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The effect of increasing visual horizons on stereotypic weaving: implications for the social housing of stabled horses

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Abstract

Stabled horses commonly perform stereotypic patterns of weaving, where the horse shifts its weight from side to side often swinging its head. Ten warm-blood types, of which five were known to reliably weave, were housed in similar 12 × 12 ft wooden loose boxes in a single stable block surrounding a courtyard. Each horse was exposed to each of five stable designs. These were: the conventional front top-half of the door open only with a view of the stable courtyard (F); front half-door open and a similar half-door open at the back of the stable with a view to the surrounding fields (FB); back open only (B); front and one-side panel open with a view into the adjacent stable (FS); and front, back and both sides open (All4). During observation days, horses were brought in from the field at 0830 h, fed concentrate at 0930 h, fed haylage at 1005 h and turned out at 1600 h. Behaviour was recorded from 0900 to 1040 h, 1200 to 1300 h and 1500 to 1600 h. Weaving was most common prior to feeding in the morning and prior to putting out to pasture in the afternoon. There was a significant effect of stable design on weaving, with less weaving in the FS and All4 designs than the F treatment. There was also a significant effect of stable design on repetitive nodding, though in this case, FB, B, FS and All4 designs each reduced nodding compared with the F treatment. The effect of stable design can be explained in a number of ways. Firstly, it could be the novelty of the environmental change, though there was no evidence in this study of an increase in stereotypy with prolonged exposure to the new stable designs. Secondly, opening windows may increase opportunities for environmental interaction, and the expression of new activities may compete with stereotypic behaviour for the horse's time. Thirdly, the open windows may allow expression of specific activities such as environmental

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monitoring or social interaction that are denied by the conventional stable.

Keywords: Weaving; Stereotypic behaviour; Stable; Horse; Social behavior

1. Introduction

A number of repetitive oral, head, limb and whole body movements have been described as stereotypic in stabled horses (Cooper and Mason, 1998; Nicol, 1999a), where stereotypic behaviour is defined as repetitive, relatively unvarying and apparently functionless behaviour patterns (Mason, 1991). A commonly observed whole body or locomotor stereotypy is weaving, which involves a weight shift from one side to the other. Weaving is usually accompanied by a lateral swaying movement of the head, though it can also involve the forequarters and sometimes hindquarters. This typically occurs whilst the horse is standing with the head over the stable door, though weaving can be performed in the main body of the stable (McGreevy et al., 1995a; Mills and Nankervis, 1999). Postal epidemiological surveys of stereotypic behaviour estimate that between 3% and 10% of stabled horses weave (McGreevy et al., 1995b; Luescher et al., 1998), though direct observation of stabled horses suggests that these questionnaire-based studies underestimate the prevalence of stereotypy in the stabled horse population (Nicol, 1999b).

Stereotypic behaviour in stabled horses is generally considered undesirable, because the repetitive activities are considered harmful or aesthetically unpleasant, because they may effect performance or because they are thought to be a reflection of poor quality of life (Cooper and Mason, 1998). Weaving, for example, may cause the untimely wearing of shoes and the legs to swell leading to lameness (McBane, 1994). Energy used whilst weaving may also cause the horse to lose condition so hard work such as racing may be impaired (Houpt, 1986). There is, however, little empirical evidence to support these claims. Nevertheless, preventative measures are often taken to reduce weaving, such as the use of an anti-weave grill. This consists of a v-shaped grill placed over the top of the stable door which prevents the horse from swaying from side to side whilst its head is over the door (Mills and Nankervis, 1999). Its effectiveness is, however, limited, as many established weavers appear to weave behind the door when weaving bars are fitted to their stable door (McBride, 1996).

A number of husbandry practices are thought to reduce stereotypy in stabled horses by increasing opportunities to perform alternative activities from the horse's behavioural repertoire. These include increased exercise or turning out (Krzak et al 1991; Luescher et al., 1998) and feeding high fibre feeds such as hay or alfalfa (Haenlein et al., 1966; Willard et al., 1977; McGreevy et al., 1995a). These changes in husbandry practice may reduce stereotypy through behavioural competition or they may reduce the underlying motivation to perform the activity itself. For example, high fibre feeds may reduce oral stereotypies by reducing the time available to stereotype or by reducing the motivation to forage through increased gut-fill or other feedback mechanisms associated with eating (McGreevy et al., 1995c; Cooper and Mason, 1998).

In this study, we investigated the effect of simple changes in stable design on the incidence of stereotypic weaving. We used treatments that altered the stabled horse's visual horizons, including a change in the single view from the stable, providing additional views over the external environment and providing a view into a neighbouring horse's stable. We were particularly interested in the response to modifications that increased opportunities for social interaction, as epidemiological studies had suggested that social isolation was a factor affecting the incidence of stereotypic behaviour in stabled horses (McGreevy et al., 1995a, Redbo et al., 1998). The study was also designed to take into account novelty, increased environmental complexity and increased opportunities to monitor the surroundings, as these factors could also reduce the incidence of stereotypic behaviour.

2. Materials and methods

2.1. Experimental subjects

Ten warm-blood type geldings were used in this trial. These were housed at the De Montfort University Equine Field Station at Caythorpe, Lincolnshire, UK. The horses came from a variety of backgrounds (Table 1). Five horses had been known to weave for at least 2 years before the beginning of the trial and five horses had not been observed weaving by the yard-staff prior to the trial.

