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Young horses' reactions to humans in relation to handling and social environment

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Abstract

Forty Danish warmblood colts in two replicates were used to investigate the effect of housing and handling in the rearing period on the reactions to humans. The horses entered the experiment after weaning and were housed either individually ($n = 16$) or in groups of three ($n = 24$). Half of the horses from each housing group were handled three times per week for a period of 10 min. Approach tests were performed in the home environment when the horses were 6, 9, 12, 18, 21, and 24 months old, and an Arena and Human Encounter test was performed in a novel environment when the horses were 12 and 24 months old, respectively. In the home environment, single-housed horses approached sooner and were more easily approached by a human than group-housed horses where no effect of handling was observed. Horses approached sooner and were more easily approached with increasing age. In the Arena and Human Encounter test, single-housed horses expressed less restless behaviour, more explorative behaviour, and less vocalisation than group-housed horses. Handled horses showed lower increase in heart rate during the test than non-handled horses. There was no difference between the number of times single or group-housed horses touched an unfamiliar person in the Arena and Human Encounter test but handled horses approached sooner than non-handled horses. It is concluded that the social environment affected the way horses reacted to humans when tested in the home environment but not in a novel environment. In contrast, handling affected the reactions to humans when tested in the novel environment but not in the home environment. However, handled horses also reacted less to the novel environment in general, thus indicating that handling is a mean of avoiding potential dangerous situations.

Keywords: Horses; Human–animal relationship; Social environment; Handling

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1. Introduction

Horses are used for various activities in relationship with humans. Consequently, a successful Human–animal relationship is important for horse husbandry. If horses are fearful of humans they are prone to be stressed whenever human contact is unavoidable. Performance is likely to be reduced if the horse is fearful and it may be dangerous to handle fearful animals. The behavioural response to humans may be influenced by environmental as well as genetic factors (Le Neindre et al., 1993). The response will depend on the nature of the previous behaviour of humans towards the animal and also by the amount of time the animals have spent with humans (Hemsworth and Barnett, 1987). Thus, positive handling of horses is assumed to have a positive effect on the Human–animal relationship.

Group-housed animals may show less interest in contact with humans, a fact, which may interfere with the Human–animal relationship. Conversely, it is a general belief that young horses housed in groups are easier to handle due to an abreaction within peers. The latter was confirmed in a study by Rivera et al. (2002), where horses kept in groups on pasture required less time to become habituated with the activities occurring from the start of training to mounting than horses housed in single stalls. Also, the frequency of unwanted behaviour was lower for horses in groups than single-housed horses. However, due to the confounding between space allowances, housing system and social environment it is impossible to determine what caused the difference.

If the rearing environment and the amount of time young horses spend with humans are essential to their general perception of humans, it will affect their welfare directly through their own reactions towards humans and indirectly through the reaction of humans towards them. A horse that has confidence in humans is more likely to behave well when handled and thus it is in less risk of being punished or mistreated. Most studies on the various aspects of the Human–animal relationship in horses have focused on handling before weaning (Mal et al., 1994; Mal and McCall, 1996; Søndergaard and Jago, 2001; Williams et al., 2002), one on a combined schedule with handling both before and after weaning (Jezierski et al., 1999) and some on effects of either handling (Visser et al., 2001, 2002) or housing (Rivera et al., 2002) but the separate and interactive effects of handling and housing during the rearing period have not been investigated previously.

The aim of this experiment was to investigate single and group-housed horses' reactions to humans in relation to handling intensity from weaning and until 2 years of age.

2. Materials and methods

The experiment was conducted at Research Centre Foulum, Denmark as part of a larger project on the effect of rearing environment on the social and physical development of young horses.

2.1. Animals, housing and management

Forty Danish warmblood colts entered the experiment after weaning. The experiment was performed as two replicates of 20 colts entering either in September 1997 or September

