Journal of Comparative Psychology
1983, Vol. 97, No. 2, 99-106

Stability of Individual Differences in Behavior in a Litter of Wolf Cubs (*Canis lupus*)

Kevin MacDonald
University of Connecticut

This article provides data on when during development in wolf cubs stable individual behavioral differences are observable and on their stability over the first 6 mo of life despite variations in the social environment. A litter of five male wolves was tested for reaction to unfamiliar people and unfamiliar objects and in a bone competition situation. The social environment was varied by housing the animals alternately as a group, in pairs, and in isolation. Although there was a general tendency for less stability to be shown prior to 6 wk of age than after, the behaviors showed high stability over the course of the experiment. Results from the tests with unfamiliar objects indicated less stability when the animals were tested individually than when tested as a group, an effect suggesting that social structure may be a factor that increases the stability of responses to unfamiliar objects.

The study of individual differences in behavior is important because individual characteristics and relations are probably important in producing social structure as well as contributing to breeding success in social species. In this article I describe the course of development and the stability of individual differences in particular behaviors in a litter of captive wolf cubs, *Canis lupus*.

Although there is a large literature on humans about the development of individual differences and their stability over time (see Bloom, 1964; Brim & Kagan, 1980, for reviews), this has not been a focus of animal research. Recently, however, Stevenson-Hinde, Stillwell-Barnes, and Zunz (1980a) found little stability between 1 and 2.5 yr of age in rhesus moneys on a variety of tests involving such discrete behaviors as play with a ball and reactions to a mirror. Another study (Stevenson-Hinde, Stillwell-Barnes, & Zunz, 1980b), however, found stability in ratings based on observations over an entire year for CONFIDENT assessed at yearly intervals between Age 1 and Age 4. Ratings for EXCITABLE showed no stability until adulthood, whereas those for SOCIABLE emerged as significant after Age 3. These larger categories were derived from a variety of ratings by principal component analyses. There were also some significant correlations between specific infant behaviors at 8–52 wk and ratings of the above categories at 58–85 wk. The investigators concluded that there is evidence for "impressive personality continuity and consistency over time" (p. 79). The finding of greater stability of higher level categories, which essentially summarize a great deal of information from a wide variety of contexts and over a long period of time, is similar to results from human studies of attachment (Sroufe, 1979). While studies of human attachment behavior have typically found little stability for the discrete behaviors involved in attachment, attachment classification itself is quite stable (Waters, 1978), although environmental instability lowers the stability of attachment classification (Vaughn, Egeland, Sroufe, & Waters, 1979).

Previous work with wolves has emphasized testing behavior with unfamiliar objects and people as well as assessing dominance in social interactions. Fox (1972, 1973) presented data suggesting that con-

This research was supported by a predoctoral research grant from the Connecticut Research Foundation. I thank Benson E. Ginsburg and J. P. Scott for their comments and suggestions throughout the study. Statistical advice was kindly given by Phipps Arabie and John Gottman of the University of Illinois at Urbana-Champaign Department of Psychology.

Requests for reprints should be sent to Kevin MacDonald, who is now at the Department of Psychology, University of Illinois, 603 East Daniel Street, Champaign, Illinois 61820.

fident, outgoing animals tend to be dominant in social situations. Animals were tested between 7.5 and 9 wk of age for dominance, in a variety of situations involving familiar and unfamiliar objects and people, and in prey catching. At 1 yr of age, the dominance order was related to scores attained on the battery of tests given at the earlier age, with the less fearful animals tending to be more dominant.

The present data address the questions of how early stable personality differences can be observed in wolves and how stable they are over the first 6 mo of life, a time in which a wolf is integrated into the structure of the pack (Mech, 1970). Kagan (1971) pointed out that stability of behavioral characteristics over time can be due either to processes endogenous to the organism or to stability of some environmental factor. One purpose of the present design is to provide discontinuities in the environmental factors of obvious significance to stability of personality characteristics. After the age of 6 wk, prior to which they were housed together, animals in the present experiment were placed on a schedule consisting of six periods. For any one animal, four of these periods were spent paired with a littermate on a round robin basis. A fifth period was spent in isolation, with the order of isolation randomly determined, and the sixth period was spent housed as a group. If, in fact, the personality profiles of the animals do not change when subjected to these environmental discontinuities, there will be presumptive evidence that the stabilities in personality are not dependent upon some particular environmental factor and are well buffered from environmental factors.