2.2. Experimental protocol

Twelve similar 12 × 12 ft wooden loose boxes were used as the experimental stables. The loose boxes were in three rows of four, forming a U-shape around a central courtyard (Fig. 1). Each stable had four portals. These were the top half of the stable door with a view of the stable block and yard; a similar back window with a view of the surrounding fields; and two similar sized side openings with views into the adjacent

Table 1
The 10 horses used in the trial, with their age in years, the number of years that they had been known to be weaving, their breed and their history of use prior to the trial

Horse	Age	Years	Breed	History of use
Salesman	11	3	Thoroughbred	Dressage
Cruze	18	5+	Thoroughbred	Dressage
Boots	11	3+	Thoroughbred X	Eventing
Jerome	9	2+	Thoroughbred	Riding club
William	12	3	Hannoverian	Hunting
Tom	18	0	Thoroughbred X	Eventing
Buddy	14	0	Thoroughbred	Schooling
Geordie	12	0	Thoroughbred	Flat-racing
Lloyd	8	0	Thoroughbred	Flat-racing
Stoney	9	0	Thoroughbred	Flat-racing

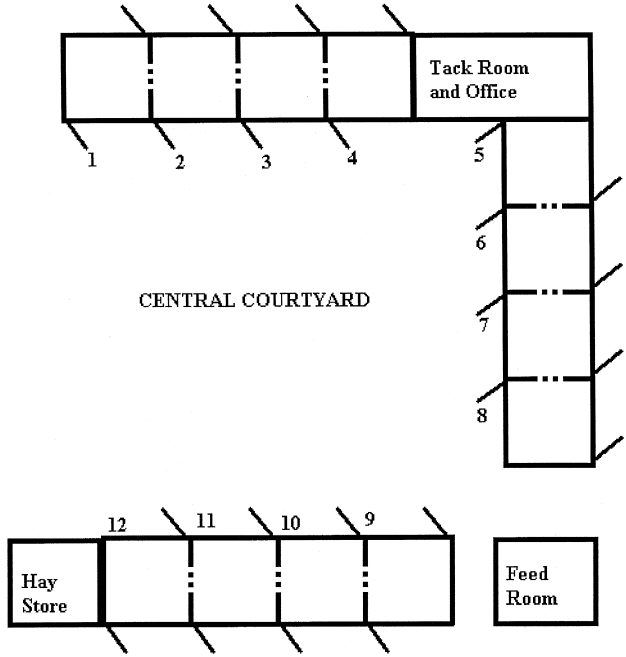

Fig. 1. The stable block showing the 12 stables around a central courtyard. Each stable has a single front opening with a view of the central courtyard, a single back window with a view of the surrounding fields and one or two grilled side windows with views into the adjacent stable.

stable, but with grills to restrict contact between horses. There was also a single, close glazed window in the front of each stable. The stables were bedded with either paper or shavings, according to the horse's normal management.

Each horse was exposed for a period of 5 days to each of five stable design treatments. These were: the conventional front half-door open only (F); front half-door open and rear half-door open (FB); rear half-door open only (B); front and one side grill open (FS); and front, back and both side grills open (All4). In each week, two horses were exposed to each treatment and a new stable location allocated to each horse according to a predetermined schedule (Table 2), which was designed to minimise order effects. At night and between each treatment, the horses were group housed in fields adjacent to the stable block for a period of 2 days. No other horses were housed in these paddocks during the period of the trial.

During observation days, horses were brought in from the field at 0830 h and fed concentrate at 0930 h. The concentrate ration consisted of 0.2 kg Quiet Pencils (Allen and Page, Norfolk Mill, Thetford), mixed with a ''double handful'' of Dengie Hifi (Dengie Crops, South Minster, Essex) and water for all horses except Tom, who received the same quantity of Hifi, but mixed with 1.0 kg Quiet Pencils and water. At 1005 h, the empty, concentrate buckets were removed and the horses received fresh haylage. They then remained largely undisturbed until 1600 h when they were returned as a group to the pasture.

Table 2
The stable and treatment for each horse in each week of the trial

Horse		Week1	Week2	Week3	Week4	Week5
Weavers						
Salesman	Stable	3	9	7	5	2
	Treatment	ALL4	FS	F	FB	B
Cruze	Stable	5	7	6	3	5
	Treatment	FB	B	F	ALL4	FS
Boots	Stable	8	2	3	4	6
	Treatment	FB	F	B	FS	ALL4
Jerome	Stable	6	4	10	1	3
	Treatment	F	FB	ALL4	FS	B
William	Stable	1	11	4	8	11
	Treatment	FS	ALL4	B	FB	F
Nonweavers						
Tom	Stable	2	3	12	10	12
	Treatment	ALL4	F	FS	B	FB
Buddy	Stable	12	1	9	2	10
	Treatment	B	FB	FS	ALL4	F
Geordie	Stable	4	6	11	7	9
	Treatment	FS	B	ALL4	F	FB
Lloyd	Stable	9	12	8	6	7
	Treatment	B	FS	FB	F	ALL4
Stoney	Stable	7	10	5	11	8
	Treatment	F	ALL4	FB	B	FS

On each treatment day, the horses were observed from 0900 to 1040 h, 1200 to 1300 h and 1500 to 1600 h. Behaviour was recorded by scan sampling each horse once every 2 min for the duration of each observation period. During this time, the observer walked a fixed route around the outside of the yard and into the central area so each horse could be observed without disturbance. A pilot study had been carried out for 2 days prior to the start of this study. This allowed refinements to the proposed methodology to be used in the main study. This time also assessed the potential for an observer effect on the behaviour of the horses during recording. Initially some horses responded to the presence of the observer, but they appeared to habituate quickly, i.e. within a couple of minutes. Observer effects were therefore believed to have been minimal in the main trial as the observer was in place before observations began.

