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Motivation for social contact in horses measured by operant conditioning

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ABSTRACT

Although horses are social animals they are often housed individually with limited social contact to other horses and this may compromise their welfare. The present study included eight young female horses and investigated the strength of motivation for access to full social contact, head contact and muzzle contact, respectively, to a familiar companion horse. Horses were housed individually next to their companion horse and separations between pens prevented physical contact. During daily test sessions horses were brought to a test area where they could access an arena allowing social contact. Arena access during 3 min was given after completion of a predetermined number of responses on a panel. Fixed ratios (FR) of 8, 16, 24, 32 and 40 responses per arena access were applied in a random order, one per daily test session, within each test week (Monday to Friday), and the number of rewards per daily test session was recorded. All horses could access all three types of social contact in a cross-over design, and an empty arena was used as control. Motivational strength was assessed using elasticity of demand functions, which were estimated based on the number of rewards earned and FR. Elasticities of demand for the three types of social contact were low (−0.20), and not significantly different, although increasing FR still resulted in a decrease in rewards obtained for all three types of social contact ($P < 0.001$). Across FR-levels horses earned more rewards for social contact than for an empty arena, as shown by much higher intercept values (2.51 vs. 0.99; $P < 0.001$). However, the elasticity of demand for infrequent access to an empty arena (−0.08) was lower than for social contact ($P < 0.01$) and not significantly different from zero ($P = 0.07$). Horses performed more social behaviour the lesser the restriction on social contact (full > head > muzzle). However, the finding that horses showed a similar and high motivation for all three types of social contact suggests that they are valued equally highly in a situation where the alternative is no social contact.

1. Introduction

Domestic animals are frequently subjected to varying degrees of parental or social deprivation, but the extent to which this reduces welfare depends on the natural social structure of the species concerned. The isolation of young or adolescent primates typically produces long-term and serious physiological and behavioural changes indicative of stress and reduced coping abilities (Olsson and Westlund, 2007). In contrast, the effects of social isolation on rodents are more variable (Krohn et al., 2006; Olsson and Westlund, 2007). Maternal deprivation has especially profound effects on stress susceptibility and also increases the likelihood that the young of many species will develop abnormal behaviour (Latham and Mason, 2008). However, these effects can sometimes be ameliorated by

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social buffering, if young animals are kept with other familiar companions (Newberry and Swanson, 2008). The degree and nature of the social conditions experienced by young mammals can thus have both short and long-term effects on welfare.

Despite a wealth of information on the effects of social isolation in primates and rodents, relatively little is known about horses. Although horses are social animals they are often weaned early and then housed individually with limited social contact to other horses. There are strong indications that this may compromise their welfare. For instance, young individually housed horses performed more stress-related behaviours and spent less time eating than pair-housed controls (Visser et al., 2008). Furthermore, when grouped on pasture the social interactions of young horses previously housed individually were more aggressive than those of young horses previously group housed (Christensen et al., 2002).

Lack of social contact is also one cause of development of abnormal behaviour in stabled horses (Nicol, 1999; Waters et al., 2002; Visser et al., 2008). The stereotypic behaviour 'weaving' is especially sensitive to the degree of social contact provided (McAfee et al., 2002) and the performance of this behaviour can be reduced by allowing stabled horses increased visual contact with neighbouring conspecifics, or by providing them with mirrors or images of other horses (Mills and Davenport, 2002; Mills and Riezebos, 2005). Thus, even limited social contact may improve the welfare of stabled horses.

