Critical Periods in the Development of Social Behavior in Puppies

J. P. SCOTT, Ph.D.

AS PART OF A PROGRAM for the study of heredity and social behavior in dogs, the author and his colleagues have made a thorough study of the development of social behavior in puppies, with the idea of finding out the times at which heredity was most likely to exert its effects. As we did so, we also observed that there were certain periods in which environmental factors were particularly likely to affect behavior. As a result we have, from time to time, reported evidence on what we have called the critical period hypothesis.[16, 18] This idea is one which is basically related to certain clinical ideas concerning the effect of early experience on later mental health and behavioral adjustment. It is therefore important that it be clearly understood.

Critical Period Hypothesis

What is the critical period hypothesis? In the first place it is in certain respects no longer a hypothesis but a well-established generalization which can be stated as follows: All highly social animals which have been so far studied show early in life a limited period in which the group of animals with which the individual will form positive social relationships is determined. To take a few of many examples, the slave-making ants raid the nests of other species for eggs and larvae. As the captive ants grow up, they become attached

to their captors and take care of their young, and no longer recognize their own species. The experiments of Lorenz[9] with the newly hatched greylag geese which quickly form a social bond with the first moving object they see, whether goose or human, have dramatized the findings of Heinroth and others that contact with the young birds in the proper stage of development establishes a strong social relationship regardless of the species concerned. Lambs that are taken at birth and raised on the bottle form social relations with people rather than other sheep and become as a result quite unsheeplike in many respects.[13] The dog is particularly interesting because the process of socialization with human beings is a normal part of its life as a domestic animal. Dogs are more closely attached to people than are many animals, and develop a relationship which is in many ways similar to the human parent-child relationship. Furthermore, the critical period for socialization in the dog does not begin at birth but approximately three weeks later.[15]

The existence of critical periods for the process of primary socialization can therefore be taken as established. Other parts of the critical period hypothesis, namely, that there exist certain periods of sensitivity to psychological damage, still remain as hypotheses and need a great deal more experimental evidence before they are accepted.

The existence of critical periods of any sort implies certain subsidiary hypotheses. The first of these is that the critical period has a physical basis and results from the state of anatomical, psychological, and physiological development of the animal. The second is that hereditary variability between species

will affect the course of development. We have found in a limited survey of different forms that such differences are great, and they do not consist simply of the condensation or elongation of a standard type of development. The order of developmental events may even be reversed in different species. It does look, and this is the third hypothesis, as if the social development of any particular species is strongly correlated with the social organization of the adult.[14] For example, in dogs there is a close association between mother and puppies during the first 3 weeks in life, but since the permanent social relations of the puppy are formed after this period and at a time when the mother leaves the litter for long periods, the result is that the strongest relationships are formed with the litter mates. This relationship is in turn the basis of pack organization of adult dogs and wolves. A final hypothesis is that there should be genetic variability in the course of development *within a species,* which means that the time of onset of critical periods and their relative sensitivity should vary from individual to individual. This paper will be chiefly concerned with the evidence which we have been able to gather regarding the physical basis of the critical period for primary socialization in the puppy.

Normal Development

I shall first describe the normal course of social development in the puppy. The newborn pup is a very immature animal, being both blind and deaf and unable to move except in a slow crawl. Its movements are slow and shaky, and its reflexes sometimes occur seconds after stimulation. In spite of being deaf it whines loudly if cold or without food. Its chief needs appear to be warmth, milk, and elimination, and these are taken care of by reflex behavior. If moved away from the mother the puppy will crawl, usually in a circle, throwing the head from side to side. If it comes into contact with the mother it attempts to nurse. When it succeeds it pushes with its head and forepaws and also with the hind feet. In doing this it touches and so

stimulates the other puppies in the litter. Any touch will initiate exploratory movements. The mother also frequently stimulates the puppies by nosing them and licking the genital and anal areas. This produces reflex elimination as well as stimulating the pups to exploratory movement and nursing.

This is the typical behavior of puppies in the *neonatal period.* No immediate change is observed in their behavior. They gradually grow somewhat stronger and quicker until the opening of the eyes, which typically occurs just before 2 weeks of age. This marks the beginning of the *transition period,* one of very rapid change and development. At its beginning the eyes open, and at its end the puppy gives a startled reaction to sound. It can walk instead of crawl, and can move backward as well as forward. Its first teeth appear, it takes solid food, and it begins to urinate and defecate without assistance by the end of the period, which typically occurs just before 3 weeks of age.

