes of behaviours, taken together, constitute the class of behaviours termed social behaviours.

In the sections that follow, studies falling under the general rubric of affiliative behaviour will be reviewed. Within the introduction three basic issues will be addressed. Firstly, does affiliative behaviour occur between rats. Secondly, if so, what purpose might it serve for the animals involved. Finally, what factors influence the occurrence of affiliative behaviour in rats.

The first section of the introduction - studies of the affiliative behaviour among rats - deals primarily with the first two issues, while the second section - the modification of affiliative behaviours in rats - focuses on the third. In this first section, the studies fall into three major sub-topics: (1) The social approach, or affiliation, com-

ponent in the behaviour of rats - the incentive value of social contact for rats, (2) the transmission of information about the environment between rats, and (3) the influence exerted on the behaviour of one rat by the presence and behaviour of an interacting conspecific.

Studies of Affiliative Behaviour of Rats

Social approach and contact between rats. In summarizing the results of several experiments in which rats were placed together in pairs in a circular open-field, Latane (1974) reported that rats spend somewhere in the vicinity of 40 to 70 per cent of their time in direct physical contact. In contrast, the time afforded to non-social objects has been estimated to be around 10 per cent of the time available while in the open-field (Latane and Glass, 1968; Latane and Werner, 1971; Latane, Poor, and Sloan, 1972; and, Latane, Joy, Meltzer, Lubbell, and Cappell, 1972). The amount of time spent in contact with another rat, unlike that for a non-social object, increases with time. This has been found for observation periods as long as seven and one-half hours (Latane and Steele, 1975).

Latane (1974) has noted that social affiliation in rats appears to asexual in that rats are no more sociable in cross-sex pairings than in same-sex pairings. Further evidence to this effect comes from an experiment by Angermeir (1960) in which male rats learned to press a bar to obtain access to another rat. Angermeir found that the sex of the

rat had no apparent influence on the subjects's rate of responding. These findings lend support to Grant's contention that there is an approach component to the social behaviour of rats which is independent of mating behaviour.

Walton and Latane (1971) have provided some evidence indicating that the social attraction between rats is species-specific. They found that rats will spend only 10 to 15 per cent of the time available in physical contact with a gerbil: A figure which approximates that spent with a non-social object.

These studies, then, demonstrate the affiliative tendencies or gregariousness of rats. They also suggest that rats affiliate for reasons other than aggression or mating. Moreover, these affiliative behaviours seem to be selectively directed in that they are apparently species-specific. It now remains to examine what purposes, if any, these affiliative behaviours may serve.

The transmission of information between rats. One question that has concerned researchers for some time is "Do rats learn about their environment from other rats, and, if so, by what mechanisms?" Angermeir, Schaul, and James (1959) tested the performance of rats using a social learning paradigm. Rats were trained to run at the sound of a buzzer by being placed with other rats that had been conditioned with electric shock to run at the onset of the signal. The naive animals were thus able to avoid the aversive stimulus. On the basis of these results the rats

were said to have learned an avoidance response via social mediation, without ever having experienced the incentive stimulus (shock). At the very least these results suggest that the behaviour of one rat can serve as a cue for the behaviour of another rat.

In a related study Church (1957) trained thirsty rats to follow previously trained leader rats in an elevated T-maze to gain access to water. Subsequent to this, an incidental light cue was introduced in such a way that the leader rats responded consistently with respect to it. After a series of trials with the leader rats, the following rats were given 20 trials alone. On 77 per cent of these trials they went to the arm of the maze marked by the cue to which the leaders had been consistently responding. Church considered these findings to demonstrate the transmission of learned behaviour between animals.

Recently, Galef and others have studied this process of transmission of information using rats in a somewhat more naturalistic context. In one experiment Galef and Clark (1971) showed that when a colony of wild rats had learned to avoid one of two palatable diets as a result of its association with poison, pups born into that colony did not eat any of the diet avoided by the adults. Furthermore, they continued to avoid the diet when they were removed to a new environment separate from the adults. Galef (1971), in a separate study, demonstrated that the interaction between the adults and the pups is one in which the pups

tend to approach the areas in which the adults are located and subsequently to begin to feed there. Moreover, Galef demonstrated that this process is integral to the weaning of the rat pups, which, in following the mother to the food source, first begin to eat solid food. These findings demonstrate a role for social affiliation in the development of behaviour.

A similar phenomenon has been observed in adult animals (Steinger, 1950). If a group of rats discover a food source, the behaviour of the first rats finding the food usually determines whether or not the remaining members of the group eat from it. If a few animals pass the food source without eating from it, other animals will not eat from it. Furthermore, Steinger observed that when the first animals reject the food, they mark it with their urine or faeces. It appears that it is in this manner that information about food sources is transmitted throughout the group to members that have no direct experience with them.

These studies on the transmission of information between rats lead one to the tentative conclusion that it is because rats serve as attractive stimuli for other rats, or because rats are affiliative, that features of the environment that attract one rat will come to attract another. Davitz and Mason (1955) have suggested another role for affiliative behaviour in rats as a result of their studies on the influence of social factors on fear behaviour. The authors have found that the presence of a non-fearful, naive animal

can reduce the magnitude of a fear response in a second animal. Animals trained in a conditioned emotional response (CER) situation exhibited less freezing in the presence of a naive animal.

A similar effect has been reported by Latane and Glass (1971). In their study rats were observed in an open-field either in pairs or alone. The animals which were tested in pairs were less fearful (showed a greater amount of exploratory behaviour, less defecation, freezing, etc.) than were those tested alone.

Possible interpretations of these data are either that the presence of a second animal has a "calming" effect on an animal in a fear provoking situation, or that the introduction of a second animal elicits a competing response tendency, e.g., exploration, curiosity. Both interpretations would predict a decreased amount of freezing under social conditions.

The findings of these studies suggest that affiliative behaviour serves a functional role in the behaviour of the rat. This affiliation appears to facilitate the transmission of information about the environment between animals, and to produce a "calming" effect on an animal in a fear provoking situation. Moreover, these findings imply that, in general, the behaviour of one rat is influenced by that of another.

<u>The "social facilitation" effect.</u> The conclusion that followed from the review of studies in the previous section,

that the behaviour of one rat is influenced by that of another, bears directly on a phenomenon known in the literature as the social facilitation effect. The social facilitation effect has been defined by Crawford (1939) as any increment in the rate of an ongoing behaviour of an individual that derives from the presence of a conspecific.

Harlow's (1932) finding that rats housed in pairs ate more than rats housed alone was interpreted as an example of socially facilitated eating behaviour. Similarly interpreted was Larsson (1956) finding that rats 'performing' in groups were seen to reach a higher number of ejaculations per hour and to achieve ejaculation in a shorter period of time than were rats 'performing' in isolated pairs. Simmel (1961) found that the introduction of a naive rat into a compartment already occupied by another rat would facilitate the exploration of a novel object in that compartment by the latter animal. Levine and Zentall (1974) found that rats would bar-press for food at a higher rate while in groups of three than alone. Triechler, Graham, and Schweikert (1971) found that rats which learned to bar-press for food in an alone condition showed a greater resistence to extinction while in a group condition than while alone. In a study designed to examine the effects of social factors on survival stamina, Rivero (1971) tested rats for running endurence in alone or grouped conditions. The animals performed in a motorized treadmill until complete exhaustion ensued. Rivero found that animals performing in the group condition

ran significantly longer than animals running alone. Rasmussen (1939), however, found that paired rats took longer to learn a shock avoidance contingency than did rats performing alone. Levine and Zentall (1972) found a a similar social interference effect on the rate of paired rats' learning of a bar-press contingency compared to that of animals performing alone. This finding is reminiscent of those mentioned earlier on the "calming" effect of a second animal. There we saw that freezing, interpreted as evidence for fear, was reduced under social conditions.

Thus while these studies all demonstrate that the presence of a conspecific can influence the behaviour of a target rat, there is contradictory evidence about the direction of the "facilitation" effect on the ongoing behaviour. Some studies report an increment in the rate of the ongoing behaviour while others report a decrement.

Zajonc (1965) in a review of this evidence noted that those studies reporting a decrement usually involved a response that was in the process of being acquired by the animal. Whereas increments were more often associated with well-learned responses. According to Zajonc the effect of the companion animal was to increase the level of general arousal in the performing animal. Increased general arousal, he stated, should result in an increase in the observed rate of well-learned responses (high-habit strength responses) and a decrease in the observed rate of unfamilar responses (low-habit strength responses). Moreover, Zajonc stated

that the integral feature of the social facilitation paradigm, that which initiates the increase in the level of general arousal in the 'facilitated' animal, is the "mere presence" of the companion; no other feature of the companion, including its behaviour, exerts any influence on the degree of the social facilitation effect.

Zajonc's ideas can be criticized on both intuitive and experimental grounds. It would not be difficult to imagine, for example, that a highly practiced high-rate response could easily be disrupted by the introduction of a second animal. Indeed Zajonc's explanation can account for only a portion of the results from studies on the social facilitation effect. Strobel (1972), for instance, found an interference effect when the performance of a well-practiced bar-press response by paired rats was compared to that of rats performing alone. Similar results with other species have been reported by Tolman (1968). It should be noted that Strobel, rather than using co-acting animals (animals engaged in the same response with the same degree of proficiency), used one trained animal and another which was naive to the bar-press contingency. Most of the previously mentioned studies had used co-acting animals, that is, a feeding animal facilitated feeding, a running animal facilitated running, etc. It might be the case that in those studies reporting a social interference effect, the paired animals provided one another with stimuli for behaviour (e.g., play, social grooming, etc.) that would

compete with the acquisition or performance of an arbitrarily chosen response. Moreover, in those studies reporting an increment in the rate of some behaviour, there was presumably a decrement in the rate, of some other behaviour. Thus the apparent contradiction found in these studies may simply be a matter of which behaviour is being measured.

It is quite possible that no one hypothesis is sufficient to account for all the data which derive from so-called social facilitation studies. Tolman (1968) outlines three ideas about the ways in which a social stimulus might function to bring about the social facilitation effect. One notion is that the social stimulus might elicit the social facilitation effect by acting as a releasing stimulus, or as part of a releasing stimulus. Armstrong (1951) introduced a similar idea when he suggested the term mimesis to replace social facilitation and defined it as "The reproduction by one animal of the instinctive behaviour patterns of another". A similar definition of social facilitation has been offered by Altman (1966) with the difference that Altman does not assume that the behaviour patterns must be innate. Armstrong and Altman, however, speak of the induction of behaviour, thus these definitions do little to explain why there might be a change in the observed frequency of an ongoing behaviour due to the presence of another individual. Moreover, these definitions are not quite as explicit as their authors intended. Hinde (1953) points out that the term mimesis suffers much from ambiguity. The releasing stimulus idea, however, does illustrate a

possible role of the behaviour of the companion, and might account for results showing a social interference effect due to the a released competing behaviour.

Another account of social facilitation states that the social stimulus serves to attract the attention of the subject to a non-social stimulus that in turn elicits the facilitated response. This idea is mentioned by Thorpe (1956) who introduces as an illustration Lorenz's (1935) observation of ducks confined to a pen in which there is but one opening. If one of the birds finds the opening and escapes, he may, in doing so, attract the attention of the others to the opening whereupon they also may escape.

This idea is similar to the one discussed earlier in the studies of learning through observation. The results of the studies by Galef and Clark (1971) and Galef (1971) are clearly open to this sort of interpretation which depends heavily on the attraction of one animal for the other. In these studies the adult animals facilitated the weaning of the rat pups by attracting their attention to the feeding site, and thus into contact with solid food. The food then served as the stimulus which, given the appropriate central motive state of hunger and the necessary biological development, elicited the consumatory response. These principles might well be extended to account for other examples of social learning. Through affiliative behaviour, an animal would be brought into contact with new features of the environment that might have some biological significance for

that animal. If, then, the animal behaved in respect to the object in a manner similar to the second animal it would appear as though the behaviour had been learned through observation. A similar explanation of observational learning has been offered by Bindra (1974). It should be noted that this explanation can be used to account for most of the facilitation phenomena that were the basis of the releasing idea.

Motivational explanations of the social facilitation effect state that the social stimulus serves to make the subject more reactive to some non-social stimulus which in turn elicits the facilitated response. Zajonc's arousal hypothesis is an example of a motivational explanation. Another is that of Altman's (1966) notion of mutual stimulation in which the arousing effect one animal has on another is said to be a function of their interaction. This explanation, unlike that of Zajonc's, requires that the companion not merely be present, but actually interacting with the subject.

It should be noted that all of the explanations, with the exception of Zajonc's, attribute a role to the behaviour of the companion animal. Zajonc has for some reason insisted that it is the mere presence, and no other feature of the social stimulus, that is responsible for the social facilitation effect. The mutual stimulation idea would seem to predict that the greater the degree of interaction between two animals, the greater would be the magnitude of the social facilitation

effect. A recently conducted pilot study (Meaney, Note 1) was designed to test this prediction based on the finding that social affiliation among rats increases if the animals are deprived of social contact for a period of time prior to testing (Latane, Nesbitt, Eckman, and Rodin, 1972). In this study all animals were housed individually (social deprivation) prior to being tested for social facilitation measured by increases in the amount of activity in a open-field. Half of the animals were given a brief period of exposure to another animal prior to being tested. It was reasoned that this exposure would reduce the effect of social deprivation and thus to decrease the degree of affiliative behaviour of these animals. It was found that animals so treated were less influenced by the introduction of a companion animal, that is, showed less of a facilitation of activity, than animals not given the pre-test exposure. This finding was interpreted as evidence that the affiliative behaviour of the animals, and not simply their mere presence, influences the degree of social facilitation.

In a related study, Barefoot, Aspey, and Olson (1975) found that rats spent more time in physical contact with a novel partner than with a cagemate. This finding would seem to indicate that novelty enhances social affiliation between rats. Similarly, Taylor (1976) tested the approach behaviour of rats to low-aggressive and to high-aggressive conspecifics. When originally given the choice between a rat or no rat, the animals overwhelmingly chose the rat.

This social preference, however, was influenced by the aggressiveness of the target rat; more-aggressive rats were approached less frequently than less-aggressive rats. These findings suggest that the aggressiveness, as well as gregariousness and novelty, of a companion animal influence the affiliative behaviour of rats.

Summary. In summary, the studies cited thus far have demonstrated a number of features of the social behaviour of rats. These can be summarized as follows: (1) There appears to be a social approach component to the behaviour of rats that is independent of aggressive or mating behaviours. (2) Rats can acquire information about the environment from the behaviour of other rats. This "transmission" of information appears to be possible because rats are attracted to each other. (3) The behaviour of one animal can be influenced by the presence of an interacting companion. This influence appears to take the form of either a "calming" effect on an animal, as for example, in a fear provoking situation, or a stimulating effect, as exemplified by the social facilitation effect. Although these two influences appear to be paradoxical, they are probably both situation and companion dependent and will be understood only after a more detailed account of the nature of the social interactions between rats is at hand.

The Modification of Affilative Behaviours in Rats

A first step in the analysis of the mechanisms under-

lying a behaviour such as affiliative behaviour in the rat is to study the behaviour as a function of both developmental and concurrent factors. In the case of affiliative behaviour the developmental factors studied to date have been those of social or isolated rearing conditions. Concurrent factors studied to date have been manipulations of the companion animal through, for example, surgical or pharmacological treatments, or manipulations of the living environments of the animals being studied, for example, social housing vs. isolated housing. It should be noted that the distinction between these concurrent housing manipulations is not based on the actual procedure involved, but rather on the age of the animals. Thus, socially isolating an adult animal refers to a housing manipulation, while the same procedure with younger animals refers to a rearing manipulation.

Concurrent factors - physiological manipulations. Joy and Latane (1971) conducted a study in which rats were tested for affiliation in an open-field under one of three drug conditions: Adrenalin (which the authors reasoned would induce a fear-like state), Chlorpromazine (a tranquillizer), and a placebo. The results revealed that the animals given adrenalin were more affiliative than were those given a placebo, which were, in turn, more affiliative than those given chlorapromazine.

Shillito (1970) treated male rats with either parachlorophenylalanine (PCPA) or placebo injections. PCPA has

been reported by Koe and Weissman (1966) to lower 5-hydroxytryptamine (5-HT) in the brains of rodents, but not to affect noradrenaline or dopamine concentrations. In lowering the 5-HT levels in the brain PCPA acts to reduce the influence of the serotonergic system; a system thought to be involved in behavioural inhibition (Fibiger and Campbell, 1972). Thus, PCPA may tentatively be considered as behaviourally, serving a disinhibitory function. Shillito noticed that rats treated with PCPA and housed in groups, with treated or untreated rats showed a profound hair loss. Isolated rats, whether treated or untreated, showed no loss of hair. Subsequent observation revealed that animals treated with PCPA show a greater frequency of chasing each other, rolling over, and social grooming than vehicle-treated animals. It appears that pharamacological treatments that have an excitatory influence on the central nervous system (CNS) are correlated with an increase both in the amount of social affiliation behaviour in which rats will engage and in the vigor of the interaction.

Using surgical rather than pharmacological manipulations of the CNS Johnson, Poplawsky, and Bielauskas (1972) compared the affiliative tendencies of rats with lesions of the septal forebrain to normal animals. Johnson et al found that rats with lesions of the septal forebrain were both more affiliative (spent more time in physical contact) and hyperemotional (emotionality ratings) in comparison with controls.