Method

Subjects

The subjects were members of a litter born in May 1977 at the University of Connecticut. The pack at this time consisted of an alpha male, an alpha female, and five 2-yr-old wolves (born May 1975) which were the offspring of the two alpha animals. The parents were obtained from a zoo, but their previous history is unknown. The alpha female was older than the alpha male and dominated him.

From birth to 4 wk of age, the litter, consisting originally of seven males and one female, was housed with the mother in a kennel run with a shelter at one end. Two males died and the female was removed by 4 wk of age, which left five males as experimental subjects.

Procedure

At 4 wk of age, the litter was removed and group housed in a 2.44 × 2.44 m enclosure with chain link fencing on both ends. (See Table 1 for a summary of the experimental schedule.) At 44 days of age, the preliminary assessments of behavior were completed and the six period cycles, described above, were initiated. The periods started at 3 days each and were lengthened to 5 days in the course of the experiment. Thus, an entire cycle of pairing and isolation would last from 15 to 25 days, after which the animals would

Table 1
Schedule of the Experiment

Days	Testing schedule	Housing
1–28	Testing Period 1	Entire litter with mother in wolf compound.
29–44	Testing Period 1	Housed as a litter in a 2.4 × 2.4 m pen.
45–59	No testing	This 15-day period was divided into five 3-day sections. For four of the five sections, each animal was paired with each of the other littermates; the fifth was spent in isolation. The order of pairings and isolation was randomly determined.
60–66	Testing Period 2	Housed as a litter in a 4.9 × 2.4 m pen.
67–81	No testing	This 25-day period was divided into five 5-day sections. For four of the five sections, each animal was paired with each of the other littermates; the fifth was spent in isolation.
82–91	Testing Period 3	Housed as a litter in a 4.9 × 2.4 m pen.
92–106	No testing	Same as Days 45–59.
106–113	Testing Period 4	Housed as a litter in a 4.9 × 2.4 m pen.
114–138	No testing	Same as Days 67–81.
139–150	Testing Period 5	Housed as a litter in a 4.9 × 2.4 m pen.
151–175	No testing	Same as Days 67–81.
176–187	Testing Period 6	Housed as a litter in a 4.9 × 2.4 m pen.

be group housed and further testing would be performed until the next cycle. During the cycles, the animals received no human contact except that necessary when the pairings were changed. When paired, the animals were housed in 4.88 × 2.44 m pens, with a partition that allowed caretaking activities to take place out of sight of the animals. When isolated, the animals were housed in a 3.1 × 2.44 m pen with a similar partition.

Active person test. This test was performed with each animal separately, and the persons were altered for each test so that no person was ever used twice. The person sat with legs crossed on the floor of the 4.88 × 2.44 m arena, with an open door separating the arena into two halves, and called to the animal in a loud voice while gesturing with his/her arms in a very obvious manner. The persons were instructed to attempt to be fairly threatening, rather than to be as attractive as possible to the animal, so that exaggerated gestures and loud tones of voice were not altered if the animal failed to approach. If the animals approached, they typically assumed submissive postures, with ears back and body crouching low. Animals that did not approach showed fear rather than aggression, remaining as far away from the person as possible but usually watching the person intently. Although there was no difference in the overall pattern of results, the animals tended to show greater fear of male experimenters than females, a common finding in work with canids.

Unfamiliar objects (together) test. Unfamiliar objects, such as ropes, rakes, boxes, and hoses, were placed on the side of the arena opposite the grouped animals and arranged in various arrays. A door joining the two sides of the arena was then opened, and the order of the animals going to the unfamiliar objects was recorded.

Unfamiliar objects (individual) test. Unfamiliar objects similar to those used in the previous test were placed on one side of the arena, and the animals were placed on the opposite side individually. The time taken to go to the opposite side of the arena was recorded. After 4 min the test was terminated.

Bone competition test. The use of a bone competition test, in which animals were allowed to compete for a bone, is somewhat controversial. Scott and Fuller (1965) used the test to determine dominance in dog puppies, and Fox (1972) used the test to determine dominance in litters of wolf cubs. Zimen (1981), however, stated that the test reveals only feeding ranking order which is an "object-related" relation in which the purpose is not to diminish the area of freedom of others. True social dominance is a relation in which the latter condition is met.

