



Horses prefer their rider: A strange situation test adaptation shows behavioural evidence for partner-specific bonding

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ABSTRACT

Background: The relationship between horses and humans is often described as cooperative and affective, yet empirical studies on horse–rider bond remain scarce. Previous findings on horse–human relationships yielded conflicting results on whether and how horses show bonding like behaviour toward their owners.

Aims/Objective: We tested whether horses show partner-specific approach and proximity toward their primary rider compared with an unfamiliar experimenter in an adapted Strange Situation Test, and whether the rider's presence was associated with behavioural patterns indicative of safe haven and secure base effects.

Methods: Thirty horse–rider pairs participated in a behavioural test conducted in an indoor riding arena, which included several episodes: recall by owner/experimenter, separation both from rider and experimenter, reunion with rider/experimenter, and exposure to a potentially frightening object in order to examine secure base effect. We compared horses' social behaviours (i.e. proximity, approach, gazing behaviour, etc.) toward their riders versus the unfamiliar experimenter, as well as their stress-related signals (i.e. manure, vocalization) across these episodes.

Results: We found that horses approached their rider significantly faster than the experimenter during recall and reunion episodes and spent significantly more time in close proximity to the rider across multiple contexts. Our findings indicate that horses' gazing behaviour is influenced more by the human's level of interactiveness than by familiarity. However, no conclusive evidence emerged for a "safe haven" effect during exposure to the frightening stimulus. Rider sex had no effect on the horses' social or stress related behaviours.

Conclusions: These findings suggest that horses may form specific bonds with their riders, characterized by different social behaviours consistent with certain criteria of attachment theory. The study highlights the importance of incorporating socio-emotional components into analyses of human–horse relationships and underscores the relevance of comparative attachment frameworks in equine behaviour research.

1. Introduction

Attachment theory was originally developed to describe the emotional bond between human infants and their primary caregivers [1, 2]. Since then, it has been extended to a variety of animal–human relationships, including those between dogs and their owners [3]. From an ethological perspective, attachment is a biologically based behavioural system that evolved to promote proximity and social cohesion, particularly under conditions of stress [4,5]. It manifests as a consistent preference for a specific individual, proximity-seeking and proximity-maintenance behaviours, and distinct reactions during separation and reunion episodes [6,7]. In their seminal study, Topál and

colleagues [3] adapted Ainsworth's Strange Situation Test (SST) to assess attachment behaviour between family dogs and their owners. Their results demonstrated that adult dogs showed attachment-like patterns toward their owners, including signs of separation distress and increased proximity-seeking upon reunion. Despite individual differences, attachment classifications comparable to those observed in children (secure, insecure-avoidant, insecure-resistant) could be identified in dogs. These findings highlighted the relevance of the SST as a tool for comparative attachment research in nonhuman species.

More recently, attention has turned to other domesticated animals that form close cooperative bonds with humans, such as horses. Horses (*Equus caballus*) have been selectively bred for human use over millennia

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and have demonstrated sensitivity to human communicative signals [8, 9]. Early life experiences can exert long-term effects on horses' behaviour and their relationship with humans. For example, Lansade, Bertrand, and Bouissou [10] reported that neonatal handling influenced foals' manageability, reactivity, and learning abilities later in life. These findings highlight the importance of early human–horse interactions and underscore the need to investigate how horses respond to their familiar rider compared to an unfamiliar experimenter.

Previous studies have demonstrated that horses can discriminate between human faces and recognize familiar individuals [11], suggesting that they possess the cognitive capacity to distinguish among specific humans. This provides a strong rationale for investigating whether they respond differently to their rider compared with an unfamiliar experimenter. Recent research has further shown that horses can differentiate between human actions based on underlying intentions, reacting differently when a human is unwilling versus unable to provide food [12]. These findings indicate that horses interpret human actions as goal-directed, supporting the examination of partner-specific responses toward riders versus unfamiliar humans. Horses are also capable of cross-modal recognition of human sex based on voice and facial cues [13], and they respond to human-directed speech in ways comparable to dogs and infants [14,15]. Together, these findings point to a complex socio-cognitive toolkit that may facilitate the formation and expression of human–horse bonds.

Anzulewicz et al. [16] demonstrated that horse–rider interactions can be affected by the sex of both the rider (male vs. female) and the horse (e.g., horses handled by male riders were reported to be more defensive and harder to catch, yet less likely to pull on the reins). This suggests that horses' bonding-like behaviours toward their riders may also be shaped by the riders' sex. In domestic dogs an owner-specific “secure-base” effect has also been documented: the mere presence of the caregiver increases task persistence and exploratory engagement, whereas their absence reduces these behaviours [17]. Building on this comparative evidence, we explored whether a similar secure-base-like influence operates in horses – specifically, whether the rider's presence facilitates exploration while separation elevates arousal-driven exploratory activity.

Exploration in horses can also be heightened by novelty and expectancy violation. When an uncovered mirror is presented, for instance, horses show increased selective attention and contingency-checking behaviours, reflecting arousal-driven exploration rather than behaviour anchored in a secure base [18]. This pattern suggests that exploratory activity may increase under conditions of uncertainty, complementing rather than contradicting tests of rider-specific secure-base effects examined in the present study.

