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Exploring synchronicity in the heart rates of familiar and unfamiliar pairs of horses and humans undertaking an in-hand task

Jo Hockenhull[1*], Tamsin J Young[2], Sarah E Redgate[3] and Lynda Birke[4]

[1] School of Veterinary Sciences, University of Bristol, UK; [2] Biology and Environment, Glyndwr University, UK; [3] School of Animal, Rural and Environmental Sciences, Nottingham Trent University, UK; [4] Department of Biological Sciences, University of Chester, UK

*Corresponding author:
Animal Welfare and Behaviour Group, School of Veterinary Sciences, University of Bristol, Langford House, Langford, Bristol BS40 5DU, UK.
Email:Jo.Hockenhull@bristol.ac.uk

Abstract

Physiological responses that occur in horses and humans during their interactions, on the ground and during ridden work, have been investigated in a number of studies with some conflicting results. These suggest that in some situations emotional state may be transferred from humans to horses and that there is the potential for the heart rates of horse-human pairs to become synchronised during ridden work. Here we explore the effect of familiarity on the physiological responses of horse-human pairs completing a task in-hand, using heart rate as an indicator for emotional state. We investigated differences in heart rate response between familiar and unfamiliar pairings and the possibility of heart rate synchronisation within each pair. Complete sets of horse and human heart rate data were available for seventeen horses. We found a significant order affect with higher horse heart rates seen the first time around the course regardless of whether a familiar or unfamiliar handler was leading (Wilcoxon test: $Z=-2.67$, $P<0.05$). However, despite this, the horses' mean heart rates for each course were significantly higher with the unfamiliar handler than with the familiar handler (Wilcoxon test: $Z=-4.46$, $P<0.001$). In contrast, human heart rates were higher when paired with a familiar horse compared with an unfamiliar horse (Mann-Whitney U test: $Z=-5.08$, $P<0.001$). Significant correlations between horse and human heart rate were seen in three familiar pairings and two unfamiliar pairings. Our findings indicate that the relationship between horse and human heart rates during interactions is not straightforward or consistent between horses and humans, and is likely to depend on a number of factors such as experience of the test situation. Although the lower heart rates seen in horses being led by their

familiar handler suggest that they are more relaxed with someone they know, this could not be said for the human partner.

Keywords: anxiety; familiarity; heart rate; horse-human relationship; synchronicity

Introduction

As people who care for, spend time with and/or ride horses one thing we seek is a close bond with an individual horse. We have grown up with this ideal percolating the majority of children's fictional equestrian literature, for example My Friend Flicka (O'Hara 1941) and The Black Stallion (Farley 1941).

Outside of the realms of fiction, this ideal has manifested itself in the wave of 'natural horsemanship' training philosophies and approaches that have emerged over recent years. While there are differences in the types of language used and the exact practices promoted by proponents of each approach, these philosophies are typically marketed as means by which communication with horses and therefore the horse-human relationship can be improved above and beyond that which can be achieved through more 'traditional' training practices (Parelli 1993; Roberts 1997; Birke 2008). The popularity of these approaches provides strong evidence of people's desire to enhance their relationship with their horse, something which has been further substantiated through ethnographic investigations in this area (Brandt 2004; Birke 2007, 2008; Keaveney 2008).

Scientific study has also turned towards the horse-human relationship in the desire to develop a greater understanding of how horses and humans interact. These studies have used observations of equine behaviour, often in conjunction with physiological measures, to explore different facets of the horse-human relationship; although, it should be noted that physiological measures do not always correlate with behavioural observations (for example

see Yarnell, Hall & Billett 2013). One area that has received attention is whether nervousness can be transmitted from rider to horse. For a long time many people who own or work with horses have taken this as fact (Keaveney 2008) but it had previously received relatively little scientific attention. As fearful behaviour from horses is a common cause of horse-riding accidents (Keeling & Ladewig 2010) research into the transmission of emotional state between horse and human has important implications for rider safety and horse welfare, as well as the potential for improving competitive performance (Peeters et al. 2013). Studies in this area have typically used changes in horse heart rate as an indicator of psychological changes (Keeling, Jonare & Lanneborn 2009), although additional physiological measures such as heart rate variability and cortisol release have also been used (Becker-Birck et al. 2012; Ille et al. 2013).