There are, however, reasons to suppose that under certain conditions competition over food reflects dominance. Scott and Fuller (1965) and Fox (1972) were both able to obtain results that were consistent over time, and, in the case of Fox, data are presented showing an association between the bone competition test and other tests involving social leadership, reactions to unfamiliar people, and so on, as well as with dominance behavior assessed at 1 yr of age. The bone test need not be a feeding situation since, as in the present case, the test may be performed relatively infrequently and use food items that are relatively uncommon in the animals' diet, items that are prized by the animals. In the captive pack at the University of Connecticut, there was little competition over the normal dog chow given the animals, but when bones were first given to the animals, intense competition broke out, and the dominant animals obtained the great majority of the bones (personal observation, 1978). Schenkel (1967) and Zimen (1981) also noted a ritualized "displaying of the bone" which is associated with dominance.

In the present experiment, a bone was thrown into the pen in full view of all the animals, and the behavior of the cubs was recorded. The animal or animals controlling the bone after a steady state was reached were recorded. No attempt to rank the other animals was made.

The data involved either the rankings of the animals on the test [unfamiliar objects (together) test] or latencies to approach objects or people (active person test, unfamiliar objects tests). Since the latency data were derived from tests with an absolute ceiling

Table 2
Data for the Unfamiliar Objects (Together) Test

	Animal				
Day	2	3	4	5	6
27	—	—	—	—	—
29	—	—	—	—	—
29	—	—	—	—	—
31	—	—	—	—	—
32	3	3	3	5	1
38	3.5	3.5	3.5	3.5	1
39	1	3	2	5	4
42	2.5	1	4.5	2.5	4.5
43	2	1	4	4	4
44	4	2	4	4	1
44	3	2	4.5	4.5	1
44	3	2	4.5	4.5	1
60	3	2	4	5	1
60	3	1	4	5	2
61	2	3	4	5	1
63	3	2	4	5	1
83	3	2	4.5	4.5	1
83	2	3	4.5	4.5	1
84	4	2	4	4	1
86	2	3	4.5	4.5	1
86	2	3	4	5	1
89	2	3	4.5	4.5	1
106	2	3	4.5	4.5	1
111	2.5	2.5	4.5	4.5	1
139	3	2	4.5	4.5	1
140	2.5	2.5	4.5	4.5	1
142	3	2	4.5	4.5	1
147	2.5	2.5	4.5	4.5	1
147	2.5	2.5	4.5	4.5	1
177	3	2	4.5	4.5	1
181	2.5	2.5	4	5	1
187	3	2	4.5	4.5	1
Sum of ranks	74.5	65.0	116.5	125.5	38.5

Note. Rankings are from the most bold (1) to the least bold (5).

and did not approximate a normal distribution, a nonparametric test, the Kendall coefficient of concordance (Siegel, 1956), was used. This test is a method of estimating the average correlation (W) between the experimental subjects over the tests given. If the animals were ranked in the same way on every instance of a test, the average differences between conditions are at a maximum, and the coefficient of concordance is 1. As discrepancies exist between subjects with regard to the ranking, W will fluctuate between 0 and 1.

Results

Table 2 shows the results for the unfamiliar objects (together) test. After a period of no response and variable response, a consistent pattern developed by Day 44, with Animal 6 almost invariably taking the lead in investigating objects. Animals 2 and 3 either followed Animal 6 up to the unfamiliar object or remained behind in an intermediate area near the opening to the other chamber. Animals 4 and 5 typically stayed back and did not approach the opening. Kendall's coefficient of concordance was significant ($W = .75, p < .001$), which indicated that the pattern was stable over this time interval. However, when the eight tests conducted in the first testing period were considered separately, the coefficient ($W = .29$) was nonsignificant. This contrasts sharply with the results for the eight tests conducted over the last two testing periods, in which $W = .98, p < .001$.

Table 3 shows the results for the unfamiliar objects (individual) test. Again, the Kendall coefficient of concordance is significant ($W = .42, p < .02$), which indicates consistency in the rankings. There is considerable early variability within this overall consistency, however. In the first testing period (Tests 1–6), Animal 6 ranked anywhere from 1 (boldest) to 5 (most timid).