At approximately 3 weeks of age the puppy first begins to notice other individuals at a distance and shows evidence of conditioning and habit formation. This is the beginning of the period of *socialization,* in which its primary social relationships are formed. At almost the same time the mother begins to leave the puppies unattended, so that there is a tendency for the strongest relationships to be developed with the litter mates rather than the mother. During the next few weeks it is easy for the human observer to form a positive social relationship with the puppy. This period of primary socialization comes to an end somewhere around 7 to 10 weeks of age, which is the normal period of weaning. This does not mean that the puppies are self-sufficient with regard to food. Studies of wolves show that the pups are not able to hunt at all until 4 months of age, and are not really independent until 6 months of age.[10] In the domestic dog, food is normally supplied by man, but in the wild state it is provided by the hunting parents. This period, which ends with the sexual maturity of the puppy, is called the *juvenile* period. In some of our domestic breeds estrus of the females

occurs as early as 5 months, but in the ancestral wolves this does not happen until the end of the second year.

We can see that there might be several critical periods affecting the development of new social relations, that of primary socialization at 3 weeks, the time when sexual relations are established at the end of the juvenile period, and that when the parental relationships are established as a new generation of pups is born. We are here concerned primarily with the first of these periods, the period of primary socialization, because we can make the assumption that the end of the primary social relationships will strongly affect the degree of adaptation and adjustment in later relationships.

Anatomical Basis for Social Behavior

Function is of course related to form, and form in turn to the process of growth. Let us examine the anatomical changes which accompany changes in social behavior. In the young pups there are three sorts of external changes which are easy to follow, the eruption of the teeth, the opening of the eyes, and the opening of the external ear canal. The last is somewhat harder to follow and is probably less reliable than the other two.

All the following data are based on observations of purebred puppies reared under the standard conditions of our long-term experiment on genetics and social behavior.[17] The total numbers differ slightly from table to table because complete information was not gathered on all animals in the early part of the experiment.

The first teeth to appear are the canines, followed shortly by the incisors, which all come in together except that the corresponding upper teeth come in before the lower. No animals show teeth at 2 weeks, nearly half have some teeth by 3 weeks, and nearly all have at least the upper canines through the gums by 4 weeks of age. An eruption of the teeth therefore coincides with the beginning of the period of socialization.

The teeth erupt the earliest in basenjis and beagles (Table 1), and wirehaired terriers

TABLE 1. ERUPTION OF UPPER CANINE TEETH

| Breed | No. | % Erupted at | | |
		2 weeks	3 weeks	4 weeks
Basenji	51	0	79	100
Beagle	54	0	74	100
Cocker spaniel	67	0	22	100
Sheltie	30	0	30	100
Wirehaired fox terrier	31	0	14	89
TOTAL	233	0	47	99

are definitely slower than all the rest. The shelties are unusual in that the lower teeth develop relatively fast and, in certain animals, the lower canines actually appear before the upper.

The eyes typically open about 2 weeks of age or slightly before. Very few are partly open at 1 week, the majority are open at 2 weeks, and all animals have the eyes completely open by 3 weeks of age (Table 2). The opening of the eye is the first external sign of the transition period. Eighty-five per cent of the purebred puppies have the eyes partly open at 2 weeks, and we can estimate the average time at 13 days. There is, however, individual variability and differences between breeds. The eyes open earliest in cocker spaniels and beagles, a little later in basenjis, and much slower in shelties and wirehaired terriers.

The opening of the ears is a more prolonged process and comes a little later than that of the eyes. Over half the animals show the ears at least partly open at 2 weeks, and all are completely open at 4 weeks. The differences between strains are not great. The shelties appear to be the most rapid, and the

TABLE 2. OPENING OF THE EYE

| Breed | No. | % Completely open at | | |
		1 week	2 weeks	3 weeks
Basenji	43	0	65	100
Beagle	49	0	94	100
Cocker spaniel	51	2	94	100
Sheltie	25	0	31	100
Wirehaired fox terrier	27	0	11	100
TOTAL	195	0.5	67[a]	100

[a] Average with equal weight for breeds = 59.

TABLE 3. PUPILLARY REFLEX (EYE OPEN OR
PARTLY OPEN)

		% Animals responding at			
Breed	No.	1 week	2 weeks	3 weeks	4 weeks
Basenji	42	0	57	98	100
Beagle	45	0	78	98	100
Cocker spaniel	51	0	88	100	100
Sheltie	26	0	38	96	100
Wirehaired fox					
terrier	24	0	13	83	100
TOTAL	188[a]	0	62[b]	96	100

[a] Not observed in 8 additional animals: 1 basenji, 4 beagles, 3 terriers.
[b] Average weighted equally for breeds = 59%.

TABLE 4. FUNCTION OF THE EAR
Animals giving startle responses to some sort
of sound

			Age	
Breed	No.	2 weeks	3 weeks	4 weeks
Basenji	43	0	72	100
Beagle	49	0	84	100
Cocker spaniel	57	2	61	100
Sheltie	24	0	62	100
Wirehaired fox				
terrier	27	4	92	100
TOTAL	200	1	74	100

wirehaired terriers the slowest, with the other breeds being intermediate and showing only slight differences.