While Keeling, Jonare and Lanneborn (2009) found evidence that rider nerves were transmitted to the horse during a ridden experimental task when the riders were expecting something potentially frightening to happen, studies based on measures taken during normal ridden work in a training and/or performance environment did not find a similar relationship. Increased heart rate and cortisol levels of riders did not appear to equate to a correspondingly high increase in the heart rate and cortisol levels of their horses (Becker-Birck et al. 2012; Ille et al. 2013; von Lewinski et al. 2013), indicating that in the training/performance environment horses may not respond physiologically to the nerves of their riders.

126 Factors likely to affect the nerves of people interacting with horses, including
127 their attitude and experience, have also been investigated for their effect on
128 the horse. Behavioural and physiological changes have been observed in
129 horses when handled from the ground by people with a negative or positive
130 attitude towards them suggesting that horses can discriminate between
131 people with different attitudes (Chamove, Crawley-Hartrick & Stafford 2002;
132 Hama, Yogo, & Matsuyama 1996). However, in both of these studies handler
133 attitude was fundamentally determined by their experience and confidence in
134 handling horses, and only a limited number of horses were used (n=1 and n=2
135 respectively).
136
137 The effect of human experience on the horse's physiology has also been
138 studied in the context of ridden work, but no evidence was found for a
139 difference in stress response when the horse was ridden by experienced
140 riders in comparison to being ridden by inexperienced riders (Ille et al. 2013).
141 However, the authors qualified their findings by stating that both groups had
142 some degree of experience with horses and the results might not be the same
143 if the horse's response to experienced riders was compared to that resulting
144 from being ridden by true beginners (Ille et al. 2013).
145
146 These studies raise the question of whether the handlers' experience with
147 horses is the important factor in the impact they have on the horse's
148 physiology and/or behaviour, or is it their confidence, attitude or a combination
149 of these factors? And what of familiarity – the handlers' experience of that
150 specific horse and the relationship they have between them? There has been

151 some suggestion that rider familiarity, rather than experience *per se*, may
152 have an influence on equine fear responses (König von Borstel & Krienert
153 2012) and that the heart rates of established, competing horse-rider pairs can
154 become synchronised during the undertaking of a dressage test (Bridgeman,
155 Pretty & Terry 2011). However, the effect of familiarity on physiological
156 responses of horses and humans during their interactions from the ground
157 has not been explored.
158
159 Heart rate (HR) was chosen as the physiological measure of horse's
160 emotional reactivity during the obstacle course, as it has been successfully
161 used for similar purposes in other studies (for example equine reactivity to
162 novel objects, Visser et al. 2002; and quantifying equine temperament, Visser
163 et al. 2003). Both HR and heart rate variability (HRV) represent the net
164 interaction between vagal (reducing HR) and sympathetic (increasing HR)
165 regulation, and von Borell et al. (2007) suggests both to be suitable measures
166 of emotional reactivity in varying animal species. Their findings do, however,
167 suggest HRV could be a more accurate measure of sympathovagal balance,
168 but urge caution in its use suggesting data from at least five minutes of
169 recording is necessary, and the age and sex of subjects should be
170 standardised together with time of day. Within subjects data collection is also
171 deemed more meaningful than between subjects. Since this study made use
172 of a variety of different horses from which data was collected in the presence
173 of familiar and unfamiliar handlers, and immediate measures of HR were
174 necessary at set points, it was deemed that HR would serve as a suitable
175 physiological indicator of emotional reactivity.

176

177 The aim of this study was to investigate the effect of horse and handler
178 familiarity on the heart rate of both parties during completion of an in-hand
179 task. We also wanted to see if synchronisation of horse-human heart rates
180 occurs when working together in-hand rather than under saddle, and if so,
181 whether this phenomenon is found in both familiar and unfamiliar pairings.

182

183 **Materials and methods**

184 The study received ethical approval from the University of Chester,
185 Department of Psychology Ethics Committee. We recruited 21 human
186 volunteers (hereafter 'handlers') and their horses from four different UK
187 equestrian establishments between June 2010 and September 2012 through
188 a network of personal contacts who themselves recruited volunteers in person
189 at their respective locations and from their own horse-owning contacts. All
190 volunteers were given a participant information sheet containing information
191 about the study and how the data would be used, and were asked for their
192 consent to participate.

193

194 Study design

195 Handlers were asked to lead their own or an unfamiliar horse around a course
196 marked out in an enclosed arena (approximately 20m wide x 40 or 60m long).
197 All horses were familiar with the arena used with the exception of horses 7
198 and 9 at location 2 (see Table 1). Three of the arenas were outdoors and one
199 was indoors.