Companion animals show attachment-like bonds to familiar humans that can be investigated through separation–reunion paradigms adapted from the Strange Situation Procedure (SSP). In dogs, SSP studies have shown that reunion episodes elicit proximity-seeking and contact behaviours toward the owner compared with a stranger, while exploratory and independent play behaviours typically decrease during reunion with the attachment figure [19–21]. Importantly, these behavioural indices only weakly correspond to owners' self-reported relationship quality, underscoring the value of direct behavioural measures in assessing human–animal bonds [22,23]. Building on this approach, we applied SSP-style episodes to horse–rider dyads, contrasting responses to the rider and a neutral experimenter to test for rider-specific bonding [10, 24,25].

In the present study we investigated horses' social behaviours toward their riders and an unfamiliar experimenter across four structured episodes of the adapted SST test (i.e. recall, separation, reunion, and a mildly arousing ‘scary’ episode). We quantified gaze toward each person, approaches, time spent in proximity, exploratory behaviour, vocalizations, and defecation. We hypothesized (H0) that horses will display bonding-like social behaviours toward their riders. Specifically, we predict that horses will direct more gaze toward the rider than

toward the experimenter and will approach and remain in proximity to the rider more than to the experimenter [26]. We further predict that during the *Separation episode*, horses will appear more unsettled than in other episodes, as evidenced by increased stress-related behaviours (i.e. vocalizations and exploration) and more time spent gazing toward or standing near the human entrance. In *Reunion episodes*, horses are expected to prefer interaction with their rider over the experimenter, reflected in shorter approach latencies, longer proximity durations and more rider-directed gaze [27,28]. During the *Scary Object episode* (as an indicator of a potential “safe haven” effect) horses are predicted to approach the rider more quickly than the experimenter [29,30].

Alternatively, we may hypothesize that no rider-specific bond has developed (H1). If so, horses' responses toward the rider and the experimenter will not differ consistently across these behavioural measures or episodes.

However, based on previous findings that horses handled or ridden by male humans are more often described as harder to catch and more defensive than those handled by female humans [16], we may also predict that rider sex will moderate bonding-like responses during reunion (H2). Specifically, compared with female riders, horses paired with male riders will show weaker rider-directed affiliation – reflected in a lower probability of first approach, longer approach latencies, reduced proximity and rider-directed gaze and stronger arousal markers (e.g., increased entrance-gazing and/or vocalization). We will test this as a *Rider Sex* × *Episode* interaction with a priori contrasts focused on the reunion episodes.

2. Materials and methods

2.1. Ethical approval

This research was approved by the Human Research Ethics Committee (EPKEB) at the Hungarian Academy of Sciences (No. 2022-85). All riders gave their written consent to engage in the research in accordance with ethics approval, and all procedures were carried out in accordance with the relevant rules and regulations of the EPKEB and the applicable laws of Hungary.

2.2. Participants

The study involved 30 horse–rider pairs. One horse was excluded due to an unusable video recording. In the group of horses (*Equus caballus*), there were 11 gelding, 6 stallion and 12 mares aged 5 to 21 years ($M = 10.03 \pm 0.84$ years). The group of riders included 15 women and 14 men with a mean age of 30.88 ± 2.19 years. The horses were from 14 different breeds: Hungarian Sport Horse ($n = 3$), Belgian warmblood ($n = 1$), Czech warmblood ($n = 1$), Danish warmblood ($n = 1$), Holstein ($n = 1$), Hanoverian ($n = 1$), Oldenburg ($n = 1$), Westphalian ($n = 1$), KWPN ($n = 1$), Friserian horse ($n = 3$), Haflinger ($n = 1$), Kisber ($n = 1$), Lipizzaner ($n = 11$) and unknown breed ($n = 2$). According to sport discipline, the horses were classified into 5 categories: jumping horses ($n = 5$), dressage horses ($n = 8$), army horses ($n = 12$), leisure horses ($n = 1$), and mixed sport horses ($n = 3$). (Army horses also took part in dressage competitions.) Each pair had a minimum history of six months of exclusive interaction, during which the horse was handled and ridden only by the assigned rider. All participants were actively involved in sport or leisure riding.

2.3. Experimental Setup

The behavioural test was conducted in two different 20×40 m indoor arenas (Fig. 1). Testing took place in a familiar indoor arena at each horse's home stable. These arenas were temporarily unused during that period of the year, providing a controlled, low-traffic environment. Horses were not transported to unfamiliar arenas to avoid transport-related risk (welfare, safety) and to maintain owner participation. One

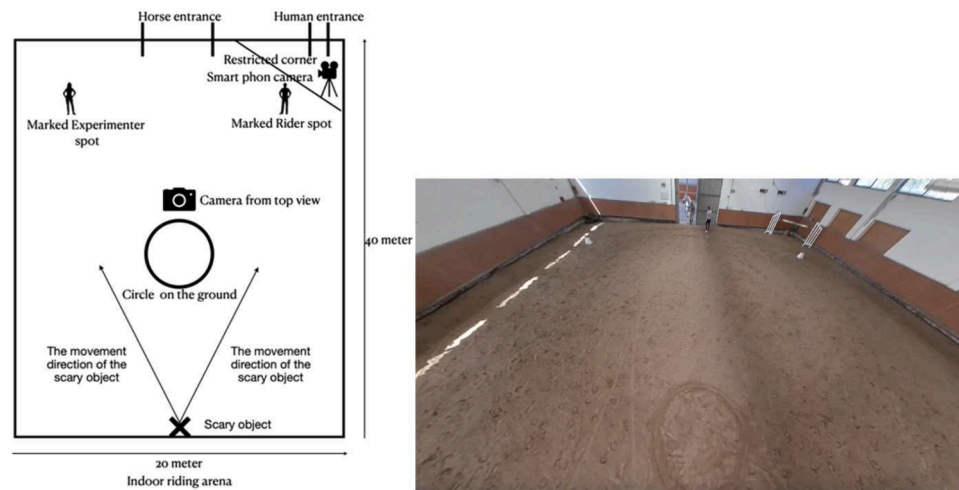


Fig. 1. Schematic layout of the experimental setup in the 20 × 40 m indoor arena, showing the designated entrances, restricted corner, and camera positions.