1999 at a mean age of 4.3 (±0.5) and 5.0 (±0.5) months, respectively. Six stallions sired the colts; four sires in each replicate. In each replicate, eight horses were housed singly in boxes of 9 m^2 and 12 horses were housed in four groups of three horses in boxes of 27 m^2 (Fig. 1). Separation between boxes consisted of walls of plastic planks (DAN Egtved A/S, Denmark) up to 1.2 m and vertical bars with a distance of 8 cm from 1.2 to 2.5 m allowing the horses to see, hear, smell and touch but not physically interact with neighbouring horses. There were two rows of boxes as shown in Fig. 1. The rows were separated by 3 m closed walls of plastic planks. Each box was equipped with an automatic drinker. The front of each box consisted of vertical bars with a distance of approximately 30 cm allowing the horses to feed from the floor in front of each box. Horses were fed ad libitum once a day with a total mixed ration of chopped grass silage, chopped hay, chopped straw and concentrate, molasses and minerals. During the housing period, horses were given 3 h of daily exercise in paddocks according to their housing, i.e. single-housed horses alone and group-housed horses in groups of 3 (Fig. 1). Paddocks for single-housed horses were 20 m × 40 m and paddocks for group-housed horses were 45 m × 90 m. All horses were exercised in the same paddocks every day. Each paddock was used by two pens in the stable, i.e. two single-housed horses or two groups of horses in the morning and afternoon, respectively. The horses were housed from mid-September to -May. They spent the summer grazing in one joint group whereupon they returned to their previous housing conditions during the following winter. The experiment ended when the horses entered the second summer period, i.e. when they were 2 years of age. Half of the horses in each replicate and in each housing system were handled three times per week for a period of 10 min during each housing period. Handling was performed in an arena in the same building as the stable (Fig. 1). Five people (two males and three females) were involved in the handling during the 4-year period, and one of the two main trainers (one male and one female) was always present during handling. Handling involved leading, tying up, touching, lifting feet, etc. From the time the foals were purchased at an age of approximately 2 months till weaning owners were instructed not to handle their foals unless for necessary veterinary treatments. Non-handled horses were only handled for monthly weightings, farrier and necessary veterinary treatment. There was no physical contact between the caretaker and the horses while feeding or at any other times. When going to and from the paddocks horses were running loose in a runway and no handling of the horses was needed. Visitors to the stable were only allowed to enter the part of the stable where the handled horses were (Fig. 1) and were kept at distance from the horses.

In the first replicate, one horse from the single-housed, handled treatment was culled due to injury at 6 months of age. In the second replicate, one horse from the group-housed, handled treatment was culled due to health problems at 18 months of age.

2.2. Tests and variables

To evaluate the Human–animal relationship both in terms of age and environment three tests were performed several times. Two approach tests were performed in the home environment, i.e. the exercise paddocks to simulate an unstressed situation, and an Arena and Human Encounter test was performed in an unfamiliar and less spatial environment to create a slightly stressful situation in order to evaluate if reactions to humans are depending on the situation.