Table 3
Data for the Unfamiliar Objects (Individual) Test

	Animal									
	2		3		4		5		6	
Day	Lat	Rank	Lat	Rank	Lat	Rank	Lat	Rank	Lat	Rank
39	13	3.0	4	1.0	97	4.0	140	5.0	6	2.0
40	7	3.0	11	4.0	6	1.5	6	1.5	15	5.0
41	11	3.0	5	1.5	5	1.5	80	5.0	31	4.0
43	13	3.0	3	1.0	240	5.0	7	2.0	20	4.0
44	125	3.0	17	2.0	240	4.5	240	4.5	9	1.0
44	2	2.0	2	2.0	121	4.0	2	2.0	240	5.0
61	4	2.5	4	2.5	4	2.5	15	5.0	4	2.5
62	45	3.0	2	1.0	83	4.0	240	5.0	35	2.0
63	145	2.0	240	4.0	240	4.0	240	4.0	17	1.0
65	240	4.0	4	2.0	240	4.0	2	1.0	240	4.0
66	13	1.0	45	2.0	240	4.0	240	4.0	240	4.0
86	95	3.0	3	1.5	240	4.5	240	4.5	3	1.5
87	29	3.0	18	2.0	240	4.5	240	4.5	15	1.0
90	80	3.0	45	2.0	240	4.5	240	4.5	40	1.0
91	13	1.0	37	3.0	60	4.0	240	5.0	20	2.0
106	2	1.0	3	2.0	240	4.5	240	4.5	55	3.0
110	22	2.0	30	3.0	200	4.0	240	5.0	18	1.0
110	240	4.0	42	2.0	240	4.0	240	4.0	16	1.0
112	42	2.5	42	2.5	190	4.0	240	5.0	30	1.0
140	240	4.0	105	2.0	240	4.0	240	4.0	16	1.0
142	157	3.0	8	1.0	240	4.5	240	4.5	13	2.0
144	240	4.0	75	2.0	240	4.0	240	4.0	23	1.0
177	207	4.0	140	2.0	165	3.0	240	5.0	34	1.0
181	40	4.0	20	2.0	25	3.0	240	5.0	2	1.0
182	240	4.0	26	2.0	240	4.0	240	4.0	20	1.0
187	78	3.0	8	2.0	165	4.0	240	5.0	3	1.0
Sum of Ranks		75		54		99.5		107.5		54

Note. Lat = latency (in seconds) to enter the side of the arena with the unfamiliar objects, up to a maximum of 240 sec.

Table 4
Data for the Unfamiliar Active Person Test

	Animal									
	2		3		4		5		6	
Day	Lat	Rank	Lat	Rank	Lat	Rank	Lat	Rank	Lat	Rank
38	2	2.0	120	4.5	2	2.0	120	4.5	2	2.0
43	2	1.5	75	3.0	2	1.5	120	4.5	120	4.5
44	2	2.0	12	4.0	2	2.0	2	2.0	120	5.0
59	2	2.5	120	5.0	2	2.5	2	2.5	2	2.5
60	2	1.5	6	4.0	2	1.5	3	3.0	120	5.0
61	2	2.0	120	4.5	2	2.0	2	2.0	120	4.5
62	2	2.0	6	4.0	2	2.0	2	2.0	120	5.0
83	2	2.0	120	4.5	2	2.0	2	2.0	120	4.5
112	2	2.0	20	4.0	2	2.0	2	2.0	120	5.0
113	90	3.0	120	4.5	5	2.0	5	1.0	120	4.5
142	120	4.0	120	4.0	2	1.5	2	1.5	120	4.0
145	35	3.0	120	4.5	2	1.5	2	1.5	120	4.5
148	45	3.0	120	4.5	2	1.5	2	1.5	120	4.5
148	120	4.0	120	4.0	2	1.5	2	1.5	120	4.0
177	120	4.0	120	4.0	2	1.5	2	1.5	120	4.0
181	120	4.0	120	4.0	2	1.0	20	2.0	120	4.0
182	120	4.5	10	3.0	2	1.5	2	1.5	120	4.5
182	120	4.0	120	4.0	2	1.5	2	1.5	120	4.0
Sum of ranks		51		74		31		38		76

Note. Lat = latency (in seconds) to enter the side of the arena with the active person, up to a maximum of 120 sec.

