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Influence of male and female petters on plasma cortisol and behaviour: can human interaction reduce the stress of dogs in a public animal shelter?

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Abstract

During their second or third day in public animal shelter, juvenile/adult dogs were exposed to a venipuncture procedure. Then the dogs were either not petted or were petted in a prescribed manner by either a man or a woman; 20 min later, a second blood sample was collected. There was a clear increase in cortisol levels 20 min after the first venipuncture in juvenile/adult dogs that were not petted, but not in dogs that were petted by either a man or a woman. Additional comparisons showed that the petting procedure also inhibited the cortisol response following venipuncture in puppies. However, petting did not reduce the cortisol response to housing in the shelter per se. During petting, dogs made few attempts to escape, frequently were observed in a relaxed posture, and panting was common in juvenile/adult dogs. When dogs were petted immediately following removal from the living cage, those petted by women yawned more often and spent more time in a relaxed, head-up posture. Together, these results indicate that a previously observed sex difference in the effectiveness of petters in reducing the cortisol response was not due to some difference in odor or other nonbehavioural stimulus quality of men and women. Subtle aspects of petting technique appear to have pronounced effects on physiological and possibly behavioural responses of dogs confined in a shelter. Petting may be an effective means of reducing the cortisol responses of dogs to other common aversive situations, such as

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routine medical examinations and vaccination procedures at veterinary clinics as well as shelters.

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1. Introduction

The hypothalamic-pituitary-adrenal (HPA) axis is generally regarded as the body's primary stress-responsive neuroendocrine system. HPA activation culminates in an increase in adrenal secretion of glucocorticoid hormones (e.g., cortisol) into the circulation. Although a multitude of stressors can activate the HPA axis, it is especially sensitive to psychogenic stressors, that is, those that produce no physical insult (Mason, 1975). Psychogenic stressors with effects on HPA activity include: exposure to novel or threatening surroundings (Friedman and Ader, 1967; Friedman et al., 1967; Hennessy and Levine, 1978; Deinzer et al., 1997), separation from attachment objects (Mendoza and Mason, 1986; Hennessy, 1997), unpredictability of external events (Muir and Pfister, 1986; de Boer et al., 1989), and lack or loss of control over environmental contingencies (Coover et al., 1971; Hanson et al., 1976). Prolonged and/or repeated elevations of HPA hormone levels can have numerous adverse consequences. These appear to include various forms of psychopathology (e.g., anxiety disorders) as well as other disease states and even brain damage (Sapolsky, 1992; Schulkin et al., 1994; Sapse, 1997).

Stressors used in the laboratory often have direct counterparts in the lives of domestic animals. For domestic dogs in many industrialized nations, a common experience that would be expected to be a potent stimulus for HPA activation is confinement in an animal or rescue shelter. It is known that exposure of dogs to novel or restrictive housing conditions can elevate HPA activity (Tuber et al., 1995; Beerda, 1997). Moreover, it is clear that housing even in a well run shelter involves not only novelty, but also other potential psychogenic stressors, such as: separation from any former attachment objects, unpredictable noise, disruption of regular routines (e.g., walks for elimination), and a general loss of control over environmental contingencies. One must also consider the adverse long-term impact that this experience might have on the behaviour and/or physiology of the animal. For instance, it has been suggested that the trauma associated with abandonment may lead to some of the behaviour problems (e.g., 'separation anxiety') commonly encountered in dogs adopted from shelters (Voith and Borchelt, 1985; Wells and Hepper, 1992).

Recently, we measured the plasma cortisol of dogs in a public animal shelter (Hennessy et al., 1997). During the dogs' first day in the shelter (day 1), they exhibited cortisol levels that were almost three times those of pet dogs sampled in their owners' homes. There was not a significant decline in cortisol concentrations until day 4 or 5 of confinement. Thus, there was evidence of continued HPA activation during the first three days in residence. We also examined cortisol levels before and after 20 min of human interaction (primarily petting) with a man or a woman. Interaction with a woman, but not a man, prevented the initial venipuncture procedure from producing an additional

increase in cortisol levels. The first purpose of the present study was to further examine this sex difference in effectiveness of the petter. The second purpose was to document the behaviour of the dogs during interaction with men and women. The third purpose was to compare the response of puppies versus older dogs. The final purpose was to determine if the cortisol response to housing in the shelter per se could be reduced by the petting procedure.