of the riding arenas had two separate entrances – one designated for horses (horse entrance) and the other for human participants (human entrance). The other arena had a single doorway serving as the horse entrance; no separate human entrance was available. Across the two locations, we tested 16 and 14 horses, respectively. Video recordings were made using two fixed-position cameras, one mounted overhead (kodak PixPro sp360 4 K) and one positioned laterally (iPhone 13 pro max smartphone), along with two wireless microphones (Boya BY-V2) to capture auditory data, including vocalizations.

2.4. Procedure

We adapted the Strange Situation Test (SST) originally developed for dogs [3] to the horse–rider context. Horses wore a halter; no tack was used. During all episodes the horse was untethered and free to move. The test protocol consisted of six consecutive episodes designed to assess social preference, attachment-related behaviors, and stress responses toward the familiar rider (R) and an unfamiliar experimenter (E).

Episode 1. Recall by the Rider

The start line was marked 5 meters from the horse entrance. At the beginning of the episode, the horse was released at the start line, while the rider walked to the marked center circle (2 m diameter) located 20 meters from the horse entrance, near the centre of the arena. The recall position was within this circle and the rider was allowed to move freely inside it (see Fig. 1). The rider had 60 s to attempt to recall the horse. If the horse approached the rider within 1 meter, the episode ended. If the horse did not approach within 60 s the rider was permitted to approach the horse to within 2 meters and attempt to recall again, for an additional 60 s. During this episode the experimenter stood in the restricted corner of the arena, remaining visible and approachable. When the episode ended, the rider caught the horse, led it back to the starting line and then moved to the restricted corner.

Episode 2. Recall by the Experimenter

In this episode, the experimenter stood in the centre circle and initiated the recall (see Fig. 1). If the horse approached the experimenter within 1 meter, the episode ended. If, however, the horse did not approach the experimenter, within 60 s, the experimenter was allowed to approach the horse to within 2 meters and attempt to recall again, for another 60 s. The rider was standing in the restricted corner during Episode 2, she/he was visible and approachable.

If the horse approached the experimenter within 1 meter, the episode ended. If the horse did not approach within 60 s, the experimenter was allowed to approach the horse to within 2 meters and attempt to recall

again, for another 60 s.

Episode 3. Separation

At the end of Episode 2, the experimenter and the rider left the arena together, leaving the horse alone. The separation episode lasted 60 s.

Episode 4. Reunion part 1

After this, the rider and the experimenter re-entered the riding arena together. The rider walked to the marked spot, located 6 meters from the restricted corner and 3 meters from the wall (see Fig. 1) and stood silently for 10 s before greeting the horse. Meanwhile, the experimenter remained in the restricted corner or near the entrance through which they had returned, remaining visible and approachable to the horse.

Episode 5. Reunion part 2

After that, the experimenter walked to her marked position located 8 meters from the rider's marked spot (see Fig. 1). She stood silently for 10 s and then greeted the horse.

Episode 6. Scary object

Following the reunion phase, the rider caught the horse and led it within the center circle. During this time, the experimenter brought a bucket of carrots and offered it to the horse to encourage it remain in the circle (see Fig. 1). After this the rider and the experimenter returned to their designated positions in the two corners near the horse entrance. The rider's marked spot was located 6 meters from the corner and 3 meters from the wall, on the left side of the horse entrance. The experimenter's marked spot was positioned symmetrically on the right side (see Fig. 1). The *scary object* was a plastic bottle containing small-sized stones decorated with blue and yellow crepe paper. It was positioned at the far end of the arena, 40 meters from the horse entrance, in the middle, and partially buried in the sand (see Fig. 1). The object was attached to a long string allowing it to be moved remotely. In half of the trials the rider pulled the string to move the object; in the other half, the experimenter performed this action.

Sessions were video-recorded using two cameras, one mounted overhead, positioned precisely above the centre of the marked circle (20 meters from the horse entrance), and one mounted on a fixed tripod at the side of the arena in the restricted corner (left side of horse entrance, 3 meters from the corner). Recordings were timed using a stopwatch synchronized with the video.

2.5. Behavioural measures

Horse behaviour was coded frame-by-frame from the video

recordings using Solomon coder (<https://solomon-coder.software.info-rmer.com/>). The following variables were analysed:

- **Gazing behaviour** (duration, time%): proportion of time the horse spent gazing toward the rider, experimenter, entrances, or the scary object.
- **Approach** (latency, sec): time elapsed between a defined time marker (e.g. the start of an episode; from release in Episodes 1 and 2, etc., - see Results for details) and the first approach, defined as the initiation of a clear movement toward a target (rider, experimenter, scary object or entrances).
- **Proximity** (duration, time%): proportion of time the horse spent within 1 meter of the rider, experimenter, or entrances.
- **Stress indicators** (duration or frequencies): exploratory behaviours (% time), vocalizations (frequency), defecation (frequency).

