Anim. Behav., 1966, **14**, 273–281

BEHAVIOURAL EFFECTS OF DIFFERENTIAL EARLY EXPERIENCE IN THE DOG

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The effects of various experimental procedures on behavioural development notably electro-shock, 'handling' or 'gentling' and cold exposure, instigated either prenatally (Thompson & Sontag, 1956) or at specific times postnatally have been reviewed by Thompson & Schaeffer (1961), Denenberg (1962b) and Levine (1962b). A great variety of stimuli have been employed, differing in modality and intensity thus differing in the degree of stress exerted upon the organism and their effects on subsequent development. Post-natal handling by giving a variety of stimuli such as cold exposure or electro-shock for example, during the neonatal period results in animals that are more docile to handle, are less emotional (Levine, 1957a) have superior learning abilities (Denenberg & Bell, 1960; Bernstein, 1957) and also have heavier adrenal glands, elevated corticosteroid levels (Levine, 1962a) and greater survival rates in stressful situations (Bovard, 1954; Levine, 1957b). Handling (also termed 'gentling') early in life or prenatally (Denenberg, 1963) therefore may be regarded as a stress phenomenon that produces psycho-physiologically superior animals which are better able to resist physical stress and are less susceptible to emotional disturbances and can adapt better to novel situations.

Brain weights, cholinesterase levels, cortical thickness and learning abilities are significantly greater in rats reared in an enriched environment (Levine & Alpert, 1959; Rosenzweig *et al.*, 1962a, b; Bennet *et al.*, 1964; Krech *et al.*, 1962; Tapp & Markowitz, 1963). In contrast to rearing animals in social isolation, the development of social attachment (imprinting, Hess, 1959) may be modified by socializing the animal with another species, usually to man or to related species (Thorpe, 1958). Such selective social deprivation studies have shown how early experience during the critical period can greatly alter the establishment of primary social relationships among different animals such as the squirrel and lamb (Denniston, 1959; Scott, 1958). Such altered socialization has been found to effect learning, fear responses, sexual behaviour and social preference. Similar observations have been made by Fox (1965a) on the development of socialization, effects of domestication and dog–human relationships in the dog.

Considerable work in the past has been conducted on the effects of early experience on perception and sensory feedback, and it is now well recognized that subnormal stimulation may disrupt discriminative and manipulative abilities (Nissen, Chow & Semmes, 1951; Held & Hein, 1963) as well as deterioration of receptor organs (Riesen, 1961). Early handling also has a differential effect on animals of different genetic background (King & Eleftheriou, 1959). Also the age at which handling is undertaken can result in widely differing effects, suggesting that there are certain critical periods when treatment has a maximal effect (Denenberg, 1962a), also modified by the intensity of stimulation (Denenberg & Kline, 1964).

Paulson (1965) in a study of the development of evoked responses to photic stimulation reported that ducklings exposed to photic stimulation prior to hatching showed more mature evoked potentials with shorter latencies than non-exposed controls.

Meier (1961) reported that early handling of Siamese kittens resulted in faster development of mature EEG patterns and that the handled cats were more docile and easier to handle than controls. White & Castle (1964) have shown that postnatal handling of human infants results in superior exploratory behaviour over their controls who were institution reared subjects.

Early social deprivation or isolation in phylogenetically diverse species such as fish (Shaw, 1962), rats (Griffiths, 1961), chickens (Padilla, 1935) and in the monkey can result in the emergence of a wide variety of behavioural deficits or abnormalities. In monkeys, stereotyped (e.g. rocking) and autistic behaviour, inferior learning abilities, fear of novel objects and unpredictable emotional reactions to slight environment changes have been observed (Seay, Hansen & Harlow, 1962; Berkson & Mason, 1964; Harlow & Harlow, 1962; Harlow *et al.*, 1963, 1964; Jensen & Tolman, 1962; Mason & Green, 1962; Menzel, 1963; Sackett, Porter & Holmes,

1965). Dourth & Brown (1961), Casler (1961) and Bowlby (1951) have reviewed these problems in relation to child development.