In a follow-up study Poplawsky and Johnson (1973) compared rats with either lateral septal, medial septal, or cingulate cortex lesions to controls using the same procedures as before. They found that rats with medial septal lesions affiliated to a greater extent than did controls, but were not hyperemotional. Whereas animals with lateral septal lesions were hyperemotional, engaged in more aggressive behaviour, but did not affiliate more than did controls. Cingulate cortex lesions did not affect the open-field social behaviour of the animals.

It should be noted with reference to these findings that Poplawsky and Johnson defined "chase", "attempted mount", "craw-over", "crawl-under", and "olfactory genital contact" behaviours as aggressive encounters. It is questionable that these behaviours constitute aggression in rats (see Grant and MacKintosh, 1963). Indeed, Barnett (1958) has referred to crawl-over, crawl-under, and chase behaviours in rats as "friendly" gestures. Moreover, Grant (1963) has shown that these behaviours occur most frequently with sniffing, following, and approach behaviours, and not with aggressive behaviours. Similarly, attempted mounting and anogenital sniffing are difficult to conceive of as aggressive behaviours. It would seem more accurate to conclude that the interactions involving animals with lesions of the lateral septal area were more vigorous, and this is consistent with the finding that these animals were hyperemotional.

19

These studies indicate that manipulations which have, what has been considered to be, an excitatory or disinhibiting effect on the CNS, affect the manner in which animals interact. In the Joy and Latane, and the Johnson et al. studies the effect was an increase in the amount of time spent in physical contact. In both the Shillito and the Poplawsky and Johnson studies the effect was an increase in the vigor of the social interactions of the animals. Thus both the amount of the affiliative behaviour and the manner in which the animals interact were affected.

Concurrent factors - stimulus features of the companion. Latane, Joy, Meltzer, Lubbell, and Cappell (1971) attempted to determine the critical stimulus features affecting the attractiveness of one rat for another. Rats were given tests of approach and physical contact to a variety of stimuli. Familiar and unfamiliar objects such as stuffed, anesthezied, tethered, and free roaming rats, rats varying in static stimulus qualities such as normal, dyed, shaven, or perfumed and rats under varying degrees of sensory impairment such as normal, blind, shaven, anosmic, or whiskerless were used as stimuli. Variations in the static qualities or sensory capabilities of the other rat had little affect on the degree of social affiliation. Variations in the dynamic qualities of the companion, however, did influence social attraction: Rats were more attracted to rats that could move and respond to them, and were less attracted to those that were in some way constrained and

thus less able to interact physically. Latane et al. concluded that "the quality of behaviour and the possibility of interaction mediate gregariousness in rats." Underscoring this point is finding by Latane and Hothersall (1972) that one of the few effective forms of a 'surrogate rat' is a responsive human hand. The authors suggest that the feature which distinguishes this form from less successful forms, e.g., a tennis ball, is its responsivity - its ability to interact.

Concurrent factors housing manipulations. One of the experimental manipulations that has been found to influence the degree to which rats will affiliate is that of depriving them of social contact for an extended period of time. Latane, Nesbitt, Eckman, and Rodin (1972) housed 44-day old male rats either in pairs or individually, for periods of time ranging from 15 minutes to 15 months. Periods of social isolation longer than 2 weeks led to a significant increase in social affiliation. Short periods of isolation, from 15 to 360 minutes, had no effect on social affiliation. Sloan and Latane (1972) found that rats housed alone, but given regular periods of handling did not show the increase in social affiliation typical of isolates. Physical enrichment of the environment did not, however, reduce the increased sociability of isolated rats. These results further support the conclusion that the critical factor determining the social affiliation in rats is the physical interaction between the animals. In a further attempt to

establish the important feature of the adult isolation effect on subsequent affiliative behaviour, Walton and Latane (1972) housed rats either in pairs, in pairs but with a wire mesh screen separating the animals, or in isolation. The animals were maintained in these conditions for 1 week prior to tests for social affiliation. The results showed that the group permitted visual, but not physical, contact were indistinguishable from those completely isolated. These findings all point to the conclusion that the primary incentive event for affiliative behaviour is physical interaction, that is, affiliative behaviour is maintained by the opportunity to engage in physical interaction with another animal. Furthermore, for normally reared animals, periods of isolation in adulthood lead to subsequent increases in affiliative behaviour.

The obvious question that follows from this is, what factors make a social interaction experience with a member of the species a positive incentive event? This is, in part, a developmental question closely related to the whole problem of social attachment. One general hypothesis assumes that mere exposure to a salient species can lead to 'liking' and social attachment. One form of this hypothesis assumes that during the first few days of life the range of stimuli to which the infant organism can effectively be exposed to decreases. This 'learning' process has come to be known as imprinting (Lorenz, 1965). Thus, a major assumption of imprinting is that the process which results in the formation

of social attachment bonds is effective only during the very early period of the organism's life. Another form of this hypothesis assumes that mere exposure to a salient stimulus at <u>any</u> time in the life of the organism can lead to increased 'liking' and social attachment. Exponents of this hypothesis (e.g., Cairns, 1966; Scott, 1962; Zajonc, 1972) suggest differing limitations to this assumption, but all agree that familiarity breeds liking and not disinterest, or least of all, contempt. The reason, according to this view, that animals prefer to affiliate with members of their own species is that the normal conditions of life are such that they are most exposed to members of their species. This appears to be so with rats which, as reported by Latane (1974), prefer to affiliate with rats rather than gerbils - which in turn prefer to affiliate with gerbils rather than hampsters, etc. The exposure hypothesis cannot, however, account for the results of studies on housing and affiliation. Latane et al (1972) found that rats isolated for as long as 15 months affiliated more with conspecifics than did socially housed animals. Such a period would seem sufficiently long in a rats life span to make it less familiar with conspecifics than would an animal housed continuously in social conditions. Nevertheless these animals were more attracted to conspecifics than were the socially housed animals. Likewise the finding that rats spend more time with novel partners than with cagemates (Barefoot et al, 1975) supports the view that while familiarity may breed species-specific

attraction, novelty may account for intraspecies attraction.

Developmental factors. Ashida (1964) examined the modification of affiliative behaviour in male and female rats brought about by differential early rearing experience. In this study both male and female animals were used; virtually all the studies discussed here have employed male animals exclusively. Ashida housed 21-day old rats for 18 weeks in one of three conditions: in isolation, in same-sex pairs, or in groups of five same-sex animals. The tests of affiliative behaviour consisted of placing the animal in the start compartment of a two compartment box and then opening a door to a narrow passageway leading to the goal compartment which contained another rat. If the subject entered the goal compartment it was allowed to stay there for 15 seconds, and was then returned to the start compartment. This procedure was repeated for a 10 minute period. The number of crossings made by an animal was considered to be the indicant of the animal's affiliative tendency. The number of crossings was found to be a function of both sex and rearing condition. Group-housed animals had higher crossings scores than did animals housed in pairs, which in turn crossed more often than isolates. Overall, females made more crossings than did males. It is difficult to conclude, however, that these differences reflect differences in affiliative behaviour. Studies conducted since 1964, examining the emotional and exploratory behaviours of rats reared in social isolation or in groups have shown that

isolated animals are more fearful of novel situations and are less likely to explore under such conditions than are socially reared animals (Moyer and Korn, 1966; Syme, 1973; Morgan, 1973). Moreover, it appears that not only are females more active in novel situations regardless of rearing condition (Archer, 1974), but they are also less likely to be affected by early rearing conditions than are males (Levine, 1974). Since Ashida's testing situation could well be considered as novel for the animals, it may well be that he was measuring exploratory behaviour and not affiliative behaviour.

Becker (1971) attempted to examine the same variables as had Ashida, using a variant of Latane's open-field test of affiliation. Male and female rats, 22 days of age, were housed for 100 days in either isolation or three to a cage. Testing involved placing animals of the same sex and rearing condition in an open-field for 200 seconds. At 10-second intervals the experimenter recorded whether or not the animals were in the same square (an index of affiliation). This was done for all animals, once a day, for 10 days. It was found that for the first 5 days the male isolates were more affiliative than were the males reared in social conditions. After the fifth day, however, the effect was completely reversed; the socially reared males were more affiliative than were the male isolates. This reversal was a function of both an increase in the affiliation between socially reared males, and a decrease in the affiliation

between isolation-reared males. The two female groups did not differ significantly at any point during testing; their scores consistently fell between those of the two male groups.

In a second experiment Becker examined the effects of social density of rearing on affiliation. Groups of four male and female rats were housed by sex wither in single width cages (high social density) or in double width cages (low social density). These housing conditions were initiated at 22 days and maintained until 7 months of age. The testing procedure was the same as that used in the first experiment. The males reared in the low density social condition were significantly more affiliative than were the males reared in the high density social condition. As in the first experiment, the two female groups did not differ from each other and their scores fell between the two male groups.

Although these results do not clearly indicate the effects of rearing conditions on adult social behaviour, they do suggest that male and female rats are differentially affected by early rearing conditions. It appears that the affiliative tendencies of female rats may be less influenced by manipulations in the early rearing conditions than are those of male rats.

Lore and Flannelly (1977) established small colonies of adult laboratory animals, half of which consisted of rats reared from weaning in same-sex groups, and half of rats

reared from weaning in isolation. Virtually no fighting was observed among the members of either type of colony. Adaptational differences, however, were evident. Adjustment to group living was reported to be more difficult for the rats reared in isolation than for those reared in groups. Although all females gained weight and all males lost weight, the isolate males lost twice as much as the socially reared males, and the isolate females gained only half as much as their socially experienced counterparts.

In a second experiment reported by the same authors, unfamiliar "intruder" rats, reared either in isolation or in social conditions, were introduced into the colonies. Behavioural observations were made during the intruders first hour in the colony and a later physical examination of the animal was conducted. The results showed that only isolation-reared intruders that were introduced into a colony of socially reared rats suffered serious physical injury and large weight losses.

Lore and Flannelly report that the results of some later work revealed that socially reared rats, when in a position of being attacked, often produce ultrasonic signals. The authors speculate that these signals may serve to inhibit the attack of another animal. The possibility then exists that if this behaviour is dependent on the previous social experience of the animal, that isolation-reared intruders were less able to inhibit the aggressive behaviour of the members of the socially experienced colony.

The results of these developmental studies suggest that variations in the early environment of a rat can alter the development of social behaviour. Becker's results point to a differential influence of rearing conditions on male and female rats. Lore and Flannelly's work suggests that isolated rearing alters the effectiveness of a rat's social behaviour or "social skills". These findings in combination indicate the need to study in greater detail the extent to which the affiliative behaviour of male and female rats is modified by early social experience, and to determine how, what rats do while in social contact is modified.

As a first step, however, it is necessary to study the affiliative behaviour of male and female rats in standard laboratory situations, and in doing so, to develop a method for specifying in greater detail what it is that rats do while socially interacting. In the series of experiments to be described in this thesis the affiliative behaviour of male and female rats was studied under two standard conditions. Both the degree and the quality of the social interactions were measured. Following these preliminary studies, the same behaviours were studied as a function of concurrent housing condition and as a function of early rearing condition.

Experiment 1

One noticeable feature of the studies reviewed in the introduction was the virtually exclusive use of male animals as subjects. The results of those few studies in which both male and female animals were used, however, indicate that there may well be qualitative as well as quantitative differences in the patterns of social interations of male and female rodents. Thus, Experiment 1 was designed to examine the affiliative behaviour of male and female rats in two different tests. The first was an open-field test of gregariousness used by Latane (1969). In this test animals are placed in an open-field in pairs and the amount of time spent in physical contact is recorded. This measure has been assumed to be a meaningful index of affiliation. The second situation was a social facilitation test in which the socially facilitated activity in an open-field was examined.

Method

Subjects

The animals used in this experiment were 10 male and 10 female Hooded rats obtained from the Canadian Breeding Farm and Laboratories, La Prarie, Quebec. On arrival, the animals were housed individually in standard wire mesh cages and were not handled until the first day of testing, 20 days later. The animals had free access to food and water throughout the duration of the experiment. At the

time of testing the animals were approximately 90 days old.

Apparatus

The tests were conducted in an 81 x 81 cm open-field, the floor of which was marked off into 36 equal squares. A 12 db noise, produced from a Grason-Stadler (Model 901B) noise generator, served to mask extraneous noises throughout the testing sessions. A 25-watt light bulb, hung 1 m above the open-field, was the sole source of lighting in the room during testing. A manually operated cumulative clock was used to record the amount of time spent in contact.

Procedure

Test of gregariousness: The two groups of 10 rats were assigned to five same-sex pairs. All pairs were tested on the same day in a random order. The animals were transported to the laboratory in two separate containers and then the two animals of the pair were placed, one at a time, in opposite ends of the open-field. They were allowed to move about freely for a period of 10 minutes. During this period the experimenter recorded the amount of time the animals spent in physical contact in each of 10 time-blocks of 55 seconds each. The last 5 seconds of each minute were used for recording purposes. Tail contact was not considered as physical contact.

Social facilitation test: As in the previous test the animals were assigned to 10 same-sex pairs. Two

test sessions were conducted; for each session the pairs were composed of different animals. The composition of the pairs was also different from that of the test of gregariousness. Again, the animals were transported to the laboratory in separate containers. Testing was done over a 2-day period.

During the first testing session, one animal was designated as the target animal and the other as the stimulus animal. The target animal was placed in a designated start spot in the open-field. During the next 5 minutes the number of square-crossings made by the target animal was recorded in five 55-second time-blocks. The location of the animal's right front paw was used to determine in which square it was positioned. After 5 minutes the stimulus animal was placed in the open-field in the corner farthest from where the target animal was positioned at that particular moment. The number of square-crossings made by the target animal was recorded for the next 5 minutes, in five 55-second time-blocks. At the end of this period the animals were returned to the colony.

For the second session, one member of each pair was a target animal from the previous session, and the other a stimulus animal. For this second session the roles were reversed. The tests were conducted in an identical manner to the first session.

Results and Discussion

Test of gregariousness: The time-spent-in-contact

scores for pairs of animals during each time-block were analyzed using a two-way analysis of variance (Winer, 1962) for sex x time-block. A summary of the ANOVA is presented in Table 1. An examination of the results revealed that both the sex of the animal and time-block had a significant influence on the amount of time spent in physical contact. The sex x time-block interaction was not significant.

It can be seen from Figure 1 that the male pairs consistently spent more time in contact than did the female pairs. Also, it can be noted that the time spent in contact increased as a function of time in the test situation. Overall, it was found that the male animals spent approximately 35 to 40 per cent of their time in physical contact. This finding, as well as that of the increased time spent in contact over time, confirm those of Latane and his co-workers (Latane, 1974), indicating that, most likely, a similar phenomenon was being measured in the present study.

Social facilitation test: The square-crossing data from each time-block were analyzed using a three-way analysis of variance for sex x alone/paired conditions x time-block. 'Alone' refers to that period of time prior to the introduction of the stimulus animal, while 'paired' refers to that period of time following the introduction of the stimulus animal. A summary of the ANOVA is presented in Table 2. The results showed that there was a significant effect due to the introduction of the stimulus animal

Table 1

Test of gregariousness - Experiment 1:

Summary table of the ANOVA

Source	df	Mean Square	F	p
Sex	1	676.00	5.23	.05
Subjects	8	129.24		
Time-Blocks	9	331.93	2.61	.01
Sex x Time-Blocks	9	23.24	.18	.99
Time-Blocks x Subjects	72	127.24		

Table 2

Social facilitation test - Experiment 1:

Summary table of the ANOVA

Source	df	Mean Square	F	p
Sex	1	1372.88	2.97	.11
Alone/Paired	1	12230.05	42.96	.001
Subjects	18	461.98		
Time-Blocks	4	492.15	5.16	.001
Sex x Alone/paired	1	1909.62	6.71	.02
Sex x Time-Blocks	4	65.98	.69	.60
Alone/paired x Time-Blocks	4	71.28	.88	.48
Alone/Paired x Subjects	18	248.68		
Time-Blocks x Subjects	72	95.29		
Sex x Alone/Paired x Time-Blocks	4	100.20	1.23	.20
Alone/Paired x Time-Blocks x Subjects	72	81.33		

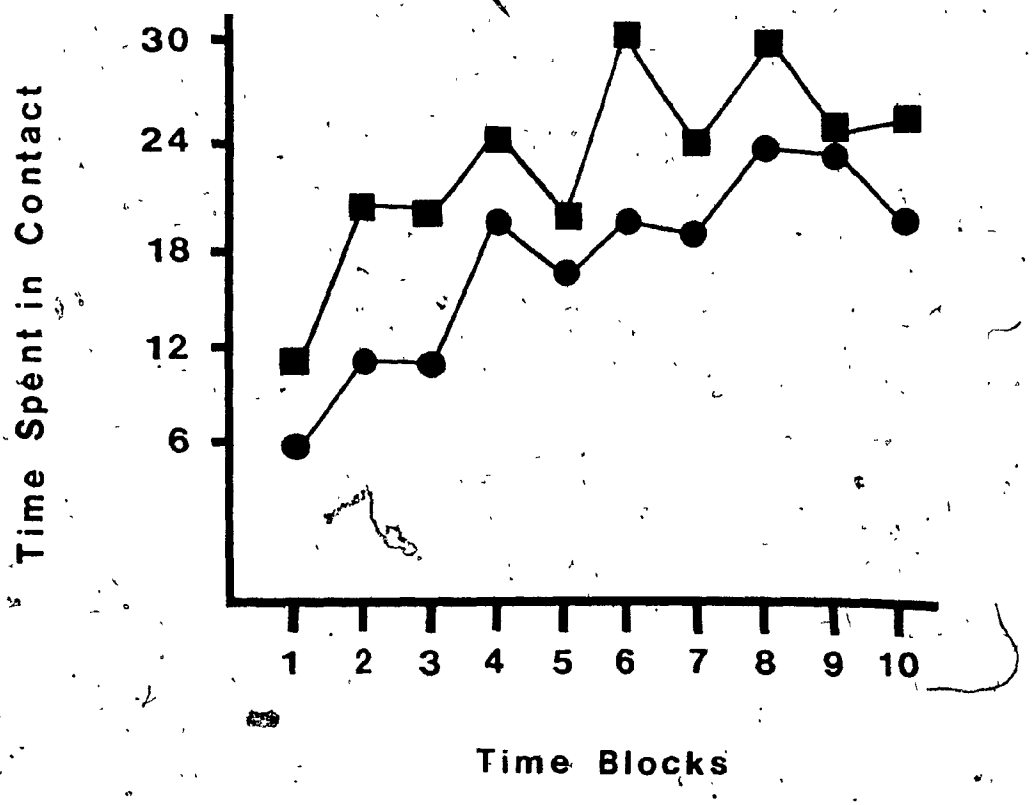

Figure 1. Time spent in contact over time by males (■) and females (●).