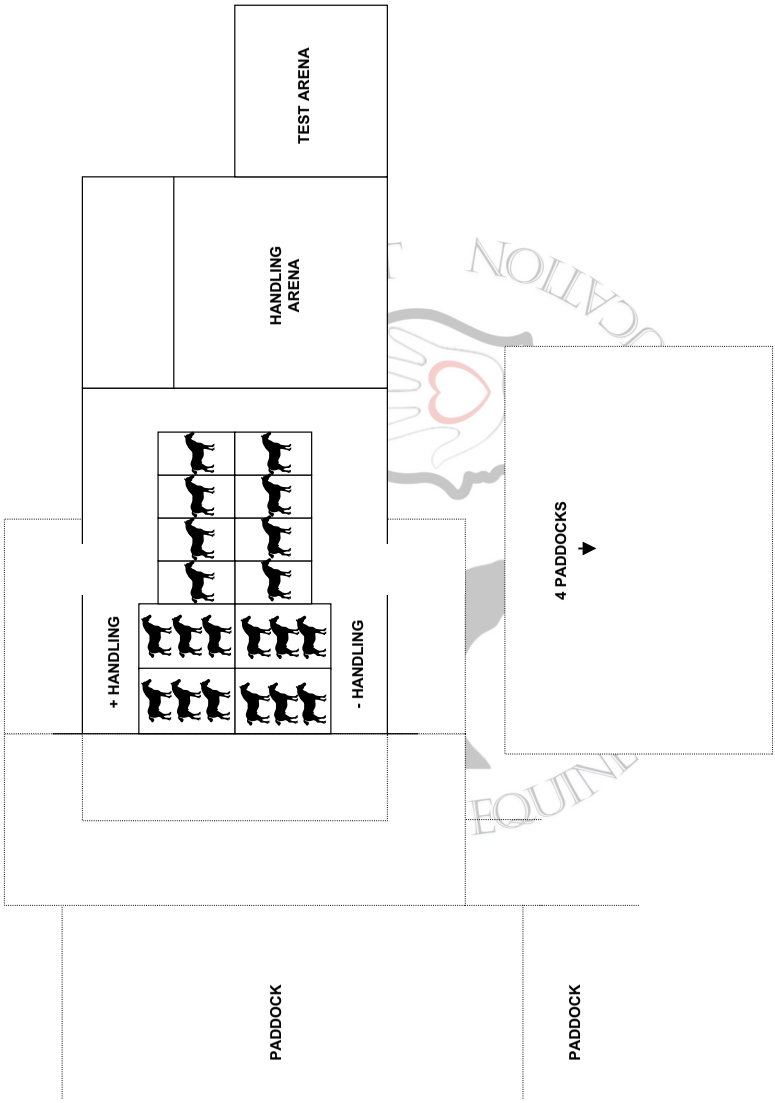

Fig. 1. Overview (not scaled) of stable, handling arena and test arena. The test arena was not permanent but only present during the Arena and Human Encounter test. The test arena was situated outside the building. The VAA test and the FHA test were performed in the exercise paddocks.

2.2.1. Voluntary Animal Approach test (VAA test)

The test was performed three times during each winter period when the horses were 6, 9, 12, 18, 21 and 24 months old, respectively. It was performed in the paddocks approximately 2 h after the horses were let out.

The test was adapted to horses from similar tests used on calves by Jago et al., 1999; Krohn et al., 2001, 2003. An unfamiliar person entered the paddock away from the horse/horses and walked to the middle of the paddock. Latency in seconds until a horse had its head within a distance of 1 m and latency until the horse touched the person was recorded. The maximum test time was 3 min.

For the first replicate, the test was performed by a different person each time, i.e. in total six people, whereas for the second replicate the same person performed all the six tests. Due to this change in procedure the two replicates were analysed separately.

For the statistical analyses, only latency to touch the person was used as only a few horses came close to the test person without touching.

2.2.2. Forced Human Approach test (FHA test)

The test was performed approximately 20 min after the Voluntary Animal Approach (VAA) test. The test was adapted to horses from a similar test used on heifers by Krohn et al., 1999. After finishing the VAA on all horses the same person entered the paddock away from the horse/horses and approached a horse slowly with approximately one step per second with hands hanging by the side. If the horse stood still when the person was within a 2 m range (category 2 given below) the person slowly raised his hand to allow the horse sniff it. If the horse sniffed the hand the person slowly attempted to touch the neck of the horse. Horses within a group were approached one by one in a pre-determined order. A horse was scored from 1 to 4 on the following scale:

1. The horse moved away from the person before he/she got within a 2 m range.
2. The horse stood still when the person was within a 2 m range.
3. The horse sniffed the person's hand.
4. The person could touch the horse on the neck.

As for the VAA test, six people performed the test for the first replicate and the same person performed all the tests in the second replicate. Due to this change in procedure the two replicates were analysed separately.

2.2.3. Arena and Human Encounter test

The test was performed at the end of each housing period when the horses were 12 and 24 months old respectively, in an outdoor test arena, which was unfamiliar to all horses. The arena was built of plywood upon asphalt ground. The arena measured 4.88 m × 4.88 m and the walls were 1.83 m high. One side of the arena was next to the wall of the horse stable (Fig. 1). On the side opposite the stable, there was a double door in the wall of the arena. The test arena only existed during testing and apart from the duration of the Arena and Human Encounter test horses were never on this side of the stable.

Each horse was equipped with a heart rate monitor (Polar® Horse Tester) in the home pen and left there for at least 15 min with a person watching to avoid pen mates or the

horse interfering with the equipment. One electrode was placed behind the scapula on the right withers; the other electrode was placed ventrally on the left side of the abdomen. The skin of the horse was moistened with water and the electrode smeared with gel to improve conductivity. Heart rate was calculated as averages at 5 s intervals.

Each horse was led to the outdoor arena by the experimenter and then released (period 1). After 3 min an unfamiliar person entered the arena and stood next to the wall on the opposite side from the entrance for 3 min (period 2). Hereafter, the person left the arena and the horse was alone for 3 min (period 3). Regarding the test performed on the first replicate when they were 12 months old, period 3 was not included, and the test person caught the horse by the end of period 2. Otherwise, the experimenter entered the arena at the end of period 3, caught the horse and led it back to the stable.

The behaviour of the horse during all the three periods was recorded using scan sampling with a 10 s interval. Behaviours recorded were standing, standing alert with elevated neck and intense orientation of the ears and eyes, pawing, sniffing floor/wall while standing or walking, sniffing person (period 2 only), walking, trotting and two tracking (Waring, 1983). Besides, all occurrences of rearing, defecation, blowing, nickering, and whinnying were recorded. In period 2, latency in seconds to first contact with the person and number of contacts with the person were recorded. Time taken to be caught after period 3 was recorded. Heart rate was measured throughout the test and variables were: Mean heart rate (beats per minute (bpm)) in period 1, 2 or 3 and when the horse was led to and from the arena as a deviation from the baseline heart rate (bpm), determined as the mean heart rate the last 5 min before the experimenter entered the pen to lead the horse to the arena. An increase in heart rate was assumed to reflect the level of emotions as shown by Visser et al. (2002).