By Day 86, there was almost no variation in the rankings of any of the animals. However, by the end of the first testing period (Day 44), Animals 2, 3, and 4 are quite stable, and Animal 5 already has three very high rankings out of the six tests given up to that time. Thereafter, Animal 5 has only one ranking below a 4. Indeed, if the tests done in the first testing period are considered separately, the coefficient of concordance ($W = .18$) is insignificant, whereas the corresponding procedure done on the four tests performed in the last testing period yielded a W of .89 ($p < .001$). In addition, since Kendall's W for the unfamiliar objects (together) test was higher than that for the unfamiliar objects (individual) test (.75 vs. .42), there is reason to believe that approach to the unfamiliar objects was more stable in the social situation. Finally, although Animal 6 almost invariably ranked first on the unfamiliar objects (together) test, Animals 3 and 6 have nearly identical sums of ranks on the unfamiliar objects (individual) test.

Table 4 shows results for the active person test. Again, the Kendall coefficient of concordance is highly significant ($W = .65$, $p < .001$), which indicates consistency of the behavior over the time of testing. However, there are some suggestions of variations within the overall pattern of consistency. Animal 2 has very low ranks initially, which indicates relatively high attraction to strangers, followed by higher ranks on the tenth test (Day 113) and thereafter. Animal 5 scores high on the first two tests, but is very low ranking later, which indicates high attraction. Animal 6 was variable in the beginning, but after Test 5 (Day 60), he consistently showed low attraction to strangers. As in the previous tests, there was an overall tendency for rankings found in the first testing session to be less stable: The three tests conducted in the first testing period yielded a nonsignificant $W = .56$, whereas the four tests conducted in the last testing period yielded a $W = .99$ ($p < .01$).

Table 5 shows the results of the bone competition tests. Here, on Day 30 and afterward, only the animal that successfully defended the bone is recorded since, on many occasions, it was impossible to rank the others. Again, there was a period of little or no response followed by a consistent pattern developing by Day 30. Later

Table 5
Data From Bone Competition

Day	Animal	Day	Animal	Day	Animal
17	2, 3	60	6	146	2
18	2, 3, 4	62	6	146	6
19	3, 5	82	6	147	3
20	3, 5	91	6	147	3
21	2, 3, 5	107	6	147	3
23	2, 3, 5	108	6	148	4
30	6	110	6	149	6
35	6	111	5	149	6
37	6	113	2	149	6
41	6	113	6	150	6
42	6	113	6	177	6
43	6	139	6	178	6
44	6	146	2	179	6
		146	6	180	6

Note. After Day 30, only the animal controlling the bone is listed. Prior to this, the most aggressive animals are listed, since no one animal controlled the bone.

in the experiment, other animals at times got the bone, either because Animal 6 was fighting for it with another animal, or was not interested, or, on one occasion, the other animal seemed to win in a fight. On Day 146, Animals 2 and 6 fought for the bone, and the former appeared to win and claimed the bone with no interference from the latter. However, Animal 6 still won the bone most often, even in trials after Day 146. During the last testing period, he got the bone on each occasion with almost no interference from the others.

Discussion

There is a definite trend in much of the data indicating early variability in test ranks followed by increasing consistency, a result that is also found in longitudinal studies of personality development in humans (Moss & Susman, 1980) and rhesus moneys (Stevenson-Hinde et al., 1980b). Most of the consistency was developed by Day 44. By this time, leadership in investigation of unfamiliar objects was established, competition over bones was consistent, and reactions to unfamiliar people fairly consistent. The largest changes prior to Day 44 were observed in Animal 5. Animal 5 was clearly the most fearful animal at the time of the first observations of the litter. On several occasions he bit or attempted to bite people handling him. However, during Weeks 3–6, he showed decreasing fear behavior and ultimately became one of the friendliest toward people. Something of the opposite trend was noted in Animals 2 and 6. Both animals remained friendly with their familiar handlers, but Animal 6 showed signs of greater fearfulness around Day 40, which are reflected in his unfamiliar person test scores (Table 4). Animal 2 became more fearful of strangers much later, approximately Day 114. Animal 3, on the other hand, showed almost no variation in his ranking on the various tests. Thus, within the overall consistencies, there are individual patterns of developmental variation.