(alone/paired variable). It can be seen from Figure 2 that this effect is due to the rather large increase in the number of squares crossed by the target animal following the introduction of the stimulus animal. The mean number of squares crossed by both the male and female target animals for each of the five time-blocks in which the animals were paired was greater than at any point prior to the introduction of the stimulus animal.

The presence of a main effect due to the alone/paired conditions would seem to indicate that the test condition used was appropriate for eliciting a social "facilitation" effect. The fact that the greatest increase in activity occurred in the first time-block after the introduction of the stimulus animal, further supports the view that activity meaningfully reflected the reaction of one animal to the introduction of the other.

The results of the ANOVA also reveal that there was a significant effect of time-blocks on the activity of the animals. As shown in Figure 2, this effect can be attributed to the decrease in the number of squares crossed by both groups during the latter time-blocks of both the alone and paired conditions.

Although there was no main effect of sex, the sex x alone/paired conditions interaction was significant. It can be seen from Figure 2 that this interaction effect is due to the differential reaction of the male and female target animals to the introduction of the stimulus animal;

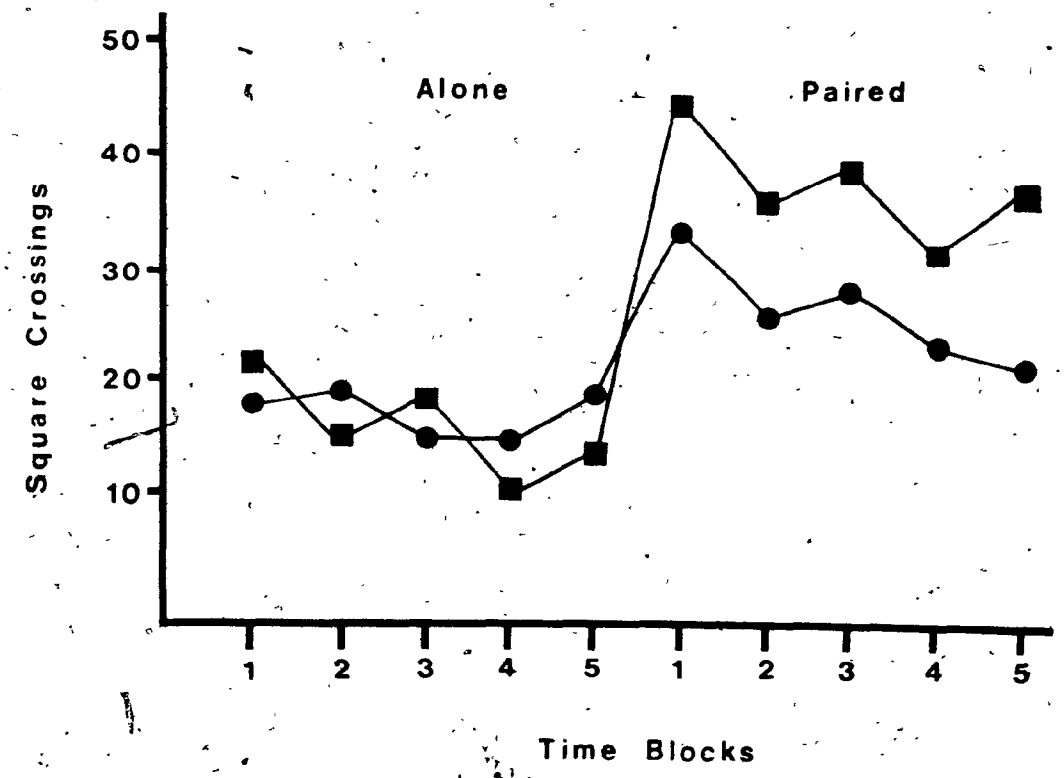

Figure 2. Square-crossing scores over time for males (■) and females (●) in the alone and paired conditions.

males were more responsive, at least in terms of activity, than were females.

The results of the social facilitation test and the test of gregariousness would seem to indicate that there is a difference between the affiliative tendencies of male rats and those of female rats. Moreover, from Figure 2 it can be seen, that while both male and female animals showed an increase in activity in the paired condition of the social facilitation test relative to the alone condition, the increase was substantially greater amongst the male animals. This indicates that, within this test situation, the behaviour of the male animals was influenced to a greater extent by the introduction of an interacting same-sex conspecific than was that of the female animals. These findings, taken together, suggest that, at least in the two test situations in Experiment 1, the affiliative tendencies of male rats are stonger than those of female rats.

Experiment 1a

Although the results of Experiment 1 revealed a sex difference in the affiliative behaviour of rats, it cannot be discerned from the data whether this is a difference of kind or simply one of degree: That is, whether females engage in different affiliative behaviours than do males, or whether they merely engage in the same behaviours less frequently.

While studying the agonistic behaviours of wild rats

in an artificial colony, Barnett (1958) observed that the social relations between male animals and those between female animals differed in terms of aggressive behaviours; females were less responsive to same-sex conspecifics that were the males, except while protecting a litter. In a study comparing the social behaviour of prepubescent male and female rats, Olioff and Stewart (1977) found that male pups engaged in more rough-and-tumble play behaviour than did the female pups. These findings would seem to suggest that the social interactions of male rats are more vigorous than are those of female rats.

If a similar pattern of sex differences exists in adult rats, then one might expect that there would be differences between the affiliative behaviours of male rats and those of female rats. One might further expect that these differences would reflect the differences in young animals, such that the affiliative behaviours of males would be more vigorous than those of the females.

Experiment 1a was designed to investigate this issue. As in Experiment 1, adult male and female rats were tested for both gregariousness and for social facilitation. This time, however, video tapes were made of the testing session. The tapes were subsequently analyzed and scored for different affiliative behaviours. These behaviours included rough-and-tumble play, social grooming, passive conduct, chase, sniffing, and passing-by. Two additional categories were, not-interacting/same quadrant, and not-interacting/

different quadrant. These were added to provide an additional index of gregariousness, namely that of social distance. The same measures were used in both the test of gregariousness and the social facilitation test and, thus, allowed for a comparison between the affiliative behaviours of the animals in the two test situations.

Method

Subjects

The subjects were the same as in Experiment 1. They had been maintained, as before, in socially isolated housing conditions since the completion of Experiment 1 (approximately 20 days prior to the start of this experiment).

Apparatus

While the basic apparatus used in this experiment was the same as that used in Experiment 1, two changes were introduced. The camera of a Sony Video Tape Recorder (VTR) system was mounted about 75 cm above the open-field. For recording purposes the size of the open-field was reduced to 61 x 61 cm. This reduction resulted in 16 rather than 36 equal squares. Lighting was provided by a series of 15-watt light bulbs hung around the perimeter of the open-field at a

height of about 60 cm.

Procedure

The testing procedure was the same as in Experiment 1. As in Experiment 1, the composition of all pairs was unique to that testing session. The sole modification to the design was that in the social facilitation test there were seven 55-second time blocks rather than five.

The two measures, time-spent-in-contact (gregariousness) and number of squares crossed (social facilitation) were analyzed as in Experiment 1. The video tapes were scored using a time-sampling procedure in which the interactions of the animals were scored once every 3 seconds. The behavioural categories constructed were both mutually exclusive and exhaustive. Thus, only one score could be given for each time sample. The categories were defined as follows:

1- Chase: The active pursuit of a moving animal by another animal.

2- Sniffing: Any form of sniffing directed at the other animal.

3- Passive Contact: Instances when the animals were in direct physical contact, but were either motionless or directing their behaviour toward something other than the second animal.

4- Rough-and-Tumble Play: Instances in which one animal was crawling over, under, or pushing along another animal.

5- Social Grooming: The grooming of one animal by another.

6a- No-Interaction/Same Quadrant: For the purpose of scoring this category, the open-field was divided into four equal quadrants each composed of four squares. A score in this category indicated that the animals were in the same quadrant (proximity), but were not in physical contact.

6b- No-Interaction/Different Quadrant: A score in this category indicated that the animals were not in contact with each other, and were in different quadrants.

For consideration of the inter-rater reliability see Appendix D.

Results and Discussion

Test of gregariousness: The ANOVA (Table 3) carried out on the time-in-contact scores from this second set of tests on the same animals yielded no significant sex or sex x time-blocks effects. There was, however, a significant, but uninterpretable effect of time-blocks (see Figure 3). From Figure 3 it can be seen that the male animals spent only slightly more time in contact than the female animals. A possible explanation for these results is that in Experiment 1a the animals were being exposed to the test of gregariousness for a second time. Becker's (1971) results showed that in both males and females, socially reared rats housed in isolation were more gregarious with repeated testing. In Experiment 1 of the present study the male animals spent 41 per cent of their time in contact and the females spent 31

Table 3

Test of gregariousness - Experiment 1a:

Summary table of the ANOVA

Source	df	Mean Square	F	p
Sex	1	538.24	1.28	.29
Subjects	8	419.38		
Time-Blocks	9	262.18	2.25	.03
Sex x Time-Blocks	9	35.71	.31	.97
Time-Blocks x Subjects	72	116.65		

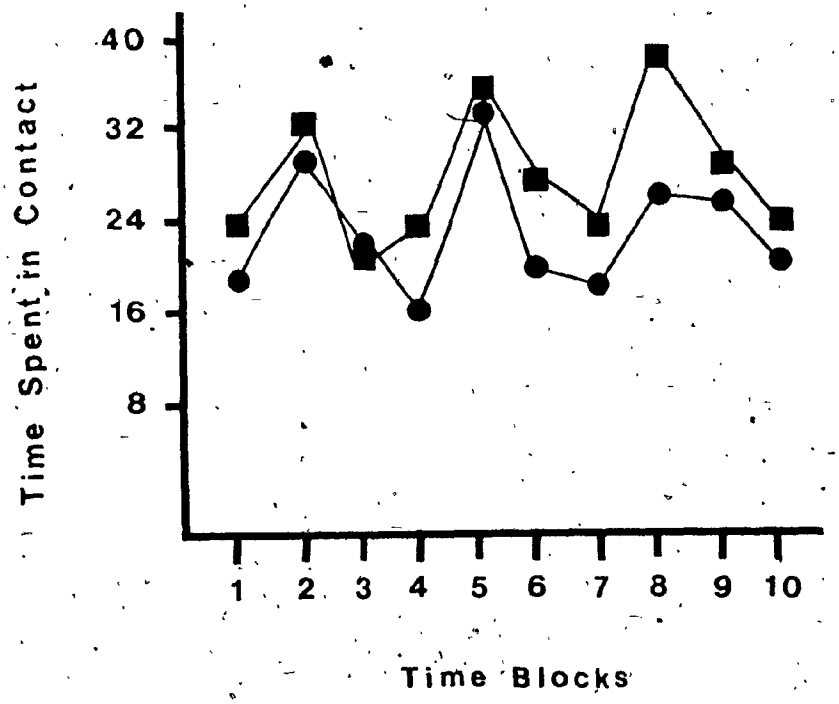

Figure 3. Time spent in contact over time by males (■) and females (●).

per cent. In Experiment 1a this increased to 51 per cent for the males and to 42 per cent for the females. Thus, those factors involved in repeated testing, i.e., handling, increased period of isolation housing, reduced novelty of the test situation, etc., seem to have influenced the amount of time spent in physical contact by the animals in the test of gregariousness.

Social facilitation test: The ANOVA (Table 4) conducted on the square-crossing scores yielded significant effects for the alone/paired conditions and for time-blocks. Although as in Experiment 1 the main effect of sex only approached significance, the sex x alone/paired condition interaction was significant. From Figure 4 it can be seen that this interaction reflects the greater increase in square-crossings in male animals than in female animals upon the introduction of the stimulus rat.

In contrast with the results of the test of gregariousness, the results of the social facilitation test do replicate those of Experiment 1. As in Experiment 1, the male animals were more responsive than were the female animals. Clearly, there seems to be a sex difference in the degree to which the presence of an interacting same-sex conspecific influences the behaviour of a rat; males being influenced to a greater extent than females.

Behavioural analysis. For the purposes of this analysis the behavioural categories were divided into two classes, those involving interactions (interaction class) and those

Table 4

Social facilitation test - Experiment 1a:

Summary table of the ANOVA

Source	df	Mean Square	F	p
Sex	1	939.89	4.04	.06
Subjects	18	230.17		
Alone/Paired	1	14500.80	112.69	.001
Sex x Alone/Paired	1	1836.03	14.27	.001
Alone/Paired x Subjects	18	128.68		
Time-blocks	6	1225.73	32.83	.001
Sex x Time-Blocks	6	57.88	1.55	.17
Time-Blocks x Subjects	108	37.34		
Alone/Paired x Time-Blocks	6	91.60	2.11	.06
Sex x Alone/Paired x Time-Blocks	6	66.01	1.52	.18
Alone/Paired x Time-Blocks x Subjects	108	43.32		

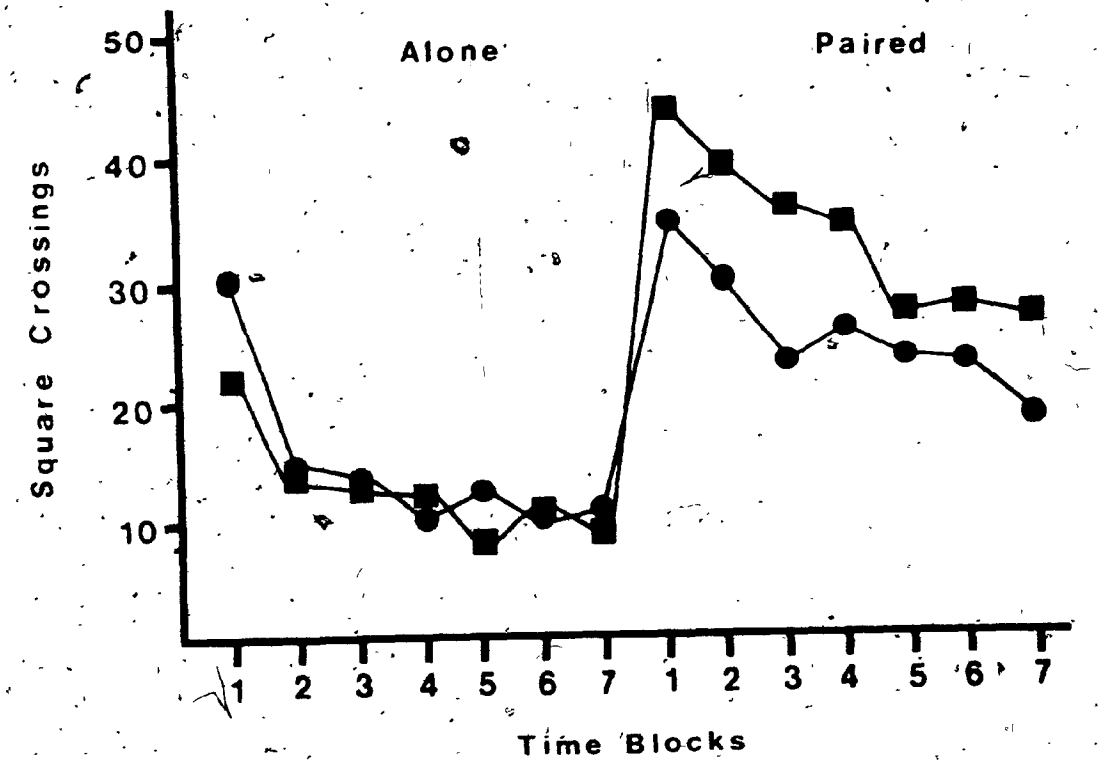

Figure 4. Square-crossing scores over time for males (■) and females (●) in the alone and paired conditions.

which did not (no-interaction class). The number of times a particular behavioural category was scored within an observational session was calculated for each pair of animals. For the categories within the no-interaction class, as well as for the interaction class as a whole, scores were expressed as a per cent of the total number of observations:

$$\frac{\text{Total score (for category/class)}}{\text{Total number of observations}} \times 100$$

For the behavioural categories within the interaction class, scores were expressed as a per cent of the total scores for all the behavioural categories within that class:

$$\frac{\text{Total score (for category)}}{\text{Total score for interaction class}} \times 100$$

This was done to avoid the possibility that a large sex difference for some behavioural category might simply reflect a difference in the total amount of time interacting.