The variability of any of these events which can be precisely timed, such as the eruption of the teeth or opening of the eyes, has a range of approximately 1 week in normal animals. The wirehaired fox terriers appear to be definitely slower in all respects, but in the other breeds the speed of development is not correlated in the different traits. It looks as if there can be separate variability in any one of these characters. One might expect that the development of all the teeth would be correlated, but even here the shelties show a relatively more rapid development of teeth in the lower jaw than do the other strains.

Function of the Sense Organs

Histological studies of the development of the puppy eye[1] indicate that the retina is not fully developed at the time of the opening of the eyes, nor even by 3 weeks of age (Table 3). However, it can be shown that the eye responds to light at a much earlier age. Some puppies will give a winking reflex to light at birth, long before the eyes open. This appears to happen most frequently in those breeds which have red hair color and light skin pigment.

As soon as the eyes open and the pupil can be clearly seen we can demonstrate a pupillary reflex when a strong light is shown into

the eye. At the same time the nystagmus reflex can also be observed. If the puppy's head is moved slowly sideways the eyes roll or flick back and forth. This, however, is probably a reflex controlled by the nonauditory portion of the acoustic nerve rather than by sight. Incidentally, puppies do not shown nystagmus in reaction to a moving object or rotating cylinder held in front of them.

The above reflexes concerned with eye function appear early in development, but it is probable that these are responses to light and darkness, and that the capacity to perceive images is not developed until 4 or 5 weeks of age.

The onset of function in the ears is much more definite (Table 4). Only 1 per cent of the puppies give a startle reaction to sound by 2 weeks of age, and 74 per cent give a reaction at 3 weeks of age. We may therefore estimate that the average time is about 19.5 days. There is considerable genetic variability between the breeds, and the wirehaired terriers have the highest percentage of animals which give a definite startle reaction.

As with the eyes, there is no evidence that the puppies use their ears in finer ways at first. The tendency to startle to all sorts of loud sounds persists for a week or two.

All the puppies gave some reaction to odors at birth. They give reliable avoidance reflexes to two substances, oil of anise and a proprietary drug used as a dog repellant, which is a compound related to citronella. Eighty-three per cent of all puppies gave the avoidance response to the repellant, and a smaller number to oil of anise. Harman found that the

TABLE 5. Appearance of the "Wink Reflex"
to Touch

Breed	No.	% Responding by		
		Birth	1 week	2 weeks
Basenji	43	86	100	
Beagle	49	96	98	100
Cocker spaniel	51	74	98	100
Sheltie	26	69	100	
Wirehaired fox				
terrier	27	63	100	
Total	196	80	99	100

parts of the brain connected with olfaction
were unmyelinated at birth, and it is probable
that these reactions to odor are largely con-
nected with the sense of taste rather than
true olfaction. In the human subject both
substances can be detected in both the nose
and throat. There is some observational evi-
dence that hungry puppies react to the smell
of milk in the neonatal stage, but we have no
definite evidence on this point.

With regard to other senses, puppies defi-
nitely react to pain and touch at birth. The
majority of all newborn animals give a "wink-
ing reflex" to touch and nearly all of them
show this by 1 week of age (Table 5).

In general, the function of the sense organs

at birth is quite limited, but all senses are at
least partially functional at approximately 3
weeks. Prior to the beginning of the period of
socialization it is impossible for the animal to
be stimulated by many environmental
changes. Those stimuli which are effective
are ones which set off the reflexes connected
with eating and other vital processes. In
effect, the very young puppy is insulated from
many sorts of environmental stimulation.

Development of the Central
Nervous System

Observation of puppies in the neonatal and
transition stages gives no indication that the
animals learn in the way that adults do. For
example, a puppy placed on the scales may
crawl to the edge and fall off. When he is put
in the situation repeatedly he does the same
thing time and again, with no improvement
in adjustment.

The only change in behavior for some time
after birth is that the puppies become some-
what faster and stronger in their simple be-
havioral reactions. Fuller et al.[5] found that
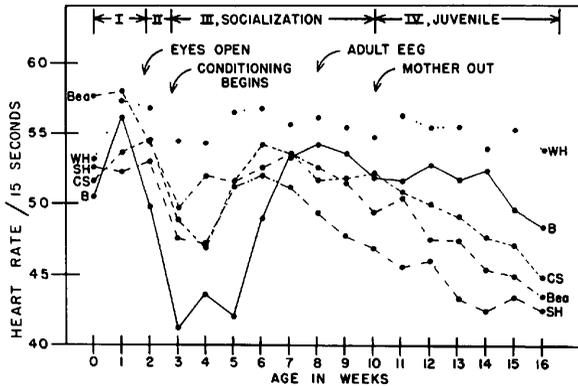the avoidance behavior of puppies could be

Fig. 1. Average heart rates at different periods in development. Note that all breeds show a
lower rate during the early part of the period of socialization than they do either earlier or later
The heart rate change probably measures the puppy's emotional reaction to being picked up, and
indicates unusual emotional sensitivity at this age.

easily conditioned to sounds shortly before 3 weeks of age. This could not be done previously, and the change in an individual animal's behavior occurred from one day to the next. This change is, of course, related to the development of the function of hearing, but no conditioning to other sensory stimuli could be obtained at earlier ages. Responses were given to taste and touch, but did not produce conditioning. James and Cannon[7] confirmed Fuller's results and found that the avoidance reaction to a mild electric shock is restricted to the part stimulated by 28 days of age, indicating that psychological development is still going on.