At each scan, each horse's position and activity was recorded. The positions were ''Front'': head over front door; ''Back'': head over back door: ''Sides'': orientation towards side grill; and ''Inside'': head over neither door and in no specific orientation. The horse's activity could be divided into broad categories of behaviour, such as repetitive behaviour (including stereotypies), ingestive behaviour and general activity, which were then subdivided into more specific activities. The definition of stereotypic behaviour can lead to confusion as functional explanations have been offered for these activities. These include a general coping response as discussed by Cooper and Nicol

(1993) and Rushen (1993), or a means of expressing specific, functional patterns of behaviour within the limitations imposed by the captive environment (Nicol, 1999b). Wood chewing, for example, has been described as an adaptive response to a low fibre diet (Redbo et al., 1998) and may not be considered a stereotypy because it is quite variable in performance and because it may not be subject to emancipation from its original causal factors (Nicol, 1999b). Nevertheless, it may still be useful to consider wood-chewing with other repetitive oral activities as they share some descriptive homology and because wood-chewing may precede or be associated with the performance of oral stereotypies (Cooper and Mason, 1998; Nicol, 1999a).

For these reasons, care was taken to define behavioural categories in terms of their observable elements rather than their functional significance (Lehner, 1996) and although we distinguished between various repetitive oral activities during scan sampling, we grouped these rare activities together for analysis and presentation of results. ''Weaving'', therefore, was recorded if the horse repeatedly swung its head from side to side and ''Nodding'' was recorded if the horse repeatedly swung its head up and down. A number of repetitive oral activities were defined including: ''Wood-chewing'', where the horse bites and ingests wooden substrates; ''Crib-biting'', where the horse grasps and pulls on other surfaces such as the metal at the top of the stable door or the edge of the side grills; ''Bucket-biting'', where the horse bites at the rim or handle of a feed or water bucket; and ''Licking'', where the horse repetitively licks part of the stable such as the walls.

Ingestive behaviour was recorded as one of three activities: ''Feed'', if the horse was eating concentrate; ''Forage'', if the horse was eating haylage or bedding; and ''Drink'', if it was drinking water. If horses were not engaged in repetitive or ingestive behaviour, then their general level of activity was recorded as one of four types of activity. These were: ''Walking'', if there was any degree of ambulation; ''Alert'': horse standing with eyes fully open, ''Dozing'': horse standing motionless with eyes closed or semiclosed; and ''Lying'': sternal or lateral recumbence.

2.3. Analysis of data

For analysis, the data were divided into five observation periods. These were: from start of morning observation to feeding of concentrate (0900–0930 h, PreFeed); from feeding of concentrate to feeding of haylage (0932–1004 h, MidFeed); from feeding of haylage to end of morning observation (1006–1040 h, PostFeed); the first afternoon observation (1200–1300 h, Early Afternoon); and the second afternoon observation (1500–1600 h, Late Afternoon). The number of scans for each position and each activity was calculated as a percentage of the total number of scans for each observation period. This was angular transformed so it was suitable for parametric analysis. Individually, oral activities, such as woodchewing, cribbiting and licking, were rarely recorded in this study, so these were grouped as repetitive oral activities (''Oral'') for analysis.

Data were analysed in Minitab 12 using a repeated measure General Linear Model Analysis of Variance (ANOVA). In the ANOVA model, data were blocked by horse ($df = 8$) nested within prior classification as weaver or nonweaver ($df = 1$). The five stable designs ($df = 4$), 5 weeks ($df = 4$), 5 observation days of each week ($df = 4$) and five observation periods ($df = 4$) were used as factors. Interactions between day of

observation, observation period and stable design were also included in the ANOVA model which left 1112 residual degrees of freedom for analysis. The positional categories Front, Back and Sides could not be performed in all the stable designs and for these categories the appropriate factor and residual degrees of freedom are quoted in the results. Tukey's *t*-tests were used to further investigate the source of variation due to stable design.

Only one activity (eating concentrate) could not be analysed using this model, as horses only ate concentrate in the MidFeed observation period. Consequently, for feeding, the effects of stable design, horse, observation day and observation week were analysed using data only from the MidFeed observation. The effect of time of day was assessed by calculating the average time spent feeding in each of the five observation periods for each horse, and analysed using a Friedman ANOVA with data blocked by horse and time of day as a factor.