200

The course was designed to promote interaction between horse and handler by including obstacles to negotiate and changes in pace and direction, requiring the pair to make a number of turns and adjustments in terms of their position alongside each other. The course was completed in walk with the exception of four trot strides towards the end. The course is outlined in Figure 1. After an initial circle around the outside of the arena, the pair entered the chicane (A), then walked around to a 'gate' marked by two cones (B) where the handlers were asked to halt and then move the horse backwards four steps. They then walked forwards and went in and out of the cones (the slalom, C), and then through three more 'gates' (D). The pair then circled around the arena so they were alongside the slalom cones (C) where they were asked to trot for four strides before returning to the set-up point. All horses were led in a head collar and lead rope. The circuit took approximately 5 minutes to complete.

Each horse was led around the course two times, once by a familiar handler and once by an unfamiliar handler in a cross-over design with stratified random sampling so that eleven horses were first led by a familiar handler and ten by an unfamiliar handler. There was a short break of approximately five minutes between rounds during which the horse was asked to stand at the set-up point. Both handlers were present throughout and able to observe each other's rounds, this was to allow the handlers to discuss their perceptions of how the horse went for them and the other handler in a brief interview conducted after the horse had completed both rounds of the course (see Birke & Hockenhull 2015). All horses and handlers wore Polar RS800 heart rate

226 monitors whilst undertaking the course. The data loggers for each monitor
227 were positioned as close as possible to the monitor for both horse (on the
228 surcingle around the horse's girth) and handler (on the handler's wrist). No
229 interference between the two heart rate monitors was observed. Each round
230 was videoed for subsequent behavioural analysis and this has been reported
231 elsewhere (see Birke & Hockenhull, 2015).
232
233 Due to recording issues with either the horse or the human heart rate
234 monitors, heart rate data were ultimately available for seventeen of the 21
235 horses and their familiar and unfamiliar handlers, with each horse that was
236 missing heart rate data or lacked heart rate data from one or both of their
237 handlers being excluded from the analyses.
238
239 Subjects
240 Horses
241 Heart rate (HR) was measured from 17 horses whose ages ranged from 2 to
242 25 years (Table 1). The horses' median age was 12 years with an
243 interquartile range (IQR) of 7.5-17.5 years. The horses included a variety of
244 breeds spanning natives to thoroughbreds. The length of time the horses had
245 known their familiar handler ranged from six months to fourteen years with a
246 median (IQR) of 4 years (0.88-6 years).
247
248 [Table 1 about here]
249
250 Handlers

All handlers were required to have experience of, and be confident in handling, horses. This was ascertained through discussion with the people involved. In total 22 different handlers were used in this study. Sixteen of these were familiar handlers who led their own horse (one handler led two of her own horses). The unfamiliar handlers were a convenience sample, typically people present at the location or the time of the study who were not familiar with the study horse. In three instances the unfamiliar person also completed the test as a familiar handler with their own horse and three handlers only led unfamiliar horses. Handler age ranged from <20 to 61-70 years with a median (IQR) of 21-30 (<20-31-40) year. Their horse experience ranged from 2 years to over 30 years, with a median (IQR) of 14 (10-24.25) years. Only two of the handlers were male, reflecting the bias towards women owners/carers in the UK leisure horse population (Boden et al. 2013; Hockenhull & Creighton, 2013). It has been suggested that human gender does not impact on horse behaviour (Henry et al. 2005; Hausberger et al. 2008) and therefore no efforts were made to address the sex bias in our handlers.

[Table 2 about here]

Data

The heart rate monitors were set-up to record beats per minute (bpm) calculated every 5 seconds. The monitors were started immediately before the horse and handlers undertook the course and were stopped as soon as they finished it. Absolute heart rate was used to aid comparison with similar studies