The scores on each behavioural category for the pairs of male animals were compared to those of the female pairs using Mann-Whitney U-Tests (Seigel, 1960). All tests were two-tailed with the accepted level of $p<.05$.

In general, the interactions between the animals may be characterized as follows. In both test situations, in the initial phase of the session, the animals engaged primarily in chase and sniffing behaviours (see Figure 5). In the test of gregariousness both animals slowly approached one another and then engaged in alternate bouts of mutual sniffing and of exploration of the test environment. In the social facilitation test the target animal approached the stimulus

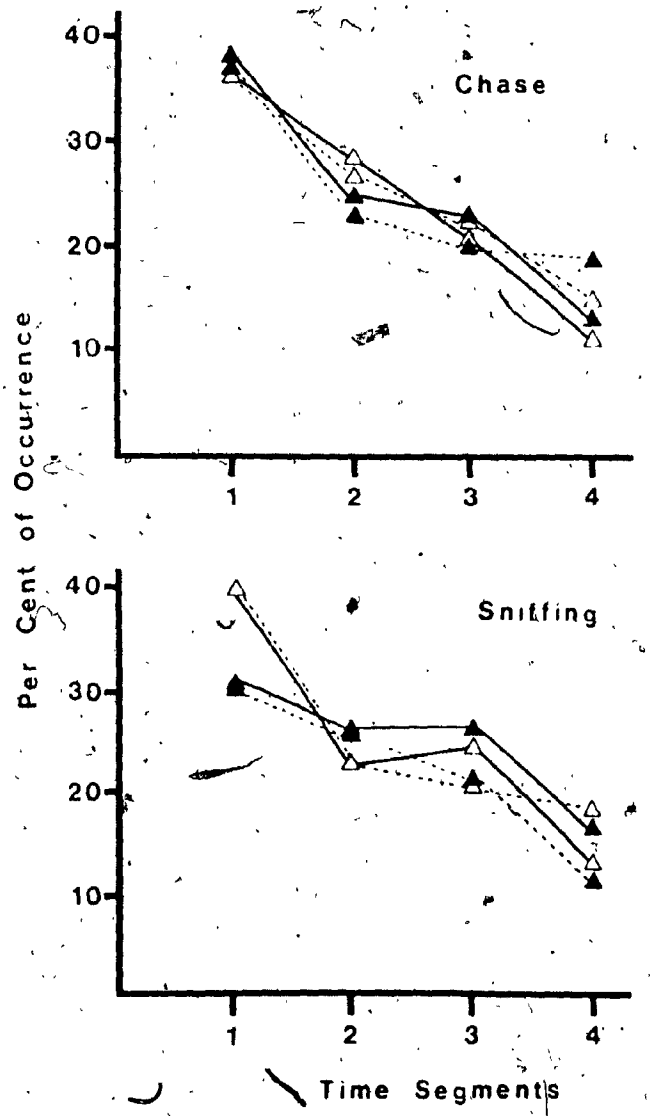

Figure 5. Per cent of occurrence of chase and sniffing behaviour over time segments (toal time/4), for males (▲) and females (△), in the test of gregariousness (---) and the social facilitation test (——).

and while the stimulus animal was exploring the test environment, would chase and sniff it. This would continue until the stimulus animal, its curiosity apparently sated, would turn its attention to the target animal. After this initial phase of the test session, the animals became increasingly more passive in their interactions (see Figure 6). This sequence was generally true for both males and females. Males, however, engaged in social interactions of longer duration than did the females (see Table 5).

The results of the behavioural analysis are presented in Tables 6 and 7, and in Figures 7 and 8. The raw scores for all observations can be found in Appendix A. It can be seen that there were a number of differences between the social interactions of the male rats and those of the female rats. The differences that were statistically significant were as follows: (1) Males engaged in more rough-and-tumble play behaviour than did females, (2) males engaged in more chase behaviour than did females, (3) females engaged in more social grooming behaviour than did males, and (4) in the social facilitation test, females tended to spend more time not interacting than did males ($p=.06$). In addition, it can be noted that, in contrast to the test of gregariousness in Experiment 1, animals in the social facilitation test spent less time in contact as time in the test situation increased (see Figure 6).

To summarize, the behavioural analysis indicated that the social interactions between male animals were more

Table 5

The Duration* of the social interactions of male and female pairs

Sex	Mean Duration**
Males	4.28
Females	3.18

* Duration of an interaction is number of consecutive time-samples in which the animals were interacting. Each no-interaction score indicates the end of an interaction. The mean duration is calculated by dividing the total interaction scores by the number of interactions.

** This difference is significant ($U = 16$; $p = .02$).

Table 6

Occurrence of interactions as a per cent of total observations

Test of gregariousness

Sex	No-Interaction Same/Quadrant	No-Interaction Diff/Quadrant	Interaction
Males	17	25	58
Females	15	33	52

Social facilitation test

Sex	No-Interaction Same/Quadrant	No-Interaction Diff/Quadrant	Interaction
Males	13	16	71
Females	17	20	63

Table 7

Statistical analysis of the behavioural data for each category in both tests

Test of gregariousness

Category	U	p
Chase	0	.005
Sniffing	8.5	.25
Passive Contact	7.5	.18
Play	3	.02
Social Grooming	0	.005

Social facilitation test

Category	U	p
Chase	7.5	.001
Sniffing	38	.20
Passive Contact	43	.34
Play	17.5	.02
Social Grooming	1.5	.001
No-Interaction	21	.03

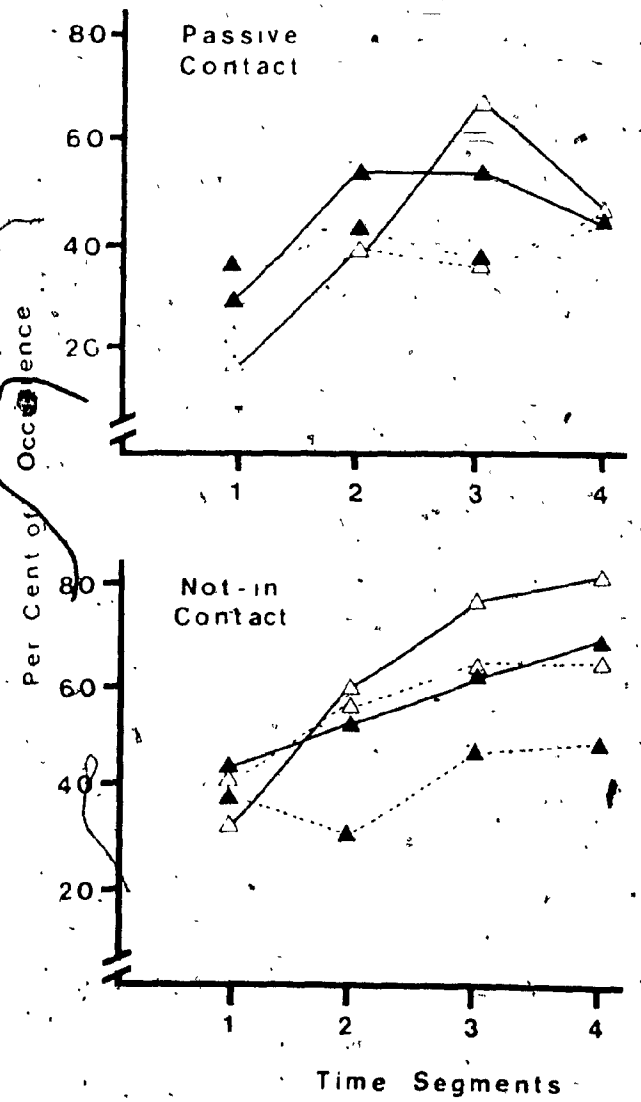

Figure 6. Per cent of occurrence of passive contact behaviour over time in the test of gregariousness (---) and the social facilitation test (——), and not-in-contact - same Quad. (---) and diff Quad. (——) - for the social facilitation test for males (▲) and females (△).

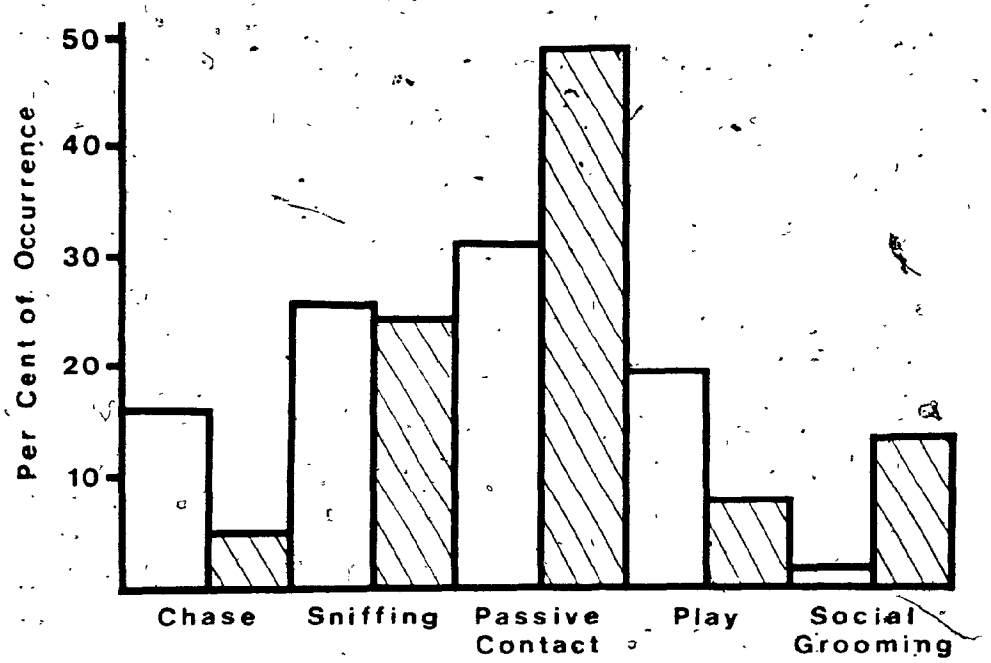

Figure 7. Per cent of occurrence for each behavioural category for males ( ) and females (\\) in the test of gregariousness.

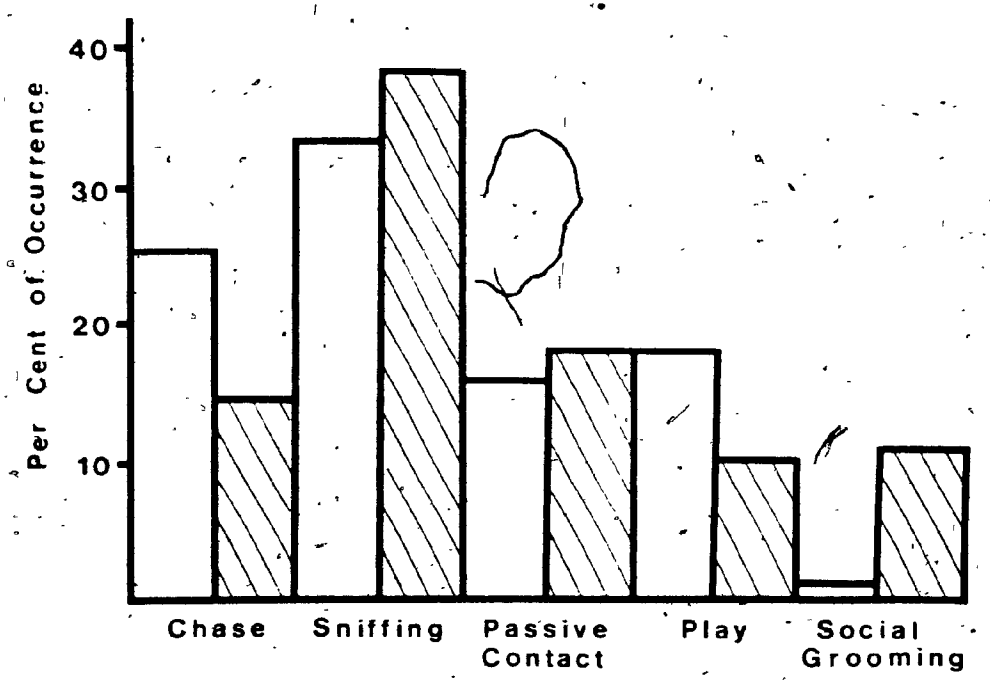

Figure 8. Per cent of occurrence for each behavioural category for males ( ) and females (\\) in the social facilitation test.

vigorous than were those between the female animals. Males engaged more often in rough-and-tumble play behaviour and chase behaviour, while females engaged more frequently in social grooming behaviour and appeared to be somewhat more passive in their social interactions. These differences were apparent in both the test of gregariousness and the test for social facilitation. It is also worth noting that, in the test for social facilitation, the male animals spent more time in contact (less time not interacting) than did the females.

Experiment 2

The results of Experiments 1 and 1a suggest that there is a fundamental difference between the affiliative behaviour of male rats and that of female rats. This has been demonstrated both in terms of the tendency to maintain social contact and in the degree to which the behaviour of one rat is influenced by the presence of an interacting conspecific. Moreover, it has been shown that these differences exist at both quantitative and qualitative levels.

Within the framework of the introduction, the question that would seem to follow from these findings is whether the affiliative behaviour of male and female rats is influenced by a concurrent housing manipulation previously shown to affected the degree to which male rats will affiliate, that of differential social housing (Latane, Nesbitt, Eckman, and Rodin, 1972). Specifically, the question is whether the affiliative behaviours of male and female adult rats are

similarly affected by social deprivation. The results of the previous experiments might suggest that because male rats are more responsive to same-sex conspecifics, they would be more influenced by social deprivation. Again, the findings of Experiment 1a suggest that both quantitative and qualitative measures of the social interactions would be of interest. Thus, Experiment 2 was designed to examine the degree to which social deprivation might influence the affiliative behaviours of male and female animals in the two test situations used in the previous experiments. It was expected that, in comparison to socially housed animals, animals housed in social isolation would show a greater amount of time spent in contact and a greater amount of socially facilitated activity. Moreover, it was predicted that these differences would be greater in the male animals than in the female animals.

Method

Subjects

The subjects used in this experiment were 24 male and 24 female Hooded rats obtained from the previously mentioned supplier. On arrival, half of the animals, 12 males and 12 females, were housed individually in standard wire mesh cages. The remaining animals were housed, by sex in double width wire mesh cages, in groups of four. The animals were not handled again until testing, 20 days later. The animals had free access to food and water throughout the experiment. At the time of testing, the animals were approx-

imately 90 days old.

Apparatus

The apparatus was the same as that used in Experiment 1a.

Procedure

The procedure was the same as in Experiment 1a with the exception that the category "passing-by" was not included.

Results and Discussion

Test of gregariousness: The time-spent-in-contact scores for each time-block were analyzed using a three-way analysis of variance for sex x housing condition x time-block. A summary of the ANOVA is presented in Table 8. An examination of the results revealed that the main effect of sex and housing condition were significant. The mean time spent in contact for each of the four groups can be seen in Figure 9.

Of particular interest was the significance of the sex x housing interaction. A Tukey post-hoc analysis (Myers, 1972) was used to determine the sources of significance. Differences between means exceeding the Critical Range of $p<.05$ were considered as significant. The results of this analysis are presented in Table 9. The results reveal that males housed in isolation spent more time in contact than did any of the three other groups. Both females housed in isolation and socially housed males spent more time in contact than did socially housed females. There was no significant difference between the socially housed males and the isolation-housed females.