3. Results

3.1. The effect of stable design

The stable design significantly affected stereotypic behaviour in the horses (Fig. 2: Table 3). Weaving was reduced by opening additional doors, with less weaving with the FS (Tukey's *t*-test: $t = -2.81$, $p < 0.05$) and the All4 designs ($t = -2.95$, $p < 0.05$)

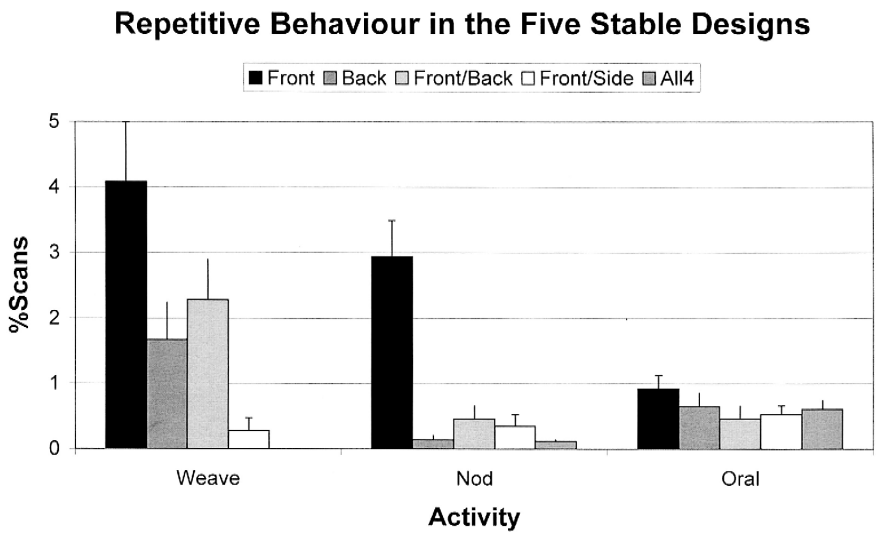

Fig. 2. The percentage of scans (mean ± standard error) observed in stereotypic weaving, stereotypic nodding and repetitive oral behaviour by the ten experimental horses in the five stable designs. Conventional front half-door open only with a view of the stable courtyard (Front). Front half-door open and a similar half-door open at the back of the stable with a view to the surrounding fields (Front/Back). Back open only (Back). Front and one side grill open with a view into the adjacent stable (Front/Side). Front, back and both sides open (All4).

Table 3
The mean percentage of scans observed in each category of behaviour in the five stable design treatments. Test statistic F calculated from ANOVA.
* $p < 0.05$, ** $p < 0.01$.
Data presented for all five treatments except,% Front which uses data from treatments F, FB, FS and All4, % Back from B, FB and All4 and % Sides which uses data from treatments FS and All4. Data for % Feed from MidFeed observation only

Behavioural category	Front only	Back only	Front and back	Front and side	All4	$F_{4,1112}$
Position						
Front ($F_{3,887}$)	43.9	–	35.1	29.7	27.2	24.3***
Rear ($F_{2,662}$)	–	29.9	11.4	–	6.6	109.8***
Sides ($F_{1,437}$)	–	–	–	4.5	5.8	3.53 ns
Inside	56.1	70.1	53.5	65.7	60.4	18.9***
Stereotypy						
Weave	4.08	1.67	2.28	0.28	0.00	9.71***
Nod	2.94	0.35	0.46	0.14	0.02	22.2***
Total	7.02	2.02	2.74	0.42	0.02	26.3***
Oral						
Feed ($F_{3,202}$)	32.8	26.6	30.9	32.8	34.0	1.99 ns
Forage	21.6	20.5	23.9	22.3	22.3	2.08 ns
Other	0.92	0.65	0.46	0.53	0.61	1.00 ns
Drink	0.34	0.15	0.44	0.26	0.22	2.19 ns
Activity						
Alert	34.6	29.2	41.9	32.9	37.1	10.2***
Doze	25.8	32.7	22.0	32.9	29.1	10.3***
Lie	0.04	0.29	0.13	0.81	1.05	2.13 ns
Walk	1.68	2.63	1.27	1.72	1.21	2.01 ns

*** $p < 0.001$.

than front alone. There was also a significant effect of stable design on nodding, though in this case all four new designs significantly reduced the behaviour compared with the conventional F design ($t < -3.99$ for each, all $p < 0.01$). In contrast, there appeared to be no effect of stable design on repetitive oral activities.

The stable design also had a predictable effect on where the horses spent their time (Table 3). For example, horses spent more scans with their head out of the front door, when this was the only available openings and more scans with their head out of the back door, when only the back door was open. There was also an effect of stable design on the activity of the horses (Table 3), with horses spending most scans standing alert with the FB design and least scans dozing. There was, however, no effect of stable design on lying or walking. There was also no difference in scans spent eating concentrate, eating forage and drinking between the five stable designs.

3.2. Activity in the observation periods and individual variation in behaviour

Overall, the horses spent about two thirds of scans standing but not engaged in any particular activity, either dozing (29.0% of scans) or alert (35.1% of scans). Eating

forage occupied 22.1% of scans, compared with 6.3% of scans spent eating concentrate and 0.3% of scans drinking. Only 1.7% of scans were spent walking and 0.5% of scans spent lying. The horses spent 3.1% of the scans performing stereotypic patterns of behaviour of which weaving took up 1.7% of scans and nodding 0.8% of scans. A number of other repetitive activities were observed in our horses. The majority of these were oral activities, including cribbing, wood-chewing, repetitive licking and scraping their teeth along the side grills and chewing the edge or the handle of the food bucket. In total, these accounted for only 0.6% of scans with only one horse spending more than 1% of scans on these activities (Table 4).

There was considerable individual variation in many of the behavioural categories (Table 4), including weaving ($F_{8,1112} = 4.54,\ p < 0.01$), as would be expected on the basis of the selection of the experimental subjects. Two of the five anticipated ''nonweavers'' were also observed weaving but this was a rare occurrence (Table 4). There was also individual variation in nodding ($F_{9,1112} = 8.34,\ p < 0.001$) with three nonweavers and one ''weaver'' showing no nodding and three horses including one ''nonweaver'' and two ''weavers'' spending more than 1% of scans nodding.