2. General method

2.1. Animals and housing

The dogs, of various and mixed breeds, were confined at the Montgomery County Animal Shelter, a large progressive shelter serving the Dayton, OH region. The population included strays, dogs brought in by their owners for various reasons, and dogs seized by shelter staff because of neglect or other violations. It was not possible to clearly document the source of many dogs, so no attempt was made to distinguish subjects on the basis of provenance. Dogs were housed in either of two large rooms (11.4×5.5 m^2) with banks of 30 metal cages of different sizes ($0.6–1.2 \times 0.7 \times 0.6–0.7$ m^3) along each of the long walls, and a row of six free-standing pens ($0.9–1.9 \times 1.5 \times 1.5$ m^3) in the middle of the room. The rooms were illuminated with a combination of overhead fluorescent and natural lighting. The lamps were not automatically controlled but were generally turned off during the night ($\sim$2400–0600 h). With occasional exception of puppy littermates, dogs were housed individually. Although the number of dogs in a room varied greatly from day to day, the rooms were routinely quite noisy due to the clanging of metal bowls and cages, the playing of music over the intercom, and the barking of dogs in the same and neighboring rooms.

All dogs arriving at the shelter were, by law, kept a minimum of 3 days unless they either were claimed by their owners or were too injured or sick to maintain. Testing for the present experiments occurred on day 2 or 3 in the shelter (day of arrival = day 1). Subjects were selected from among all those apparently healthy, nonlactating, postweaning dogs that did not appear likely to bite (i.e., we did not choose dogs that barked aggressively at the front of the cage, and we rarely chose dogs that either retreated to the back of the cage and trembled at our approach or were of reputed aggressive breeds, such as pitbulls). We also did not include dogs that were unsuitable for petting because of sanitary reasons (e.g., infested with fleas). The clear majority of the dogs in the two rooms from which subjects were selected were highly socialized toward humans as evidenced by such behaviours as tail-wagging and licking. In all, the sample appeared to be quite representative of the population of dogs that might be considered for adoption at many public shelters.

On each test day, potential subjects were first identified and then randomly assigned to conditions within age categories (i.e., puppies or juveniles/adults), given the restriction that approximately equal numbers of males and females were assigned to each condition. As a means of objectively defining age categories, dogs that possessed any deciduous canine or incisor teeth (milk teeth) were considered puppies; all others were

classified as juveniles/adults. Most dogs in the latter category appeared to be less than two years of age.

2.2. Behavioural intervention and observations

Petting of dogs occurred in a large treatment room. This room was in close proximity to, but quieter than, rooms in which the dogs were housed, and was generally not disturbed by shelter staff during test sessions. If there was a disturbance in the room, the test was stopped and the dog was dropped from the study. The petter sat quietly on the floor petting his/her dog for the 20-min session. The petter tried to encourage the dog to make body contact and used a slow hand motion, with massage of underlying muscle. The petter spoke to the dog in a soothing tone of voice.

The behaviour of dogs during the petting episode was videotaped using a camcorder (Gold Star, Model GVCE475). The content of the tapes was later scored by trained observers. The number of times that the dogs yawned and the number of seconds they spent panting were recorded. Yawning was examined because it is considered a possible displacement activity indicative of conflict; panting was included as a possible sign of anxiety or fear (Voith et al., 1987; Voith and Borchelt, 1996). The number of unambiguous attempts to escape from the petter was tallied, as was the number of seconds spent in 'relaxed, head-up' and 'relaxed, head-down' postures. These latter two measures were defined as the dog lying on the floor or petter, with a noticeable lack of muscle tension, and the head in the designated position.

2.3. Blood sample collection and hormone determination

Blood samples ($\sim$ 0.5 ml) were collected from the cephalic vein with a heparinized injection syringe. The dog was gently restrained and spoken to soothingly by one individual while another performed the venipuncture. The blood samples were collected in the room in which petting occurred. Across both experiments, the mean sample time was 118 s. All but three of the samples were collected within 4 min. Based on data from rodents, the sample time was rapid enough to ensure that the cortisol level in a particular sample was not appreciably affected by the procedure required for its collection (Davidson et al., 1968; Coover et al., 1979; Riley et al., 1981). The three samples which took up to 5 min to collect did not yield an unusually high cortisol level compared to other samples of the same condition. All samples were collected between 1000 and 1430 h.