Social facilitation test: The square-crossing scores for each time-block were analyzed using a four-way analysis

Table 8

Test of gregariousness - Experiment 2:

Summary table of the ANOVA

Source	df	Mean Square	F	p
Sex	1	2001.04	21.54	.001
Housing	1	1876.00	20.19	.001
Sex x Housing	1	900.94	9.70	.006
Subjects	20	92.91		
Time-Blocks	9	30.64	.66	.75
Sex x Time-Blocks	9	65.13	1.39	.19
Housing x Time-Blocks	9	84.80	1.82	.07
Sex x Housing x Time-Blocks	9	35.46	.76	.65
Time-Blocks x Subjects	180	46.60		

Table 9

Test of gregariousness - Post hoc analysis of differences between means of time-spent-in-contact scores of isolation and socially housed male and female animals

Sex x Housing interaction effect

CR= 93.5 q= 4.20 p= .05

Sex x Housing groups compared		Difference
Isolation males - Isolation females	1128 - 564	564*
Isolation males - Social males	1128 - 552	576*
Isolation males - Social females	1128 - 450	678*
Isolation females - Social females	564 - 450	114*
Isolation females - Social males	564 - 552	12
Social males - Social females	564 450	102*

* Significant at p=.05

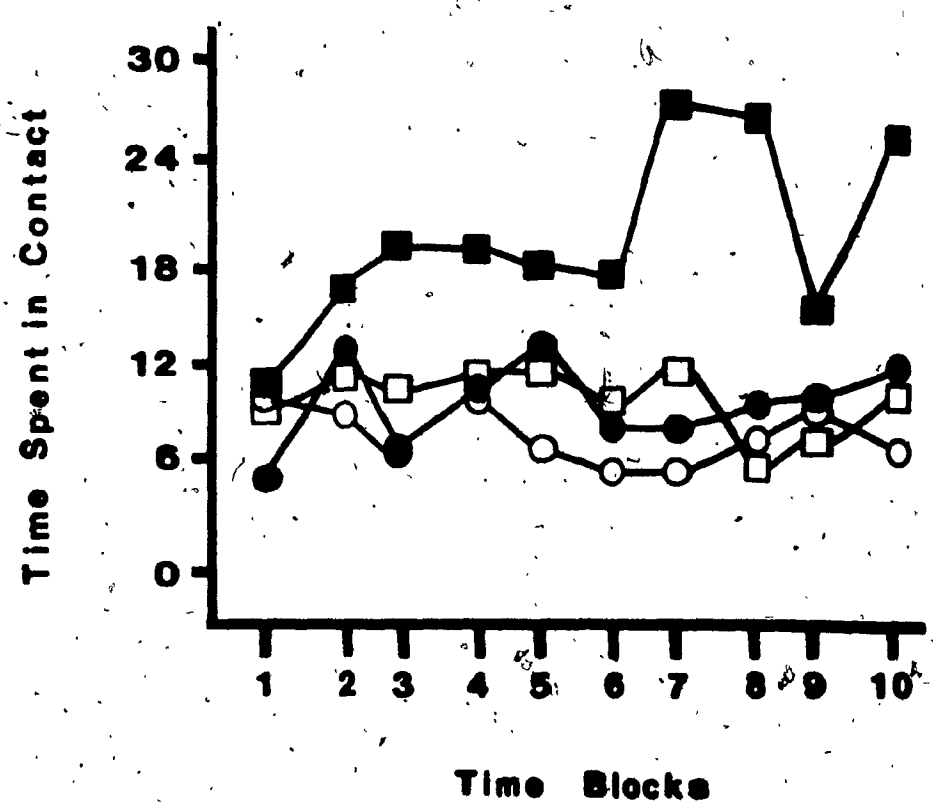

Figure 9. Time spent in contact over time by isolation housed males (■) and females (●), and socially housed males (□) and females (○).

of variance for sex x housing condition x alone/paired conditions x time-blocks. A summary of the ANOVA is presented in Table 10. Examination of the table reveals that there was a significant effect of sex on square-crossing. From Figure 11 it can be seen that females were generally more active than males, especially in the alone condition; and thus the significant sex x alone/paired interaction.

There was also a significant main effect due to the housing conditions. This appeared to be due to the greater overall activity of the isolation housed animals, but especially in the paired condition; again this is reflected in the significant housing x alone/paired conditions interaction.

The alone/paired condition main effect was also significant. As previously found, the animals were more active in the paired condition than in the alone condition. There was also a significant effect of time-blocks. It can be seen from Figure 11 that this effect was due to the general decrease in activity over the five time-blocks in both the alone and paired conditions.

Of primary interest were the interactions between sex x housing x alone/paired conditions and between sex x alone/paired conditions. A Scheffé post-hoc test (Myers, 1972) was used to determine the source of significant effects (see Table 11). Differences between means exceeding the Critical Range at $p < .05$ were considered as significant.

Table 10

Social facilitation test - Experiment 2:

Summary table of the ANOVA

Source	df	Mean Square	F	p
Sex (S)	1	1306.80	5.04	.03
Housing (H)	1	2009.01	7.75	.008
S x H	1	154.13	.59	.44
Subjects	44	259.21		
Alone/Paired (A/P)	1	4940.83	63.46	.001
S x A/P	1	980.41	12.59	.001
H x A/P	1	1116.30	14.34	.001
S x H x A/P	1	484.01	6.22	.02
A/P x Subjects	44	77.86		
Time-Blocks (T-B)	4	1174.17	30.46	.001
S x T-B	4	288.10	7.47	.001
H x T-B	4	43.20	1.12	.35
S x H x T-B	4	30.98	.81	.52
T-B x Subjects	176	38.55		
A/P x T-B	4	595.18	20.30	.001
S x A/P x T-B	4	54.31	1.85	.12
H x A/P x T-B	4	89.18	3.04	.02
S x H x A/P x T-B	4	27.25	.93	.45
A/P x T-B x Subjects	176	29.31		

Table 11

Social facilitation test - Post hoc analysis of differences between means of square-crossing data of isolation and socially housed male and female animals in the alone and paired conditions

Sex x Housing x Alone/Paired conditions interaction effect

CR= 27639 $F_{(4,44)} = 2.69$ M.Sq.E.= 3425

Isolation males (Alone - Paired) - Isolation females (Alone - Paired)	28401.9*
Isolation females (Alone - Paired) - Social males (Alone - Paired)	136.5
Isolation females (Alone - Paired) - Social females (Alone - Paired)	8772.3
Males (Isolation Alone - Social Alone - Isolation Paired - Social Paired) - Females (Isolation Alone - Social Alone - Isolation Paired - Social Paired)	39262.1*

* Significant at $p < .05$

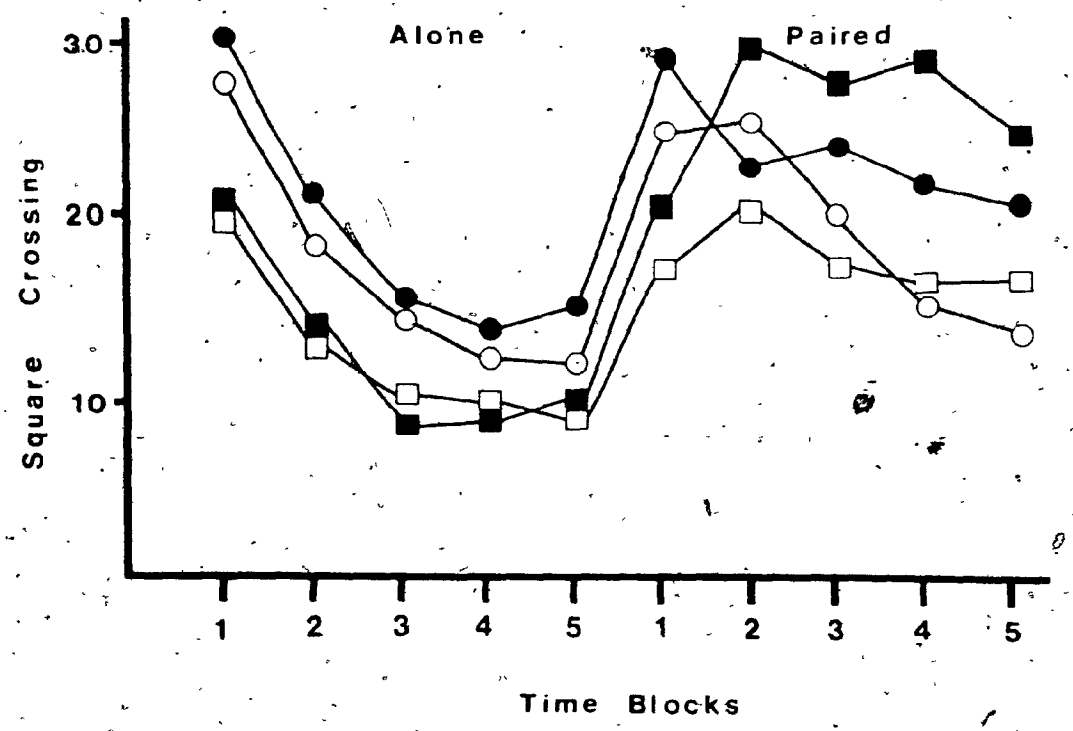

Figure 10. Square-crossing scores over time for isolation housed males (■) and females (●), and socially housed males (□) and females (○) in the alone and paired conditions.

The analysis showed that the isolation-housed males had the greatest increases in activity from the alone to the paired condition. Males, in general, showed a greater increase in activity in the paired condition than did females.

Behavioural analysis: The analysis of the behavioural data was conducted in the same manner as in Experiment 1a. The statistical analysis of the data across all four groups was done using a Kruskal-Wallis H-test (Seigel, 1960) for each of the behavioural categories. A post-hoc analysis, comparing groups pairwise within each of the behavioural categories, was done using Mann-Whitney U-tests. Ryan's test procedure (Mendenhall and Ramey, 1973) was used too as protection against an alpha error in the post-hoc analysis. All tests were conducted at the two-tailed level. These results are summarized in Table 12.

The results of the behavioural analysis from the test of gregariousness are presented in Table 13 and in Figures 11, 12, and 13. The significant findings were that (1) isolation-housed males engaged in more chase behaviour and less sniffing behaviour than did the animals in the other three groups, (2) for both male and female animals, the socially housed animals had higher passive contact scores than did animals housed in isolation, (3) again for both male and female animals, animals housed in isolation engaged in more rough-and-tumble play behaviour than did socially housed animals - this is particularly evident in the male animals, (4) isolation-housed females engaged in more social

Table 12

A summary of the results of the statistical analysis of the behavioural data from the test of gregariousness - Experiment 2

Category	H	U	p	Alpha'
Chase	6.60		.10	
Males - Females		33	.01	
Isol Males - Soc Males		8	.07	.017
Sniffing	6.20		.10	
Females - Males		31	.01	
Play	16.89		.005	
Males - Females		21	.002	
Soc Males - Soc Females		4	.01	.008
Isol Males - Soc Males		0	.001	.017
Isol Females - Soc Females		4	.01	.017
Isol Males - Isol Males		0	.001	.008
Social Grooming	10.11		.02	
Females - Males		24.5	.003	
Isol Females - Soc Females		10	.12	.017
Soc Females - Soc Males		6	.03	.008

Table 13

Occurrence of interactions as a per cent of total observations

Test of gregariousness

Group	No-interaction Same/Quadrant	No-interaction Diff/Quadrant	Interaction
Isolation			
Males	13	27	60
Females	28	30	42
Social			
Males	23	28	49
Females	30	34	32

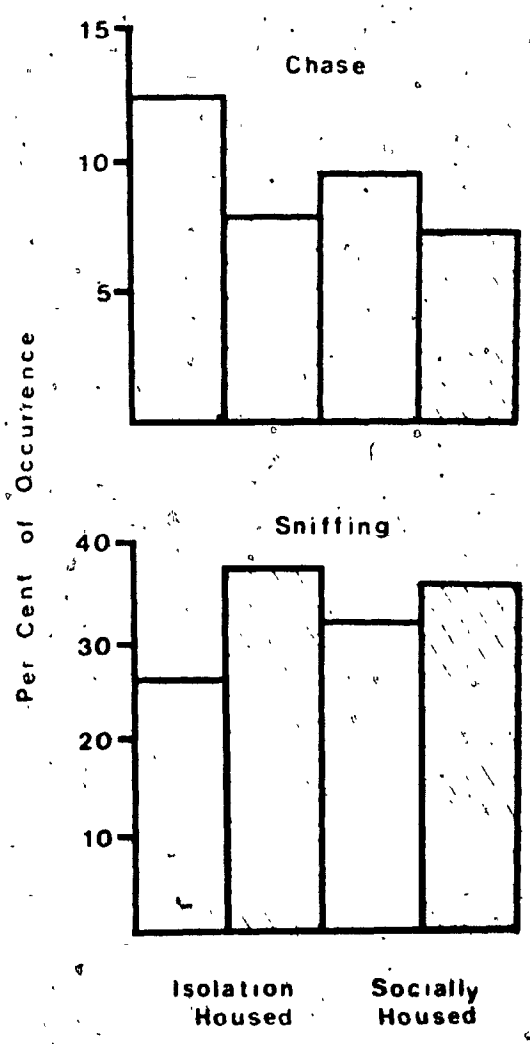

Figure 11. Per cent of occurrence of chase and sniff-behaviour for males ( ) and females (\\) by housing conditions.

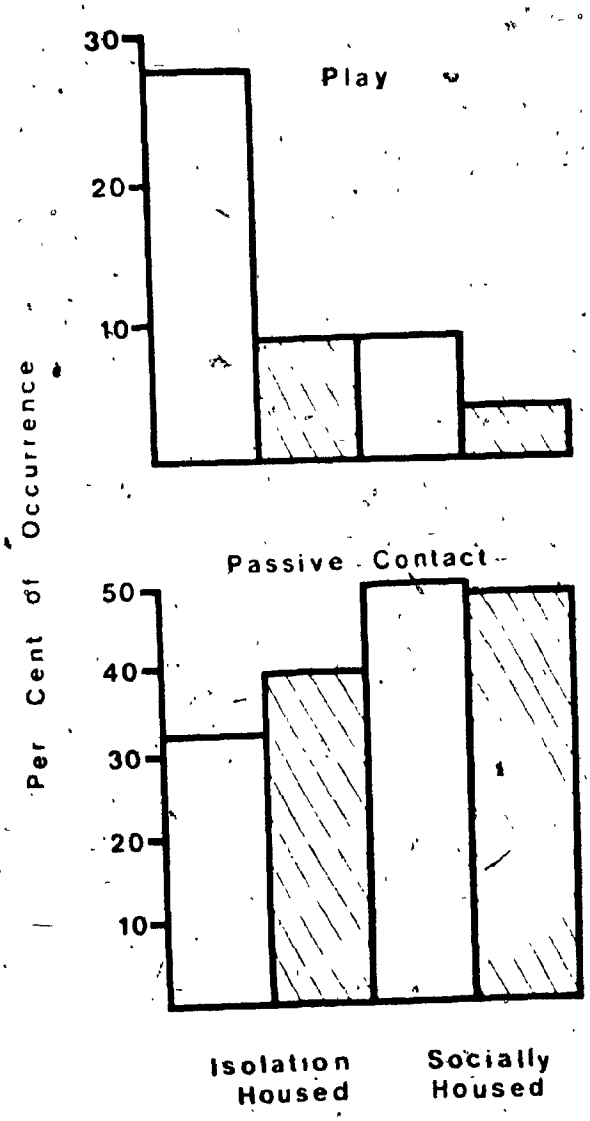

Figure 12. Per cent of occurrence of play and Passive contact behaviours for males ( ) and females (\\) by housing conditions.

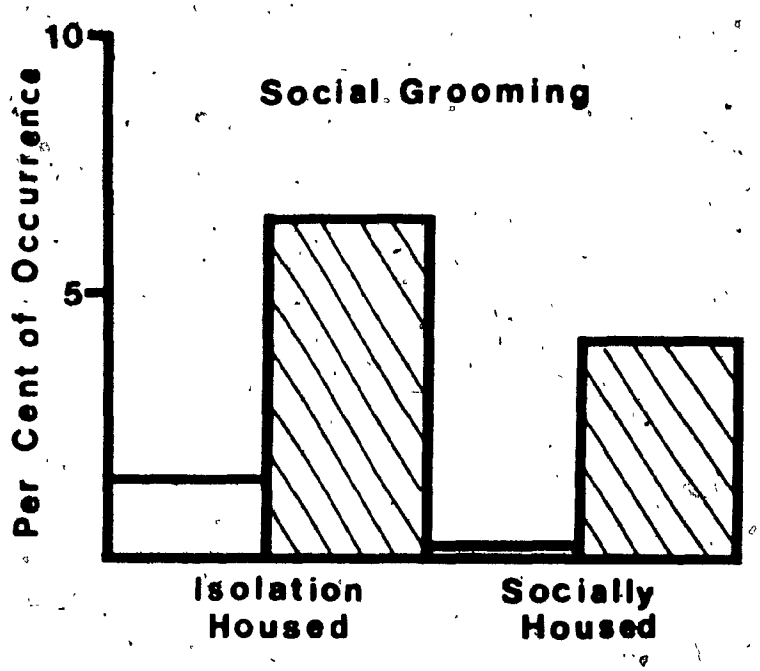

Figure 13. Per cent of occurrence of social grooming behaviour for males ( ) and females (\\) by housing condition.

grooming behaviour than any of the other groups, and (5) while isolation-housed males engaged in more physical contact than any of the other groups, all four groups spent virtually the same amount of time not in contact and in different quadrants.

The results of the behavioural analysis from the test for social facilitation are presented in Tables 14 and 15 and Figures 14, 15, and 16. The significant findings were that (1) socially housed females engaged in more sniffing behaviour than did the animals in any of the other three groups, (2) socially housed animals engaged in more passive contact than did animals housed in isolation, (3) isolation-housed males engaged in more rough-and-tumble play behaviour than did the animals in the other groups, (4) females housed in isolation engaged in more social grooming than did the animals in the other groups, and (5) while the isolation-housed males spent more time in contact than did the animals in the other three groups, it can be seen from Table 14, that the animals in all four groups spent virtually the same amount of time not interacting and in different quadrants.

Considered as a whole, the results of Experiment 2 can be summarized as follows. Isolation-housing served to increase the amount of time the animals spent in contact. This result is in accord with a similar finding of Latané et al (1972). Moreover, male animals were influenced to a greater extent by isolation-housing than were the female animals. While both groups of animals housed in isolation

Table 14

A summary of the results of the statistical analysis of the behavioural data from the social facilitation test - Experiment 2

Category	H	U	p	Alpha
Chase	6.54		.10	
Isol males - Soc Males		23.5	.001	.006
Isol females - Soc Females		44.0	.34	.017
Sniffing	4.80		n.s.	
Males - Females		138.5	.03	.025
Play	23.60		.001	
Males - Females		60.5	.001	
Isol Males - Soc Females		13	.002	.017
Isol Females - Soc Females		29	.06	.017
Soc Males - Soc Females		19	.009	.01
Social Grooming	20.70		.005	
Females - Males		72	.001	.025
Isol Females - Soc Females		9.5	.001	.017
Soc Females - Soc Males		29.5	.06	.009
No-Interaction				
Same/Quadrant	23.80		.001	
Diff/Quadrant	3.07		n.s.	