There was individual variation in where the horses spent their time, including scans with head out of the front window ($F_{9,887} = 6.61,\ p < 0.001$), back window ($F_{9,662} = 19.5,\ p < 0.001$) and orientated towards the sides ($F_{9,437} = 9.27,\ p < 0.001$). Consequently, there was also individual variation in scans spent inside the stable ($F_{9,1112} = 11.5$, $p < 0.001$). Horses also consistently varied in scans of standing dozing ($F_{9,1112} = 13.3$, $p < 0.001$), standing alert ($F_{9,1112} = 6.97,\ p < 0.001$), eating concentrate ($F_{9,202} = 5.89$, $p < 0.001$), eating forage ($F_{9,1112} = 7.19,\ p < 0.001$) and drinking ($F_{9,1112} = 2.09,\ p < 0.05$). The number of scans recorded lying and walking did not significantly vary between horses. As would be expected, weaving was more commonly observed in the

Table 4
Mean number of scans observed in selected patterns of behaviour for the 10 horses. Data presented for all five treatments except, % Front which uses data from treatments F, FB, FS and All4 and % Sides which uses data from treatments FS and All4. Data for % Feed from MidFeed observation only

Horse	% Weave	% Nod	% Oral	% Feed	% Front	% Sides	% Inactive
Weavers							
Salesman	1.00	2.05	0.56	39.4	23.2	7.5	21.2
Cruze	9.02	0.05	0.62	37.6	41.5	4.7	21.8
Boots	5.87	0.25	2.36	28.8	39.9	13.8	22.8
Jerome	0.36	1.55	0.39	26.8	32.5	5.0	37.5
William	0.32	0.00	0.15	24.7	28.9	2.1	42.2
Mean	**3.31**	**0.78**	**0.82**	**31.5**	**34.7**	**6.6**	**29.1**
Nonweaver							
Tom	0.00	0.00	0.05	44.8	32.6	0.3	27.4
Buddy	0.00	0.00	0.54	28.0	39.2	6.5	31.7
Geordie	0.00	0.00	0.10	32.0	27.4	3.2	37.7
Lloyd	0.05	0.87	0.59	22.4	39.7	5.1	26.0
Stoney	0.10	2.95	0.95	29.9	34.9	3.7	21.3
Mean	**0.03**	**0.76**	**0.45**	**31.4**	**33.2**	**3.8**	**28.8**

''weavers'' than the ''nonweavers'' ($F_{1,1112} = 12.6,\ p < 0.001$), but there were no other differences in the behaviour of ''weavers'' and ''nonweavers'' (Table 4).

There was a significant correlation between scans spent weaving and scans spent drinking in our horses (Pearson correlation, $n = 10,\ r = 0.739,\ p = 0.015$). This was, however, the only significant correlation of all the available activities apart from an inverse relationship between scans spent inside and scans spent with head over back door (Pearson correlation, $n = 10,\ r = -0.675,\ p = 0.032$). No other associations were found between level of stereotypic activity and any other activity and there was no obvious relationship between the tendency to stereotype and age, breed or prior experience in our sample population.

3.3. Differences between the five observation periods.

Time of day had a major effect on the horses' behaviour with significant variation in most patterns of behaviour. Weaving showed a peak prior to the arrival of concentrate and prior to returning to pasture (Fig. 3). Consequently, weaving was most common in the PreFeed and Late Afternoon observations (Table 5). Nodding also showed peak performance prior to the arrival of concentrate and prior to returning to pasture (Fig. 3), and was more common in the PreFeed and Late Afternoon observations than during the MidFeed, PostFeed and Early Afternoon observations (Table 5). In contrast, repetitive oral activities were very rare in the PreFeed and PostFeed observations, but more common between consumption of concentrate and delivery of fresh haylage and again

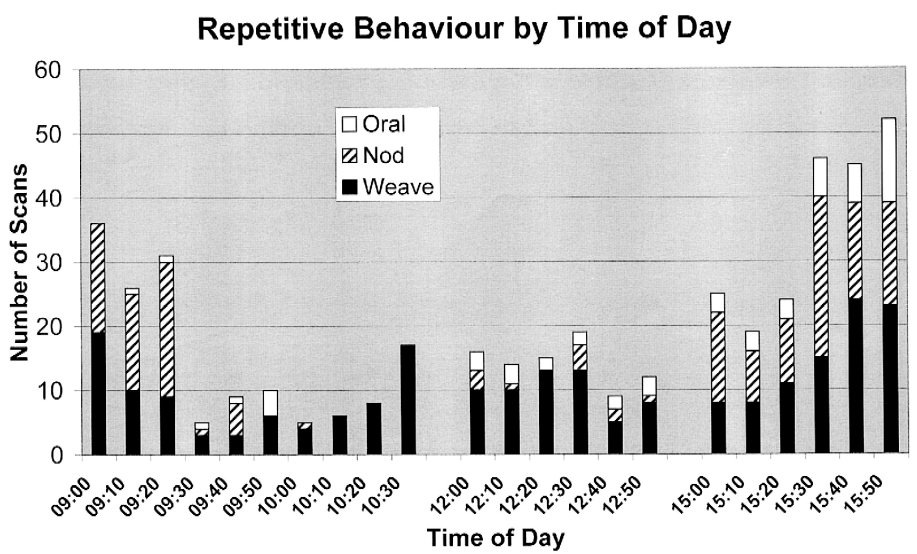

Fig. 3. The number of scans observed in stereotypic weaving (Weave), stereotypic nodding (Nod) and repetitive oral behaviour (Oral) by the 10 experimental horses in each 10 min section of the morning (0900–1040 h) and two afternoon observations (1200–1300 h, 1500–1600 h). Horses were fed concentrate at 0930 h, Haylage at 1005 h and returned to the pasture at 1600 h.

during the Early Afternoon observation and most common in the Late Afternoon observation prior to returning to pasture.