2.6. Statistical analysis

Data were analysed using non-parametric and mixed-model approaches appropriate for repeated measures and small sample sizes:

- Generalized Linear Mixed Models (GLMMs) tested the effects of episodes, rider sex (male, female), and their interaction with social behavioural variables toward the rider and the experimenter. These variables were gazing (% time) at the potential interactive partners (rider, experimenter) and the entrance as well as proximity seeking (% time spent next to the rider or experimenter). We also analysed stress-related behaviours like exploration (% time) and vocalizations (frequency).
- Mixed effects cox regression (MECRM, coxme package) was used to analyse latency to approach the rider versus the experimenter in the recall as well as in the reunion episodes. In all cosmic models we investigated the possible effect of riders' sex as well. For MECRM, the hazard ratio ($\exp[\beta]$) between levels of a given fixed effect with 95% confidence interval is given.
- We applied backward modelling (i.e. non-significant terms were eliminated from the models). In all models subject ID was included as a random grouping factor in order to control for repeated measurement. All tests were two tailed and the value was set at 0.05. In pairwise comparisons we used sequential Bonferroni corrections.

3. Results

3.1. Gazing toward the rider versus the experimenter (% time)

We analysed the percentage of time horses spent gazing toward the two potential human interaction partners (i.e. the rider and the experimenter) using a GLMM (normal distribution, identity link). The initial model included the fixed effects of Target person, Rider sex and Episode (excluding *Separation* as gazing toward the target persons was not possible in this episode). Non-significant interaction terms (Rider sex x Episode; Rider sex x Target person) and the main effect (Rider sex) were sequentially removed from the model. The final model showed a significant Target person x Episode interaction ($F_{4,270} = 20.77, p < .001$). Post-hoc comparisons revealed that horses spent more time gazing at the person who was more interactive with them during a given episode regardless of whether this was the rider or the experimenter (all $p > 0.04$). During the *Scary Object* episode, gazing durations toward the rider and the experimenter did not differ significantly ($p = 0.81$), consistent with the fact that both individuals were passive in this situation. Importantly, however, when comparing the two most interactive episodes (i.e. *Recall* and *Reunion*) horses gazed significantly more at the rider after separation than during the recall (*Recall by Rider* vs. *Separation Part 1* episodes, $p = 0.03$). No such difference was found in gazing toward the experimenter variable (*Recall by Experimenter* vs. *Separation Part 2* episodes, $p = 0.98$; Fig. 2).

Gaze toward rider vs. experimenter across episodes

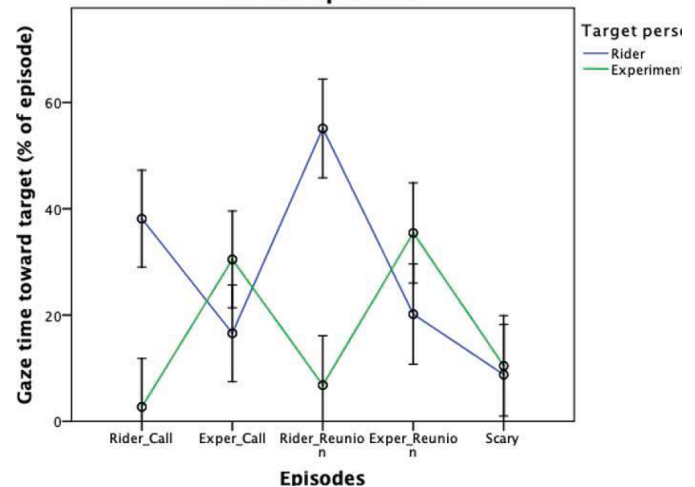


Fig. 2. Horses' gazing behaviour toward their Rider and the Experimenter through the experimental episodes.

3.2. Approach latency toward the rider versus the experimenter

MECRM models showed that the rider's sex as well as its interaction with the approached person (rider or experimenter) had no significant effect on approach latency, during either the *Recall*, or *Reunion* episodes. Consequently, these terms were eliminated from both models.

The final MECRM for approach latency revealed a significant main effect of the target person (rider versus experimenter) during the *Recall* episodes (i.e. Episodes 1 and 2; MECRM: $\chi^2_{(1)} = 16.2; p < 0.001$). In these episodes, horses approached their riders faster than they approached the experimenter ($z = -4.06, p < .001$; Fig. 3).

The final MECRM for approach latency also revealed a significant effect of the target person (rider versus experimenter) during *Reunion* episodes (i.e. Part 1 and 2; MECRM: $\chi^2_{(1)} = 5.06; p = 0.044$). In these episodes, horses again approached their riders significantly faster than the experimenter ($z = -2.02, p = 0.043$; Fig. 4).