Table 15

Occurrence of interactions as a per cent of total observations

Social facilitation test

Group	No-interaction Same/Quadrant	No-interaction Diff/Quadrant	Interaction
Isolation			
Males	12	26	62
Females	37	26	47
Social			
Males	25	24	51
Females	34	26	40

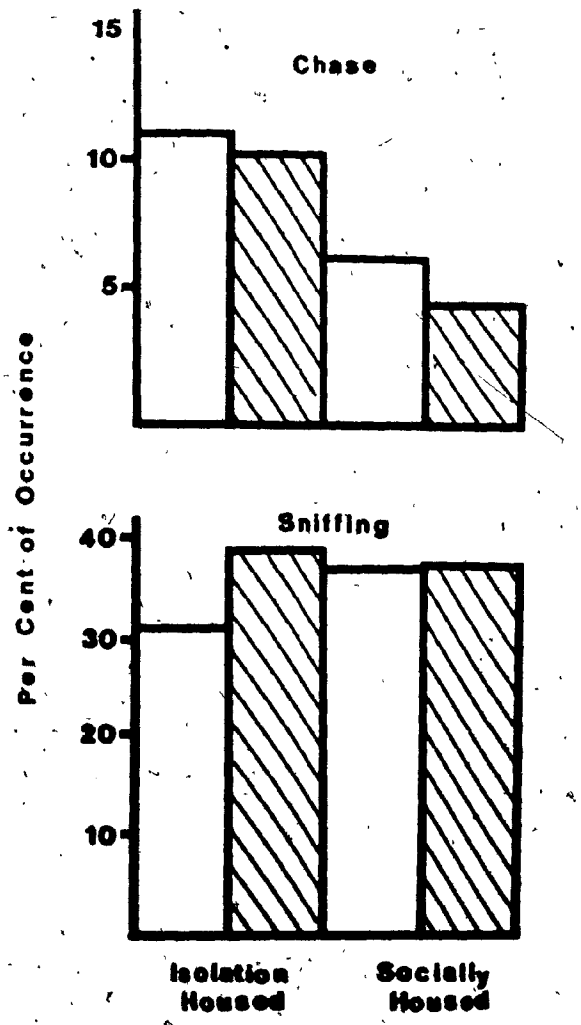

Figure 14. Per cent of occurrence of chase and sniff-behaviour for males ( ) and females (\\) by housing conditions.

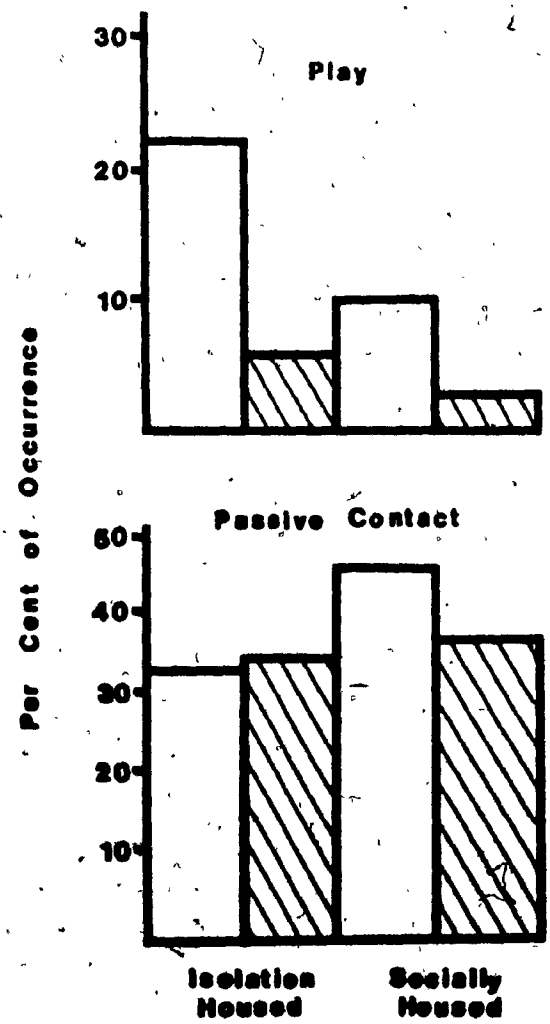

Figure 15. Per cent of occurrence of play and passive contact behaviour for males ( ) and females (\\) by housing conditions.

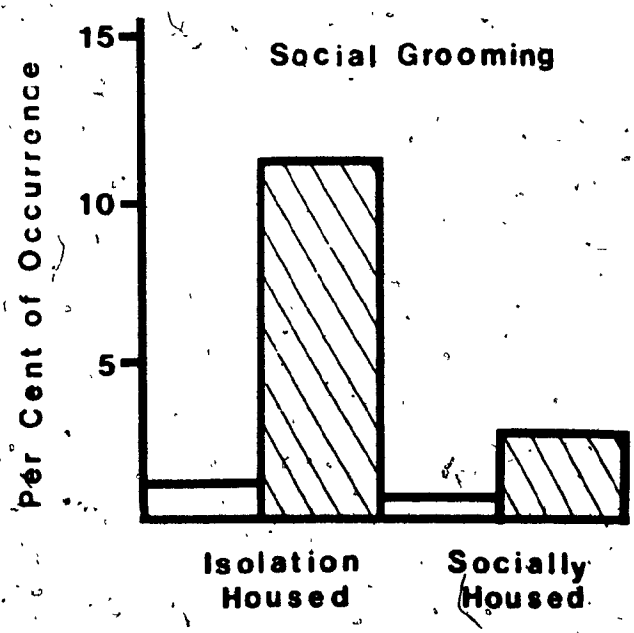

Figure 16. Per cent of occurrence of social grooming behaviour for males ( ) and females (\\) by housing condition.

spent more time in contact than did socially housed same-sex conspecifics, the effect was clearly more pronounced among the male animals.

Although males housed in isolation spent more time in contact than did animals in any of the three other groups, there was no difference between the four groups in the amount of time spent in proximity. The index of proximity used is the sum of the no-interaction/same quadrant and the interaction scores (see Tables 13 and 14). Considered in this manner, it can be said that isolation-housing influences what it is the animals do while in proximity, not whether they stay in proximity.

Isolation-housing also increased the degree to which the behaviour of one rat was influenced by the presence of an interacting conspecific. Furthermore, this influence of isolation-housing was greater among the male animals than among the female animals.

Isolation-housing not only influenced the degree to which rats engaged in physical contact, but also the nature of that contact. Animals housed in isolation were more vigorous, i.e., engaged in more chase, play, and social grooming behaviours than did those of the same sex housed in social conditions. Furthermore, socially housed animals engaged in more passive contact than did isolation-housed animals.

It should also be noted that, while isolation-housing had its greatest effects on the frequency of play behaviour

in male rats, in females the greatest effects were on the frequency of social grooming. Thus, while isolation-housing influences the nature of the social interactions, that is, it influences the vigor with which animals will interact, it does not change the relative importance of the different behaviours for the different sexes. Rather, isolation-housing results in more vigorous male-pattern affiliative behaviour in male animals and in more vigorous female-patterned affiliative behaviour in female animals.

Experiment 3

In Experiment 2 it was shown that the affiliative behaviours of male and female rats, described in Experiments 1 and 1a, were influenced by adult housing. The affiliative behaviours of animals reared in social conditions was clearly affected by periods of social deprivation in adult life. The next question to be examined, then, was the role of early rearing experience in the development of affiliative behaviour.

The specific questions Experiment 3 was designed to address were (a) do early social rearing conditions influence the degree to which animals will respond to same-sex conspecifics both in terms of time spent in physical contact and of socially facilitated activity, and (b) do early social rearing conditions influence the nature and/or the kind of affiliative behaviours that rats engage in? In order to investigate these issues, animals, reared in one of three social rearing conditions, were tested in the same

manner as in Experiment 1a.

Two of the rearing conditions used in this Experiment were those of isolation-rearing and of same-sex social rearing. The third condition, heterosexual social rearing, was included to explore the possibility that not only the presence of social stimuli influences the development of affiliative behaviours, but also the nature of the social stimuli. Since male and female rat pups engage in certain affiliative behaviours to a different extent (Olioff and Stewart, 1977), one might expect the behaviour patterns of one sex to be shifted in the direction of the other.

Thus, Experiment 3 involved the comparison of six groups - same-sex socially reared males and females, males and females reared in heterosexual pairs, and, males and females reared in social isolation - on the two tests used in the previous experiments.

Method

Subjects

The subjects in this experiment were taken from 96 male and female Hooded rats born in the Concordia University animal colony, the offspring of eight females obtained from the previously mentioned supplier. Upon arrival to the colony, the mothers were placed in maternity cages (41 x 25 x 18 cm) and given free access to food and water. All eight females subsequently gave birth to litters that ranged in size from 9 to 16 pups. All litters were born within a 36-hour period. The day on which the last litter was born

was taken to be the first day of the experiment. From birth until weaning the litters were left intact. Maintenance was done without handling the animals. All animals had free access to food and water throughout the experiment. Room temperature was maintained at about 22° C. The animal colony was on a 14-hour to 10-hour light-dark schedule (lights off at 11:00 p.m.).

On day 22, 72 of the 96 animals were randomly assigned to one of three rearing conditions: same-sex pairs, heterosexual pairs, or social isolation. The mothers were removed and 24 animals, 12 males and 12 females, were assigned to each condition with the provision that all pairs be constituted of animals from different litters.

Isolation rearing: Animals reared in this condition were housed individually in wooden cages (20 x 15 x 15 cm) with wood-chips scattered on the floor. The cages had wire tops that contained an overhead feeder and a waterbottle. No visual or physical contact with conspecifics was possible during the period of social isolation. On day 55, these animals were transferred to standard wire mesh cages (25 x 18 x 18 cm) and individual housing was maintained. The animals were not otherwise handled until testing began.

Social rearing - same-sex pairs: Animals reared in this condition were housed in same-sex pairs in standard wire mesh cages. On day 75 the animals were separated and housed individually in cages of the same dimensions. The animals were not otherwise handled until testing began.

Social rearing - heterosexual pairs: Animals reared in this condition were housed in opposite-sex pairs in standard wire mesh cages. On day 75 the animals were separated and housed individually in cages of the same dimensions. As a result of the pairings all females in this condition gave birth to a litter. All pups were removed immediately after parturition. The animals were not otherwise disturbed until testing.

Apparatus

The apparatus and testing conditions were the same as in Experiment 1a.

Procedure

The testing procedure was the same as in Experiment 1a. Testing was done over an 8 day period.

Results and Discussion

Test of gregariousness: The time-spent-in-contact scores for each time-block were analyzed using a three-way analysis of variance for sex x rearing condition x time-block. A summary of the ANOVA is presented in Table 16. An examination of the results revealed that the main effects of sex and of time-block were significant. Neither the main effect of rearing condition, nor any of the interaction effects were significant.

It can be seen from Figure 17 that the males in all three rearing conditions spent more time in contact than did the females. Moreover, although the means would seem to indicate that isolation rearing led to an increased amount

Table 16

Test of Gregariousness - Experiment 3:

Summary table of the ANOVA

Source	df	Mean Square	F	p
Sex	1	7636.0	8.94	.006
Rearing Condition	2	1028.0	1.20	.31
Sex x Rearing	2	1178.8	1.38	.27
Subjects	30	853.8		
Time-Blocks	9	340.4	3.78	.001
Sex x Time-Blocks	9	158.6	1.76	.08
Rearing x Time-Blocks	18	92.7	1.03	.43
Sex x Rearing x Time-Blocks	18	77.2	.86	.63
Time-Blocks x Subjects	270	90.1		

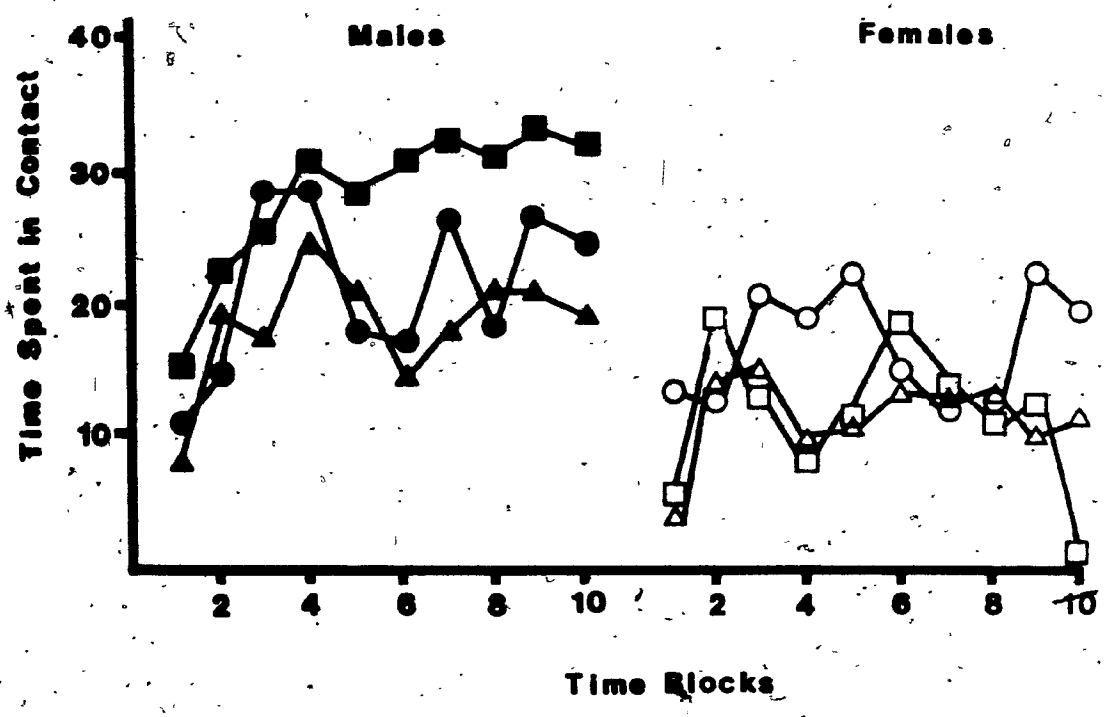

Figure 17. Time spent in contact over time for isolation reared males (■) and females (□), same sex pair reared males (●) and females (○), and heterosexual pair reared males (▲) and females (△).

of time spent in contact, especially among the male animals, it can be seen from the actual scores of the individual pairs presented in Table 17, that this effect can be accounted for by the extremely high scores of a few pairs. Within the isolation-reared male group it can be seen that while the scores for two of the pairs are high, those of the remaining four pairs are well within the range of scores for the male animals. Thus, within this test situation, there was no consistent effect of rearing condition on the amount of time the animals spent in physical contact.

Social facilitation test: The square-crossing scores for each time-block were analyzed using a four-way analysis of variance for sex x rearing condition x alone/paired conditions x time-block. A summary of the ANOVA is presented in Table 18. The results of this analysis revealed that only the main effects, alone/paired condition, and time-block, were significant. While the sex x alone/paired condition interaction was significant, none of the interactions involving the rearing condition variable were.

As in the previous experiments, there was an overall sex difference in the degree to which the animals were influenced by the introduction of a same-sex conspecific; males being influenced to a greater extent than were females. There was, however, no significant effect of rearing condition. Thus, while the results support the findings of the previous experiments, they offer no evidence that the affiliative tendencies reflected in the social facilitation test are affected by differential social rearing.