Eating concentrate was only observed in the MidFeed observation, with a peak in performance at the start of this period, which inevitably declined as most horses finished their ration (Fig. 4). There was also a peak in forage consumption following the delivery of fresh haylage, which continued throughout the duration of the PostFeed observation when horses were scanned eating haylage for nearly all of the observation period (85% of scans). By the start of the Early Afternoon observation, 2 h following delivery of haylage, forage consumption had returned to predelivery levels (Table 5). Although drinking was a rare activity in all five observation periods, there was also variation in drinking between the five observation periods with most drinking in the Early Afternoon and least drinking during the PreFeed and Late Afternoon observations.

Table 5
The mean percentage of scans observed in each category of behaviour in each of the five observation periods: PreFeed, in the half hour before the arrival of concentrate; MidFeed, between arrival on concentrate and arrival of haylage; PostFeed, in the half hour following delivery of haylage; EarlyAft, in the undisturbed hour from midday; and LateAft in the hour before returning to pasture. Test statistic F calculated from ANOVA.
* $p < 0.05$.
Data presented for all five treatments except, % Front which uses data from treatments F, FB, FS and All4, % Back from B, FB and All4 and % Sides which uses data from treatments FS and All4. Data for % Feed analysed using Friedman ANOVA

Behavioural category	PreFeed 0900–0930 h	MidFeed 0932–1004 h	PostFeed 1006–1040 h	EarlyAft 1200–1300 h	LateAft 1500–1600 h	$F_{(4,1112)}$
Position						
Front ($F_{2,887}$)	71.2	33.0	15.1	15.9	34.6	184.1***
Rear ($F_{2,662}$)	20.8	16.4	3.8	14.8	24.2	109.8***
Sides ($F_{2,437}$)	4.00	5.53	0.75	6.58	9.06	15.3***
Inside	29.0	61.5	85.3	75.8	54.2	190.8***
Stereotypy						
Weave	2.03	0.45	1.22	1.41	3.19	3.71**
Nod	2.05	0.21	0.03	0.27	1.36	11.6***
Total	4.07	0.66	1.25	1.68	4.55	10.7***
Ingestion						
Feed	0.00	31.4	0.00	0.00	0.00	40***
Forage	4.05	4.96	85.6	6.48	9.56	1678***
Other	0.33	0.69	0.13	0.67	1.35	7.29***
Drink	0.13	0.27	0.35	0.52	0.15	4.56**
Activity						
Alert	67.0	36.8	6.6	23.0	42.4	230.5***
Doze	17.0	21.0	4.9	62.5	37.1	232.7***
Lie	0.13	0.24	0.18	1.78	0.00	5.94***
Walk	2.38	1.49	0.75	1.75	2.17	5.63***

*** $p < 0.001$.
** $p < 0.01$.

There were also changes in the horses' general activity during the day (Table 5). Horses spent most scans dozing in the Early Afternoon, with less dozing in the morning observations. Horses spent least scans standing alert and dozing in the PostFeed observation, when most of the observation period was occupied by eating haylage. At other times of day, standing alert appeared to be inversely related to dozing with few scans of alert in the Early Afternoon and the most in the PreFeed observation and Late Afternoon. There was also an effect of time of day on lying and walking with most lying in the quiet Early Afternoon, and more walking in the PreFeed and Late Afternoon observations.

The position of the horses within the stable also varied across the day (Table 5). Horses spent most scans with their head out of the front door in the PreFeed observation and few scans with head out of front window in the PostFeed and Early Afternoon observations. Head out of the back window and orientation towards the sides showed similar patterns over the course of the day. Both were least common in the PostFeed observation, when horses spent most scans inside eating forage. In addition, both were most common in the Late Afternoon observation. As a consequence, horses were most commonly observed inside the stable during the PostFeed observation, with least scans in the PreFeed observation and fewer scans in the Late Afternoon, than during the Early Afternoon (Table 4).