Thompson & Heron (1954a, b) reared pups in a restricted environment (partial social isolation) from 4 weeks to 7–10 months of age. These dogs were hyperactive (highly exploratory) in novels situations and were less competent to solve a simple maze problem. They also showed diffuse reactions to novel stimuli which were either avoided if menacing, or approached if apparently inocuous, by control subjects. These inappropriate responses to possibly noxious stimuli were thought to represent abnormal development of normal fear reactions and Melzack & Scott (1957) found that restricted dogs were unable to perceive and respond appropriately (i.e. avoid) painful stimuli. Angermeir & James (1961) and Melzack (1962) have also reported the effects of early sensory deprivation on later perception in the dog and Krushinski (1962) and Fuller (1964) in long-term studies on the effects of isolation on canine behaviour found that there were genetic differences in susceptibility to the effects of isolation in the different breeds studied. These studies in the effects of domestication on the development of socialization in the dog have recently been discussed (Fox, 1965a).

Dogs reared under partial social isolation between the ages of 4 and 16 weeks developed an 'isolation syndrome', characterized by extreme activity-reduction in the intensity of social contacts and decreased manipulative behaviour (Fuller, 1964). These results are of psychiatric interest because the isolation syndrome dogs showed some symptoms similar to those of so-called autistic children. Fuller's data indicate that the events surrounding the emergence from social isolation are critical to the origin and persistence of the syndrome as a mass-fear response. The slow recovery from the syndrome does not indicate the time lag in the learning of new responses, but rather the gradual removal of a rigid activity pattern of intense avoidance behaviour.

Materials and Methods

This investigation was designed to determine the effects of differential rearing on several aspects of behaviour and development of the dog. A total of eight control, eight handled, and six partially socially isolated pups were used. Handling was carried out from the first day after birth until 5 weeks of age (representing a total of 280 hr of handling). The handling procedures briefly consisted of 1 hr of stimulation daily, comprising 10 min photic stimulation in a light and sound proof box, with a flashing light stimulus at 0·16 intensity and approximately 1 sec frequency; 10 min labyrinthine stimulation consisting of 5 min antero-posterior and 5 min bitemporal tilting at an approximate frequency of 1·5 sec through an excursion of 45° from the horizontal; 10 min auditory stimulation, 2 min each at 1, 10, 10^2 and 10^3 cycles/sec at an intensity of 1·0 V and duration of 1·0 msec. This was followed by 1 min exposure in a cold room at 37°F, 5 min in a centrifugal rotator at approximately 45 rev/min and 10 min handling during which time a series of reflexes were evoked, including the Magnus, rooting, righting, geotaxic, pain and paniculus reflexes (Fox, 1964). By eliciting these reflexes, the rate of reflex development could be assessed. The subjects were then placed in a water bath at 80°F and given 15 sec total immersion during which time they would swim; this was done during the first 3 weeks of age. Subjects were then rubbed dry on a hand towel and groomed with a soft brush for 10 min and received 2 min general cutaneous stimulation with an air jet (60°F). From 3 weeks of age onwards the handling period was increased to include 10 min play with the operator. After this handling period they were returned to the mother. Control subjects were kept under typical rearing conditions with the mother, having frequent scheduled human contact at twice daily feeding and cleaning routines. All subjects were weighed and heart rates recorded at weekly intervals while the pup was lying quietly in the hands of the investigator. The pups were weaned at 4 weeks of age, received γ-globulin and piperazine anthelminthic, and were reared singly in metabolism cages in the animal house environment. At this time subjects for rearing in social isolation were selected; these subjects had been previously raised in the same manner as the control animals. Social isolation subjects were placed in a quiet darkened room, housed in single cages and were fed and cleaned twice daily with minimal contact with the handler (approximately 1·5 min daily). It was decided to rear these pups for only 1 week in social isolation (from 4 to 5 weeks of age) to compare with observations of other workers who socially isolated their subjects for much longer periods after weaning. It must be emphasized that social isolation was only partial, for auditory and

