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The role of the image of a conspecific in the regulation of stereotypic head movements in the horse

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Abstract

Weaving is a common locomotor stereotypy in horses, which has been shown to be reduced by the presence of a mirror in the stable; however, it remains unclear whether this effect is due to the reflected image of a horse or some other property associated with the introduction of a mirror. To investigate this further, the response of six known weaving horses to each of three different types of poster was recorded. The poster images consisted of a life-size image of a horse's face (true image), a version of the same image cut into 54 squares, which were then randomly rearranged (pixilated image) and a blank (white image) display of the same size as the other posters. Four observation periods were included in each of the two days of observation per treatment condition: 08:00–08:30 h, 10:00–10:30 h, 12:00–12:30 h and 16:00–17:00 h. The first observation period was followed by the provision of concentrate feed and forage, the second observation period by exercise, the third by further forage and the fourth by concentrate feed and forage. The horses' activities and positions in the box were scanned at 1 min intervals and the number of observations registering each activity and position was calculated as a percentage of the total number of observations for each observation period.

Weaving was significantly less when the horses were provided with the image of a horse's face (mean percentage of observations $\pm$ S.E.M.; 5.56 ± 1.57), compared to both the pixilated (14.85 ± 3.06) and white (20.52 ± 4.12) images. Nodding was significantly less when provided with the true image of a horse (0.45 ± 0.15) compared to the pixilated image (2.15 ± 0.67). The

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pattern of weaving throughout the day differed from that of nodding, and together these results suggest that the two behaviours are not analogous. The presence of the image of the horse's face was associated with a significant increase in alertness ($F_{112,2} = 11.31, p < 0.001$) and recorded time spent looking at the poster($F_{112,2} = 3.46, p < 0.05$). The timing of stereotypic head movements in the horse in this study suggests that they are not associated with boredom, or lack of stimulation but rather acute frustration.

Keywords: Behaviour; Horse; Nodding; Perception; Stereotypy; Vision; Weaving

1. Introduction

Weaving is a form of locomotor stereotypic behaviour, which is defined as an obvious repetitive lateral movement of the head, neck, forequarters and sometimes hindquarters (McGreevy et al., 1995). This behaviour is visible often while the horse is standing with its head over the stable door, though weaving can be performed inside the stable (Cooper et al., 2000).

Horses are social animals, which naturally graze for a high proportion of their time and prefer to be with conspecifics (Clutton-Brock et al., 1976). However, the amount of time spent foraging, socialising and exercising by stabled horses is controlled frequently to a great degree by humans (Mills and Clarke, 2002). It has been suggested that this restriction can cause frustration, which results in a variety of behaviour problems including stereotypic behaviour patterns, such as weaving (Mills and Nankervis, 1999). However, not all horses in a similar environment show stereotypic behaviour.

It is sometimes believed that weaving affects performance (McBride and Long, 2001), inducing fatigue, uneven muscle development of the neck, inefficient feed utilisation, weight loss and may exacerbate sub-clinical orthopaedic conditions (Broom and Kennedy, 1993; Ralston, 1982; Winskill et al., 1995). It may also reduce the value of the horse (McBride and Long, 2001), so it is not surprising that many owners take steps to prevent its occurrence. Many horsemen believe that this behaviour can be learnt or copied by other horses and may refuse to allow weaving horses to be housed on their premises (McBride and Long, 2001); alternatively, weaving horses may be isolated from their companions. By contrast, weaving has been reduced significantly when horses are allowed social contact with a conspecific in an adjacent stable by means of a grilled side window (Cooper et al., 2000) or mirror (Mills and Davenport, 2002; McAfee et al., 2003). Whilst the efficacy of a mirror in reducing weaving might suggest that the social element is important, it is possible that the effect is due to some other factor associated with a change in visual input, such as apparent space or light. If weaving responds specifically to visual social cues in the environment, it might be that a poster image of a horse could also reduce weaving but an equivalent image not organised in this form would fail to have this effect, since, Kendrick and Baldwin (1987) have demonstrated that cells in the temporal cortex of sheep respond differentially to faces of sheep of their own breed, different breeds, humans and dogs. Therefore, the aim of this study was to investigate the importance of certain key visual features in the control of weaving behaviour and other repetitive behaviours like nodding,

which frequently occur at similar times, by determining whether a two-dimensional image of a horse's face would reduce weaving more than control images.