Samples were stored on ice until centrifugation to separate plasma, which was then frozen until assayed. Duplicate aliquots were assayed for cortisol using a ^{125}I radioimmunoassay kit ('Coat-a-Count', Diagnostic Products, Los Angeles, CA). Intra- and inter-assay coefficients of variation were 6% and 9%, respectively.

2.4. Data analysis

The juvenile/adult dogs were a heterogeneous assortment of intact and gonadectomized, adult and prepubertal animals. For this reason, and because Hennessy et al.

(1997) found no effect of the sex of the dog on plasma cortisol levels in the shelter, sex of dog was not treated as a variable in analyses. Nevertheless, approximately equal numbers of males and females were always tested in each condition. Cortisol levels were analyzed by analysis of variance (ANOVA), as specified in the description of each experiment. Behavioural measures often violated assumptions for parametric tests. For simplicity of presentation, all behavioural measures were analyzed with nonparametric Mann–Whitney *U*-tests. However, it should be noted that those behavioural measures not violating assumptions for parametric tests yielded equivalent results regardless of whether they were analyzed by parametric or nonparametric tests. Two-tailed significance levels were used throughout.

3. Experiment 1

In our earlier study (Hennessy et al., 1997), the finding that female, but not male, petters were effective in moderating cortisol elevations was unexpected. The petting administered by the men and women was at least superficially similar. All petters had been instructed to gently stroke the dog and speak to it in a soothing tone of voice for the 20-min period (petting in that study was supplemented with a food treat). The differential response of the dogs appeared to be due to some subtle distinction (subtle to humans at least) in the experience of the dogs with the men and women. In a general sense, the dogs may have been responding either to a nonbehavioural difference inherent in men and women as stimulus objects (e.g., a difference in odor associated with gonadal steroids) or to a difference in how the men and women touched the dogs or spoke to them. A difference in type of interaction was judged to be more likely, particularly in light of the fact that the women in the earlier study had considerably more experience working with dogs in various contexts, such as canine training classes. We reasoned that if the effectiveness of the women resided in something they were doing, then it should be possible to teach men to be as effective as the women in moderating cortisol responses of dogs. If, on the other hand, sex-specific odors or other nonbehavioural stimulus characteristics of the petters were critical, the differential effectiveness of the women should persist even after instruction of the men in technique. Therefore, following instruction described below, the cortisol levels of juvenile/adult dogs petted by men, petted by women, or not petted were compared using the same experimental procedures as in the earlier study (Hennessy et al., 1997). Behaviour of dogs during interaction with the men and women was videorecorded.

Experiment 1 assessed the effect of the petting procedure on puppies as well as juvenile/adult dogs. The long-term impact of impoundment might be greatest when it occurs early in development (Fox, 1968). Consequently, interventions to reduce the impact of impoundment may be especially important at this time. In the earlier study, only rough estimates of age were made (e.g., older or younger than a year) based on the general appearance of the dogs. No age-specific pattern of cortisol response was observed. Here we used the objective criterion of presence of deciduous teeth to define the category of ‘puppies’. Because we anticipated that there would be considerably fewer puppies than juveniles/adults available for study in the shelter, we did not

compare the effect of male and female petters on these younger animals. Rather, only puppies tested under the most effective condition of the earlier study (interaction with women) and non-petted controls were included.

3.1. Method

3.1.1. Training

Prior to the initiation of the current study, men that were to serve as petters met on several occasions with women who had participated in the study of Hennessy et al. (1997). The technique used by the women was analyzed and redacted. The essential elements written down were as follows:

> Petter should gently encourage the dog to maintain body contact with the petter. The dog should be encouraged to lean against the petter, sit, or lie down. The dog's size and controllability are factors in the position.
>
> The petter should strive for a deep massage to the dog's shoulder, back, and neck muscles, or long, firm strokes of the hand from the dog's head to the hind quarters. Since the petter will not be just working to move the skin, but the underlying muscle, pressure should vary from medium to firm. Petter will need to allow his/her intuition and the dog's response to guide him/her. Throughout the session, the petter should speak to the dog in a calm and soothing voice.

Dogs from a privately run shelter were used for practice. The men attempted to copy precisely the way in which the women interacted with the dogs. The chief changes required appeared to be in the slowness and massaging nature of the stroking and a greater emphasis on a soothing voice quality. Instruction continued until there was consensus that the men and women were treating the dogs in a comparable fashion.