olfactory stimuli from the subject and other dogs in the isolation room were not eliminated, as was the case in most earlier social isolation or deprivation studies with dogs. Control and handled subjects were reared in single cages in the animal house environment and control subjects had approximately the same amount of human contact daily as the isolation group. At 5 weeks of age the subjects were tested singly in a behaviour arena equipped with one-way windows to enable the experimenter to observe the animals without being seen. The arena contained cloth bedding from the mother of the pups and in another corner a brightly coloured child's toy. The reactions of the subjects were observed when first placed in the arena for 5 min and observations continued for a further 5 min after these objects had been removed. The objects were then replaced and a further 5 min of observations were conducted. Two observers with stop watches independently recorded the duration of certain activities of each pup throughout each of the three 5 min observation periods, and time scores were then averaged for each group. The activities observed and time-scored were as follows.

1. *Specific interaction with stimulus.* Duration of interaction with either cloth or toy including approach, play, chewing, licking, carrying and lying beside or running around the object was recorded.

2. *Non-specific exploratory.* The time spent exploring arena was recorded, including sniffing and licking walls and floor and jumping up at walls, looking up at walls (visual) and attention to extraneous noises (air-conditioner turned on as sound blanket). During this activity period, pup never approached cloth or toy.

3. *Random activity.* The time spent sitting or pacing arena without any overt reaction to cloth or toy or attention toward walls, floor or extraneous noises was recorded.

4. *Distress vocalization.* As a level of emotional arousal, the number of distressful yelps and duration of distress vocalization was recorded by one observer only while the other observer noted what else the pup was doing (random or non-specific exploratory activities). There was a high correlation between distress vocalization and random activity, and distress vocalization and non-specific exploratory (jumping up at walls).

After this 15 min testing period, the animal's approach to a passive observer in the arena was determined and then approach and following response while the observer walked around the arena. The ability of the pup to negotiate a simple wire mesh barrier placed between him and the observer was next used to assess detour behaviour. Four trials were allowed and if the animal was able to come around the barrier to the observer, one end was blocked and if there was an end preference, the preferred side was first blocked. The time taken to pass around the barrier and number of trials required were recorded. Finally, the social interactions of these differentially reared subjects was observed when they were placed together in the arena which still contained the cloth and toy. After 5 min observations the experimenter entered the arena and observed the effects of the presence of a human on the group behaviour of the pups. After these behaviour observations EEG recordings were taken using scalp electrodes (modified Mitchell wound clips), bifrontal and bioccipital on a Grass 6 channel recorder: EKG recordings were also taken. Recordings were taken while the animals were lying quietly awake and also asleep in a darkened room and were restrained in a copper-gauze box lined with foam rubber. Animals were then euthanatized and several organs dissected and weighed in the cold room at 37°F. Brain and spinal cord were dissected for amino acid, esterase and lipid analysis of various parts and for histological examination, and the adrenal glands were dissected out and prepared for epinephrine and norepinephrine analysis, and specimens of kidney, liver, sciatic nerve and lumbar muscle removed for LDH (lactic dehydrogenase) and protein analysis.

Results

No significant differences in body weight gain was observed in the different groups nor were significant differences in total brain weight observed.* When tested at 3 and 4 weeks of age for a variety of reflex tests employed to determine the degree of neuro-ontogenetic maturation (Fox, 1964), no significant differences were observed. Some handled pups, however, showed

*Analysis of brain parts so far completed indicates considerable differences between control and handled pups as compared with the isolates. The latter group were found to have significantly more GABA (glutamic aminobutyric acid) and less glutamine, threonine and alanine, and marked differences in esterases. The average percentage of epinephrine per gland was found to be 63 ± 9 per cent in the handled and 56 ± 7 per cent in the controls, there being no change in the total amine content of the adrenals due to handling but a significant increase in epinephrine. These findings will be reported in greater detail at a later date.