The main reason for housing horses individually is to avoid fights and injuries. However, the risk of fights in group housing may be more related to competition for limited resources such as space and access to feed as suggested by Jørgensen et al. (2008). Furthermore, physical contact between neighbouring individually housed horses may have beneficial effects while the risk of injury is limited. In order to weight the advantages of social contact against the risk of injury we need to know the strength of horses' motivation for various degrees of social contact ranging from full social contact to limited contact. Elasticity of demand functions may be used to assess motivational strength. When generating demand functions an increasing cost is placed on access to perform the behaviour (the reward). Performing an operant task represents the cost and typically the ratio of operant responses per reward is held fixed (fixed ratio (FR)) within test session, but is changed between sessions. The demand function describes the change in number of rewards earned as a function of the cost (FR). The elasticity of a demand function is defined as the percent change in rewards earned divided by the percent change in cost. Generally, the lower the elasticity the higher the motivation, i.e. the lower the elasticity the more the animal increase the response rate as cost increases (Hursh, 1980; Matthews and Ladewig, 1994; Jensen and Pedersen, 2008). Comparing demand functions it was shown that dairy calves were more motivated for full social contact compared to head contact only (Holm et al., 2002), but similar studies in horses have not been carried out.

The aim of the present study was to assess the motivation of horses for three types of social contact: full contact, head contact and muzzle contact. We hypothesised that horses are most motivated for full contact followed by head and muzzle contact.

2. Materials and methods

2.1. Animals, housing and management

Twelve 18-month old Danish Warm-blood fillies bred and raised at the same stud were used. All animals had been group housed in one larger group prior to the experimental period. During the first two weeks after arrival at the experimental station all 12 horses were kept in one group in a large paddock. Nearest neighbour observations (Christensen et al., 2002) were performed on three consecutive days of the last week and groups of three individuals that were frequently observed near each other were formed. Within these groups of three, two horses served as test horses while one served as a companion.

During the experimental period the horses were housed in individual pens of 2.5 m × 3.6 m. For each of the four groups the companion horse was placed between the two experimental horses. Separations between pens were 2.2 m high; the bottom 1.2 was solid while the top 1 m was made from vertical tubular metal bars covered with transparent acrylic glass allowing the test horses to see their neighbouring companion horse, but not physically interact with it. Test horses could hear and smell the other horses in the barn.

Horses were offered a mixed ration (grass silage, barley straw, rape seed cake, barley and minerals) as well as hay and water ad libitum. Fresh straw was provided as litter every morning.

On week days (Monday to Friday) horses were let out in individual paddocks for approximately 1 h prior to training or testing. Two test horses and their companion horses were let out at the same time, but they were in individual paddocks that prevented physical contact. On Sundays the horses remained in their pens throughout the day, whereas on Saturdays all horses were let out together in one large paddock for 6–8 h where they had the opportunity to physically interact with all other experimental horses. This was done to avoid any adverse long term effects of limited social contact.

2.2. Test apparatus

The test apparatus consisted of a 10 m × 11 m test arena with two parts (I and II) and a start box (Fig. 1). Part I of the test arena measured 10 m × 7 m, while part II measured 10 m × 4 m. The start box measured 1.2 m × 2.4 m and had 1.8 m high sides. An operant panel that could be operated by a nose press was placed 1 m above floor level in the corner of the start box on the right hand side of the solid door opening into the arena (Fig. 2). The right hand side of the start box was solid, while the left hand side was made from tubular metal bars. The horses could not turn around in the start box. Three outer walls of the arena were solid, while one wall was a 2.2 m high partition made from horizontal metal tubular bars facing a 1.5 m wide empty corridor. A 10 m long and 2.2 m high partition separated part I and II;

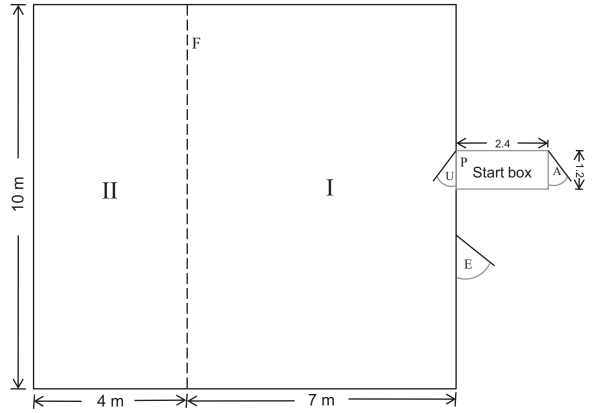

Fig. 1. Schematic illustration of the test arena and startbox. Indicated are entrance door to the start box (A), position of the operant panel (P), entrance door to the arena (U), and exit door from the arena (E). The arena was divided into two parts (I and II), which were separated by a partition (F).