3.4. The effect of day and week of observation.

There was little variation in the horses' behaviour over the 5 observation days. There was a significant effect on scans dozing ($F_{4,1112} = 7.77,\ p < 0.001$), which were less

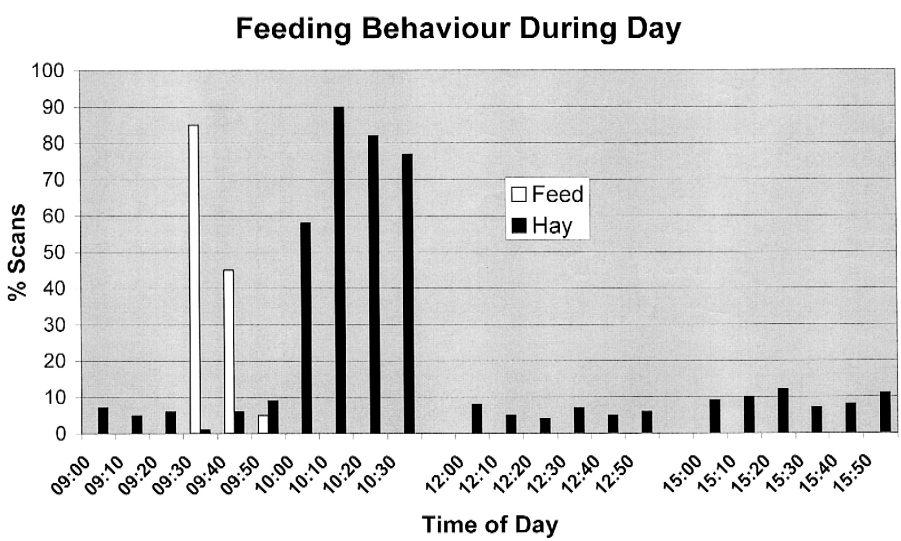

Fig. 4. The mean percentage of scans observed in eating concentrate (Feed) and eating forage (Forage) by the 10 experimental horses in each 10-min section of the morning (0900–1040 h) and two afternoon observations (1200–1300 h, 1500–1600 h). Horses were fed concentrate at 0930 h, Haylage at 1005 h and returned to the pasture at 1600 h.

commonly observed on the first day of exposure (22.1% of scans), than on the second (28.5%), third (30.2%), forth (28.5%) and fifth (33.2%) days (Tukey $t > 2.85$, $p < 0.05$ for each day). There were also significant effects on scans of horses with head out of the rear window ($F_{4,662} = 3.50$, $p < 0.01$), eating forage ($F_{4,1112} = 2.43$, $p = 0.046$) and other oral activities ($F_{4,1112} = 2.38$, $p = 0.05$). There was no effect of observation day on weaving or nodding over the 5 days of exposure to each design with 4.0% of scans engaged in these activities on the first observation day compared with 3.0%, 2.0%, 3.3% and 3.0% on each successive day.

Scans where horses were observed engaged in stereotypic activities did, however, vary over the course of the five weeks of the experiment ($F_{4,1112} = 11.9$, $p < 0.001$). Both weaving and nodding were affected by the week ($F_{4,1112} > 4.95$, $p < 0.001$) and there appeared to be a lower incidence of stereotypy in the last two weeks (1.41% and 0.73% of scans, respectively) than the first three weeks (5.03%, 2.74% and 5.45%) of the experiment. No other activities were affected by the week of the trial period.

4. Discussion

Providing additional fields of view reduced the incidence of stereotypic weaving in stabled horses that had been known to reliably weave for at least 2 years. In particular, no weaving was recorded in any of the 10 horses where all 4 doors were open. This effect appeared to be associated with increased opportunities for interaction with neighbouring horses, rather than alternative views per se, as opening front and side was almost as effective at reducing weaving as opening all four windows, whereas opening the back window without side windows did not reduce weaving. Although weaving was the focus of the study, there was also an effect on the incidence of nodding, and whilst this effect was strongest with all four windows open, any change in available windows resulted in less nodding than the conventional stable layout. No significant effect was found on repetitive oral activities, though these activities were rare in our selected population, and consequently difficult to sample using the scanning techniques chosen. The effect of changing stable design on the incidence of weaving and nodding can be explained in a number of ways.

Firstly, it could be the novelty of the environmental change. In this case the response may weaken as the horse habituates to the new environment, and stereotypic behaviour may resume with time. There was, however, no evidence of any increase in stereotypic behaviour over the 5 days of exposure to each design, with similar time spent on stereotypy on the first observation day as on the subsequent 4 days. In addition, there was less weaving seen in the fourth and fifth weeks of the experiment than the first, second and third weeks, which suggests that horses became less likely to weave as they got used to the experimental set up with time. Despite the lack of evidence for habituation to the changes in stable design in our horses, it would, nevertheless, be worthwhile to conduct a longer-term study, where horses are exposed to the treatments for weeks if not months to check for the long lasting effects of the stable changes, since horses are known to weave in boxes that allow an extensive view of the surroundings and the potential to interact with con-specifics (McGreevy et al., 1995a).

An obvious effect of opening more windows is that this may allow the expression of a greater range of activities. This could reduce the performance of stereotypies in two ways. Firstly, opening windows may increase opportunities for environmental interactions that are not directly related to the primary motivations underlying the stereotypies and the expression of new activities may compete with stereotypic behaviour for the horse's time (Mason, 1991). Alternatively, the open windows may allow expression of specific activities that are denied by the conventional stable and expressed as increased repetitive activities such as weaving (Mason, 1991; Rushen et al., 1993; Cooper and Mason, 1998). The study was not specifically designed to discriminate between stereotypy as a time filling behaviour or as a response to specific behavioural restrictions, but rather to assess the merits of a practical solution to weaving in established weavers. In practice, both explanations are viable. Stereotypic behaviour may develop as a response to specific environmental restrictions experienced in the stable, but may also increase in the horses' behavioural repertoire in the absence of many other competing environmental stimuli. More detailed sequence analysis, rather than simple scanning, would be necessary to clearly distinguish between these latter two hypotheses, though it is possible to speculate from data gathered in this study.