slightly superior coordination while standing and walking at 4 weeks. Histologic examination of motor, occipital and frontal cortex and vestibular neurons revealed no marked differences in cell density or neuron size. Heart rates were recorded in the control and handled groups only because resting heart rates were not possible to take at 5 weeks of age in the social isolation reared pups as they were hyperactive and had tachycardia. The marked differences between the handled and control groups were apparent from the second week of age onward (Fig. 1). Normally there is a decrease in heart rate from 2 weeks of age onwards due in part to an increase in vagal tone which was seen in the control subjects but in the handled group, cardio-acceleration from 2 weeks of age onwards was seen and at 5 weeks the heart rate in all handled subjects were greater by 60 beats/min, indicative of greater sympathetic tone.

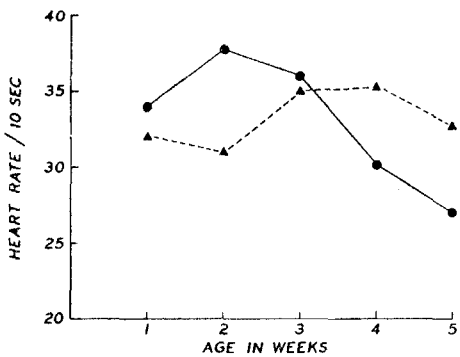

Fig. 1. Heart rates of control and handled dogs. Contrast normal decrease in heart rate in eight controls (●) at 2 weeks (due to sudden increase in vagotonia) and increase in eight handled (▲) subjects, indicative of greater sympathetic tone.

Behavioural Observations

Extreme differences were not found among individuals in the same group and this surprising uniformity facilitated comparisons among the three differentially reared groups. Generally, the handled pups were hyperactive, highly exploratory, very sociable towards humans and dominant in social situations (e.g. play) with their peers. They also performed best in the problem solving tasks of the barrier tests (Table I and Fig. 2). The handled subjects showed the greatest distress vocalization immediately after the handler had entered the testing arena and removed the cloth and toy. In contrast the control subjects were little distressed by this interference but showed great emotional arousal when first put into the arena. The social isolation subjects showed little emotional arousal in all of the test situations. Control subjects reacted more to the cloth stimulus than to the toy while handled and social isolation pups were somewhat similar in their reactions to both cloth and toy. The time spent with these specific object stimuli was contrasted by the random and nonspecific exploratory activity of the various subjects; random activity was characterized by the pup running around the arena in an aimless undirected fashion while nonspecific exploratory activity was seen when the subject would intently explore the floor, walls and door of the arena. Random activity was greatest in the isolation groups while the control group showed a high level random activity when the stimulus specific objects were present in the arena. In contrast the handled group showed increased random activity when these specific stimuli were removed. This increase in random activity in the handled group when the arena is empty is correlated with the greater distress vocalization at this time. Nonspecific exploratory activity was greatest in the handled group when the cloth and toy were in the arena but was greatest in the control group when the arena was empty. This increase in nonspecific activity in the control group is associated with their high interaction with the cloth when it is present in the arena; control subjects were therefore stimulus bound throughout and when the stimulus was removed they showed an increase in nonspecific exploratory behaviour (in contrast with the diffuse reactions of the isolates). The level of nonspecific exploratory activity in the social isolation group was similar in the three test situations and when assessed with the total random activity show the relative hyperactivity of this group. In the barrier test situation the handled pups performed best in that they required the least number of trials to negotiate the detour while the control pups reacted more slowly and showed distress vocalization in this situation (Table I). In the control group, therefore, emotional arousal in this situation prejudiced problem solving ability. The isolation group in four out of six cases were unable to negotiate the barrier while two were able to solve the detour problem but unlike other subjects did not come directly around to the observer but wandered off toward the toy or cloth. They behaved similarly to the control pups in that they became hyperactive and would run along the barrier 'pushing'

Table I. Open-field Behaviour Tests in Differentially Reared Dogs
(Detour scores expressed as percentage of correct scores per side)
Isolation from 4 to 5 weeks, handling from birth to 5 weeks