3.1.2. Animals and assignment to conditions

Juvenile/adult dogs were randomly assigned to one of three conditions: control (i.e., no petting; $n = 16$), male petter ($n = 15$), or female petter ($n = 15$). Puppies were randomly assigned to either control ($n = 14$) or female petter ($n = 14$) conditions.

3.1.3. Procedures

To begin a test session, the subject was removed from its cage and brought to the treatment room ($\sim$ 10 s) by a handler, at which time the first blood sample (pretreatment) was collected. If the dog was to be petted, it was handed to the designated petter, who was sitting quietly on the floor. The dog was never petted by an individual who had participated in the collection of the pretreatment sample. After 20 min of interaction, the second blood sample (posttreatment) was collected. In the control condition, the dog was returned to its home cage for the 20-min interval between blood draws. In all, two men (participants in the earlier study) and three women (all with considerable experience with dogs in training and other contexts) served as petters.

3.2. Results

3.2.1. Cortisol

Inspection of Fig. 1 indicates that the men in this study were at least as effective as were the women in moderating the cortisol response of dogs following collection of the pretest blood sample. A 2 (sex of petter) × 2 (pre/posttreatment) ANOVA, with the last factor treated as a repeated measure, was used to directly compare the cortisol levels of dogs petted by men and women. The ANOVA yielded no significant effects, demonstrating that: (a) being petted by a man versus a woman did not have a differential effect on cortisol levels in this study; and (b) that there was no reliable increase in cortisol levels from the first to second blood sample in juvenile/adult dogs receiving human interaction. The cortisol data of dogs petted by men and petted by women were then combined. Cortisol levels of the combined group were compared to those of juveniles/adults not receiving human interaction by means of a 2 (petted/not petted) × 2 (pre/posttreatment) ANOVA. Both main effects and the interaction were significant [petted/not petted: $F(1,44) = 4.69$, $p < 0.05$; pre/posttreatment: $F(1,44) = 18.81$, $p < 0.001$; petted/not petted × pre/posttreatment: $F(1,44) = 6.23$, $p < 0.02$]. Further analysis of the significant interaction effect was performed with tests for simple main effects. These tests showed that only for the second (posttreatment) blood sample, control dogs had higher plasma cortisol levels than did dogs receiving petting ($p < 0.01$). In summary, we found that under the conditions of this experiment, the cortisol levels of juvenile/adult dogs interacting with men were no different than those of juveniles/adults interacting with women. Among the dogs receiving no petting, the initial manipulation resulted in a clear increase in cortisol levels from the first to second blood sample. This was not the case among dogs that were petted, so that at the posttreatment sample, the juveniles/adults receiving petting had lower cortisol levels than did their counterparts in the nonpetted control condition.

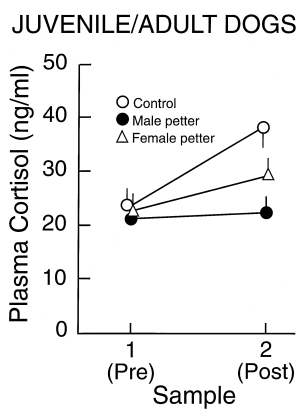

Fig. 1. Mean plasma cortisol levels of juvenile/adult dogs immediately before (Pre) and after (Post) a 20-min behavioural intervention. Dogs were either not petted (control) or were petted by either a man or a woman following the initial venipuncture. Vertical lines represent standard errors.

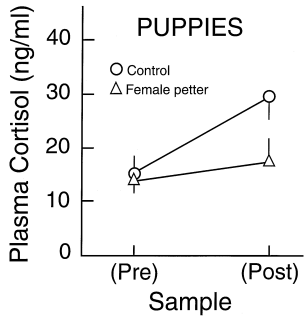

Fig. 2. Mean plasma cortisol levels of puppies immediately before (Pre) and after (Post) a 20-min behavioural intervention. Dogs were either not petted (Control) or were petted by a woman following the initial venipuncture. Vertical lines represent standard errors.