the bottom 1.2 m was solid and a metal tubular bar was mounted horizontally 2.2 m above floor level. This partition could either be ‘open’ or ‘closed’. When the partition was ‘open’ one metal tubular bar was mounted 0.2 m above the solid part giving an opening from 1.4 m to 2.2 m above floor level and allowing horses head contact over the partition. When the partition was ‘closed’ five metal tubular bars were mounted with 0.2 m between them from 1.2 m to 2.2 m above floor level and allowing horses muzzle contact between these bars. The floor of the arena was concrete and covered with a thick layer of sand mixed with fibres offering a firm and ‘earth-like’ surface.

The required operant response was a fixed number of responses on the panel in the start box, resulting in opening of the door to the arena. In the arena the horse had access to the companion horse either in part I of the arena (full contact), or in part II of the arena behind the ‘open’ partition (head contact) or behind the ‘closed’ partition (muzzle contact). An empty arena served as a control situation (control).

2.3. Training

Test horses were trained on weekdays (Monday to Friday) during sessions of minimum 20 min and maximum 50 min. After a test horse was accustomed to standing in the start box it was trained to press the panel for door opening and access to head contact with its companion in the arena. Initially, the door was opened whenever the horse’s muzzle was near the panel, but after the horse had pressed the panel correctly 3–5 successive times, it was not assisted further. During the following sessions the horse was trained to press an increasing number of times on the panel for each 3-min period of access to head contact with its companion in the arena. The number of responses for each arena access was held constant within test session (i.e. a fixed ratio of responses per reward (FR)), and was gradually increased from 1 (FR1) to 40 (FR40) over a three week period. The number of responses per reward was increased by 2–8 responses per reward in the following session depending on the horses’ responding. Whenever the horses’ response rate declined the FR was reset to FR2 the following session and gradually increased over subsequent sessions. Finally, five FR values were introduced in a random order (one value of either 8, 16, 24, 32, or 40 per daily session) during each of two 5-day weeks, where