Activities	Specific stimulus		Random	Exploratory (non-specific)	Distress (vocaliz-ation)	Detour success rates		
	Cloth	Toy				Side pref.	R. closed	L. closed
Control 8	78·0	37·2	32·5	152·3	27·2	R 1·8 L 2·3	41·5	41·5
	—	—	68·0	232·0	2·3			
	76·0	7·4	34·0	182·6	10·0			
Handled 8	52·5	38·25	22·0	187·25	17·2	R 1·6 L 2·2	93·0	96·5
	—	—	183·0	117·0	75·5			
	49·75	47·0	13·0	190·25	8·5			
Isolated 8	47·0	32·6	51·25	169·15	1·4	R 1·1 L 2·1	23·0	28·0
	—	—	136·5	163·75	3·5			
	24·7	42·5	96·0	136·8	0·1			

Underlined figures = observations when cloth and toy are removed from arena. All figures represent average time in seconds during three 5 min test periods, in which arena is full, then specific stimuli removed and replaced after 5 min.

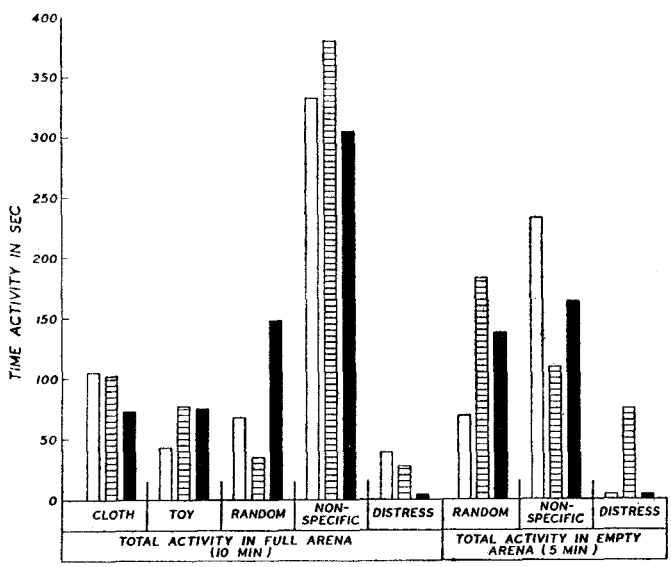

Fig. 2. Total time activity scores of differentially reared pups. For details see text. Note extreme differences in activity and distress reactions in handled and socially isolated subjects. Open columns = controls; shaded columns = handled pups; solid columns = isolated pups.

with the nose, but in contrast, they were non-vocal. In the social situation (group behaviour test) in all cases the handled pups were dominant during play and were the first to leave the group to approach the observer when he entered the arena. The control subjects were the most subordinate but would interact constantly with the group and not leave the group in contrast to the isolation reared pups who would frequently leave the playful group and either indulge in 'self

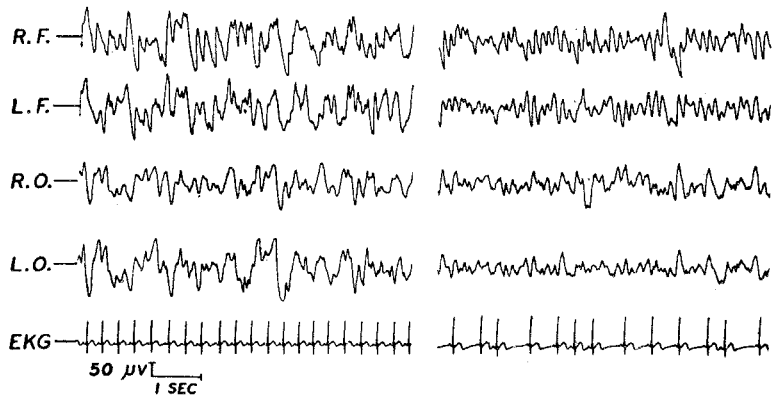

Fig. 3. Sleeping EEG of handled (left) and control (right) 5-week-old pups. Greater amplitude in handled subjects indicative of greater maturation over controls. Note bradycardia and arrhythmia in control EKG, characteristic of normal pups of this age.