276 of horse-human interactions (e.g. Keeling, Jonare & Lanneborn 2009,
277 Bridgeman, Pretty & Terry 2011; Merkies et al. 2012). Heart rate variability
278 was not used due to the short test duration (≤5 minutes) and because the
279 focus of the study was on the acute heart rate response to the test situation
280 rather than a longer-term exploration of the stress response.
281 Once the heart rate data were downloaded, the heart rate of the horse and
282 handler at sixteen set points over the course were noted and these values,
283 and the average derived from them for each subject, were used for the
284 analysis.
285
286 Statistical analyses
287 Prior to analysis the data were tested for normality using Shapiro-Wilk test.
288 Data were not normally distributed and consequently non-parametric analyses
289 were used. Wilcoxon Signed Rank Tests were used to explore whether there
290 was any effect of the order in which the horse completed the course,
291 irrespective of familiarity of the hander, on the mean heart rates of the horses
292 and whether there was any difference in the mean heart rates of horses with
293 the familiar and unfamiliar handler. Mann-Whitney U tests were used to
294 compare handler heart rates when leading a familiar or unfamiliar horse.
295 Spearman's Rank Order Correlations using the heart rates for horse and
296 handler noted at the sixteen set points of the course were used to explore the
297 relationship between the horse and handler heart rates to determine
298 synchronicity. All statistical analyses were conducted in SPSS for Windows
299 v14 (SPSS Inc, USA).
300

Results

Comparison of handler groups

Due to the overlap between familiar and unfamiliar handler groups it is inappropriate to statistically test for differences in age and experience between the groups. However, descriptive analysis of the median (IQR) showed that the groups were comparable in terms of age and experience with horses. The median (IQR) age of familiar handlers was 21-30 (<20-31-40) years with a median (IQR) of 13 (10-23.25) years' experience with horses. In comparison, the median (IQR) age of unfamiliar handlers was slightly higher at 31-40 (21-30-41-50) years, although their experience with horses was very similar with a median of 12 (10-23.50) years.

Effect of order of course completion on horse heart rate

There was a significant difference in horses' HR (bpm) between the two rounds of the course (Wilcoxon test: Z=-2.67, P=0.008). When they completed the course for a second time their mean HR was lower than during their first round regardless of whether the handler was familiar or unfamiliar (figure 2).

[figure 2 about here]

Effect of familiarity of handler on horse heart rate

Despite a significantly lower HR being recorded in horses completing the obstacle course for a second time, when horses were handled by an unfamiliar handler, regardless of whether this was for their first or second round of the course, they experienced a significantly higher mean HR as

326 compared to when they were handled by a familiar handler (Wilcoxon test: Z=-
327 4.46, P<0.001; see figure 3).
328
329 [figure 3 about here]
330
331 Effect of familiarity of horse on handler heart rate
332 When handlers were leading horses familiar to them their HR was significantly
333 higher than when they were leading horses unfamiliar to them (Mann-Whitney
334 U test: Z=-5.08, P<0.001; see figure 4).
335
336 [figure 4 about here]
337
338 Does horse and handler HR correlate during the course?
339 Of the 17 horses that completed the obstacle course, the HR of four of the
340 horses correlated significantly with the handler they were familiar with
341 (Spearman's Rank Order Correlation: Horse 3: r=-0.68, n=16, P=0.004; Horse
342 5: r=0.55, n=15, P=0.035; Horse 7: r=0.52, n=15, P=0.048; Horse 10: r=0.63,
343 n=15, P=0.011).
344
345 The HR of two of the horses correlated significantly with the unfamiliar handler
346 (Spearman's Rank Order Correlation: Horse 7: r=0.77, n=15, P=0.001; Horse
347 16: r=-0.56, n=15, P=0.029).
348
349 **Discussion**

350 The familiarity of horse and handler appears to have an effect on the heart
351 rate of both horses and humans during the completion of an in-hand task;
352 however, this effect cannot be explained by familiarity alone.
353
354 First, the finding of an order effect, whereby horses had a significantly lower
355 mean heart rate on their second round of the course, regardless of who was
356 leading them compared to their first round, was not entirely unexpected but
357 does have important implications for other studies of this kind. We tried to
358 minimise order effect in this study by testing the horses and handlers in a
359 pseudo-random order, however, one pairing always had to go first and this
360 finding highlights the need to keep potential order effects in mind when
361 interpreting results (Martin & Bateson 1993).
362
363 Despite the presence of an order effect, the mean heart rate of horses was
364 significantly higher when they completed the course with an unfamiliar
365 handler. This suggests that the horses were more relaxed completing the
366 course with a handler they knew well. The length of time that the horses had
367 known their familiar handler ranged from 6 months to 14 years. Five of the
368 horses had known their familiar handler ≤ 1 year but our findings imply that
369 this duration is long enough to build some kind of relationship with that person
370 that distinguishes them from a handler who is experienced and confident
371 around horses but who is unfamiliar to them. Behaviourally, there was an
372 observable difference between familiar and unfamiliar pairings in their
373 relaxation, coordination and attentiveness, with familiar pairings moving