We then compared the effect of the petting procedure on dogs of the two age categories. To do this, the cortisol data of puppies and juveniles/adults that either were not petted or were petted by a woman were entered into a 2 (age) $\times$ 2 (petted/not petted) $\times$ 2 (pre/posttreatment) ANOVA with the last factor treated as a repeated measure. There was a significant main effect of age, $F(1,55) = 9.62$, $p < 0.01$, with juveniles/adults having higher overall levels of cortisol than did puppies. In addition,

Table 1
Median scores and semi-interquartile ranges (SIR) of behavioural measures in Experiment 1

Behaviour	Juvenile/adult dog, male petter	Juvenile/adult dog, female petter	Puppy, female petter
Yawn			
Median frequency	1.0[a]	3.5	0.5
SIR	1.4	3.0	2.2
Pant			
Median duration (s)	128.0	191.7	0.0[b]
SIR	261.1	267.0	16.7
Attempt escape			
Median frequency	0.0	0.0	0.0
SIR	0.9	0.0	0.5
Relax, head-up			
Median duration (s)	483.5	489.0	567.0
SIR	145.5	341.0	252.5
Relax, head-down			
Median duration (s)	18.5	48.0	41.0
SIR	69.0	91.0	26.5

[a] Differs from 'juvenile/adult dog, female petter', $p < 0.10$.
[b] Differs from 'juvenile/adult dog, female petter', $p < 0.02$.

there was a significant main effect of pre/posttreatment, $F(1,55) = 28.94$, $p < 0.001$, and a significant petted/not petted × pre/posttreatment interaction, $F(1,55) = 6.50$, $p < 0.02$. Further analysis of the interaction with tests for simple main effects indicated that regardless of age, the petting procedure reduced cortisol levels in the posttreatment blood sample relative to the control condition ($p < 0.01$) (compare Figs. 1 and 2).

3.2.2. Behaviour during the petting episode

Typically, the dogs voluntarily maintained proximity with the petter for most of the 20-min intervention period. For each behavioural measure, one Mann–Whitney *U*-test was used to compare the juvenile/adult dogs interacting with a man versus a woman, and a second test was used to compare juveniles/adults versus puppies interacting with a woman. The results of these analyses are summarized in Table 1. There was a tendency ($p < 0.10$) for juvenile/adult dogs interacting with a woman to yawn more often than similar age dogs interacting with a man. No other effects due to the sex of the petter were observed. There was one effect for the age of the dog: juveniles/adults panted for a longer duration than did puppies ($p < 0.02$).

4. Experiment 2

In Experiment 1, petting prevented the initial venipuncture procedure from elevating the cortisol levels measured in the second (posttreatment) blood sample. The intervention was effective in puppies as well as in juvenile/adult dogs. However, cortisol levels were not reduced below those measured in the first blood sample. These pretreatment values were comparable to the elevated levels observed in dogs confined for the same length of time in the earlier study (Hennessy et al., 1997). There was no evidence that the 20-min period of human interaction could reduce these already heightened cortisol levels. Experiment 2 investigated whether the same intervention might be capable of reducing the response to housing in the shelter under conditions in which no additional stressor (i.e., initial venipuncture procedure) occurred.

4.1. Method

Sixteen juveniles/adults and sixteen puppies were randomly assigned to each of two (control, experimental) conditions. Three men and three women served as petters. Within each age category in the experimental condition, half of the dogs of each sex were petted by a man and half were petted by a woman. As in Experiment 1, the dog was removed from its cage and brought to the treatment room. In the control condition, a blood sample was immediately collected. In the experimental condition, the individual bringing the dog to the treatment room presented it to the petter who was sitting on the floor. The dog was petted for 20 min, followed immediately by collection of a blood sample. Petting, behaviour observation, and all other experimental details were performed as described in Section 2.

Table 2
Mean and standard error (SE) of plasma cortisol (ng/ml) in juveniles/adults and puppies either immediately following removal from the living cage (control) or following 20 min of human interaction (pet) in Experiment 2

Animals	Control	Pet
Juveniles/adults		
Mean	29.6	28.2
SE	4.1	3.1
Puppies		
Mean	13.9	13.1
SE	2.4	2.2

Juveniles/adults differ from puppies, $p < 0.001$.