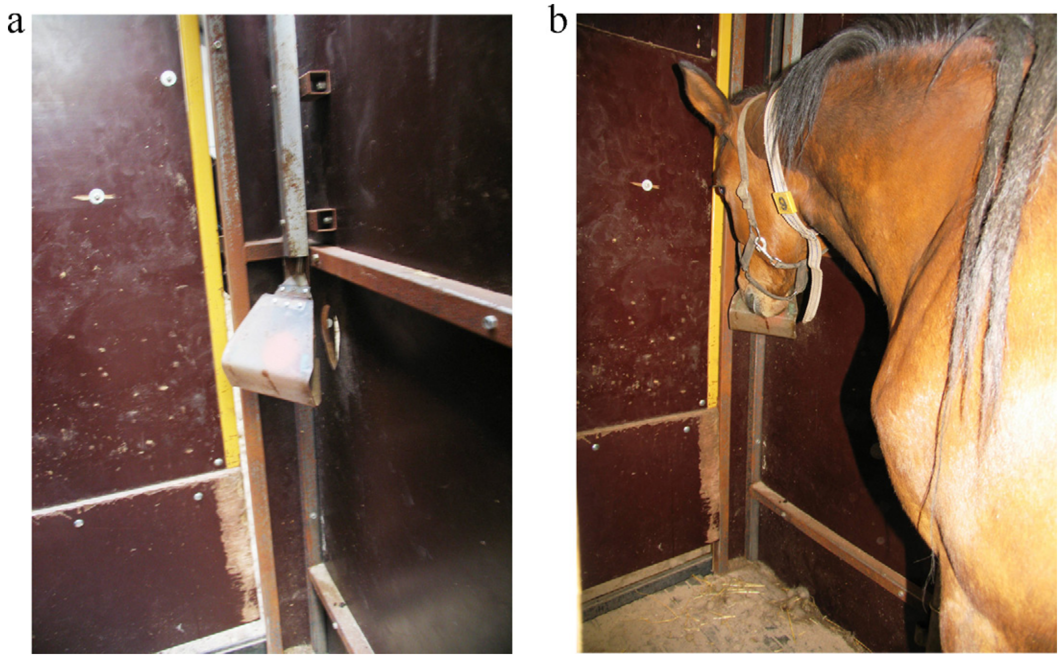

Fig. 2. Illustration of the operant panel (a) and a illustration of a horse pressing the operant panel (b).

Table 1
Experimental design.

Group	Horse	Period 1	Period 2	Period 3	Period 4
1	1	M[a]	H[b]	F[c]	C[d]
	2	F	H	M	H
2	3	H	M	F	M
	4	F	M	H	C
3	5	H	F	M	F
	6	M	F	H	C
4	7	H	F	M	C
	8	F	M	H	M

[a] Muzzle contact.
[b] Head contact.
[c] Full social contact.
[d] Control.

horses worked for head contact followed by full social contact.

2.4. Experimental conditions

The horses were tested in a cross over design with four periods of three 5-day weeks each. During the first three periods all horses worked for all three levels of social contact, one per week (Table 1), while in period 4 horses either worked for one of the 3 types of social contact, or an empty arena (Table 1). The empty arena control was not included until period 4 as demand for this resource was expected to be low and we wished to avoid the risk of response extinction. The horses were tested during daily test sessions of minimum 20 min and maximum 50 min. A random sequence of FR-values (8, 16, 24, 32 and 40) was used within each week. The horses went through 3 × 5 days of testing on each type of social contact with a new FR-value each day. The door opened at the completion of the specified FR-schedule and the horse could enter the arena. If the horse did not leave the start box within 1 min after the door had opened it was gently pushed out of the start box into the arena. After 3 min of access the horse was led out of the arena and back to the start box and the session continued. During the first 20 min the horse stayed in the start box even if pauses in pressing occurred. After 20 min the session was terminated if a pause in pressing exceeded 3 min.

Self-written software controlled door opening after a given number of responses on the panel, and collected the data for each session (number of responses, number of rewards and duration of test session (from entering the start box the first time until the session was terminated)). A monitor displayed these data during sessions in addition to time, time since last press, and time since last reward.

2.5. Statistical analyses

The first week of each period was viewed as training for a new type of contact and deleted. Thus the data set included 40 test sessions (2 weeks × 5 days × 4 periods). Data for the first three periods (the effect of type of social contact) and data for the 4th period (social contact compared to an empty arena) were analysed separately.

2.5.1. Analysis of the effect of type of social contact

Data for the number of rewards per test session and the duration of the test session were analysed according to model 1 using a variance component analysis (Littell et al., 1996). Prior to analysis the number of rewards was transformed by the natural logarithm after adding a constant of 1, and in the analysis of this variable the FR value was also transformed by the natural logarithm to obtain demand functions in log–log coordinates:

$$Y_{ijklm} = \mu_0 + \beta_0 X_m + \alpha_i + \beta_i X_m + \gamma_j + A_{kl} + A_{klj} + \varepsilon_{ijklm} \quad (1)$$

where Y_{ijklm} is the response variable, μ_0 is the expected mean level of the response variable, α_i is the effect of the ith type of social contact (muzzle, head, full), γ_j is the effect of the jth period (1, 2, 3). Furthermore, A_{kl} is the random effect of the kth animal (1, 2, 3, . . ., 8) within the lth group (1, 2, 3, 4), A_{klj} is the random effect of the kth animal within the lth group and the jth period, and ε_{ijklm} is the residual error. Finally, X_m is the FR-value (8, 16, 24, 32 and 40) and β_0 and β_i are regression coefficients. To account for the correlation between repeated observations of the same individual within week, this correlation was modelled as unstructured, i.e. no mathematical pattern was imposed on the covariance matrix (Littell et al., 1996, p. 99).