Table 17

Mean time-spent-in-contact scores for individual pairs by sex and rearing condition

Males

Isolation	Same-sex Paired	Heterosexual Paired
11.2	16.0	30.5
52.4	26.3	.3
15.8	25.6	18.5
26.0	19.6	21.9
43.0	17.4	15.5
19.5	21.5	20.5

Females

Isolation	Same-sex Paired	Heterosexual Paired
10.6	10.0	7.3
8.1	32.3	10.5
11.7	10.1	11.0
12.2	8.6	10.4
6.1	23.0	17.3
21.4	16.0	8.8

Table 18

Social facilitation test - Experiment 3:

Summary table of the ANOVA

Source	df	Mean Square	F	p
Sex (S)	1	750.0	1.61	.21
Rearing Condition (RC)	2	225.6	.48	.62
S x RC	2	800.6	1.72	.19
Subjects	42	464.7		
Alone/Paired (A/P)	1	4320.0	22.03	.001
S x A/P	1	1080.0	5.51	.02
RC x A/P	2	49.4	.25	.78
S x RC x A/P	2	191.9	.98	.38
A/P x Subjects	42	196.1		
Time-Blocks (T-B)	4	353.9	8.51	.001
S x T-B	4	229.7	5.52	.001
RC x T-B	8	24.3	.58	.79
S x RC x T-B	8	31.1	.74	.65
T-B x Subjects	168	41.6		
A/P x T-B	4	373.6	7.88	.001
S x A/P x T-B	4	21.1	.45	.78
RC x A/P x T-B	8	42.9	.90	.51
S x RC x A/P x T-B	8	24.4	.51	.84
A/P x T-B x Subjects	168	47.4		

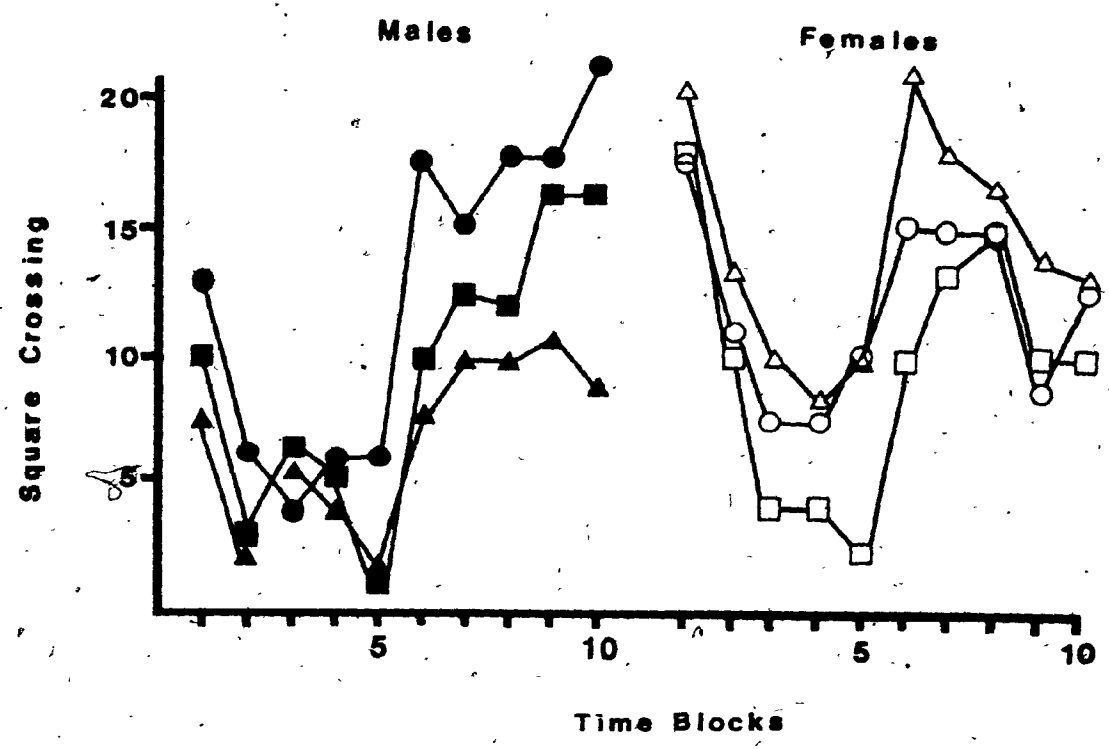

Figure 18. Square-crossing scores over time for isolation reared males (■) and females (□), same sex pair reared males (●) and females (○), and heterosexual pair reared males (▲) and females (△) in the alone and paired conditions.

In summary, the results of the two tests in this experiment do not show any reliable effect of rearing condition on either time spent in contact or on the degree to which the behaviour of one animal was influenced by the behaviour of an interacting conspecific - the so-called social facilitation effect. These results would appear to contradict those of Becker (1971), who found a significant, although unclear, effect of rearing condition on social affiliation. Both the test situations and the dependent measures used in this experiment, however, differ from those of Becker's experiment. However, even when a proximity measure similar to that of Becker's was used (see Experiment 2), there was no effect of rearing condition (see Tables 20 and 22) on affiliation in either of the test situations.

Behavioural analysis: The analysis of the behavioural data from both the test of gregariousness and the test for social facilitation was conducted in the same manner as in Experiment 2.

The results of the behavioural data from the test of gregariousness are presented in Tables 19 and 20, and Figures 19, 20, and 21. The significant findings were that (1) same sex socially reared male animals engaged in more play behaviour than males reared in social isolation, (2) overall, males engaged in more play behaviour than did females, and (3) females engaged in more sniffing and social grooming behaviour than did males. Results which approached significance included the tendency of same-sex socially reared females to

Table 22

Occurrence of interactions as a per cent of total observations

Social facilitation test

Group	No-interaction Same/Quadrant	No-interaction Diff/Quadrant	Interaction
Males			
Isolation	16.4	22.3	61.3
Same-sex	17.0	25.1	57.9
Heterosexual	9.8	37.2	53.0
Females			
Isolation	9.0	51.4	39.6
Same-sex	13.3	32.7	54.0
Heterosexual	20.2	31.7	52.1

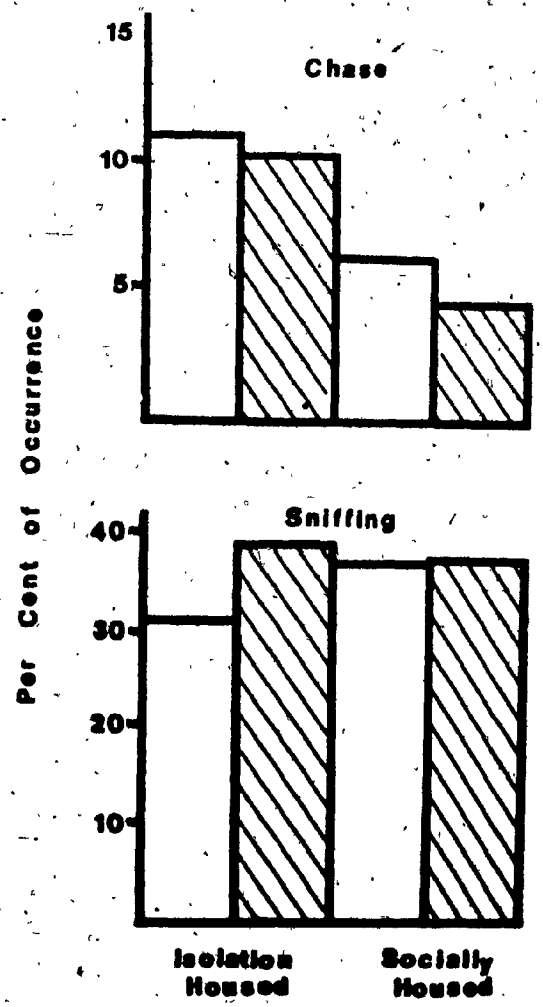

Figure 22. Per cent of occurrence of chase and sniffing behaviour for males ( ) and females (\\) by rearing condition.

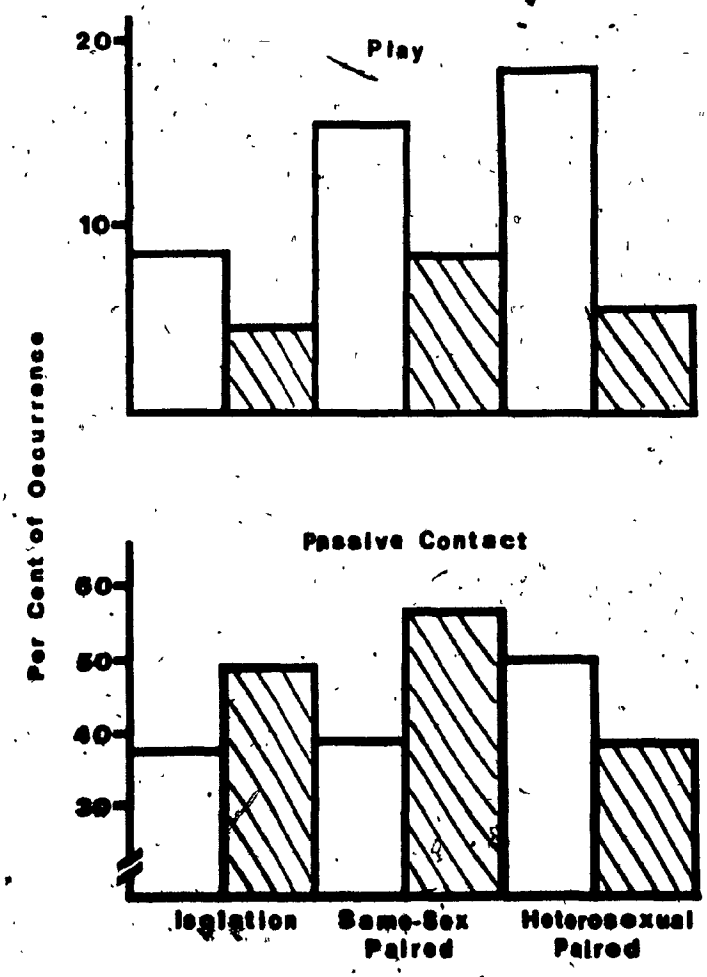

Figure 23. Per cent of occurrence of play and passive contact behaviour for males ( ) and females (\\) by rearing condition.

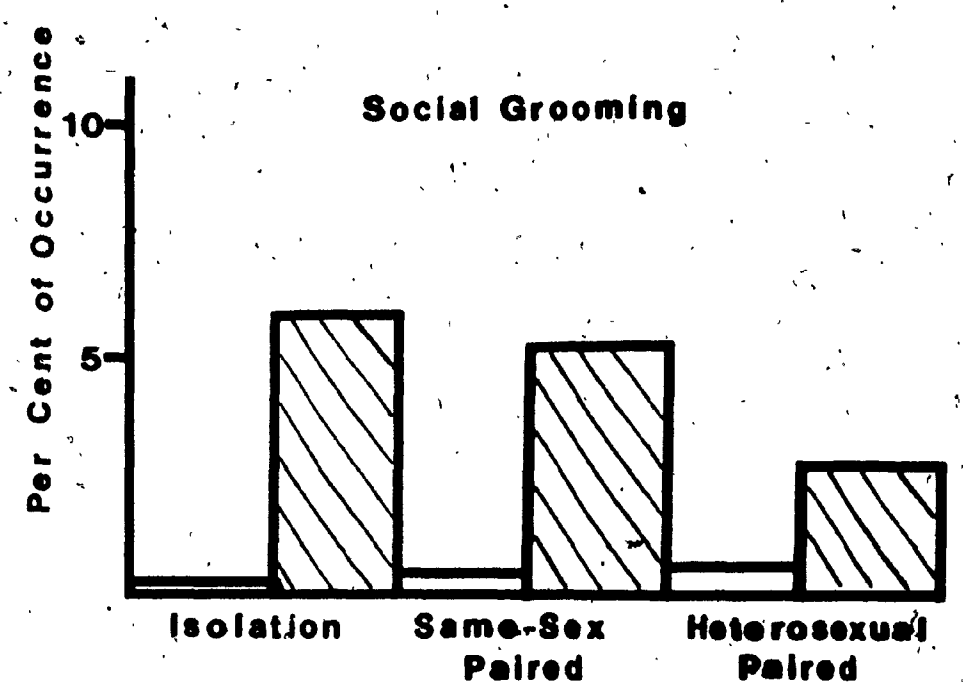

Figure 24. Per cent of occurrence of social grooming behaviour for males ( ) and females (\\) by rearing condition.

Similarly, in both test situations females reared with same-sex peers engaged in more social grooming behaviour than did females reared with an opposite-sex peer. Again, ~~it is~~ possible that the kind of social interactions female rats have during the period between 21 days until maturity may permanently alter their pattern of affiliative behaviour. As with the effects of differential housing, the results of differential early rearing were most pronounced on play behaviour in male rats and on social grooming behaviour in female rats.

Experiment 3a

The results of the first two experiments indicate that rats engage in a number of affiliative behaviours. These behaviours, as observed in the two test situations, appear to be contact orientated and 'friendly' in nature. As Latane (1974) had reported, very few instances of direct fighting are observed in the two test situations used in these experiments. Indeed, it would appear as though the social interactions between rats were, for the most part, non-aggressive. Although this conclusion is supported by other evidence in the literature (e.g., Lore and Flannelly, 1977) it does not coincide with findings such as Barnett's (1958) report of intense fighting and high mortality among rats placed in an artifical colony. Steinger (1950) also reports of intense aggression among rats in a similar test situation.

One, seemingly crucial difference between the studies reporting amiable social interactions and those reporting aggression is that of the test situation. The experiments reported here, as well as those of Latane, involved placing animals in a strange test environment for relatively short periods of time. The studies of Barnett involved placing animals in an artifical colony and then, after the colony was established, introducing new animals. It was towards these new animals that the aggressive behaviours were directed. Barnett attributes this aggression to the defense of territory by the established animals. Also, Barnett reported, as did Lore and Flannelly, that there was little fighting observed between the animals originally placed in the colony. Even Steinger's reports of fighting were unique to those situations involving intruders. Thus, aggression between rats appears to occur in test situations in which the animals have established territory.

It is not surprising therefore that actual fighting should be observed so infrequently as in the test situations used in the first four experiments. In both tests rats were placed in novel situations and were not given the opportunity to establish territorial boundaries. As Barnett has stated, the greater the degree of strangeness of an environment, the less the observed rate of aggressive behaviours.

Social interactions between rats appear to be influenced by the features of the situation in which they occur. The question of interest is to what degree would the social

interactions of rats given the opportunity of establishing territorial boundaries differ from those of animals placed in an novel situation. Experiment 3a was designed to investigate the degree to which the findings of Experiments 1, 1a, and 3 were situationally dependent.

In this experiment animals were placed in separate but adjoining compartments for a specific period of time. The compartments were separated by a barrier which, when removed, left the animals together in a single environment, half of which had been occupied by one animal and half by the other. Following the removal of the barrier the social interactions between the animals were scored according to an expanded set of behavioural categories.

Method

Subjects

The subjects used in this experiment were the same as those used in Experiment 3. Thirty-two pairs of animals were tested - six pairs of same-sex socially reared males and six of similarly reared females, six pairs of males and five pairs of females reared in social isolation, and five pairs of males and four pairs of females reared in heterosexual pairs. All animals had been housed individually in standard wire mesh cages since the completion of Experiment 3. Food and water were freely available throughout the experiment.

Apparatus

The apparatus used in this experiment was a specially

designed box. The box was made of wood and measured 61 x 46 x 31 cm. It was separated into two equal compartments by a 46 x 31 cm wooden barrier. The top of the box was a 61 x 46 cm sheet of 1 cm plexiglass perforated in several places to provide adequate air circulation. Each compartment contained an externally mounted feeder and water bottle. The floor of the box was covered with wooden chips. Lighting was provided by a series of 15-watt light bulbs hung about 50 cm above the test environment. The previously described noise mask was used throughout the experiment. The VTR camera was mounted 1 m above the test environment.

Procedure

The animals were transported to the laboratory in separate containers. One was placed into each of the compartments of the test environment. The animals were left in the test environment for a period of 20 hours prior to being tested. While in the test environment the animals had free access to food and water, and were on the same light-dark schedule as in the animal colony. At the end of the 20-hour period the partition was removed and the animals were free to interact. The VTR system was turned on immediately after the partition was removed and video tapes were made of the social interactions between the animals for the next 30 minutes. Following this 30-minute period the animals were returned to the animal colony.

The video tapes were scored using a time-sampling procedure in which the interactions of the animals were

scored once every 5 seconds. The behavioural categories used included the affiliative behaviours described in Experiment 1a as well as categories for both aggressive and pseudo-sexual behaviour. The categories were defined as follows:

1- Chase: Defined as in Experiment 1a.

2- Sniffing: Any form of sniffing directed at the other animal.

3- Passive Contact: Defined as in Experiment 1a.

4- Rough-and-tumble Play: Defined as in Experiment 1a.

5- Social Grooming: The mutual grooming of one animal by another.

6- No-Interaction: Included any observations in which the animals were not interacting.

7- Anogenital Sniffing: Any form of sniffing directed at the anogenital region of the other animal.

8- Fighting: Instances in which the animals were engaging in direct fighting.

9- Dominant/Submission Posture: Instances in which one animal was stabilly positioned over the other animal which was lying on its back.

10- Aggressive Grooming: Instances in which one animal vigorously grooms another, while firmly griping the fur of that animal, usually around the region of the neck, with its forepaws.

11- Boxing: Instances in which the two animals were standing upright facing one another and making pawing movements towards each other.

12- Kicking: When one animal kicks at the other with its hindpaw.

13- Threat Posture: Instances in which one animal arches its back, and with all four limbs extended directs its flank toward the other animal.

14- Mounting: Includes the full mounting pattern of approaching the other animal from the back, putting its forepaws on the back of that animal, executing pelvic thrusts, and finally grooming its own genitals.

Results and Discussion

For the purpose of analysis, the aggressive behaviour categories (categories 8 through 13) were added together and treated as a single category. Mounting behaviour was not scored frequently enough to merit analysis. Otherwise the analysis of the data from this experiment was conducted in the same way as in Experiment 2. The results are presented in Tables 23, 24, 25, and 26.