2. Materials and methods

2.1. Subjects

Six known weaving horses (Table 1) were used in this study. All horses were housed at the University of Lincoln's former Equine Field Station in Caythorpe, Lincolnshire, UK. All horses received the same management regime and were stabled full time.

2.2. Experimental apparatus

The horses were housed in six timber loose boxes with traditional two-part stable doors plus windows to the front, looking out onto the centre of the yard (Fig. 1) for six days. Five out of the six boxes measured 3.5 m × 3.5 m and one (stable 4) measured 3 m × 3.5 m. All boxes were made up with half a bed of paper cuttings (Paper Bedding Supplies, Springwood Farm, Newark, UK) on rubber matting according to British Horse Society routines.

The management regimen for all the horses was the same for each day of the experiment. The horses were fed a concentrated feed and forage from 08:30 h, mucked out between 08:45 and 09:45 h, lunged for 20 min between 10:30 and 11:30 h, given forage from 12:30 h and given their last feed of the day consisting of a concentrate feed and forage from 17:00 h and then mucked out.

Three treatments were applied to each horse in its own box. These consisted of the introduction of three different posters measuring 0.9 m × 0.6 m. The true image treatment (ti) was a life-size picture of a bay horse's face: the size of the face measured 0.67 m × 0.23 m (untitled image reference number 1687, The Poster Shop, Covent Garden, London). The pixilated image treatment (pi) was the same image of the horse's face cut into 54 squares, which were randomly reassembled into an equivalent shaped poster. This presented the same total visual input, but not in the form of a horse, and the blank treatment (b) was a blank white poster of the same size. All posters were covered with a mat laminate (Repropoint, Woking, Surrey) and were protected with 2 mm extruded

Table 1
Details of horses used in the study

Horse	Age (years)	Years known to weave	Breed	Sex
Cruze	22	8+	Thoroughbred	Gelding
Jerome	13	5+	Thoroughbred	Gelding
Spot	18	1/2	Appaloosa X	Gelding
Nimmy	28	15	Thoroughbred X	Gelding
Chester	17	5	Thoroughbred	Gelding
Corky	9	5	Hanoverian X	Mare

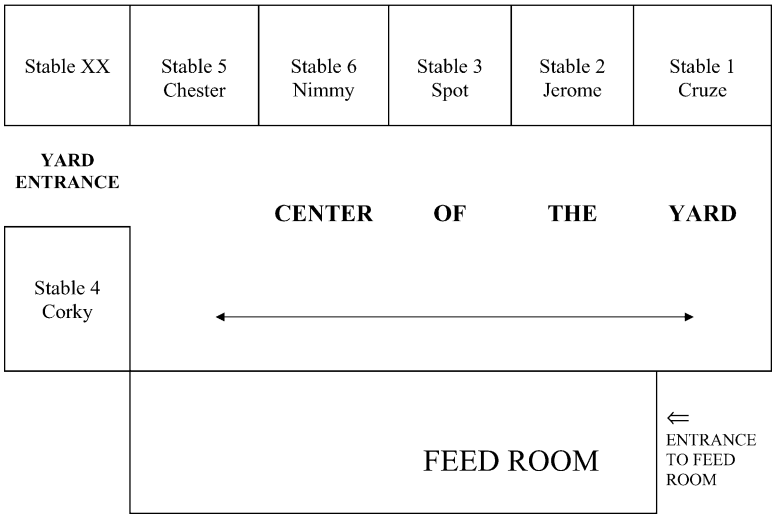

Fig. 1. Yard layout (not to scale). Double-headed arrow represents position of the experimenter during behavioural recording.

acrylic perspex with an anti-glare finish (Plastic Plus Ltd., Nottingham). They were fixed onto the wall whilst the horse was removed from the box at approximately 18:00 h the night before observations began. The posters were placed approximately 0.75 m from the front of the sidewall nearest to the stable door and approximately 1.4 m from the floor. The horses were then returned to the box.

A within subjects design was used with each horse exposed to each of the three treatments for two consecutive days. Observations were made on both days. To control for order effects, the sequence of treatments for each subject was different since there are six orders in which three treatments may be administered to a subject.