Behavioural variables in the Arena and Human Encounter test were defined for analyses as follows:

- *Restlessness*: All occurrences of rearing and defecating and number of scans with pawing, trotting, and pacing.
- *Exploration*: Number of scans where the horse is sniffing floor or wall while standing or walking and number of scans where the horse is sniffing the person.
- *Vocalising*: All occurrences of blowing, nickering and whinnying.
- Standing alert was analysed as a single variable.

On three occasions, the test ended before time because the horse escaped from the arena. This happened once in the first replicate when the horses were 2 years old. The horse was single-housed and not handled. In the second replicate, it happened once when the horses were 1 year old and the horse in question was group-housed and not handled, and once when the horses were 2 years old and the horse was group-housed and handled. For the first two horses, the test was ended in the second period and for the last horse it was ended in the first period.

2.3. Statistics

The latencies to touch the test person in the VAA test were analysed with a Cox proportional hazard model (cf. Cox, 1972). The hazard rate $\lambda(t)$, i.e. the instantaneous probability

to touch being conditional on not having touched until time t, was modelled as.

$$\lambda(t) = \lambda_0(t) \exp(\text{SIRE} + \text{AGE[months]} + \text{HOUSING} + \text{HANDLING})$$

for each replicate separately. $\lambda_0(t)$ stands for the baseline hazard rate. The correlation of the measurements within boxes was accounted for by an estimation of the variances of the estimates of the parameters with a grouped Jackknife estimate (Therneau and Grambsch, 2000).

For the FHA test, the data were analysed via a continuation-ratio model (Fienberg, 1980). The four possible responses of a horse (cp, 2.2.2.) were considered describing discrete states for which it is plausible to assume that a horse has to pass a lower state in order to reach a higher one.

The continuation-ratio models the log-odds of the probability of attaining a higher state, given that a lower state has been attained.

$$\log \frac{P(Y > i | Y \geq i; X)}{P(Y = i | Y \geq i; X)} = \alpha_i + \text{SIRE} + \text{AGE [months]} + \text{HOUSING} + \text{HANDLING}, \quad i = 1, 2, 3$$

where the observations per horse are considered to be multinomial distributed. This model allows a direct expressing of the chance or odds ratio of attaining a higher state. Correlation of measurements within pens was accounted for by calculating the variances of the estimates via the generalised estimation equation (GEE) approach of Zeger and Liang (1986).

Behaviour and heart rate variables measured throughout the Arena and Human Encounter test were analysed in a mixed model.

$$\begin{aligned} Y = {} & \text{REPLICATE} + \text{SIRE} + \text{AGE [years]} + \text{HOUSING} + \text{HANDLING} \\ & + \text{TEST PERIOD} + \text{HOUSING} \times \text{HANDLING} + \text{AGE} \times \text{HOUSING} \\ & + \text{AGE} \times \text{HANDLING} + \text{AGE} \times \text{TEST PERIOD} + \text{AGE} \times \text{HOUSING} \\ & \times \text{TEST PERIOD} + \text{AGE} \times \text{HANDLING} \times \text{TEST PERIOD} \end{aligned}$$

where pen within replicate and horse within replicate and pen were included as random effects. The correlations between the measurements taken over three successive test periods were modelled as first order autocorrelation for each horse. Non-main effect terms were excluded hierarchically from the model if they were not significant at the 10% level.

For the following factors: baseline heart rate, heart rate when led to and from the arena, time to be caught and number of times touching the person, the effect of the test period was not included. The variables vocalising, time to be caught, and number of times touching the person were log transformed [log (variable + 1)] to obtain normally distributed variables. Results are presented as least square means transformed to the original scale of the variables.

Latencies to touch the test person were analysed with a Cox proportional hazard model. The hazard rate $\lambda(t)$ was modelled as.

$$\begin{aligned} \lambda(t) = {} & \lambda_0(t) \exp(\text{REPLICATE} + \text{SIRE} + \text{AGE[years]} + \text{HOUSING} \\ & + \text{HANDLING} \times \text{REPLICATE}) \end{aligned}$$

As with the data from the VAA test, the correlation of the measurements within boxes was accounted for by using a grouped Jackknife variance estimate (Therneau and Grambsch, 2000).