Harman[6] has made histological examination of the brains of young puppies and finds that the newborn brain is myelinated in very few places, those corresponding to the parts associated with the observed reflex patterns of behavior. This lack of myelination may account for the slow movements of the young puppies, as contrasted with their more rapid responses at later ages.

A measure of actual function of the developing nervous system was obtained by Charles and Fuller[3] by taking the EEG of puppy brains at different ages. At birth the puppy brain has almost no waves at all, and there is no differentiation between sleeping and waking states. At 3 weeks, corresponding to the other differences in behavior noted above, the sleeping and waking states are differentiated, and the amplitude of waves is increased. The adult form of the EEG is achieved at approximately 8 weeks of age, which is shortly after the earliest time at which mothers normally wean their pups.

Another measure of nervous development is the heart rate (Fig. 1). At first glance this might be considered a purely physiological response. However, the heart is actually a very sensitive indicator of both body activity and various kinds of emotions. As will be seen on the graph, the heart rate of the newborn puppies is very high and stays this way through the second week. Then it takes a very decided dip at from 3 to 6 weeks, coming back up to the early level around 7 weeks of age. Thereafter the heart rate slowly de-

clines toward the adult level. These general changes seem to be independent of breed. The first change occurs at the beginning of socialization, and its end occurs at 7 weeks, coinciding approximately with the time of the adult EEG. We can suppose that this is the period when complete cortical connections are established with the hypothalamus. We can conclude that the period from 3 to 7 weeks is an especially sensitive one for emotional reactions, which corresponds to observation of overt behavior. We might also speculate that, since the cortex is not completely developed, emotional reactions during this time might be less permanently learned. On the other hand, they might be more disturbing because complete cortical control has not been established. We have here a fascinating field for further precise experiments on the effects of early experience.

The development of the nervous system and its associated psychological abilities goes through several stages. The puppy definitely does not come into the world with all its psychological abilities developed. They are, in fact, quite immature at birth and for the next 3 weeks. We would expect and have found[16] that it would be extremely difficult to produce psychological trauma upon very young puppies, and that any future effects on their behavior produced at this time would have to be made by physiological or anatomical injury.

These results raise the question of what the situation is in the human infant. Human development is obviously different from that of the puppy, but we have every indication that the neonatal human infant has a nervous system which is decidedly undeveloped. We need to know more about the origin of learning abilities in human infants before we can talk authoritatively about the effects of early experience. It is not too much to suggest that it would be contrary to the general law of biological adaptation to find that the nervous system was highly sensitive to psychological damage at such a period as birth. This, however, does not invalidate the possibility of anatomical birth injuries.

Social Behavior

The most obvious social behavior of young puppies is vocalization. This response is obviously related to various sorts of social contacts. The type of behavior involved is et-epimeletic, or calling for care and attention. In any situation in which the puppy is unable to adapt, the puppy substitutes this reaction for any attempt at adjustment on its own part. Newborn puppies whine repeatedly until they begin to nurse. Fredericson[4] has shown that, besides hunger, the sensation of cold is the stimulus most likely to produce whining. In addition, puppies will whine loudly if accidentally hurt. All these things can be alleviated by social contact.

During the early stages of development the number of whines made by the puppies while being weighed for a period of 1 minute was counted. In general the response decreases, so that by 4 weeks of age most of the puppies make no noise at all. The response is chiefly due to contact with the cold scales, and there

is evidence of breed differences, the beagles reacting with relatively small numbers of noises.

During the period of socialization the puppies begin to whine in response to being placed in a strange environment no matter whether warm or cold. Fredericson[4] has shown that this response is considerably lessened if another puppy from the same litter is placed with it. We are now gathering data on the development of this response, and it appears that isolation in a strange environment always produces a stronger reaction than isolation in the home pen.