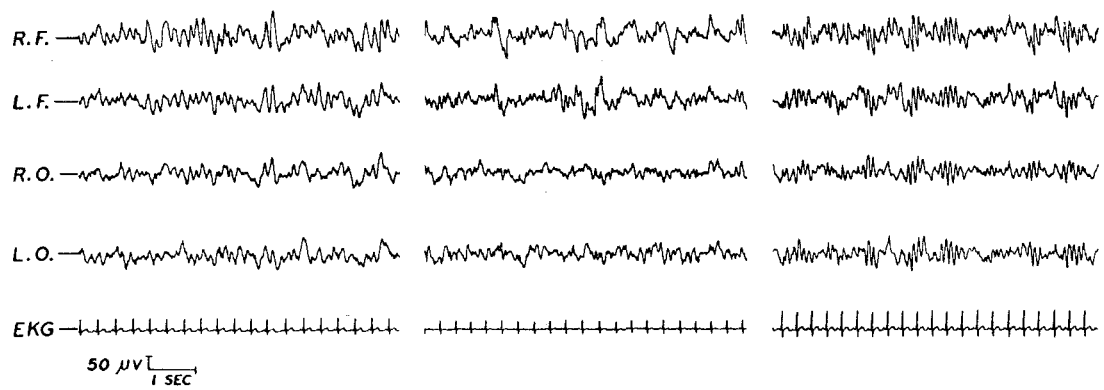

Fig. 4. Awake EEG of handled (left), control (centre) and isolated (right) 5-week-old-pups. Note 'spindling' activity associated with extreme arousal (alerting) in socially isolated pups.

play' (e.g. tail chasing) or approach the cloth or toy. During aggressive play-fighting the controls were most subordinant and the isolation pups were intermediate in that they would fight with the handled pups to a greater extent. In those litters where two handled pups were present in the group it was observed that these subjects would frequently leave the group together and explore the test arena and indulge in aggressive play away from the control and isolated pups. Approach behaviour towards the observer standing in the arena (cloth and toys still present) and following response as the observer walked around the arena was greatest in handled pups. Control pups were slower to approach and follow but in no instances did any pup actively avoid the observer. In contrast the isolation reared pups often showed passive avoidance behaviour (fearful crouching) while those that did follow only did so for a short distance and were easily diverted and would approach the cloth or toy as they came into the vicinity of these objects. Throughout the test procedures, vocalization in the isolated group was at a very low level: socialization processes may therefore be important in developing and reinforcing vocal behaviour and distress vocalization.

EEG recordings were extremely difficult to take in the isolation pups. The recordings were originally to be taken when the animals were in a similar behavioural state. To achieve this it was decided to record when the pups were lightly

asleep in the arms of the observer and could be aroused by a loud noise. Successful recordings were obtained in all control and handled pups while in the isolation subjects, it was found almost impossible to get good recordings. These animals would not rest for one moment and were constantly alert. Successful recordings were obtained in two of these subjects while they were lying quietly awake. In general the EEG activity of handled pups showed a great amplitude during light sleep as compared with the control subjects (Fig. 2). As amplitude increases with age it may be presumed to be an indication of greater maturity in the handled subjects. The EEG recordings from the isolation pups showed that there was great alerting activity with symmetrical spread throughout the frontal and occipital regions of the brain characterized by a fast frequency activity not normally seen in the alert EEG of the normally reared pup at this age.*