2.3. Behaviour measurements

There were four observation periods each day. Since it has been reported that weaving tends to occur mainly before feeding and exercise (Cooper et al., 2000; Houpt and McDonnell, 1993; Henderson and Waran, 2001), the first observation period was 08:00–08:30 h before the horses were provided with a concentrate feed and forage. The second observation period took place from 10:00 to 10:30 h before the horses were exercised. All horses were then lunged for 20 min between 10:30 and 11:30 h. The third observation period took place from 12:00 to 12:30 h before the horses were given forage again. The fourth observation period was from 16:00 to 17:00 h before the horses were provided with their final concentrate feed and forage. The horses were given 15 min to habituate to the observer, before observations began. The observer treaded a path of about 5 m from each stable, as indicated in Fig. 1, during this time and throughout the observation periods.

Intermittent instantaneous scan sampling of each horse's position and activity was performed once per minute using a pre-designed ethogram, developed from earlier pilot observations and those used in previous published studies (Cooper et al., 2000; McDonnell and Haviland, 1995; McGreevy et al., 1995; Mills and Davenport, 2002). Since posters were placed close to the stable door in a position similar to that occupied by the mirror in earlier studies (Mills and Davenport, 2002), the observer was not blinded to the treatment conditions.

The horses' activities were recorded using the following as mutually exclusive activities.

Weaving (*W*): an obvious lateral swaying movement of the head, neck, forequarters and sometimes the hindquarters (McGreevy et al., 1995).
Head nodding (*HN*): repeated raising and lowering of the head (Cooper et al., 2000).
Pawing (*P*): one front leg lifted from the ground slightly, then extended quickly in a forward direction, followed by backward movement dragging the toe against the ground in a digging motion (McDonnell and Haviland, 1995).
Oral behaviour (*ORB*): any repetitive behaviour, such as crib biting and licking parts of the stable door and walls (Cooper et al., 2000).
Alert (*A*): horse standing with its head and ears orientated towards a stimulus (poster excluded), the eyes wide open (adapted from Mills and Davenport, 2002).
Dozing (*D*): static posture, eyes closed/semi-closed, bottom lip slack, losing contact with upper lip (adapted from Cooper et al., 2000).
Ingestion (*I*): chewing and/or swallowing food or water.
Muzzling (*MZ*): horse actively touching/manipulating a physical object with its muzzle (poster excluded) (adapted from Mills and Davenport, 2002).
Head threat (*HT*): head lowered with the ears pressed caudally against the head and neck, and neck extended towards the target (McDonnell and Haviland, 1995).
Alert looking at poster (*AP*): horse facing the poster, with its head and ears orientated towards the poster and eyes apparently directly towards the poster.
Biting poster (*BP*): horse biting the poster.
Touching poster with muzzle (*MZP*): horse touching the poster with its muzzle or licking it.
Other behaviour (*OB*): any other behaviour that cannot be described by any of the above.

The horses' positions were recorded using the following as mutually exclusive categories:

Head over stable door (*HD*): horse standing at stable door with its head over the door, looking out of the stable (Mills and Davenport, 2002).
Inside stable door (*ID*): horse standing close to and facing the stable door with its head inside the stable (Mills and Davenport, 2002).
Facing poster (*FP*): horse standing facing the poster.
Facing floor (*FF*): horse standing with its muzzle near the floor.
Facing other walls (*FOW*): horse standing, facing a plain wall (no poster).
Facing stable door (*FSD*): horse standing away from stable door, looking out of stable.
Facing hay net (*FHNT*): horse orientated towards its hay net (Mills and Davenport, 2002).
Other position (*OP*): horse in a position, which cannot be described by any of the above.

2.4. Analysis of data

The number of observations for each activity and each position was calculated as a percentage of the total number of observations for each observation period. Data were arcsine transformed and then analysed using a general linear model (GLM) analysis of variance (ANOVA) (Minitab 12.0 Minitab Ltd.). Two ANOVA models were used to examine the effects of horse, treatment and time on their behaviour. In the first, individual horse, treatment, time of observation, day of the study (1–6), treatment nested within time of observation and treatment nested within day of the study were included in the model, with horse included as a random factor to accommodate repeat observations on the same subjects. The second model was similar, but included day of treatment (1–2) in place of day of study in order to investigate whether there was any evidence for a difference in behaviour between the first and second day of treatment. Where significant differences were identified, the source of this was investigated further with post hoc Tukey's *t*-tests.