This brings up another experimental problem which has been scarcely touched. There is considerable evidence[21] that there is a process of primary "localization," in which a young animal becomes psychologically attached to a particular physical environment. There may be a critical period in development for this as well as for the analogous process of socialization.
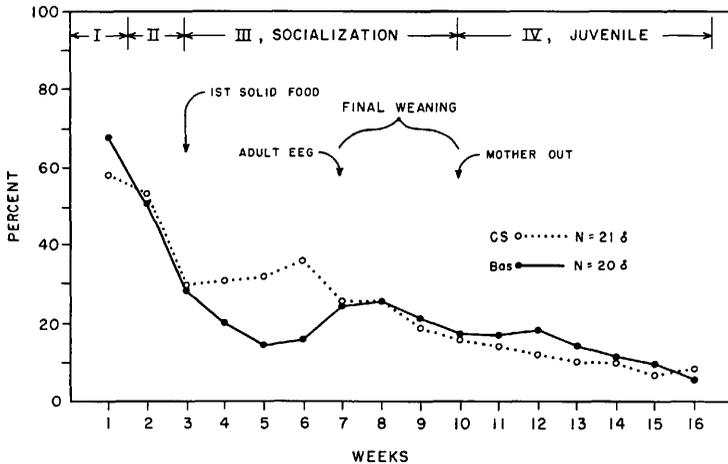

Fig. 2. Weekly percentage gain of weight in male cocker spaniel and basenji pups. Note the change in the slope of the curve at 3 weeks. This reflects both the taking of solid food and increased food motivation resulting from learning and habit formation. The difference between the two breeds reflects a genetic difference in palatability of the food supplied.

Developmental Changes in Eating Behavior

General changes from sucking to eating solid food have already been described. Our most objective measurement of eating behavior is an indirect one. The gain in weight of the animal reflects the amount eaten. If we chart the weekly gains of puppies we find, as we might expect, that the rate of gain declines week by week. However, there is a definite change in the nature of this curve at 3 weeks of age. The curve before this time is entirely dependent upon the milk supply of the mother. Afterwards the puppy has the possibility of eating solid food, and we would expect that the decline in the growth would be less rapid as soon as solid food was available. However, there is probably a psychological factor involved also. Puppies pay no attention to solid food if they get plenty of milk from the mother, even beyond the age of 3 weeks. This was definitely the case in our F_2 hybrids which were fed by F_1 mothers having an abundance of milk, even in excess of what the pups could use. In their case also the rate of decline of growth was halted after 3 weeks, indicating that the animals were taking in more food (Fig. 2). We may conclude that because of their ability to be conditioned the animals now learn to eat, increasing their food motivation.

This idea is supported by observations on hand-fed puppies. During the neonatal stage they are quite difficult to feed by ordinary means. It is hard to get them to take a nursing bottle, and they have a tendency to stop before the stomach is filled. They can be laboriously fed by a dropper, but the easiest and most practical way to insure adequate feeding is to inject milk into the stomach through a tube. The explanation is that natural feeding is stimulated by specific primary stimuli or releasers which activate certain reflexes and simple patterns of behavior. Puppies become more active and more responsive to external stimuli if hungry, but hunger has little relation to the amount of food taken.

During the transition period, between 2 and 3 weeks, the pups are much more easy

to feed. They will readily take a bottle and, if placed near a dish, they can clumsily lap the food. However, they will not take adequate amounts if the dish of warm milk is simply left with them. They still have to be stimulated by fresh food and handling several times a day in order to be properly nourished.

By contrast, puppies older than 3 weeks of age are relatively easy to feed, particularly because a supply of food can be left with them and they will continue to eat adequate amounts.

We can draw several conclusions from these observations. One is that puppies cannot be satisfactorily fed on a demand schedule before 3 weeks of age. Maternal care, together with the reflex behavior of the puppies, will provide adequate nutrition, but the puppy has not yet become a self-regulating organism with regard to eating. He needs external stimulation. Later on, when the ability to form associations and habits is developed, the hunger mechanisms, together with motivation to eat produced by learning, are sufficient to regulate the eating of the puppy in a satisfactory way. This, of course, poses certain questions regarding the reasons back of the necessity for handling human infants, a problem which has been raised by Spitz,[20] Ribble,[11] and others.

Feeding and Socialization

The simplest theory of primary socialization is that this relationship is built up through the association of food with a particular individual, and that the relationship can develop further based on this original bond. Brodbeck[2] tested this by rearing cocker spaniel puppies which were mechanically fed, and comparing their behavior with that of puppies fed by hand. In both cases the experimenter spent an equal amount of time playing with the pups. The result was that the pups which had never been fed by people still showed strong attraction to the experimenter. This indicates that feeding is not the only element in the formation of a social bond.

On various occasions we have observed puppies which through some accident to the

mother or deficiency in her milk supply were underfed. Young pups that are well-fed are fat and lethargic. In contrast, the underfed animals are active, show more interest in people, and seem to show an earlier expression of many behavior traits than do the normal ones. An opportunity to check this finding occurred recently in connection with an experiment of John A. King, in which he fed two groups of basenji puppies by hand twice a day during the period of socialization. One group was given as much as they could eat, and food was left in the dish so that they could eat later. The other group was given considerably less and their weight was much lower. Both groups were given a handling test which measures responses of the puppy to a human handler.