The results point to an inverse relation between fear of strange people and fear of unfamiliar objects, results also suggested by observations of Frank (Note 1). Animals 4 and 5 were clearly fearful of objects and unafraid of people, while Animals 3 and 6 were the reverse. Animal 2 was relatively unafraid of unfamiliar objects and became quite fearful of humans after Day 112.

There is some suggestion that whether an animal is in a social group affects his performance on similar tests. Thus, Animal 6 always led the group investigation of unfamiliar objects, with vast differences between himself and Animal 3 on their boldness with unfamiliar objects in a social context. This behavioral difference between Animal 6 and the others was not maintained by any overt assertion of dominance or aggressiveness over the others, or even attending to them, but simply by walking up to the unfamiliar objects while the others stayed back or followed him. When alone, however, Animal 3 actually had a lower approach latency than Animal 6 on many tests. In addition, although the overall rankings in the social context were similar to those in the nonsocial context, there was more variability in the latter, a condition suggesting that the social structure is one important factor in the consistency of the rankings. Finally, consistency in individual tests with unfamiliar objects developed much later than in the group tests and did not become a rigid pattern until approximately Day 86, whereas a rigid pattern was observed for the group on Day 44. Studies such as this, if continued, will

shed light on the interactions of personalities and social environment. Thus, with unfamiliar objects there is little difference between the individual and the group situation for Animals 4 and 5. However, Animal 2 is intermediate to Animals 4 and 5, on one hand, and to Animals 3 and 6, on the other, in both situations, but his behavior is relatively variable in the individual situation.

These results raise the important issue of the relation between these early behavioral profiles and later pack organization. The data of Fox (1972, 1973) clearly suggest a strong link between early personality and later dominance within the pack, and Fox (1973) wrote of social experiences during development as interacting with temperament to determine role and rank. Frank and Frank (1982) found that the most "obtrusive" pup during interactions with the foster mother at 3 mo of age eventually became the "little alpha" of the litter. In addition, observations on a litter studied at the University of Connecticut over several years (Fine, Schotte, & Trattner, Note 2) showed that one male cub was more assertive than the other two male cubs in the summer and fall of the first year of life and remained so thereafter. As the second breeding season after their birth began, he clearly dominated the other male littermates, and he assumed the beta position in the adult hierarchy (behind his father) at this time. Zimen (1981) found that dominance relations among cubs were highly unstable and that younger wolves were not submissive to young superiors. Taken together, the data suggest that although cub–cub relations may not involve true dominance, they may reveal individual differences that are later associated with dominance in adult animals. As Woolpy (1967) found, there may be a major reorganization of social behavior around the time of puberty, which results in greater individuation of social roles after this time.

The available data then are not conclusive but do suggest that, in some cases at least, early personality is an important interactant in producing later behavioral differences in wolves. Zimen (1981) also showed that it is generally more dominant animals that remain with the pack but that whether they do remain and their ultimate fate within the pack hierarchy depend on several factors, not the least of which is luck. It is thus extremely unlikely that early personality profiles are the only factors resulting in later dominance within the pack. That these profiles interact with situational factors to influence dominance interactions among adults is a reasonable and important hypothesis, and one worthy of further investigation.

The present results strongly suggest that continuity of the social environment is not essential to stability of the individual personalities of the animals or to the stability of social structure when assessed within these particular situations. After Day 44, the animals spent less than 5 wk together out of 18 wk. During these times, they were constantly changed back and forth between various pairings and complete isolation. Despite this, there was an overwhelming consistency in the results, which indicates that the traits under investigation are not maintained by some continuous environmental factor and are relatively well buffered from environmental effects. Because of the experimental manipulation of the social structure throughout the experiment, the increasing stability of the behavioral profiles of the animals cannot be explained as being due to increasing environmental consistency, an explanation proposed by McCall (1979) for increasing stability of individual differences in cognitive behavior in humans as they get older. The data are far more compatible with the view that the organism becomes increasingly refractory to environmental disruptions at later ages, as predicted by a theory of sensitive periods (Scott, Stewart, & DeGhett, 1974).

However, results from an isolation experiment (MacDonald & Ginsburg, 1981) involving wolves isolated from 4 wk to 6 mo of age suggested that this extreme treatment resulted in exaggerated personality profiles, so that the results are not to be interpreted as showing that the behaviors in question are completely resistant to environmental influence. Nevertheless, the present experiment involved more disruption than is presumably present in the wild situation, and it offers evidence from animal studies that environmental continuity

is not a necessary condition for stability of personality in a highly social species.