The data analysis for this paper was generated using the procedures SAS/GENMOD and SAS/MIXED of SAS/STAT software version 8 (SAS, 2000).

3. Results

3.1. Effects of handling

There was no effect of handling in the VAA test or in the FHA test in any of the replicates (Tables 1–4). In the Arena and Human Encounter test, there was a significant three-way

Table 1
Estimates from VAA test first replicate

Factor	Level	Reference level	Hazard rate ratio	95% CI	
				Lower	Upper
Housing	Single	Group	2.96	1.21	7.22
Handling	Non-handled	Handled	0.88	0.38	2.01
Age (months)	6	24	0.12	0.03	0.40
	9	24	0.67	0.22	2.04
	12	24	0.46	0.15	1.47
	18	24	0.31	0.08	1.26
	21	24	1.36	0.53	3.48

The hazard rate ratios are calculated with respect to the level of the hazard of the reference level. A hazard ratio larger than 1 means that the horses under the 'level' treatment approach the test person faster than those under the 'reference level' treatment. Where 1 is not included in the 95% CI there is a significant difference to the reference level.

Table 2
Estimates from VAA test second replicate

Factor	Level	Reference level	Hazard rate ratio	95% CI	
				Lower	Upper
Housing	Single	Group	3.65	1.42	9.37
Handling	Non-handled	Handled	0.62	0.25	1.52
Age (months)	6	24	0.03	0.00	0.18
	9	24	0.12	0.04	0.32
	12	24	0.25	0.13	0.48
	18	24	0.18	0.06	0.54
	21	24	0.68	0.38	1.22

The hazard rate ratios are calculated with respect to the level of the hazard of the reference level. A hazard ratio larger than 1 means that the horses under the 'level' treatment approach the test person faster than those under the 'reference level' treatment. Where 1 is not included in the 95% CI there is a significant difference to the reference level.

Table 3
Estimates from FHA test first replicate

Factor	Level	Reference level	Odds ratio	95% CI	
				Lower	Upper
Housing	Single	Group	3.68	1.64	8.23
Handling	Non-handled	Handled	0.51	0.25	1.05
Age (months)	6	24	0.11	0.05	0.26
	9	24	0.10	0.04	0.25
	12	24	0.18	0.07	0.44
	18	24	0.25	0.15	0.44
	21	24	4.29	0.77	23.89

Odds ratios are calculated with respect to the level of the hazard of the reference level. An odds ratio larger than 1 means that the horses under the 'level' treatment are more likely to be approached by the test person than those under the 'reference level' treatment. Where 1 is not included in the 95% CI there is a significant difference to the reference level.

interaction between age, handling and test period for the variable standing alert ($P = 0.05$). There was no difference in the second and the third test period but in the first period 1-year old non-handled horses stood less alert than 2-year old non-handled horses (6.2 scans versus 7.7 scans). One-year old handled horses were standing alert for 8.5 scans versus 7.7 scans for 2-year old handled horses. Baseline heart rate was slightly lower (47 bpm) for handled horses than for non-handled horses (50 bpm; $P < 0.05$). There was a significant ($P < 0.05$) interaction between the level of handling and the test period for heart rate as shown in Fig. 2. In all test periods, non-handled horses had a higher heart rate than handled horses but the difference was decreasing with test period. Handled horses approached the test person sooner in the first replicate but not in the second replicate (Table 5). At the age of 1 year handled horses were caught sooner than non-handled horses, while there was no difference at 2 years of age as shown in Fig. 3 (the interaction between handling and age was significant; $P < 0.01$).

Table 4
Estimates from FHA test second replicate

Factor	Level	Reference level	Odds ratio	95% CI	
				Lower	Upper
Housing	Single	Group	5.83	2.39	14.27
Handling	Non-handled	Handled	0.87	0.33	2.32
Age (months)	6	24	0.03	0.01	0.11
	9	24	0.16	0.07	0.40
	12	24	0.17	0.08	0.38
	18	24	0.42	0.21	0.82
	21	24	0.65	0.26	1.62

Odds ratios are calculated with respect to the level of the hazard of the reference level. An odds ratio larger than 1 means that the horses under the 'level' treatment are more likely to be approached by the test person than those under the 'reference level' treatment. Where 1 is not included in the 95% CI there is a significant difference to the reference level.

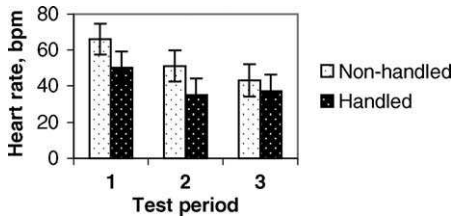

Fig. 2. Least square means and 95% CI of heart rate (bpm) in the three test periods by level of handling.