374 together in greater harmony (Birke & Hockenhull 2015), supporting the idea of
375 relaxation portrayed in the horse heart rate data.
376
377 However, the heart rates of the handlers did not follow the same trend as the
378 heart rates of the horses. Handlers leading their familiar horses had a
379 significantly higher mean heart rate than those completing the course with an
380 unfamiliar horse. It is likely that this reflects some degree of performance
381 anxiety on the part of the handler; that handlers are more anxious about the
382 task when working with their own horse in what could be perceived as a test
383 situation. In contrast, the unfamiliar handlers had less invested in the horse
384 and may not have been as concerned about its performance and how their
385 relationship with the horse could be judged. This hypothesis was supported in
386 the interviews conducted with the after the course had been completed (Birke
387 & Hockenhull 2015) and informally during the period between rounds.
388
389 This finding parallels those of published studies exploring physiological
390 differences in horses and riders between training and a public performance or
391 competition, where the rider showed a greater physiological response,
392 indicating heightened anxiety, in a performance situation that the authors
393 speculated may be due to the presence of spectators and the expectations
394 the riders placed on themselves (Becker-Birck et al. 2012; von Lewinski et al.
395 2013). Similar to our findings, these studies found no corresponding
396 physiological change in their horses (Becker-Birck et al. 2012; von Lewinski et
397 al. 2013). In contrast, Bridgeman, Pretty and Terry (2011) found that horses
398 ridden by more anxious riders had higher heart rates themselves. The

399 implications of heightened rider physiological response on performance differ
400 between published studies. Peeters et al (2013) found that increased rider
401 stress (measured via salivary cortisol) reduced performance quality whereas
402 Bridgeman, Pretty and Terry (2011) found no such association. It is worth
403 noting however, that while there was some degree of overlap between our
404 familiar and unfamiliar handler groups, there were three handlers that only led
405 unfamiliar horses and this may have affected the mean group heart rate.
406
407 The final relationship we explored was the synchronicity of heart rates
408 between horse-handler pairs. Here the results were mixed with only six of the
409 34 pairings showing any correlation between horse and handler heart rates.
410 Four of these significant correlations were familiar pairings and two were
411 unfamiliar, although the horse in one of the unfamiliar pairings was also
412 significantly correlated with his familiar handler. This contrasts to Bridgeman,
413 Pretty and Terry (2011) who found synchronisation in the heart rates of 13 out
414 of their 17 horse-rider pairs. The difference may stem from the distinction
415 between working with a horse on the ground, where horse and human are
416 only connected physically via a lead rope, and working with a horse under
417 saddle where the rider is physically in direct contact with the horse and can
418 communicate through their body (Keaveney 2008). Our findings provide no
419 real evidence for heart rate synchronisation in horse-handler pairs undertaking
420 a course with the human on the ground in a test situation.
421
422 Our findings indicate that there is a complex relationship between horse and
423 human heart rates during interactions on the ground. Familiarity appears to

have a conflicting effect on horse and handler, with horses more relaxed with someone they know and handlers seemingly affected by performance anxiety when working with their familiar horse. Intangible, hard to measure factors such as previous personal experience of working with other partners or the test situation are also likely to influence the physiological response observed and should be taken into consideration in future studies of this type.

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547 physiological measures. *Physiology and Behavior* 118, 32-39.

548

549 **Tables**

550

551 **Table 1: Details of the 17 horses used in the study for whom a complete**
552 **set of heart rate data were available.**

553

Horse id	Location[a]	Age (years)	Length of time with familiar person (years)	Sex	Breed/type[b]	Height (Hands / Inches)
1	1	11	6	M	TB	16
2	1	9	2	G	ISH	15.2
3	1	24	4	G	TB	15.2
4	1	25	7	G	DWB	16.3
5	1	17	4	M	BWB x Han	16
6	2	18	14	G	ISH	16.1
7	2	8	6	G	Exmoor	12.2
8	2	12	0.5	M	TB	15
9	2	6	5	M	Exmoor	12.3
10	3	16	0.5	G	Sec D x Trotter	15
11	3	5	1	G	Gypsy Vanner	14.2
12	3	16	0.75	G	ISH	16.3
13	3	14	5	M	Sec B	13
14	4	7	3	G	Mixed breeding	?
15	4	22	7	G	ISH	16.1
16	4	2	0.5	G	Gypsy Vanner	13.1
17	4	11	2	M	Connemara	14.2