Although the data presented here suggest that meaningful stability in behavioral development is not observable until Weeks 4–6, it is possible that earlier differences in behaviors phenotypically unlike the behaviors studied in this experiment could be predictive and continuous with the behaviors tested here. Kagan (1971) termed such phenomena "heterotypic continuities." Indeed, a pilot study (MacDonald, 1981) suggested that relative precocity in physical and behavioral development could be related to later dominance within the litter.

Reference Notes

1. Frank, H. Personal communication, October 1981.
2. Fine, M., Schotte, C., & Trattner, A. Personal communication, July 1982.

References

Bloom, B. *Stability and change in human characteristics.* New York: Wiley, 1964.

Brim, O. G., Jr., & Kagan, J. (Eds.). *Constancy and change in human development.* Cambridge: Harvard University Press, 1980.

Fox, M. L. Socioecological implications of individual differences in wolf litters: A developmental and evolutionary perspective. *Behaviour*, 1972, *41*, 298–313.

Fox, M. L. Physiological and biochemical correlates of individual differences in the behavior of wolf cubs. *Behaviour*, 1973, *46*, 129–140.

Frank, H., & Frank, M. On the effects of domestication on canine social development and behavior. *Applied Animal Ethology*, 1982, *8*, 507–525.

Kagan, J., *Change and continuity in infancy.* New York: Wiley, 1971.

MacDonald, K. B. Two experiments in the behavioral development of wolves: 1. Induction of normal behavior in isolate-reared wolves; 2. Development and stability of personality characteristics in prepubertal wolves (Doctoral dissertation, University of Connecticut 1980). *Dissertation Abstracts International*, 1981, *41*, (09), 1981, 3602-B. (University Microfilms No. DEN 81-06097)

MacDonald, K. B., & Ginsburg, B. E. Induction of normal behavior in wolves with restricted rearing. *Behavioral and Neural Biology*, 1981, *33*, 133–162.

McCall, R. B. Qualitative transitions in behavioral development in the first two years of life. In M. H. Bornstein & W. Kessen (Eds.), *Psychological development from infancy.* Hillsdale, N.J.: Erlbaum, 1979.

Mech, D. L. *The wolf.* Garden City, N.Y.: Natural History Press, 1970.

Moss, H. A., & Susman, E. J. Longitudinal studies of personality development. In O. Brim & J. Kagan (Eds.), *Constancy and change in human characteristics.* Cambridge: Harvard University Press, 1980.

Schenkel, R. Submission: Its features and functions in the wolf and dog. *American Zoologist*, *7*, 1967, 319–329.

Scott, J. P., & Fuller, J. L. *Genetics and the social behavior of the dog.* Chicago: University of Chicago Press, 1965.

Scott, J. P., Stewart, J. M., & DeGhett, V. J. Critical periods in the organization of systems. *Developmental Psychobiology*, 1974, *7*, 489–513.

Siegel, S. *Nonparametric statistics for the behavioral sciences.* New York: McGraw-Hill, 1956.

Sroufe, L. A. The coherence of individual development: Early care, attachment, and subsequent developmental issues. *American Psychologist*, 1979, *34*, 834–841.

Stevenson-Hinde, J., Stillwell-Barnes, R., & Zunz, M. Individual differences in young rhesus monkeys: Consistency and change. *Primates*, 1980, *21*, 498–509. (a)

Stevenson-Hinde, J., Stillwell-Barnes, R., & Zunz, M. Subjective assessment of rhesus monkeys over four successive years. *Primates*, 1980, *21*, 66–82. (b)

Vaughn, B., Egeland, B., Sroufe, L. A., & Waters, E. Individual differences in infant-mother attachment at 12 and 18 months: Stability and change in families under stress. *Child Development*, 1979, *50*, 971–975.

Waters, E. The reliability and stability of individual differences in infant-mother attachment. *Child Development*, 1978, *49*, 483–494.

Woolpy, J. *Socially controlled systems of mating among wolves and other gregarious animals.* Unpublished doctoral disseration, University of Chicago, 1967.

Zimen, E. *The wolf: A species in danger.* New York: Delacorte Press, 1981.

Received September 20, 1982
Revision received February 3, 1983 ■