Table 5
Estimates for latency to touch the test person in the second test period in the Arena and Human Encounter test

Factor	Level	Reference level	Hazard rate ratio	95% CI	
				Lower	Upper
Replicate	1	2	0.63	0.44	0.90
Housing	Single	Group	0.91	0.61	1.36
Handling 97	Non-handled	Handled	0.34	0.17	0.69
Handling 99	Non-handled	Handled	1.33	0.39	1.44
Age (years)	1	2	1.34	0.69	2.59

The hazard rate ratios are calculated with respect to the level of the hazard of the reference level. A hazard ratio larger than 1 means that the horses under the 'level' treatment approach the test person faster than those under the 'reference level' treatment. Where 1 is not included in the 95% CI there is a significant difference to the reference level.

3.2. *Effects of housing*

The hazard of a horse touching in the VAA test was 3.0 and 3.7 times higher for single-housed horses than for grouped housed horses, respectively. (Tables 1 and 2).

The chance of reaching a higher score in the FHA test was 3.7 and 5.8 times higher for single-housed horses than for group-housed horses in the first and the second replicate (Tables 3 and 4) ($P < 0.05$ in both replicates).

In the Arena and Human Encounter test, the interaction between housing and test period was not significant for the variable exploring ($P = 0.07$). There was no difference in the first and the third test period but single-housed horses tended to explore more in the second

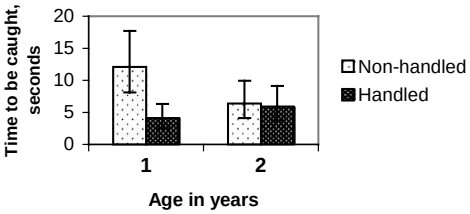

Fig. 3. Least square means and 95% CI of time to be caught (seconds) after the test by age and level of handling.

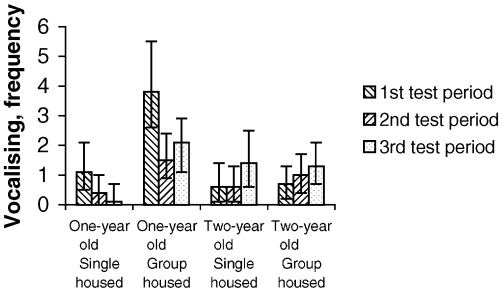

Fig. 4. Least square means and 95% CI of number of vocalisations in the three test periods by housing and age.

period than group-housed horses (7.5 scans versus 5.8 scans). The interaction between housing and test period was also not significant for the variable restlessness ($P = 0.07$). There was no difference in the first and the third test period but single-housed horses tended to be less restless in the second period than group house horses (7.1 counts versus 8.8 counts). For vocalising, there was a significant interaction ($P < 0.01$) between the effects of age, housing and test period as shown in Fig. 4. One-year old group-housed horses were vocalising more than 1-year old single-housed horses and 2-year old horses.

3.3. Effects of age

The hazard of a horse touching in the VAA test was much lower at 6 months of age than at 24 months of age in the first replicate (Table 1) but from 12 months of age and onwards it was not different from the hazard of 24 months of age. In the second replicate, the hazard of a horse touching was increasing with age except for a decline between 12 and 18 months of age (Table 2). In the FHA test, the overall evidence that age is related to getting close to a horse is stronger for the first replicate ($P = 0.08$) than for the second ($P = 0.17$). The effect was not linear but overall increasing with age, the level at 6, 9, 12 and 18 months being significantly lower than at 24 months of age (Tables 3 and 4).

In the Arena and Human Encounter test, an interaction between the effects of age and test period for the variable exploring was not significant ($P = 0.08$). There was no difference in the first two test periods but 1-year old horses explored more than 2-year old horses in the third period (7.5 scans versus 5.5 scans). A three-way-interaction between age, handling and test period for the variable standing alert was observed as stated previously ($P = 0.05$). As to vocalising there was a significant interaction ($P < 0.01$) between the effects of age, housing and test period as stated previously.

Baseline heart rate was higher for 1-year old horses than for 2-year old horses (54 bpm versus 43 bpm; $P > 0.0001$), but it increased more for 2-year old horses (39 bpm) than for 1-year old horses (25 bpm) when they were led to the test arena ($P < 0.0001$). There was a significant interaction ($P < 0.05$) between the effects of age and test period for heart rate as shown in Fig. 5, although there was no difference between the age groups within each test period. The heart rate after the test was higher for 2-year old horses (61 bpm) than for 1-year old horses (46 bpm; $P < 0.0001$).