3. Results

The amount of weaving varied significantly between the six subjects ($F_{112,5} = 6.79$, $p < 0.001$), and both the treatments and time of day significantly affected horse behaviour and position during the study. There was also a significant interaction between treatment and time of observation (observation periods 1–4) on weaving ($F_{112,6} = 2.28$, $p < 0.05$). Day of treatment had no effect on the amount of repetitive behaviour expressed by the horses and so the results from the first ANOVA are considered here.

3.1. Effects of treatments on behaviour

The effects of the treatments on all behaviours and locations are summarised in Table 2.

The horse image was associated with significantly less 'weaving' (W) compared to both of the other treatment conditions (Tukey's *t*-test: b versus ti, $t = 4.86$, $p < 0.001$; pi versus ti, $t = 2.93$, $p < 0.05$). However, there was no significant difference between pixilated and blank poster (Tukey's *t*-test: pi versus b, $t = 1.93$, $p = 0.14$). Nonetheless, all subjects were seen to weave to some degree under all treatments (Table 3).

The horse image was associated with significantly less 'head nodding' (HN) compared to the pixilated image (Tukey's *t*-test: pi versus ti, $t = 2.38$, $p < 0.05$). Significantly, more time also was spent alert with the horse poster compared to the blank poster (Tukey's *t*-test: b versus ti, $t = 3.05$, $p < 0.01$). A similar effect was seen on the number of observations spent alert looking towards the poster (Tukey's *t*-test: b versus ti, $t = 2.75$, $p < 0.05$). Number of observations recording the horse 'facing poster' (FP) also varied with treatment but pair-wise differences between treatments were not identified. Similarly, the treatments affected the number of observations recording the horse 'inside stable door' (ID) position ($F_{112,2} = 3.44$, $p < 0.05$). However, Tukey's *t*-test did not identify specific pair-wise differences between the treatments.

Table 2
The effects of the different treatments on activity and position of the horses in the stable

	Treatments			$F_{112,2}$
	Blank (%)	Pixilated image (%)	Horse image (%)	
Behaviour				
Weaving	20.52	14.85	5.56	11.97***
Head nodding	1.667	2.153	0.451	3.01*
Pawing	2.22	1.285	0.868	0.71
Oral behaviour	0.1042	0.00	0.348	1.33
Alert	46.25	53.40	59.27	11.31***
Dozing	14.20	15.03	16.53	0.18
Alert looking at poster	0.312	0.556	1.458	4.20*
Biting poster	0.0694	0.00	0.00	1.00
Muzzling poster	0.0348	0.1388	0.0348	0.94
Muzzling	0.417	0.0684	0.694	2.37
Ingestion	13.40	12.26	14.41	0.15
Head threat	0.382	0.0348	0.714	1.82
Oral behaviour	0.417	0.486	0.521	0.07
Position				
Head over stable door	71.01	73.58	70.59	0.26
Inside stable door	3.51	0.868	0.764	3.44*
Facing poster	0.764	0.764	4.37	3.46*
Facing other walls	8.65	11.98	7.95	1.02
Facing stable door	1.70	0.764	1.285	0.51
Facing hay net	6.67	6.01	5.94	0.03
Facing floor	6.70	5.97	9.10	0.92
Other position	0.00	0.0694	0.00	1.00

See main text for full definition of behaviours and positions.
* $p < 0.05$.
*** $p < 0.001$.

Table 3
Percentage of observations observed weaving for each horse under each treatment

Horse	Blank	Pixilated image	Horse image
Cruze	39.00	29.67	7.33
Jerome	2.33	3.67	0.67
Spot	25.00	13.00	10.67
Nimmy	51.00	19.33	21.00
Chester	12.00	25.00	2.00
Corky	1.33	1.33	0.33

3.2. Changes in behaviour over time

The time of observation (observation periods 1–4) was associated with a significant difference in the proportion of observations recording weaving (Table 4), with a significant difference occurring between every observation period with the exception of the second (10:00–10:30 h) versus the third (12:00–12:30 h) observation periods (Tukey's *t*-test: second observation period (10:00–10:30 h) versus first observation period (08:00–