Discussion

The observations obtained from the handled group of pups indicates that in this experiment handling caused increased adrenal activity (reflected in the ontogeny of the heart rate and adrenal percentage of norepinephrine at 5 weeks), confirming the observations by other workers on the effects of the early handling stimulation in the rat and mouse reviewed earlier in this paper. The only significant neurologic finding was slightly superior locomotor ability and equilibratory coordination in the handled pups. We may surmise that reflex development in the dog normally proceeds at a maximal rate postnatally and was little affected by the manipulations in this experiment. However, the general behaviour and electrocortical activity of the handling group compared with the control group showed marked differences in that the EEG was more mature and handled animals showed similar changes in their behaviour patterns as reported in handling studies in other species. They performed superiorly in the problem solving situation (the barrier test) and showed less emotional arousal in this situation. In group behaviour the handled pups were the dominant individuals and these pups showed the greatest attraction to man. The isolation-reared pups in spite of being isolated for such a short period of time at the early part of the critical period of socialization (which extends from 3½ to 12 weeks of age, Scott & Marston, 1950; Scott, 1962) behaved similarly to pups reared for much longer periods in social deprivation. They were hyperactive and showed diffuse reactions to novel objects and paid more attention to their physical environment than to their litter mates when tested in the group situation. They had the lowest emotional attachment or attraction for man and showed the most inferior problem solving abilities. The EEG of these isolation subjects resembled the recordings obtained by Scherrer & Fourment (1964) in the rabbit, in that there was constant alerting characteristic of the high level of behavioural arousal. Similar to the observations of Fisher (1955) pups reared in social deprivation isolated themselves from the group and would play in a solitary fashion (self play). It is interesting that such profound changes in behaviour following this short period of isolation results in similar symptoms to those described in pups reared for much longer periods in isolation. In contrast, abnormal fear reactions and adaptive approach and avoidance response were not observed in these isolation subjects, whereas Fuller (1964) reported such abnormalities in pups isolated for up to 16 weeks of age. This is to be expected because by 5 weeks of age the approach behaviour is normally at maximum intensity and avoidance behaviour is poorly developed (Freedman, King & Elliot, 1961). Long term isolation (partial social deprivation) results in inappropriate avoidance or approach responses to novel stimuli. On emergence from long term isolation, exploratory behaviour is overshadowed by mass avoidance behaviour and fear of novel stimuli. Long term isolation rearing therefore causes deficit in the establishment of fear responses and by 16 weeks of age the capacity for long lasting fear responses is developed. There is also a lack of response to social stimuli (autistic) and inhibition of aggressive behaviour. In the present study it is conceivable that the effects of isolation if extended over a longer period may be made more permanent but as social isolation was discontinued earlier on the critical period of socialization, the effects are transient. Thus, early plasticity affords greater adaptability.

*This spindling activity has been further confirmed in five pups isolated from 4–5 weeks. Chronic electrodes were implanted and gave superior recordings. The spindling phenomenon disappears 4–7 days after emergence from isolation. Evoked responses to photic and auditory stimuli are also of shorter latency in isolates, indicating intense arousal (data to be published).

Summary

The effects of handling from birth to 5 weeks

and isolation from 4 to 5 weeks were studied in twenty-two dogs and contrasted with the behaviour of control subjects raised under normal rearing conditions. Differences in behaviour, heart rate and EEG activity were evident in the three differentially reared groups of dogs and were attributed to the effects of handling and isolation in the experimental groups as compared to the control group. Preliminary biochemical data (adrenal and CNS analysis) are included and some correlation in the differentially reared groups is shown. These data in part support similar findings in other species reviewed in this paper.

Acknowledgments

The authors wish to acknowledge the assistance of Mr J. Briggs and the facilities provided by the Galesburg State Research Hospital, and are most grateful to Dr Williamina A. Himwich for advice and encouragement throughout this study. We are also indebted to Drs H. C. Agrawal and G. R. Pscheidt of this laboratory, and Professor Jon Kabara of the University of Detroit for preliminary biochemical data. Some of this data together with a clinical orientation to the problem of early experience were recently presented by the senior author at the 20th Annual Meeting, Society of Biological Psychiatry, New York, 1965.

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(*Received* 21 *June* 1965, *revised* 21 *January* 1966; *Ms. number*: A352)