In addition to the effect on weaving and nodding, changing the stable design had a major effect on where the horses chose to position themselves. With alternative or additional fields of view, the horses were less commonly observed with their head out of the front door and more commonly scanned when they were orientated towards the other available portals. This alone might explain the decrease in weaving and nodding, as these activities are principally carried out by horses whilst holding their head out of the front door of their stable. There does, however, appear to be more to the effect of increasing field of view than reducing time spent with the head out of the front door. Horses could and did use the back door for weaving (albeit less often than the front door) and although FB and All4 produced similar drops in front orientation, All4 resulted in no observations of weaving in our experimental horses, whilst weaving was still commonly observed in the FB design.

The decrease in stereotypic behaviour with the increased field of view could support the hypothesis that stereotypic behaviour is a time filling activity (Mills and Nankervis, 1999) or a response to boredom (Kiley-Worthington, 1987). If increased fields of view provide environmental distractions or greater opportunity to monitor the surroundings, then there is less time to spend on a time filling activity such as a stereotypy. Overall, however, the evidence for stereotypy as a time filling activity was poor in this study. The horses may have performed little stereotypic weaving in the MidFeed and PostFeed observations when there was a high degree of behavioural competition from feeding activities, but stereotypy was also rare in the Early Afternoon observation when there was little environmental disturbance and horses spent most scans dozing and inactive. Furthermore, weaving was most common prior to stimulating environmental disturbances such as receiving concentrate and the return to pasture (Fig. 3), when the horses' general activity was also at its greatest.

These findings are, however, consistent with weaving acting as a response to specific motivational states related to motivationally significant events as has been suggested by other studies of the daily patterning of stereotypic behaviour. Weaving is conventionally

thought to be a prefeeding stereotypy with a peak in weaving immediately prior to feeding concentrate (Henderson et al., 1997). In contrast, oral stereotypies are often thought of as post feeding behaviour (Gillham et al., 1994; McGreevy et al., 1995c), representing the perseverance of feeding or foraging motivation following a short, concentrated feed (McGreevy and Nicol, 1998).

In our study, we found a low incidence of repetitive oral activities following feeding of concentrate, but this can be simply explained. The horses were provided with fresh haylage shortly after they received their concentrate, so they could direct any foraging motivation towards an appropriate substrate. Many studies have found that providing high fibre feeds such as hay significantly reduces stereotypy in horses (Willard et al., 1977) and it has been suggested that oral stereotypies and eating forage are behavioural substitutes (McGreevy and Nicol, 1998).

Housing in a stable places limitations on the horse's ability to perform a number of activities including monitoring the environment, controlling feed intake and performing social behaviour. Our changes in stable design did not increase opportunities to forage, but they did increase the opportunities to perform both monitoring and social behaviour, both of which are likely to be phylogenetically important activities to the horse. Opening the back door provided an alternative or additional field of view, whereas opening the side grills not only provided a view into the adjacent stables, but also allowed the horse greater opportunities to interact with its neighbours. The opening of the side portals had the strongest effect on stereotypy, with FS treatment having a similar effect to All4, whereas in the FB, the horses still spent much time weaving. Opening the side windows did not allow horses to perform all social interactions, as the grills restricted tactile interactions, but horses were nevertheless able to see each other.

Several authors have speculated that social housing can reduce stereotypy (McGreevy et al., 1995a; Cooper and Mason, 1998; Nicol, 1999a). To date, there have been no other systematic investigations into the direct effect of reducing social isolation on the incidence of stereotypic behaviour in stabled horses, but a number of epidemiological studies support the hypothesis. In their study, McGreevy et al. (1995a) found that box designs that allowed visual contact between horses were associated with a lower level of stereotypic behaviour, whilst Redbo et al. (1998) reported less social contact with companions as one of several factors that resulted in a higher incidence of stereotypic behaviour in Thoroughbred race-horses compared with Standardbred trotters.

Increasing social contact between stabled horses can, however, lead to behavioural problems. Our horses formed part of a stable social group, who were turned out together and were, consequently, very familiar. Housing unfamiliar horses, or horses with aggressive tendencies may allow antagonistic social interactions which may decrease the horses' quality of life. In addition, there is a concern about the social facilitation or copying of stereotypies in stabled horses (Kiley-Worthington, 1987; McBane, 1994). Whilst there is no empirical or scientific evidence that housing a known weaver or cribber on a stabled yard suddenly ''infects'' previously nonstereotypic horses, there is, however, the potential for social transmission of behaviour within a group of horses. A number of studies have investigated social learning in the horse and these have generally found that adult horses do not efficiently use observational learning to guide behaviours such as feeding preferences (Baker and Crawford, 1986; Nicol, 1999a). In our study, it

was noted that opening the side grills provided an additional potential cribbing surface and that occasionally when one horse used the window edge to crib, its neighbour would show interest in the cribbed area. Although we saw no evidence that the observing horse, subsequently, cribbed itself, local enhancement is a potential mechanism for the social transmission of behaviours (Nicol, 1995).

In conclusion, our study found that increasing visual horizons significantly reduced established patterns of stereotypic weaving and nodding in stabled horses particularly if they provided additional opportunities to view or socially interact with neighbouring horses. This was, however, a relatively short term study conducted on a stable social group of horses with a rigid routine, but there is no evidence that increasing social opportunities had any adverse effects on our horses or that the effect of changing stable design wore off with time.

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