2.5.2. Analysis of social contact compared to an empty arena

In period 4 data for 'muzzle', 'head' and 'full' was grouped as 'social' and analysed separately according to model 2. Prior to analysis the number of rewards was transformed by the natural logarithm after adding a constant of 1, and in the analysis of this variable the FR value was also transformed by the natural logarithm to obtain demand functions in log–log coordinates:

$$Y_{im} = \mu_0 + \beta_0 X_m + \alpha_i + \beta_i X_m + \varepsilon_{im} \quad (2)$$

where Y_{im} is the response variable, μ_0 is the expected mean level of the response variable and α_i is the effect of the ith type of social contact (social, control) and ε_{im} is the residual error. X_m is the FR-value (8, 16, 24, 32 and 40) and β_0 and β_i are regression coefficients. To account for the correlation between repeated observations of the same individual within week, this correlation was modelled as unstructured.

2.6. Behavioural observations

The behaviour of the test horses while in the arena was recorded during the 3rd week of periods 1, 2 and 3 via video cameras. For each horse and session (1 week × 5 days × 3 periods) the duration of staying in proximity of the companion (within one m), as well as the duration of social sniffing, social grooming, social play behaviour and self grooming was recorded according to the descriptions given in Waring (2003). These variables were analysed according to model 1.

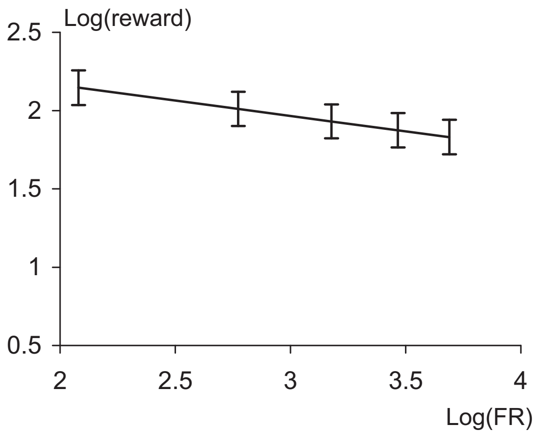

Fig. 3. The combined demand function for full, head and muzzle contact based on data from the first three periods. Standard errors are indicated.

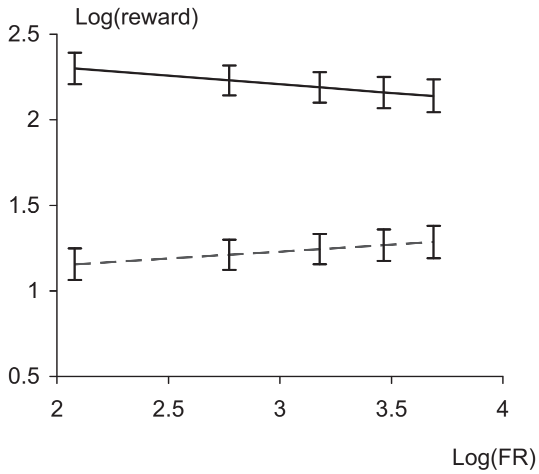

Fig. 4. The demand function for social contact (solid line) and an empty arena (hatched line) based on data from the fourth period. Standard errors are indicated.

3. Results

3.1. The effect of type of social contact

The type of social contact offered in the arena did not affect the demand for arena access and the following common demand function could be fitted in log–log coordinates ($y = 2.55 - 0.20x$ ($SE_{intercept} = 0.15$, $SE_{slope} = 0.034$), Fig. 3). The slope of this demand function was negative and significantly different from zero ($F_{1,141} = 32.33$; $P < 0.001$).