3.3. Proximity to the rider and the experimenter (% time) across episodes

We analysed the percentage of time horses spent near the potential interactive humans (i.e. rider and the experimenter) using a GLMM

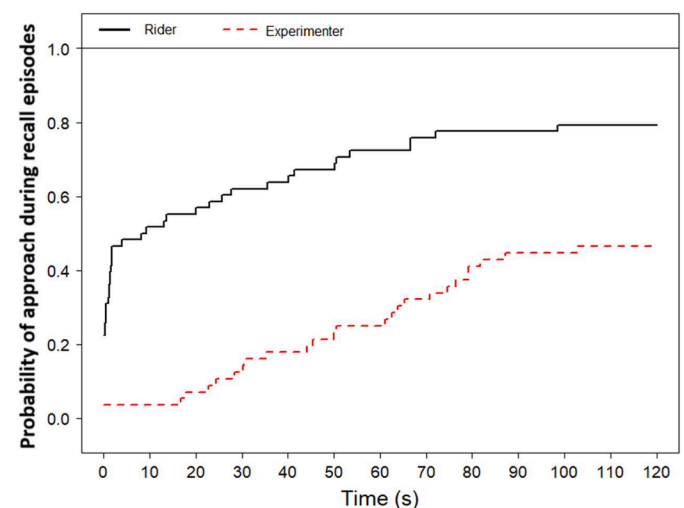


Fig. 3. Latency of approaching the rider and the experimenter during *Recall* episodes (Episode 1 and 2).

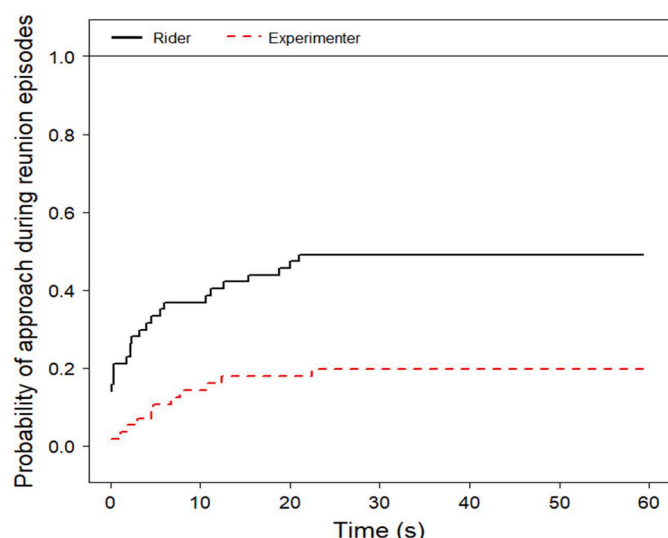


Fig. 4. Latency of approaching the rider and the experimenter during reunion episodes (Episode 4 and 5).

(normal distribution, identity link). After testing the effect of Target person, Episode (excluding *Separation* as proximity to the target persons was not possible during this phase), Rider sex, and their interactions, we sequentially removed non-significant interactions (Rider sex x Target person; Rider sex x Episode) and the non-significant main effect (Rider sex) from the model. The final model revealed a significant Target person x Episode interaction ($F_{4,270} = 5.18, p < .001$). Post-hoc comparisons indicated that horses spent significantly more time near their riders than near the experimenter in all episodes (all $p < 0.04$) except during the *Scary Object* ($p = 0.39$) and the *Recall of the Experimenter* episodes (0.21). The most robust difference was found during the *Reunion Part 2* episode when the experimenter greeted the horse after the separation, yet horses remained close to or increasingly sought the proximity to their riders (see Fig. 5). In contrast, during the *Scary Object* episode, horses did not search for proximity to either the rider or the experimenter.

3.4. Gazing toward the human entrance (% time) across episodes

We analysed the percentage of time horses spent looking toward the

human entrance across episodes using a GLMM (normal distribution, identity link). The interaction term as well as Rider sex as main effect were not significant and were therefore removed from the model.

The final model retained Episode as the only significant predictor of looking toward the entrance ($F_{5, 163} = 8.08, p < .001$; Fig. 6). Post-hoc comparisons showed that horses spent significantly more time gazing toward the human entrance during the *Separation* episode than in all other episodes (all $p \leq 0.02$). No other pairwise differences were significant. In all remaining episodes, attention to the entrance was essentially absent (all other pairwise $p > 0.05$).

3.5. Exploration behaviour (% time) as stress-related signal

We analysed how Episodes, Rider sex and their interaction affected the relative time horses spent exploring the environment using a GLMM with normal distribution and identity link. The interaction term as well as the main effect of Rider sex were not significant and were therefore removed from the model. The final model indicated a strong main effect of Episode on exploration time ($F_{5, 163} = 15.995, p < 0.001$; Fig. 7). Exploration was highest during the *Recall by the Rider* and *Separation* episodes, intermediate during *Recall by the Experimenter*, and lowest during both *Reunion* episodes and the *Scary Object* episode (all $p < 0.001$, Fig. 7). Exploration time did not differ between *Recall by the Rider* and *Separation*, but both exceeded all *Reunion* and *Scary Object* episodes (all $p < 0.001$). Overall, exploration was greater both when the rider was present and during *Separation*, consistent with rider-facilitated (“secure-base”) exploration versus arousal-driven exploration under isolation.

3.6. Vocalization (frequency) as stress related signal

We analysed vocalization rate using a GLMM (for multinomial logistic regression). The interaction term as well as the main effect of Rider sex were not significant and were therefore removed from the model. The final model showed a significant main effect of Episode on vocalizations ($F_{1, 163} = 11.76, p = 0.001$). Post-hoc comparisons revealed that vocalizations occurred more frequently during the *Scary Object* than during the *Recall by the Experimenter* and both *Reunion* episodes (all $p < 0.05$, Fig. 8).