In puppies raised in a different situation in which most of the food comes from the mother but in which there is considerable handling from 5 weeks on, there is a big decline of the timidity score between 5 and 7 weeks, which may be taken as a measure of the process of socialization. In the experimental pups, whose contacts with people were started at 4 weeks and confined to feeding, the timidity score at 5 weeks averaged very nearly as low as the other animals at 7 weeks. The average score stayed slightly higher in subsequent weeks than the controls, but not significantly so. At an early age, and using a genetic type of animal susceptible to the development of timidity, animals which are totally dependent for food show a greater degree of socialization than those only partially dependent.

Another obvious result was that there was a differentiation between the reaction to the person who did the feeding and another person who did not. This difference appeared more strongly as the pups grew older. All this indicates that the process of feeding does contribute importantly to social relationships but does not constitute the whole process.

The difference between the hungry and nonhungry animals was not as great as had been anticipated. There was a great deal of individual variability in behavior. However, hungry animals did show a consistently greater proportion of investigation and food begging in their responses than did the controls.

Sucking Frustration

Levy's experiment on puppies[8] indicated that the canine equivalent of thumb sucking could be produced by sucking frustration. Levy's experiment extended over a relatively long period in the development of the puppy, including the transition period and the early part of the period of socialization. Because of the importance of sucking in early development and its disappearance later, there should be a limited period in which this effect could be produced.

Ross, Fisher, and King[12] experimented with this possibility using the technique of sudden weaning, after which the pups could obtain food only by lapping or eating solid food. The experiment was done on a group of 34 experimental and 24 control animals. None of the experimental puppies developed spontaneous body sucking, but they did show an increased tendency to suck a finger of the experimenter. When this was analyzed in relation to age of the puppy, it was found that all the puppies weaned between the ages of 10 and 18 days showed more finger sucking than the controls. After this date many experimental animals were as low as the controls, although there were some indications of smaller effects. There were no effects at all by the time the animals were 5 weeks of age.

We can draw two conclusions. One is that there is an obvious change in the puppies' behavior with regard to sucking at the beginning of the period of socialization. Up to this time a puppy deprived of its mother will readily suck objects which are put into its mouth. After this point it shows very little tendency to suck. The simplest explanation is that the power to discriminate between objects which give nourishment and those which do not has been developed.

The other conclusion is that the simple and sudden deprivation of the opportunity to nurse does not by itself produce the neurotic form of body sucking. Whether there is a

TABLE 6. Estimated Developmental Ages in
Days for Significant Events

	Mean and Standard Deviation		
Breed	Eyes completely open	Ears startle to sound	Teeth Eruption, upper canines
Basenji	13.1	19.6	18 6
Beagle	11.0	18.7	19.1
Cocker spaniel	11.0±1.9	20.2±2.9	23.3
Sheltie	15 2	20.3	22.6
Wirehaired fox terrier	16.9	17.8±2.2	24.3±3.0
Total	13.0±2.3	19.5±2.3	20.8±2.9

critical period for this latter phenomenon is
yet to be determined.

Hereditary Variability

As can be seen in Table 6, there is con-
siderable evidence that hereditary variability
in development exists, both between indi-
viduals and between breeds. For example,
cocker spaniels are the first to open their eyes,
are slow to develop the startle response to
sound, and are intermediate between the
other breeds with regard to the development
of teeth. The wirehaired terriers were the
slowest to develop in every trait observed ex-
cept the startle reaction to sound, in which
they are the fastest. There is every indication
that the different sense organs and anatomical
characteristics vary in the speed of develop-
ment independently of each other. There is
no one highly correlated pattern of develop-
ment which is slowed down or speeded up
as a unit.

Assuming that the age of onset of each de-
velopmental event falls into a normal curve,
we can estimate the average time and vari-
ability of each event. As seen by Table 6,
there is approximately 3 days' difference be-
tween the fastest and slowest breeds. Eighty-
six per cent of all animals should fall within
a range of 1 week. If anything, these estimates
of variability are probably too great, since
they are based on the 1 per cent or so of ani-
mals which are as much as a week away from
the normal.

The species as a whole shows a develop-

mental pattern which is not departed from
except in cases of gross abnormality. Events
occur in the general order described in the
early part of this paper, so that we can speak
of definite periods of development. We can
set the beginning of the transition period at
13 days with a normal range of 3 or 4 days
on either side. Similarly, we can place the
beginning of the period of socialization at
approximately 19.5 days with a similar range
of variability. This means that when experi-
mental procedures are employed in which
time is the experimental variable, close atten-
tion must be paid to the breed and the state
of individual development. Two litters of
puppies of exactly the same chronological age
could give completely different results.