Table 4
Mean ± standard deviation (S.D.) level of weaving recorded during the different observation periods

Observation period	Percentage observations: mean ± S.D. (%)
(1) 08:00–08:30 h (before concentrate and forage feed)	28.80 ± 30.29
(2) 10:00–10:30 h (before exercise)	0.833 ± 2.306
(3) 12:00–12:30 h (before forage feed)	6.30 ± 13.80
(4) 16:00–17:00 h (before concentrate and forage feed)	18.29 ± 20.39

Table 5
Mean ± standard deviation (S. D.) level of head nodding recorded during the four observation periods

Observation period	Percentage observations: mean ± S.D. (%)
(1) 08:00–08:30 h (before concentrate and forage feed)	1.759 ± 2.581
(2) 10:00–10:30 h (before exercise)	0.00 ± 0.00
(3) 12:00–12:30 h (before forage feed)	1.019 ± 2.497
(4) 16:00–17:00 h (before concentrate and forage feed)	2.92 ± 6.55

Table 6
Mean ± standard deviation (S.D.) level of weaving recorded on each day of the experiment

Day	Percentage observations: mean ± S.D. (%)
1	9.86 ± 19.82
2	12.43 ± 23.65
3	19.31 ± 26.03
4	21.60 ± 28.02
5	12.01 ± 19.05
6	6.11 ± 10.28

08:30 h), $t = 7.86$, $p < 0.001$; third observation period (12:00–12:30 h) versus first observation period (08:00–08:30 h) $t = 6.33$, $p < 0.001$; fourth observation period (1600 h–1700 h) versus first observation period (08:00–08:30 h), $t = 2.96$, $p < 0.05$; fourth observation period (16:00–17:00 h) versus second observation period (10:00–1030 h), $t = 4.91$, $p < 0.001$; fourth observation period (16:00–17:00 h) versus third observation period (12:00–1230 h), $t = 3.37$, $p < 0.01$).

Head nodding was also significantly affected by time of observation ($F_{112,3} = 4.43$, $p < 0.01$), with no head nodding observations recorded during the second observation period. Tukey's *t*-test revealed that the head nodding at this time was significantly less than during the fourth observation period ($t = 3.53$, $p < 0.01$; Table 5).

Day 6 (Saturday) was associated with significantly less weaving than either of days 3 (Wednesday) or 4 (Thursday) (Tukey's *t*-test: day 6 versus day 3, $t = 3.03$, $p < 0.05$; day 6 versus day 4, $t = 3.55$, $p < 0.01$; Table 6). The differences between other days were not significant.

4. Discussion

The image of a horse's face appeared to significantly reduce both weaving and head nodding, whilst the same quantity of stimulation provided by a randomly pixilated

version of this image did not have the same effect. There was no evidence that the effect changed significantly between the first and second day of use of the poster. A significant reduction of weaving and head nodding has been reported previously following the use of a mirror in the stable (Mills and Davenport, 2002; McAfee et al., 2003), and these results suggest that the image of the horse is one feature of this treatment which reduces these behaviours. It does not, however, exclude the potential for other changes, such as a change in the perceived space associated with the introduction of a mirror to reduce stereotypic head movements. This work also raises some interesting questions about perception and the regulation of behaviour in horses. Whilst it has been established that horses can discriminate between two- and three-dimensional images (Timney and Keil, 1996, 1999), it would seem that some behaviours have the potential to be modulated by two-dimensional sensory input alone, without the need for the more complex processing of the third dimension. This might arise from the use of relatively simple feature detectors, which determine certain salient stimuli in the environment and regulate behaviour as a consequence. Such a process is widely recognized in other species, e.g. the toad (Ewart, 1987), but has not been reported in horses or in relation to the control of stereotypic behaviour in other species. Grzimek (1943) has reported that horses would respond to even quite stylised images of horses in a similar way to live animals, and so it may be that a range of normal behaviours in the horse are modulated by relatively simple stimuli. The mechanism behind the effect recorded here is worthy of further investigation, as it may have serious implications for evaluating the welfare significance of the performance of repetitive behaviours, such as weaving and head nodding and their management.