4. Discussion

One part of our findings aligns closely with an attachment-based account of the horse–rider relationship. Classic attachment theory predicts selective proximity seeking toward a preferred individual, rapid

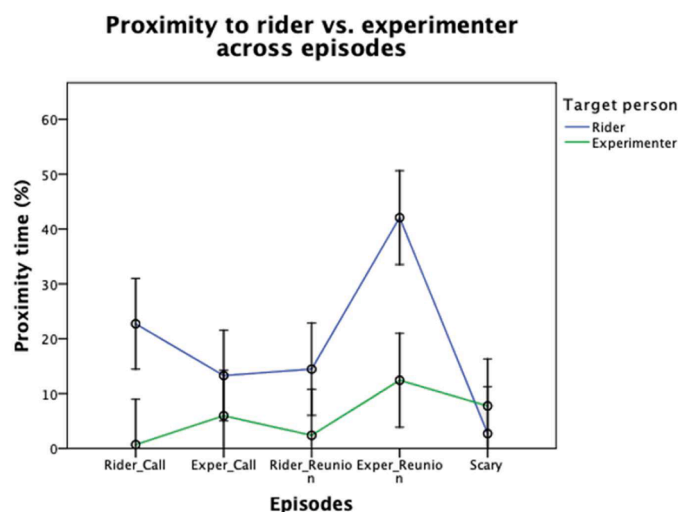


Fig. 5. Relative time (%) horses spent near (within 1 m) to the rider and the experimenter through the episodes.

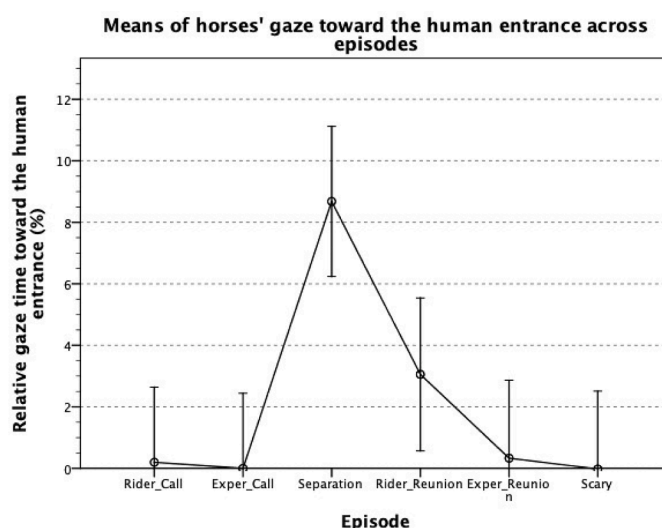


Fig. 6. Relative time spent looking at the human entrance by the horses.

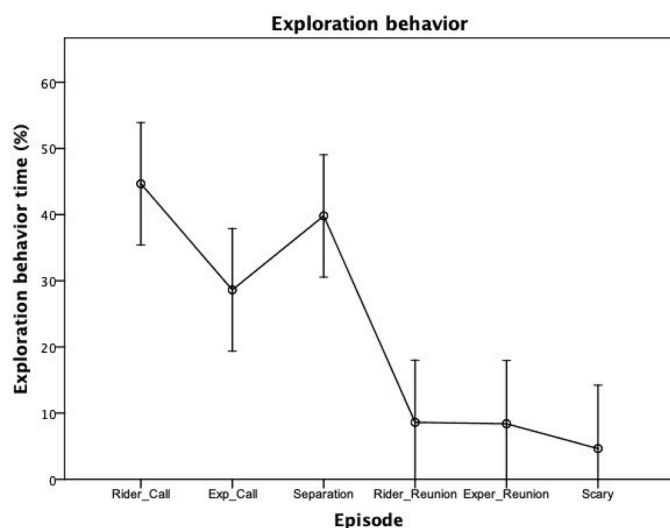


Fig. 7. Mean exploration time across episodes (±95 % CI).

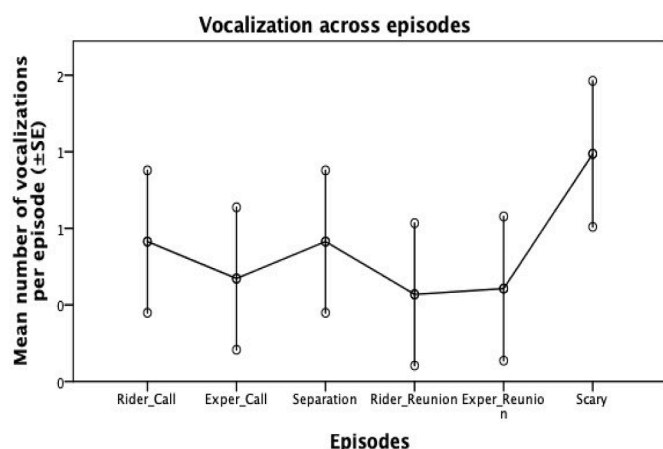


Fig. 8. Vocalizations across episodes.

We also coded defecation (manure) as a putative stress marker, but its incidence was too low for meaningful statistical analysis, so we do not report results for this measure.

approach upon reunion, and greater willingness to explore when an “attachment figure” is available (Ainsworth, 1969; Bowlby, 1958, [1]; Bowlby, 1972). Across measures, a mixed pattern emerged: approach latency and proximity consistently favoured the rider (supporting the H0 rider-specific bonding account), whereas gazing behaviour (toward the currently engaged human or toward the entrance) and vocalization tracked context or arousal rather than partner identity (supporting the H1, an alternative account of general human-directed social affiliation).