Conclusions

At the beginning of this paper I stated
that there is a definite critical period for the
process of socialization, and that it must rest
on a physical basis. The data which I have
just presented show that there is a definite
physical basis in the dog, and that there are
two important points where sudden changes
occur. One of these is the point just before 3
weeks, where there are changes in the ability
to be conditioned, in the EEG, in the emo-
tional responses indicated by the heart rate,
in the ability to hear, and in the growth rate
and method of nutrition. The other point at
7 to 8 weeks is so far defined only by the adult
EEG and the change in emotional reaction
measured by the heart rate. Final weaning
sometimes occurs as early as this date.

To summarize, the puppy before 3 weeks
of age is highly insulated from its environ-
ment by the immature state of development
of the sense organs, by the lack of ability for
conditioning, and by maternal care. From 3 to
7 weeks the puppy is in an extremely inter-
esting stage in which its sense organs and
cerebral cortex are not yet completely devel-
oped but in which it has extremely sensitive
emotional reactions and is capable of making
associations. This is the time when primary
socialization normally takes place and during
which it is easiest for a dog owner to establish

a strong social bond. These facts provide us with an experimental opportunity to analyze some of the theories of the effects of early experience on later social adjustment and mental health.

Comparing these with results on human babies, we see that we need more fundamental facts about human development. We know a great deal about babies from birth until 10 days of age. After this time mothers and babies leave the hospital and disappear into the home where there is little opportunity for scientific study. Facts and information are very scarce until about the age of 2 years when the babies begin to emerge from the home and appear in nursery school. It is precisely this period in which we are most likely to find the period corresponding to the primary period of socialization in the dog, if it exists. As I mentioned above, one of the most important basic facts yet to be adequately described is the development of simple learning ability in young infants.

One of the biggest problems in predicting human development is the element of individual variability in behavior. The study of development in the different dog breeds, where we should get the maximum possible variability in development, gives us some hint as to what we might expect in human beings. There is considerable individual variability, and variability between dog strains. However, the timing does not vary a great deal in terms of the length of the period of development. The changes at 3 weeks of age in puppies appear to take place within a week for all animals. If we assume that the life span of a dog is one sixth that of a human, we might expect a human range of variability of 6 weeks. Actually, the possible range in early development is probably considerably less than this.

The existence of a critical period for primary socialization is so widespread in the animal kingdom that there is every reason for suspecting that a similar period exists in human development. If so, we are faced with a number of questions:

1. When? In other animals, the critical period may occur immediately after birth or hatching, or fairly late in development, as it does in the puppy. The human infant is somewhat more mature than a puppy at birth, but far less so than a lamb. We would expect that the critical period would not begin immediately after birth, and the evidence that we have indicates that it may begin as early as a month or 6 weeks, or as late as 5 or six months. However, any social relationship depends on the behavior of two individuals, and the period immediately after birth may be a critical one for the mother, although the evidence from adoptions indicates that mothers can form a strong social relationship at other times.

2. How long? The period of primary socialization certainly lasts as long as the period of complete dependency on the mother, up to 1½ or 2 years, and possibly even longer.

3. By what means? The positive behavioral mechanisms which establish primary social relationships, such as feeding, contact, handling, and the like, are difficult to understand without experimental data. Likewise, we would expect to find negative mechanisms which prevent the socialization of infants to strangers, such as the anxiety or fear reaction to strangers described by Spitz.[19] Their understanding would be immensely important as a means for bringing about a better identification with other human beings, and a broader range of tolerance.

4. Why? This brings us down to the primary data in this paper, and raises the question of the physical basis of critical periods in the human infant. As I have indicated above, animal experiments indicate the type of thing we should look for: the development of sensory and motor organs, the development of the central nervous system, and the power of simple learning, the development of social behavior patterns, and the development of individual hereditary differences. We have much information on the first two, and far less on the rest. It is this kind of evidence which is the easiest to get on human subjects, and without this firm foundation we shall never be on safe ground.

Seen in this light, our study on the dog provides the opportunity for the experimental analysis of environmental and hereditary in-

fluence on an undeveloped nervous system. The dog is an animal which is capable of forming a type of social relationship with people very similar to the human parent-child relationship. We should be able to find out whether early emotional experiences produce lasting effects. Without evidence, it is just as logical to suppose that an immature nervous system would be less severely affected. It will take a long time and will be a laborious and expensive job to obtain the needed facts, but we should eventually be able to bring the phenomena of early social experience out of the realm of conjecture into that of established scientific fact.

Summary

1. The existence of a critical period for the establishment of primary social relationships is a well-established phenomenon in social animals. This paper has dealt with the physical and hereditary basis of the critical period in the dog.

2. Normal social development in the puppy can be divided into several periods based on changes in social relationships. Several of these may be critical, but the most important is that of primary socialization, beginning about 3 weeks of age.

3. The beginning of this period is accompanied by certain anatomical changes: the eruption of the teeth and the opening of the ears. Eyes open at an earlier date.