The duration of the test session decreased with increasing FR ($F_{1,118} = 11.96$; $P < 0.01$) from 48 min at FR8 to 42 min at FR40. The common function describing the decrease in test session duration as a function of FR was $y = 49 - 0.17x$ ($SE_{intercept} = 6.96$, $SE_{slope} = 0.05$).

There was no effect of period on any of the variables. The covariance parameter for animal within group and period was significantly different from zero (0.114 (SE 0.050); $Z = 2.28$; $P = 0.01$).

3.2. Social contact compared to an empty arena

Demand functions for social contact ($y = 2.51 - 0.10x$), and an empty arena ($y = 0.99 + 0.08x$ ($SE_{intercept} = 0.15$, $SE_{slope} = 0.042$)) differed. The demand function for an empty arena had a lower intercept than that of social contact ($F_{1,14} = 54.80$; $P < 0.001$; Fig. 4), and the slopes were significantly different ($F_{1,18} = 9.48$; $P < 0.01$). While the slope of demand for social contact was negative ($t_{1,18} = -2.42$; $P = 0.03$), the slope of the demand function for an empty arena was not significantly different from zero ($t_{1,18} = 1.93$; $P = 0.07$).

The duration of the test session was unaffected by FR, but shorter for an empty arena than for social contact (29 vs. 46 (SE 1.50) min; $F_{1,74} = 8.66$; $P < 0.01$).

3.3. Behavioural observations

Test horses stayed within 1 m of their companion for longer the lesser the degree of restriction of social contact during reward periods (Table 2). Test horses also performed more social play behaviour the lesser the degree of restriction of social contact during reward periods (Table 2). Test horses performed more social grooming when they had access to full social contact or head contact than muzzle contact, while they performed less self grooming when they had access to full social contact than head or muzzle contact (Table 2). A significant interaction between FR and contact type was found for social grooming ($F_{2,13} = 36.63$; $P < 0.001$); for full social contact the level of social grooming decreased with increasing FR (−0.03), while for head and muzzle

Table 2
Means and standard errors (SE) for the duration of the recorded behavioural elements when horses had access to full, head and muzzle contact.

	Contact type			SE[a]	$F_{2,33}$ =	P<
	Full	Head	Muzzle			
Duration (s per 3 min reward)						
Within 1 m[b]	12.2a (149)	7.89b (62.3)	3.70c (13.7)	0.62	24.89	0.001
Social play	27.24a	11.18b	0.28c	2.98	14.28	0.001
Sniff head/body[b]	0.94 (0.88)	1.02 (1.04)	1.30 (1.69)	0.11		
Social groom[b]	4.96a (24.6)	4.08a (16.65)	0.97b (0.94)	0.56	19.26	0.001
Self groom[b]	1.28b (1.64)	2.63a (6.92)	2.37a (5.62)	0.25	4.65	0.02

[abc]Within rows, values with different letters are significantly different ($P < 0.05$).
[a] Standard error of mean.
[b] Variables square-root transformed before analysis (back transformed estimates are given in brackets).

contact the slope was not significantly different from zero (0.01).

4. Discussion

Contrary to expectation, we did not find a higher demand for full social contact compared with either head contact or muzzle contact. However, as expected, the horses were more reluctant to work for access to an empty arena than for social contact.

The results show that young female horses will work for access to physical social contact during short daily test sessions if their routine daily access to social contact in the home environment is limited to visual, olfactory and auditory contact. The results also show that the demand for social contact is inelastic and thus the motivation is high.