Certain aspects of horses’ behaviour clearly indicated that their own rider held a particular social significance for them. When rider and experimenter re-entered simultaneously after the *Separation* episode, most horses oriented to and engaged with the rider first. Horses also approached the rider more rapidly and spent more time in the rider’s proximity in most episodes. Measures linked to arousal (e.g., vocalizing and entrance-gazing) varied by context, peaking in the *Scary object* episode and *Separation* episodes, indicating that these episodes affected horses as expected. Exploration showed a complementary pattern: it was elevated when the rider was present (consistent with a social-buffering influence), and, also during separation (consistent with arousal or frustration-driven behaviour). Taken together, several bonding-like behaviours indicate partner-specific, rider-directed social preference rather than a generic human-directed affiliation.

Studies adapting Ainsworth’s Strange Situation Test (SST) to dogs show that separation–reunion paradigms reveal key components of attachment – separation distress and targeted proximity seeking [3]. We applied this logic to horses, using a modified version of the SST paradigm in which the rider and an unfamiliar experimenter re-entered simultaneously after *Separation* episode allowing horses to ‘choose’ between the two humans. Simultaneous partner entry is methodologically important because it minimizes the possibility that proximity seeking merely reflects attraction to any returning human. At the same time, further systematic work is needed to evaluate the importance of this design feature in equine studies. Consistent with this design, our behavioural variables – first choice of the rider during greeting after separation, shorter approach latencies and greater approach and proximity to the rider in almost all episodes – indicate selective proximity seeking in favour of the rider. Other behavioural measures (i.e. gazing and vocalizations), by contrast, primarily reflected more general affiliation toward humans as well as arousal. Although we did not attempt SST-style classifications (secure/insecure), our results converge with Topál et al.’s central claim: domesticated animals display partner-specific, human-directed bonding, and in horses this effect is stronger toward the rider than toward an unfamiliar human. Building on this literature, our separation–reunion paradigm shows that horses’ responsiveness to humans is not merely generic but partner-specific. These converging findings indicate rider-directed social preference consistent with cooperative bonds previously described in horses (cf [8, 9]). Importantly, our results suggest that approaches, movement dynamics, and spatial positioning relative to human partners are the most informative behavioural variables for assessing bonding or specific human-directed affiliation in horses.

Studies on social cognition in humans and non-human animals generally treat looking or gazing as one of the most commonly coded behaviours for attention, affiliation, aversion, motivation and related processes (e.g. [31]). In horses, however, we found that gazing pattern throughout the test primarily followed the (inter)active human partner. More specifically, horses gazed more at the moving human, suggesting that their gaze primarily tracked movement or ongoing action rather than the identity of the human partner. Regarding horses’ gazing behaviour toward the rider and the experimenter, differences were found only between the two most interactive episodes. Horses gazed more at the rider during the first part of the *Reunion* episode than during *Recall*, whereas no such difference appeared for the experimenter. This pattern is consistent with transient rider-oriented monitoring following separation. Gazing toward the human entrance emerged specifically during *Separation*, further indicating reunion-seeking when the horse was left-alone. Overall, these findings suggest that gaze may not be the most suitable behavioural variable for assessing bonding in horses. In dogs, by contrast, human-directed gazing is a core communicative cue that covaries with personality and with emotional comfort provided by owners, and it typically skews toward the owner rather than an unfamiliar partner [27]. This species difference raises the possibility that gazing serves partially different socio-functional roles in domesticated herbivores (prey species) versus carnivores (predators), warranting targeted comparative research.

It is important to note that our results do not provide any support for a rider-specific safe heaven effect in horses – an effect well-documented in dogs [17] as well as in human infants with their primary caregivers (e.g. [32]). We expected that horses would seek proximity to their riders during the *Scary object* episode. Instead, we found that they moved away from the object but not toward either human partner (i.e. rider or experimenter). One possibility is that the object was insufficiently threatening; however, vocalizations peaked in this episode, indicating elevated arousal. Another plausible explanation is, that as prey animals, horses’ primary reaction to threat is flight or avoidance, which may override affiliative proximity seeking – even toward familiar humans – under heightened arousal. Prior work shows that fear tests reliably evoke escape-oriented responses in sport horses [33], and that social

buffering typically requires the presence of a calm conspecific; buffering from companions is context-dependent and not guaranteed under acute threat. Our findings therefore suggest that fear-based paradigms may be suboptimal for probing safe-haven effects in horses. Future work is needed to develop a more suitable scenario for studying these attachment-related effects in horse-human relationships.

Analysis of exploratory behaviour also revealed informative patterns. Exploration increased when the rider was present, suggesting that horses may feel sufficiently secure to explore in their rider's presence. This pattern is broadly consistent with a secure-base-like effect, previously described in dogs [3]. However, exploration was also elevated during *Separation* episode, likely reflecting arousal or frustration rather than social comfort [18]. Thus, both the presence and absence of the rider promoted exploration, but likely via different underlying mechanism. Consequently, exploratory behaviour – like gazing – may be ambiguous as a standalone indicator of bonding in horses.

If we look at stress signals, first it is important to note that horses produced less stress signals during our test than expected. We originally planned to analyse both vocalizations and manure production, however, the latter occurred so rarely that statistical analysis was not feasible. Regarding vocalizations, horses typically vocalized none, one or at least two times per episode on average. This contrasts with dogs, which often vocalize extensively during separation from owners (e.g., [23]). In our study, horses vocalized more frequently only during the *Scary object* episode, suggesting that vocalization in horses is more likely to reflect acute arousal or distress triggered by external stimuli rather than attachment-related responses toward familiar humans. Accordingly, vocalizations appear to be a relatively weak proxy for attachment in horses compared with proximity-based measures.