4. Its beginning is also closely associated with the appearance of the function of the ears. The senses of touch and taste (including tasting gases) are present at birth. The eye is sensitive to light before it opens, but not completely functional until some time after.

5. Changes in the heart rate appear which correspond to changes in the EEG and ability to be conditioned.

6. At 3 weeks there is a change in the rate of growth, which may be attributed to both additional food and to a psychological change in food motivation.

7. Experimental evidence indicates that feeding is an important factor in socialization, but not the only factor.

8. There is a marked change in the finger-sucking response of weaned puppies at an age corresponding to the beginning of the critical period.

9. Hereditary variability of the exact time of onset of the critical period exists both between individuals and between breeds. However, the functional variability appears to be smaller than that in the accompanying anatomical changes.

10. In the period immediately following birth the puppy is strongly protected from psychological influences. During the critical period it becomes highly sensitive, at a time when the sense organs and nervous system are still not completely developed. The exact effects of experience during this time are still to be determined.

11. These data suggest facts which must be ascertained in order to establish the existence and duration of a similar critical period in human infants. They also suggest ways in which important clinical theories can be experimentally tested.

Hamilton Station
P.O. Box 847
Bar Harbor, Maine.

References

1. BLUME, D. A study of the eye of the dog. In preparation.
2. BRODBECK, A. J. An exploratory study on the acquisition of dependency behavior in puppies. *Bull. Ecol. Soc. Am.* 35:73, 1954.
3. CHARLES, M. S., and FULLER, J. L. Developmental study of the electroencephalogram of the dog. *Electroencephalog. & Clin. Neurophysiol.* 8:645, 1956.
4. FREDERICSON, E. Perceptual homeostasis and distress vocalization in puppies. *J. Person.* 20: 472, 1952.
5. FULLER, J. L., EASLER, C. A., and BANKS, E. M. Formation of conditioned avoidance responses in young puppies. *Am. J. Physiol.* 3:462, 1950.
6. HARMAN, P. J. Private communication.
7. JAMES, W. T., and CANNON, D. J. Conditioned avoiding responses in puppies. *Am. J. Physiol.* 168:251, 1952.
8. LEVY, D. M. Experiments on the sucking reflex and social behavior of dogs. *Am. J. Orthopsychiat.* 4:203, 1934.

9. LORENZ, K. Der Kumpan in der Umvelt des Vogels. *J. Ornithol. 83:137, 1935.*

10. MURIE, A. *The Wolves of Mt. McKinley.* Washington, D.C., G.P.O., 1944.

11. RIBBLE, M. A. Infantile experience in relation to personality development. In HUNT, J. M. (Ed.): *Personality and the behavior disorders.* New York, Ronald Press, 1944.

12. Ross, S., FISHER, A., and KING, D. The effect of early enforced weaning on sucking behavior of puppies. In preparation.

13 SCOTT, J. P. Social behavior, organization and leadership in a small flock of domestic sheep. *Comp. Psychol. Monogr. 18:1, 1945.*

14. SCOTT, J. P. The relationships between developmental change and social organization among mammals. *Anat. Rec. 111.73, 1951.*

15. SCOTT, J. P. "The Process of Socialization in Higher Animals." In *Interrelations Between the Social Environment and Psychiatric Disorders.* New York, Milbank Mem. Fund, 1953.

16. SCOTT, J. P., FREDERICSON, E., and FULLER. J. L. Experimental exploration of the critical period hypothesis. *J. Person. 1:162, 1951.*

17. SCOTT, J. P., and FULLER, J. L. *Manual of Dog Testing Techniques.* Bar Harbor, Maine, Jackson Laboratory, 1950.

18. SCOTT, J. P., and MARSTON, M. V. Critical periods affecting the development of normal and maladjustive social behavior of puppies. *J. Genet. Psychol. 77:25, 1950.*

19. SPITZ, R. A. Anxiety in infancy: A study of its manifestations in the first year of life. *Internat. J. Psycho. Analysis 21:1, 1950.*

20. SPITZ, R. The psychogenic diseases in infancy *Psychoanalyt. Study Child 6:255, 1951.*

21. THORPE, W. H. *Learning and Instinct in Animals.* London, Methuen, 1956.

Public Health Fellowships

Two Public Health fellowships are available at the Peter Bent Brigham Hospital to individuals who have had two years of training in a psychiatric hospital. The position offers an opportunity in a general hospital setting to a person interested in senior supervision by psychoanalysts especially interested in problems having to do with psychophysiological disturbances. The setting and the supervision provide experience in developing good working relationships with internists and surgeons in the care of their patients. The American Board of Psychiatry and Neurology gives credit to this program for one year of training.

Applicants for the year July 1, 1958, to July 1, 1959, should send curriculum vitae to Dr. Henry M. Fox, Associate Clinical Professor of Psychiatry, who is in charge of the program. The address is. Peter Bent Brigham Hospital, 721 Huntington Ave., Boston 15, Mass.