4.2. Results

4.2.1. Cortisol

A preliminary 2 (sex of petter) × 2 (age) ANOVA revealed no main or interaction effect of sex of petter (Fs < 1). Data of dogs petted by men and petted by women were then combined. A 2 (condition) × 2 (age) ANOVA yielded only a main effect of age,

Table 3
Median scores and semi-interquartile ranges (SIR) of behavioural measures in Experiment 2

Behaviour	Juvenile/adult dog, male petter	Juvenile/adult dog, female petter	Puppy, male petter	Puppy, female petter
Yawn[a]				
Median frequency	4.0	5.5	0.5	6.5
SIR	1.7	3.2	2.2	2.7
Pant[c]				
Median duration (s)	259.5	128.5	0.0	29.0
SIR	372.7	122.7	4.7	65.5
Attempt escape[d]				
Median frequency	1.5	0.5	0.0	0.0
SIR	0.7	1.0	0.0	0.2
Relax, head-up[b]				
Median duration (s)	173.0	278.0	224.5	641.5
SIR	152.0	345.0	109.0	119.7
Relax, head-down[c]				
Median duration (s)	4.5	31.0	168.0	42.0
SIR	10.0	45.0	205.2	39.0

[a] Male petter vs. female petter, $p < 0.05$.
[b] Male petter vs. female petter, $p < 0.02$.
[c] Juvenile/adult vs. puppy, $p < 0.05$.
[d] Juvenile/adult vs. puppy, $p < 0.01$.

$F(1,60) = 25.85$, $p < 0.001$. As in Experiment 1, the juveniles/adults had higher plasma cortisol levels (28.9 ± 2.5 ng cortisol/ml plasma) than did the puppies (13.5 ± 1.6 ng cortisol/ml plasma). The petting procedure did not affect cortisol concentrations under the conditions of this experiment (Table 2).

4.2.2. Behaviour during the petting episode

For each behavioural measure, one Mann–Whitney *U*-test was used to compare all dogs petted by a man to all dogs petted by a woman. A second Mann–Whitney *U*-test was used to compare all juveniles/adults to all puppies. Results are summarized in Table 3. There were two effects for the sex of the petter: dogs interacting with women yawned more frequently ($p < 0.05$) and spent more time in the relaxed, head-up posture ($p < 0.02$) than did dogs interacting with men. In addition, there were three significant effects for age: juveniles/adults panted for a longer duration ($p < 0.05$), attempted to escape more often ($p < 0.01$), and spent less time in the relaxed, head-down posture ($p < 0.05$) than did puppies.

5. Discussion

In Experiment 1, the venipuncture procedure required to collect the first blood sample resulted in higher cortisol levels 20 min later if the dogs spent the intervening interval in the living cage. This elevation was prevented if the dogs spent the 20 min with a human stranger that stroked and spoke soothingly to them. Unlike the earlier study (Hennessy et al., 1997), exposure to men as well as women was found to be effective in Experiment 1. The significance of this finding is two-fold: First, it is clear that the differential response to women and men in the earlier study was not a result of some odor or other nonbehavioural stimulus property characteristic of women or men. Second, minor variations in the nature of the interaction with the dog appear crucial in determining the neuroendocrine response. It should be emphasized that in the previous study the petting administered by the men and women was superficially similar; yet, dogs petted by men exhibited a significant increase in cortisol levels across the treatment period. As indicated above, we believe that the differential effect of men and women in the earlier study probably related to the greater experience of the women with dogs in training classes and other contexts. This included experience with a specific type of interaction (the 'soft' exercise; Tuber, 1986) which is similar to the form of petting that the women reported to use. The earlier results might also be accounted for by differences in the way in which men and women typically interact with dogs (i.e., differences that are not simply a function of differential experience of these particular men and women with dogs). Under at least some conditions, men and women appear to differ in the way in which they typically touch and talk to their dogs (Smith, 1983; Brown, 1984). Voice quality alone might be hypothesized to have had some effect in the study of Hennessy et al. (1997), especially in view of earlier findings that simple acoustic variables can affect canine behaviour (McConnell, 1990). When the men attempted to emulate the way in which the women interacted with the dogs, including a greater emphasis on gentle soothing speech, the men became as effective as the women in preventing HPA reactivity to the venipuncture procedure.

Puppies had lower levels of plasma cortisol overall than did the older animals. This might reflect the lower baseline levels of cortisol in puppies (Palazzolo and Quadri, 1987) upon which the stress of impoundment was superimposed. The lower levels might also indicate that confinement in the shelter was perceived as less stressful by the puppies than by the older dogs. In any event, the results of Experiment 1 indicate that in puppies, as in juvenile/adults, the behavioural intervention prevented the venipuncture procedure from producing any further elevation in cortisol levels.