The statistically significant findings were that (1) males engaged in more rough-and-tumble play behaviour than did females, (2) socially reared males engaged in more play behaviour than did males reared in social isolation, (3) females engaged in more social grooming behaviour than did males, and (4) males engaged more often in

Table 23

Per cent of occurrence for each of the affiliative behavioural categories by sex and rearing condition - Experiment 3a

Group	Chase	Sniffing	Passive Cont	Play	Soc Grooming
Males					
Isolation	5	36.8	23.6	9	0
Same-sex	6.8	25.7	36.0	13	1.5
Heterosexual	5	20.1	29.1	11.6	5.1
Females					
Isolation	2.4	21.6	43.2	2.6	7.2
Same-sex	4.3	25.9	31.4	7.8	15.9
Heterosexual	.9	16.7	43.5	8.4	19.3

Table 24

Per cent of occurrence for each of the aggression and pseudosexual behavioural categories by sex and rearing condition - Experiment 3a

Group	Fight	Sub/Dom Posture	Aggr Grooming	Boxing	Kicking	Threat Posture	Mount
Males							
Isolation	6.8	1.5	2.7	3.5	4.7	8.3	0
Same-sex	2.8	2.8	3.2	2.8	1.2	2.1	1
Heterosexual	2.2	2.8	5.6	3.4	3.2	1.8	1.2
Females							
Isolation	.6	1.6	1.8	.4	.8	2.8	0
Same-sex	.7	.7	2.2	.7	2.5	.1	0
Heterosexual	0	2.8	2.5	0	.3	0	0

Table 25

Occurrence of interactions as a per cent of total observations

Experiment 3a

Group	No-interaction	Interaction
Males		
Isolation	61.8	38.2
Same-sex	60.9	39.1
Heterosexual	55.3	44.7
Females		
Isolation	66.6	33.4
Same-sex	62.7	37.3
Heterosexual	62.1	37.9

Table 26

A summary of the results of the statistical analysis of the behavioural data - Experiment 3a

Category	U	p
Chase		
Males - Females	82.5	.04
Play		
Males - Females	55	.003
S-S Males - Isol Males	8	.07
S-S Males - S-S Females	5	.02
Social Grooming		
Females - Males	9	.001
Aggrassive Behaviour (total)		
Males - Females	41.5	.001

aggressive behaviour than females. Results which approached significance were that (1) socially reared females engaged in more social grooming behaviour than did females reared in heterosexual pairs, (2) socially reared males engaged in more play behaviour than did socially reared females, and (3) males engaged in more chase behaviour than did females.

Most notable were the sex differences in affiliative behaviour. In the present experiment it was found that males engaged in more chase and play behaviour, while females engaged more often in social grooming behaviour. Thus, despite the changes in the features of the test situation these sex differences in affiliative behaviour are consistently observed.

The most obvious difference between the results of this experiment and those of the previous experiments was the occurrence of aggressive behaviours. This finding would seem to indicate that the procedure was, to some extent, successful in introducing the feature of territoriality into the test situation.

In summary, then, the aggressive behaviours observed in this experiment indicate that the social interactions of rats are not always 'friendly' in nature. Rather they are influenced by certain features of the environment, such as territoriality. Despite the consistent presence of aggression between the pairs, however, the social interactions were more often scored as affiliative behaviour than as aggressive behaviour. Thus, it is naive to assume that rats

do not show intraspecies aggression given the appropriate situational stimuli. Even in such situations, however, rats continue to engage in affiliative behaviour.

General Discussion

The results of the experiments reported in this thesis clearly demonstrate that rats affiliate for reasons other than aggression or mating. Even within a test situation in which aggressive behaviours between pairs were observed, the social interactions between the animals were more frequently scored as affiliative behaviours than as aggressive behaviours. It would seem, although the function of specific behaviours is little understood, that affiliative behaviours constitute an important, distinct, and perhaps the most basic class of social behaviours.

The most consistent finding throughout the experiments was that of the sex difference in affiliative behaviour. Except in tests which represented a second exposure of the animals to the test situation (i.e., Experiments 1a and 3a), male animals spent more time in contact than did female animals. Males, as indicated in the tests for social facilitation, were also more influenced by the presence of an interacting same-sex conspecific than were females. these findings, taken together, indicate that male rats are more responsive to same-sex conspecifics than are female rats.

Also demonstrated was a sex difference in the kinds of affiliative behaviours in which male and female rats engaged most. Male animals consistently engaged in more rough-and-tumble play behaviour than did female animals. Males also tended to engage in more chase behaviour than did females.

Conversely, females consistently engaged in more social grooming behaviour than did males. This pattern of results suggests that the social interactions between male animals are not only more frequent than are those of female animals, but are also more vigorous.

The results of Experiment 3a indicate that these qualitative sex differences observed in Experiment 1a are not unique to novel situations, but are also observed in situations in which territorial boundaries have been established. Interestingly, affiliative behaviours, in this test situation, were observed both before and after sequences of aggressive behaviours. This suggests that the occurrence of affiliative behaviours, although influenced by features of the test environment, are not situationally dependent.

Similar sex differences in affiliative behaviours have also been described in other species. Owens (1975) reports that among free-living baboons, males engage in rougher forms of interactions (including rough-and-tumble play behaviour) and interact more often than do females. Similar findings are reported by Hinde and Spencer-Booth (1967) with rhesus monkeys. When female baboons did interact, according to Owens, it was in a manner different from that of the males. Female interactions were described as mauling Mauling consisted of what might be considered to be social grooming behaviour. These findings, in part, extend to the behaviour of human children. Blurton-Jones (1967) has

observed that rough-and-tumble play is more prevalent between boys than between girls. It would seem from these observations that, among mammals, the social interactions of males are more vigorous than are those of females. Moreover, it may be that these differences are based on a greater social responsivity of males than of females.

The findings of Experiment 2 clearly indicate that the affiliative behaviour of adult rats is influenced by extended periods of social deprivation. Rats housed in isolation as adults spent more time in contact and showed greater socially facilitated activity than did socially housed animals. Thus, the isolation-housing of normally reared rats markedly increases their responsivity to same-sex conspecifics.

The effects of isolation-housing are also, in part, sex dependent. In terms of the quantitative measures, isolation-housing had a greater influence on the affiliative tendencies of the male animals than on those of the female animals. This result further supports the contention that males are more responsive to same-sex conspecifics than are females, in that they are more influenced by periods of social deprivation.

The social interactions of isolation-housed animals were not only more frequent than those of socially housed animals, but were also more vigorous. Males housed in isolation engaged in more chase behaviour and more play behaviour than did socially housed males. Whereas the most

pronounced affects of isolation housing on females were on the frequency of social grooming behaviour. That is, males as a result of isolation housing, do not simply engage more often in all categories of affiliative behaviours, but rather they engage more often in those categories most specific to males (i.e. chase and play behaviour). The same is true of females: Isolation-induced affilative tendencies enhance the frequency of social grooming behaviour between females. Isolation-housing appears, then, to increase the responsivity of the animals to the social stimulus and not to determine which affiliative behaviours are influenced. In cases, for example, where a male animal is housed in isolation for an extended period of time and then introduced to another male animal, the influence of isolation-housing will be manifested in the appropriate male-pattern of affiliative behaviours. Similarly, among female animals, isolation-housing increases the appropriate female-pattern of affiliative behaviours.

This analysis implies that the occurrence of any affilaitive behaviour, and perhaps any social behaviour, is a function of the interaction between the affiliative tendencies of an animal, the nature of the companion, and features of the situation. Thus far we have considered only the aspect of sex-type in discussing the nature of the companion. It is, however, not unreasonable to assume that the strength of the affiliative tendencies of the companion animal are also of importance. There is evidence

that the behaviour of rats in a test of social facilitation is influenced to a greater extent by socially deprived companions than by companions that are not socially deprived (Meaney, Note 1.). Thus the affiliative tendencies of the companion seem to be an important aspect of the nature of the social stimulus. Certainly this analysis, and the evidence in support of it, suggest that the determinants of affiliative behaviour are more complex than such simple consdierations of whether or not the social stimulus was physically present (e.g., Zajonc, 1972).

Although the quantitative measures taken in the two tests were influenced by isolation housing in adult life, they were not affected by early rearing condition. The findings of Experiment 3 indicate no reliable effect of rearing condition on either time spent in contact or on socially facilitated activity. When considered together with the confusing findings of Becker (1971), it can be concluded that tests of time spent in contact or socially facilitated activity are too general to reflect the subtle differences in affiliative behaviour due to differential social rearing conditions.

Another possible reason for the lack of an effect of early rearing on these measures may be found in the nature of early experience effects. Cummins, Livesey, and Evans (1977) have suggested that the effects of differential rearing cannot be considered to be universal across organisms within a particular species. That is, the development

of some organisms, as a result of biological factors such as genetical constitution, will be more dependent on the quality of the early environment while that of others will be less so. If this is indeed the case, one cannot assume that a particular early environmental manipulation will have the same effect on all subjects within a rearing condition. This reasoning suggests that a new approach be taken to the question of the role of early social experience in the development of affiliative behaviour.

One approach would be to examine the percentage of animals affected by manipulations at different periods of development. This could also involve examining the degree to which animals are affected, and the degree to which certain behaviours are affected. Also, of obvious interest, are the factors which distinguish between those animals that are vulnerable to early environmental manipulations and those that are not.

Differential social rearing did influence the frequency of particular adult affiliative behaviours in the present study. Male rats reared in social isolation consistently engaged in less rough-and-tumble play behaviour than did males reared with a same sex peer. Among females, rats reared with an opposite sex peer engaged in less social grooming behaviour than did females reared with a same-sex peer. These results parallel those found with socially isolated housing in adult animals to the extent that the effects on male animals are manifested in the male-pattern of affiliat-

ive behaviour and the effects on female animals are shown in the female-pattern of affiliative behaviour. At the very least, these results suggest that when examining the effects of early experience on the behavioural development of male and female animals it is essential to consider behaviours that are appropriate to the sex.

A possible basis of the differences in the affiliative behaviours observed in the experiments reported in this thesis may be found in studies on the effects of physiological treatments in early development. Olioff and Stewart (1977), for example, have shown that, while male rat pups engaged in more rough-and-tumble play behaviour than did female pups, testosterone treatment in early perinatal life increased the time spent by females engaging in play behaviour to levels comparable to those of normal males. Similar effects have been obtained from studies with rhesus monkeys. Goy (1970) reports that females exposed to testosterone in utero displayed essentially male patterns of affiliative behaviour, including male-like play behaviour and aggression. These results indicate that the degree to which rats will engage in play behaviour is largely determined by exposure to testicular androgens in early life.

Although speculative at this point, one might consider that the components of affiliative behaviour, probably the most rudimentary forms of social behaviour, are basically innate in origin. Sex differences in these behaviours are most likely linked to differences in the early hormonal

environment between males and females. What is influenced by early social experience, is the strength of the general tendency to affiliate with conspecifics.

This analysis is similar to an interpretation made by Goy (1974) about the affects of differential social rearing on the development of social behaviour in nonhuman primates. Goy notes that the behavioural deficiencies supposedly caused by inadequate social experience are quite often remediated by social exposure to peers in later life. What remains most profoundly disturbed, however, are the animals 'emotional relationships' with other animals. Riessen (1971), for example, found that inadequate early social experience appears to result in animals showing excessive fear of other animals and in a general timidity in social situations. Indeed Harlow (1965) has stated that the "basic response patterns (of heterosexual behaviour) will be acquired as long as ... affectional responses are given an adequate opportunity to develop."

The emotional relationship or affectional responses referred to in these remarks are easily likened to the affiliative tendencies considered in the present study. Thus, it appears that, among mammals, that aspect most influenced by early social experience is the development of mormal affective responses to social stimuli - or affiliative tendencies. What social behaviour that does occur is, then, a function of the interaction between the nature of the social stimuli, the features of the situation, and the

affiliative tendencies of the animals involved.

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Appendix A

Raw scores in total observations for each of the pairs by sex for each behavioural category in the test of gregariousness

Males	Chase	Sniffing	Passive Cont	Play	Soc Grooming
	12	32	22	7	1
	24	25	32	11	0
	15	25	27	40	1
	13	14	36	9	4
	7	23	26	23	5
Females					
	4	26	46	13	14
	0	14	14	2	8
	0	11	70	5	5
	5	17	33	4	8
	6	30	32	5	9

Raw scores in total observations for each of the pairs by sex for each behavioural category in the social facilitation test

Males	Chase	Sniffing	Passive Cont.	Play	Soc. Grooming
	7	25	21	22	6
	22	26	4	26	2
	34	28	8	23	2
	11	18	13	14	0
	17	39	14	21	1
	15	27	20	10	1
	19	28	14	15	1
	33	26	14	13	0
	22	21	17	23	1
	27	28	13	10	0
	16	32	13	3	2
Females					
	7	25	21	22	6
	10	28	12	5	10
	6	25	20	5	14
	7	30	3	5	4
	15	32	17	14	2
	9	30	13	5	17
	12	32	5	10	12
	13	33	7	2	10
	17	18	14	4	6

Appendix B

Raw scores in total observations for each of the pairs by sex and housing condition for each behavioural category in the test of gregariousness

Isolation Housed

Males	Chase	Sniffing	Passive Cont.	Play	Soc. Grooming
	13	18	25	23	1
	4	29	29	15	5
	14	24	18	41	3
	9	20	26	21	1
	9	18	28	14	2
	11	13	29	18	1
Females					
	2	20	24	5	9
	8	34	10	8	1
	2	13	24	2	3
	3	21	39	7	7
	8	20	18	4	2
	3	18	17	2	5

Socially Housed

Males:	Chase	Sniffing	Passive Cont.	Play	Soc. Grooming
	6	12	45	4	0
	6	23	29	6	0
	4	11	20	3	0
	7	12	26	8	0
	4	27	31	2	0
	3	11	15	3	2
Females:					
	2	16	26	2	0
	2	7	36	1	2
	5	16	11	2	2
	2	18	24	1	2
	3	24	28	1	3
	3	22	15	3	2

Raw scores in total observations for each of the pairs by sex and housing conditions for each behavioural category in the social facilitation test

Isolation Housed

Males	Chase	Sniffing	Passive Cont.	Play	Soc. Grooming
	5	27	16	6	0
	6	17	14	14	0
	3	14	16	9	0
	5	15	18	15	0
	7	20	31	11	3
	6	12	16	12	1
	3	22	39	9	1
	16	11	20	27	2
	4	22	13	12	4
	10	21	16	13	5
Females					
	3	20	10	2	2
	0	13	15	0	2
	2	19	14	0	8
	8	8	24	7	3
	4	16	10	4	6
	5	21	17	4	5
	8	20	13	2	7
	9	19	19	4	5
	2	16	23	3	6
	3	15	11	1	3

Socially Housed

Males	Chase	Sniffing	Passive Cont.	Play	Soc. Grooming
	2	9	28	3	1
	1	10	21	10	0
	4	28	14	3	0
	3	14	19	0	0
	2	23	17	1	0
	0	10	15	2	0
	7	24	17	3	0
	2	11	13	9	0
	2	20	18	5	4
	2	8	33	5	2
	5	15	22	3	1
Females					
	5	20	12	2	0
	2	15	11	2	2
	7	30	9	1	1
	5	15	7	0	3
	4	19	9	1	2
	4	24	11	0	0
	6	26	23	0	3
	4	19	16	3	1
	1	13	15	1	1
	4	9	23	2	3

Appendix C

Raw scores in total observations for all individual pairs by sex and rearing condition for each behavioural category in the test of gregariousness

Males

Isolation	Chase	Sniffing	Passive Cont.	Play	Soc. Groom.
	14	12	13	7	0
	6	21	17	1	0
	18	19	28	15	1
	0	8	110	6	0
	16	17	18	4	0
Same-sex					
	3	18	56	18	0
	13	16	53	6	1
	9	12	32	14	2
	2	10	33	10	3
	8	9	42	14	6
Heterosexual					
	2	14	72	16	0
	0	0	0	0	0
	0	16	26	6	2
	6	14	54	11	0
	9	21	20	14	0
	3	9	32	8	2

Females

	Chase	Sniffing	Passive Cont.	Play	Soc. Groom.
Isolation					
	1	6	31	0	1
	1	10	29	1	6
	8	22	16	10	6
	1	20	5	0	8
	0	7	80	2	4
Same-sex					
	2	10	20	2	2
	0	15	87	2	13
	4	11	25	2	1
	2	4	24	2	3
	5	21	46	6	13
	0	14	48	2	5
Heterosexual					
	1	15	20	1	0
	6	17	27	0	3
	4	17	19	1	5
	5	27	33	6	10
	9	11	15	5	0

Raw scores in total observations for all individual pairs by sex and rearing condition for each behavioural category in the social facilitation test

Males

Isolation	Chase	Sniffing	Passive Cont	Play	Soc Groom
	0	0	1	0	0
	2	13	26	1	1
	6	9	17	8	0
	4	21	15	4	0
	8	18	12	6	0
	0	9	25	6	0
	4	16	23	0	0
Same Sex	10	10	7	6	0
	13	8	28	10	0
	7	18	23	1	2
	3	17	8	4	0
	7	7	20	10	0
	1	6	12	1	0
	10	13	18	13	0
Heterosexual	0	0	0	0	0
	0	10	29	13	0
	11	8	27	13	0
	4	12	27	5	0
	10	14	22	10	0
	2	12	26	7	4
	3	5	19	9	0

Females

Isolation	Chase	Sniffing	Passive Cont	Play	Soc Groom
	4	13	3	2	0
	3	18	10	0	1
	3	10	15	1	2
	3	12	18	1	0
	5	7	17	4	3
	0	7	39	0	7
	0	0	0	0	0
Same Sex	9	15	16	5	5
	3	11	38	2	2
	1	9	26	4	3
	6	8	21	8	1
	1	7	21	2	1
	0	5	8	1	1
	0	14	39	3	1
	1	7	13	4	2
Heterosexual	12	17	13	4	1
	6	17	14	3	2
	11	10	15	1	0
	0	2	37	6	0
	0	0	0	0	0
	8	25	12	1	2
	4	23	12	0	2
	2	12	14	0	0