In light of previous research showing that a handler's or rider's sex can influence equine behaviour [16], we explicitly tested for effects of rider sex. Rider sex showed no main effect on core rider-directed outcomes (e.g., proximity seeking, approach latency, gazing) and did not interact with episode. This mirrors findings in domestic dogs, where attachment patterns do not reliably differ between animals with female versus male owners [34]. Despite survey-based indications of effects related to riders' or handlers' sex [16], our results suggest that, at least in sport horses, female and male riders do not elicit different behavioural responses in tests designed to measure bonding or attachment-like behaviours. Future studies should disentangle biological sex from gendered handling style and quantify interaction history to determine when human sex meaningfully alters horse-human dynamics. Before summing up our results, it is important to note that our study was conducted on sport horses who were actively ridden and cared for by their specific riders. It has been shown that neonatal handling and the amount of high-quality interaction with a particular human can affect horses' social behaviour (e.g., [10]) which could plausibly amplify later partner-specific responsiveness to a familiar rider. Thus, the rider-directed effects observed here may partly reflect the cumulative history of coordinated work between horse and rider. Moreover, the sport horses in our sample were routinely exposed to temporary social separation during travel, warm-up, and competition. This lifestyle likely buffered their stress responses during the test and enabled the experiment to be conducted without conspecifics, thus reducing the risk of panic [9] and perhaps facilitating rider-directed behaviour. Future research should directly measure or experimentally manipulate (i) early-life handling (e.g., handled vs. minimally handled foals) and (ii) the quantity and quality of rider-horse joint activity (training intensity, competition history) to determine how these factors moderate rider-directed effects.

In summary, our adaptation of Ainsworth's Strange Situation Test (SST) proved to be a successful method for examining bonding-like behaviour in horses toward their riders. The paradigm retained the core components of attachment testing – separation, reunion, and simultaneous access to two social alternatives – while yielding clear, partner-specific dissociations across converging measures (approach

dynamics, proximity, and first orientation upon reunion). To our knowledge, this is the first equine study to implement an SST-style paradigm without the presence of conspecifics, a condition previously deemed unfeasible for pasture-kept horses because isolation often elicits panic and disrupts testing (see e.g., [9]). By working with sport horses accustomed to brief social isolation during training and competition, separations were fully feasible and ethically manageable, allowing us to evaluate attachment-relevant behaviour under mild challenge – a methodological advance over earlier equine work. Our analysis identified behavioural variables such as proximity seeking, approach latency and duration, that proved to be relevant for assessing order-directed responsiveness. Together, these measures support the interpretation that the horse-rider relationship extends beyond simple conditioned familiarity and may involve a deeper affiliative system supporting social cohesion and emotional security. Although further research is needed to examine underlying neurochemical mechanism, the behavioural parallels observed here represent an important step toward situating equine-human interactions within the broader framework of attachment theory [1,35,36].

5. Conclusion

Our study shows that horses preferentially orient to and engage with their own rider during the test – they approach the rider (regardless of rider sex) more rapidly and spend more time in close proximity across episodes. In contrast, gaze primarily tracked the interactive (moving) human partner, and vocalizations reflected context-driven arousal rather than rider-specific social affiliation. Conceptually, we developed a Strange Situation Test adaptation for horses that dissociates partner-specific bonding indicators (approach latency, proximity) from more general social affiliative behaviours (gazing) and arousal markers (vocalizations). This work situates research on equine-human relationships within a broader comparative framework, clarifies which behaviours are most diagnostic of rider-directed bonding, and offers practical insights for training and welfare. By highlighting the rider's role in facilitating secure, socially supported exploration, our findings underscore the practical importance of fostering strong, positive horse-rider relationships for both training success and overall equine welfare.

Declaration of generative AI and AI-assisted technologies in the manuscript preparation process

During the preparation of this work the author(s) used ChatGPT (OpenAI) in order to improve the clarity and readability of the English text (e.g. rephrasing sentences, checking style and grammar). After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the published article.

Ethics statement

complies with the ethical principles of the Journal of Equine Veterinary Science and Elsevier.

We confirm that:

1. The manuscript provides an honest and accurate account of the work performed. All data are genuine and have not been fabricated, falsified or inappropriately manipulated, and the methods are described in sufficient detail to allow replication.
2. This submission is original. Where work or words of others have been used, these have been properly cited or quoted and any necessary permissions have been obtained.
3. The manuscript has not been published previously in whole or in part and is not under consideration for publication elsewhere.

4. All authors have made substantial contributions to the work, have approved the final version of the manuscript and agree to be accountable for all aspects of the work.
5. Generative AI tools (ChatGPT, OpenAI) were used only to assist with improving the English language and style of the manuscript under human supervision. This use is disclosed in the manuscript in a dedicated "Declaration of generative AI and AI-assisted technologies" section. No AI tools were used to generate or manipulate data, analyses or images.

CRedit authorship contribution statement

A.B. Kovács: Writing – review & editing, Writing – original draft, Visualization, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **J. Topál:** Writing – review & editing, Validation, Supervision, Methodology, Conceptualization. **A. Gergely:** Writing – review & editing, Validation, Supervision, Project administration, Methodology, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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