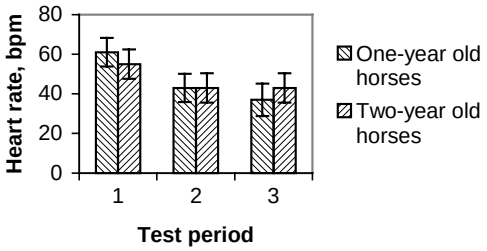

Fig. 5. Least square means and 95% CI of heart rate (bpm) in the three test periods by age.

Regarding the time taken to catch the horse after the test there was a significant interaction ($P < 0.01$) between the age of the horses and the level of handling as stated previously.

3.4. Other effects

There was no effect of sire in the VAA or FHA test in any of the replicates, although there was a low *P*-value ($P = 0.06$) in the FHA test for the second replicate. The effect of sire was significant for heart rate and for restlessness ($P < 0.05$) but was not significant for vocalising ($P = 0.09$).

In the first replicate, the horses explored slightly less (5.1 scans versus 7.9 scans) and stood alert more (8.3 scans versus 6.2 scans) than in the second replicate ($P < 0.05$). There was a tendency for horses in the first replicate to show a more restless behaviour than for horses in the second replicate (9.7 counts versus 7.8 counts; $P = 0.07$). The baseline heart rate was slightly higher in the first replicate (50 bpm versus 46 bpm; $P < 0.05$) and the heart rate increased more during the test (55 bpm versus 39 bpm; $P < 0.05$). The heart rate after the test tended to be higher (60 bpm) in the first replicate than in the second replicate (47 bpm; $P = 0.07$).

As to number of contacts with the person in test period 2 there were no significant factors at all.

4. Discussion

In the tests performed in the home environment (VAA and FHA test), there was no effect of handling but an effect of age and housing. Single-housed horses approached sooner and were more easily approached by a human than group-housed horses. In general, the hazard of a horse approaching and the chance of approaching a horse were increasing with age. In the test in the unfamiliar environment, single-housed horses tended to be less affected by the situation as they showed less restless behaviour, explored more and vocalised less. Handled horses had a lower increase of heart rate, approached the test person sooner and were caught sooner after the test than non-handled horses. One-year old horses had a higher baseline heart rate, a higher increase of heart rate, vocalised more, but also explored more in the Arena and Human Encounter test than 2-year old horses.

Our tests were chosen in order to reflect some practical situations. In the home environment, it is desirable to have horses that either approach or are easy to approach whereas in the novel environment the most important factor might be how aroused they are. If horses are aroused they might be more prone to react by fleeing which may create a dangerous situation. In this sense our results are contrasting. For the situation in the home environment housing seems to be the most important factor while in the novel environment the level of handling seems more important.

With the amount of handling applied we expected an effect on the horses' reaction towards humans. Non-handled horses were only led or touched by humans at monthly weightings or at treatments by the farrier and veterinarian. Apparently, those few contacts with people have not resulted in a negative effect on the way in which they perceive humans as shown by their reactions in the FHA test, i.e. not fleeing. Rather it seems that the non-handled horses have preserved some curiosity towards people which the handled horses have lost as shown by their reactions in the VAA test. In the tests in the home environment, the challenge for the horses is very small. It is very easy for the horses not to have contact with people whereas the test in the novel environment requires handling in order to equip the horses with the heart rate monitor. Besides, in the arena the horses could not get as far away from the test person as they could in the home environment. So, in the slightly stressed situation in the novel environment handled horses react less to the situation in general and seem to find comfort in the presence of a human. This may be very important as Marchant et al. (2001) found that response in heart rate in a novel object test correlated positively to a score of anxiety in the horses, i.e. horses with a higher increase of heart rate were more anxious.

In accordance with our results, Hemsworth et al. (1996) found that handling of pigs and cattle shortened their latency to approach a test person, in an arena test situation, and handled pigs interacted more with the test person than non-handled pigs, whereas handled cattle spent more time with the test person than non-handled cattle. Also, Bertenshaw and Rowlinson (2001) found that handled heifers had a shorter latency to approach a person in a test arena than non-handled animals.

Visser et al. (2002) tested 41 Dutch warmblood horses in a novel object test and a handling test when they were 9, 10, 21 and 22 months old, respectively. Like in our Arena and Human Encounter test, they found that in the novel object test the trained horses had a lower increase in heart rate than the non-trained horses even when the change was corrected for the physical activities of the horses, whereas in the handling test there was no difference in heart rate between trained and non-trained horses. Also, Jezierski et al. (1999) found that handled horses had a lower heart rate and had a higher score for manageability than non-handled horses. It seems that handling horses affect their reactions towards a novel environment and to humans when the situation is slightly stressful.