In neither experiment was there evidence that the 20-min intervention used here had any palliative effect on the HPA response to the sheltering experience per se: Petting never resulted in cortisol levels that were lower than those of dogs that were undisturbed by the experimenters prior to blood sample collection. This lack of effect may simply indicate the inability of a single 20-min intervention to reduce the chronic stress of the dogs. On the other hand, the absence of effect might reflect reduced sensitivity of some component of the HPA axis following protracted cortisol elevations. For instance, if adrenal sensitivity to ACTH had been reduced, a brief lowering of ACTH secretion due to human interaction might not result in an immediate reduction in plasma cortisol levels. With only the single (cortisol) measure of HPA activity, this issue cannot be resolved.

The broad, applied goal of the research program from which this report derives is to evaluate methods that would be practical to reduce the stress of dogs confined in shelters. A 20-min period of intervention was chosen because this was judged to be a duration that would be practical for shelter staff or volunteers to employ in the shelter environment. We compared dogs that were petted in the treatment room to dogs spending the same length of time in their living cages. Effects of the petting procedure may have been more dramatic if compared to a control group of dogs exposed to the novelty of the treatment room without petting for the 20-min session. However, the interest here was in how the intervention compared to no intervention, not in whether petting in a novel room reduced cortisol levels relative to exposure to a novel room without petting.

Research in a public shelter precludes the measurement of 'nonstressed' levels of cortisol, at least from dogs housed in the shelter. Therefore, it is not possible to accurately gauge the magnitude of the elevation of cortisol levels in the dogs in this study. Hennessy et al. (1997) found that pet dogs sampled in their owners' homes had cortisol concentrations that were approximately a third of those found in dogs on days 1–3 in the shelter. In that study, the cortisol levels of dogs (mostly juveniles and adults) during these first days in the shelter were comparable to pretreatment levels of juvenile/adults sampled on day 2 or 3 in the present study. For this reason, we are confident that the cortisol levels measured here in juvenile/adult dogs were substantially elevated over true resting levels at all sampling points.

The behaviour of the dogs during the petting episode rarely was patently fearful, and never was aggressive. Although some uneasiness often was evident, as suggested by the yawning and panting measures, dogs generally appeared to seek contact with the person and often assumed a relaxed, recumbent position during the petting episode. Juvenile/adult dogs consistently panted for longer periods than did the puppies. When the petting intervention followed the collection of a blood sample (Experiment 1) there was a

tendency for dogs interacting with women to yawn more than those interacting with men. When dogs were taken directly from the living cage to the petter (Experiment 2), this difference in yawning was statistically significant, and dogs with female petters engaged in the relaxed, head-up posture for longer periods than did dogs with men. Additional age differences also emerged under these conditions. Juveniles/adults attempted to escape more often and spent less time in the relaxed, head-down posture than did puppies. It seems that the adults may have been more compliant following the minor stressor of venipuncture than when taken directly from the cage, whereas the puppies may have been more consistently compliant. It is curious that in Experiment 2 the dogs interacting with women exhibited higher levels of both a behaviour suggestive of conflict (yawning) as well as a behaviour thought to reflect reduced stress or agitation (relaxed, head-up posture). Despite the training procedure, and despite equivalent effects on the plasma cortisol measure, there were still differences in the behaviour of the dogs petted by men and women.

The results of this study attest to the importance of human interaction for the welfare of domestic dogs. The present findings, together with earlier results showing that petting can eliminate the tachycardia of dogs to electric shock (Lynch and McCarthy, 1967), indicate that contact with a human can moderate or prevent both HPA and autonomic responses to acute stressors. Moreover, human contact has been found to be more effective than canine contact both in quieting puppies isolated in a novel environment (Pettijohn et al., 1977), and in reducing the cortisol response of adult dogs tested under similar conditions (Tuber et al., 1995). It seems that domestication has resulted in humans acquiring a pervasive social influence on the behaviour and physiology of the dogs they have selected and bred largely for qualities as companions. Human interaction, particularly tactile contact, represents a potentially powerful tool for ameliorating the distress of dogs in confinement. In addition, our results suggest that petting may be an effective means of reducing the HPA response of dogs to other common aversive situations, such as routine medical examinations and vaccination procedures at private veterinary clinics as well as shelters.

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