The demand functions for the three different types of social contact did not differ, which suggests that full, head and muzzle contact are valued equally highly. We hypothesised that horses would value full social contact most followed by head and muzzle contact because the lesser the degree of restriction the more elements of social behaviour is possible. The behavioural observations confirm this; horses played more the lesser the degree of restriction of social contact, and full and head contact resulted in more social grooming. However, elasticities of demand functions do not support the hypothesis of a higher value of full social contact followed by head and muzzle contact. Therefore, it may be that horses do not distinguish between the three levels of social contact and that they value the interactions that are possible when they have muzzle, head and full contact equally highly. This is in contrast to the study by Christensen et al. (2002) where horses that had been individually housed with muzzle contact to the neighbouring horse for several months showed a rebound of social behaviour when full contact was subsequently permitted. The discrepancy between these two studies may be that in the present study the horses had access to full social contact during several hours once weekly to avoid any adverse long term effects of limited social contact.

Although it is a safer strategy to allow the target behaviour to be performed only during test sessions, we allowed social contact on Saturdays to avoid any adverse long term effects of limited social contact. This meant that the economy was open, i.e. an additional source of social contact was provided outside the test sessions. Previously, Ladewig et al. (2002) showed that an additional source of water before or after a daily test session increased the elasticity of the demand for water in rats, presumably because rats ingested more free water on days with a high operant cost. In the present study the horses could interact freely on pasture during 6–8 h on Saturdays, whereas on Sundays they remained in their home pens. If the free access on Saturdays had affected operant responding during tests sessions, we would have expected horses to work increasingly hard from Monday to Friday. This was checked in an initial explorative analysis and found not to be the case.

However, it cannot be ruled out that the free access to social contact in the present experimental set-up has affected the results, and in future studies free access to social contact out side the test session should be limited to a minimum.

In a previous study on dairy calves the motivation for full social contact was found to be higher than the motivation for head contact (Holm et al., 2002). The discrepancy between this and the present study may be due to species as well as age difference, but it may also in part be explained by differences in methodology; the calves in the afore mentioned study were prevented from physical as well as visual contact in their home pens, while the horses in the present study were prevented from physical, but not visual, contact in the home pens. It is possible that the horses were working to maintain visual contact with their companion, and only a set-up including a measure of motivation for access visual contact can test this hypothesis.

Horses were reluctant to work for an empty arena. This was illustrated by the lower intercept of the demand function for the empty arena. The slope of this demand function was inelastic, but this may be an artefact of the experimental plan. In the control situation the minimum session length of 20 min may have been too long because the horses may have perceived it as aversive to stand in the start box for 20 min. This may have resulted in them earning a few rewards irrespective of FR value.

The point that the horses may have perceived it as aversive to stand in the start box may also have caused them to work for arena access irrespective of type of reward. We generated single demand functions where the animal works for one resource at the time. However, in the present study we investigated the value of various degrees of social contact to provide an outlet for social motivation. When we focus on one particular motivation we may also consider the level of demand, or intercept. In addition, to identify those stimuli that best provide an outlet for a particular motivation it may be better to give the animal a choice and to impose a cost on that choice. One method that applies this approach is termed analysis of cross-points between concurrent demand functions (Sørensen et al., 2001; Jensen and Pedersen, 2008), where the animal is presented with two options of varying cost. The benefit of presenting the animal with such a weighted choice, rather than a range of prices for one opportunity, is that the animal has a cheaper alternative when the price of one option is high. Isolation, or limited social contact, may be so aversive to horses that in the present experiment they worked equally hard for muzzle, head and full social contact because there was no alternative.

In conclusion, the study shows that young female horses acquired an operant response to get access to social contact and that they are highly motivated for social contact. The finding that horses showed a similar and high motivation for all three types of social contact suggests that they perceived them to be of equally high value in a situation where the alternative is no physical social contact. Thus, horses should be given access to physical contact (minimum muzzle contact) in their home pens. Regarding methodology, future studies should explore if analysis of cross-points between concurrent demand functions for different types of social contact to horses is a more sensitive method to assess social motivation in horses. Finally, the extent to which measures of motivation correlate with other indicators of welfare could be examined in horses, as has been done for other species (Nicol et al., 2009).

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