The hazard of a single-housed horse touching in the VAA test was higher than for a group-housed horse, a fact indicating that single-housed horses are more curious and more interested in contact with humans than group-housed horses. Similar results have been seen in calves housed singly or in pairs (Lensink et al., 2001). Although the VAA test is often termed as a test of fear it may be more related to the motivation for investigatory behaviour as shown by Marchant et al. (1997). Also, for the horses tested in a group there may be an affect of how the other horses in the group react to the person, i.e. social learning. This has been shown in cattle by Munksgaard et al. (2001).

For group-housed horses, the Arena and Human Encounter test implies both a novel environment and an isolation from group mates which may be a greater challenge to them than it is to single-housed horses to which only the novel environment is a new challenge, assuming that single-housed horses do not feel part of a group although they are stabled next to other horses. This assumption is supported by the greater number of vocalisations for group-housed horses when they are 1 year old, and by the fact that single-housed horses tended to be less restless than group-housed horses. Additionally, single-housed horses were exploring more in the second test period than group-housed horses. It is assumed that exploration is characterised by approach and direct investigation, and that fear is characterised by avoidance. On the same horses, Christensen et al. (2002) showed that the bond between neighbouring single-housed horses is weaker than the bond between group mates, an observation, which is supported by our observations in the Arena and Human Encounter test. Group-housed calves were more distressed than single-housed calves as shown by more bawling, attempts to escape and prancing when isolated in a novel environment but after just 3 days of habituation there was no difference (Purcell and Arave, 1991). A similar habituation was seen in relation to the horses in the way that there was no difference in number of vocalisations when they were 2 years old. Rivera et al. (2002) found that horses housed singly in stalls reacted more to initial training in a round pen than horses reared on pasture in groups but in this case the effect of social environment is confounded with the effect of indoor–outdoor environment which may be the reason for our contrasting results.

The chance of a horse approaching in the VAA test was increasing with age in both replicates (Tables 1 and 2) but with a less clear picture in the first than in the second replicate. This could be due to the different test procedures as described previously. In the second replicate, there was a slight decline between the ages 12 and 18 months where there was a release of treatments indicating that the daily exposure to humans in the winter season is important in the human-horse relationship.

The younger the horses are, the more they react, both in their home environment and in the novel environment. This is reflected in their reactions towards humans, their behaviour and vocalisation, and their heart rate. The effect of age in the human and animal approach tests may be an effect of habituation to humans due to the daily feeding by humans but it can also be an effect of the psychological development that horses undergo with age. These results are in accordance with the results from Visser et al. (2001) who found that there was a higher increase in heart rate for horses tested at 9 and 10 months of age than for horses tested at 21 and 22 months of age. Levels of baseline heart rate were similar to the ones found in our study. Visser et al. (2002) had a larger difference between baseline heart rate and heart rate measured in the test than we did (approx. 85 versus approx. 50), which may be due to the fact that there were more opportunities for physical activity in their test situations. They estimated that physical activity accounted for 23.3 up to 42.3% of the increase in heart rate. As the horses in our study were limited by space, i.e. they could not canter and only trot for few steps, it is likely that most of the increase in heart rate is a non-motor effect, i.e. an indication of emotionality.

The models included sire and replicate because they were a part of the set-up for the experiment. The effect of sire was significant in a few cases indicating that behaviour in test situations may involve genetic factors as shown by Wolff and Hausberger (1994) on foals before weaning and on riding horses (Wolff and Hausberger, 1996). In the present

experiment, the horses were from 4 sires within each replicate in order to account for any genetic effects rather than to analyse them specifically.

Single housing seems to improve the Human–animal relationship as evaluated in these tests, at least in the home environment. On the other hand, group housing has a huge beneficial effect on the social behaviour of young horses (Christensen et al., 2002) so our results might be more useful as an explanation for some behavioural reactions rather than as a reason to keep horses isolated. In the Arena and Human Encounter test, group-housed horses reacted slightly more to the isolation than single-housed horses showing that it might be important to habituate horses to isolation when they are reared in groups.

5. Conclusion

It is concluded that the social environment affected the horses' reactions to humans, when tested in their home environment but not in a novel environment. Single-housed horses sought contact sooner and were more easily approached than group-housed horses. In the novel environment handled horses had a lower heart rate and sought contact to a test person sooner than non-handled horses.

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