Whilst both weaving and head nodding were reduced significantly by the poster image of the horse compared to the pixilated image, these behaviours should not be considered analogous since the pattern of occurrence of the two behaviours and their response to the interventions differed. Most weaving occurred in the presence of the blank image, whilst most head nodding occurred with the pixilated image and only the true image reduced head nodding significantly. Also, whilst most weaving occurred during the first observation period of the day, most head nodding occurred during the last one.

It seems unlikely that the increased time spent alert and alert towards the poster was due solely to the novelty of the visual information provided by the horse poster, since the pixilated image would be equally novel and no such effect was seen with this image. It would, therefore, seem reasonable to suppose that some quality of the image was also important in the expression of these behaviours. In studies involving a mirror, a conspecific and no modification to the stable (Mills and Davenport, 2002), the presence of the image of a horse had no effect on behaviours not associated directly with the introduced stimulus. Therefore, the response in the current study might reflect the form of the image presented, which was of a horse with ears pricked, a common expression in the attentive horse in response to significant environmental stimuli (Waring, 2003). Such behaviour in a conspecific may increase arousal in other individuals, as the horse is a prey species, dependent upon environmental monitoring to detect potential threats in and avoid them through flight. In contrast to the findings found in the studies of Mills and Davenport (2002) using mirrors, muzzling activity directed to the horse image was not increased significantly in the present study.

Stereotypic weaving in the horses was significantly affected by time of observation. When the observation period took place before the horses were fed, there was significantly more weaving compared to prior to exercise (Table 4). It appeared that weaving was significantly higher prior to the first (08:00–08:30 h) and the fourth (16:00–17:00 h) observation periods in the anticipation of concentrate feed and forage, compared to prior to forage alone (third observation period; 12:00–12:30 h) or prior to exercise (second observation; 10:00–10:30 h). The increase of stereotypic weaving at these times might be explained by differences in arousal in anticipation of commodities of different values. Cooper et al. (2000) also found that horses displayed more weaving behaviour prior to concentrate feed than prior to hay only. The finding that stereotypic weaving occurred significantly more during the first observation period (08:00–08:30 h) than during the fourth observation period (16:00–17:00 h), both of which preceded the feeding of concentrate feed, could reflect the different times of food deprivation leading up to the delivery of feed. In the first observation period it was approximately $15\frac{1}{2}$ h since the horses had been fed compared to approximately $5\frac{1}{2}$ h prior to the fourth observation period, and approximately 4 h prior to the third observation period. However, since the horses were given at least twice as much forage in the late afternoon (17:00 h), it seems that anticipation of the amount of forage alone does not explain the intensity of weaving. Nonetheless, the results suggest that the repetitive behaviour was significantly affected by what the horses were anticipating, indicating that they are not a response to boredom or the barreness of the environment, but rather acute frustration.

Weaving occurred least during the second observation period (10:00–10:30 h) and no head nodding was observed during this period (Table 5). Several factors may be involved in this. The horses were fed only $1\frac{1}{2}$ h before the start of the second observation period (10:00–10:30 h), and therefore, spent most of their time on ingestion (of forage) followed by dozing. The yard was also at its quietest during the second observation period (10:00–10:30 h) when people on the yard went for their mid-morning break. McAfee et al. (2003) found a marked increase in weaving associated with the return of student activity on a yard. Stereotypic weaving also occurred least on day 6 (a Saturday, when there was less activity on the yard) and this too is consistent with the hypothesis that yard activity and frustration increases the behaviour and that it is not associated with boredom. Whether the response is due to frustration, or some form of social conditioning by people on the yard deserves further investigation. If the novelty of change in environment (prior to start of the study, all horses were moved to the part of the yard where the study took place) was a factor, which reduced weaving, it would have been expected that weaving would increase over the days of the study, but this was not the case, with most weaving occurring on days 3 and 4.

5. Conclusion

Weaving and head nodding appear to be behaviours, which are, at least in part, modulated by relatively simple social stimuli. Whilst a static two-dimensional image of a horse's head has the potential to reduce these behaviours in the short term, this does not mean that their occurrence is triggered by social stimuli. The intensity of stereotypic head movement is associated with times of increased activity on the yard and anticipation of

specific events, which may or may not be associated with increased social contact. It seems unlikely that the behaviours are a response to boredom. Further studies are warranted, which might investigate the specific role of a wider range of social stimuli.

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