554 [a] Location of testing 1=livery yard June 2010; 2=private yard September 2012; 3=livery yard
555 September 2012; 4=livery yard March 2011

556 [b] ISH = Irish Sports Horse, TB = Thoroughbred, DWB = Dutch Warm Blood, BWB = British
557 Warm Blood, Han = Hanoverian, Sec B or D = Welsh Section B or D

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563 **Table 2: Details of the familiar and unfamiliar handlers used with each**
564 **horse in the study.**
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	Familiar handler			Unfamiliar handler		
Horse	**Age category**	**Sex**	**Experience with horses (years) at time of testing**	**Age category**	**Sex**	**Experience with horses (years) at time of testing**
1	21-30	M	12	31-40[a]	F	22
2	<20	F	16	31-40[a]	F	22
3	<20	F	12	31-40[a]	F	22
4	31-40	F	28	31-40[a]	F	22
5	21-30	F	20	?	F	?
6	31-40	F	30	31-40[a]	F	24
7	31-40[b]	F	25	31-40[a]	F	24
8	31-40[c]	M	>10	31-40	F	24
9	31-40[b]	F	25	31-40[c]	M	>10
10	<20	F	5	61-70[d]	F	27
11	<20	F	10	41-50[e]	F	10
12	21-30[f]	F	14	61-70[d]	F	27
13	<20	F	10	21-30[f]	F	14
14	41-50[e]	F	10	21-30[g]	F	2
15	21-30	F	19	21-30[g]	F	2
16	21-30	F	10	41-50[e]	F	10
17	41-50	F	>30	41-50[e]	F	10

567 [a,b,c,d,e,f,g] letter denotes the same handler.

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572 Figure 1. The layout of the course completed in walk (in an anticlockwise
573 direction) by all horse-handler pairs, with the exception of four strides of trot
574 which occurred alongside the slalom (C).
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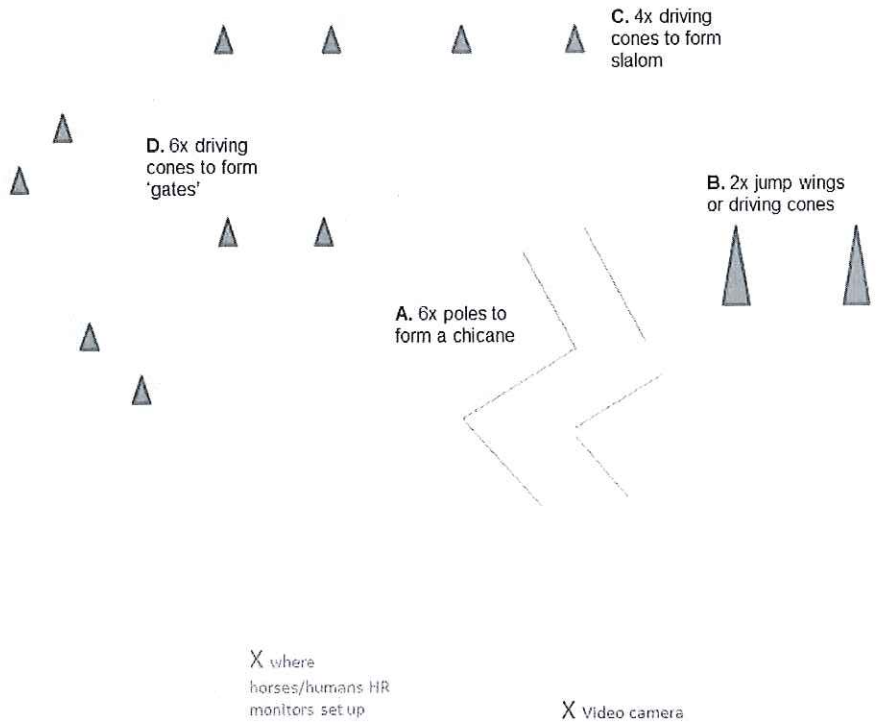

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Figure 2. There was a significant difference in mean heart rate (bpm) of horses as they completed the first and second round of the course, regardless of whether a familiar or unfamiliar person was handling them.

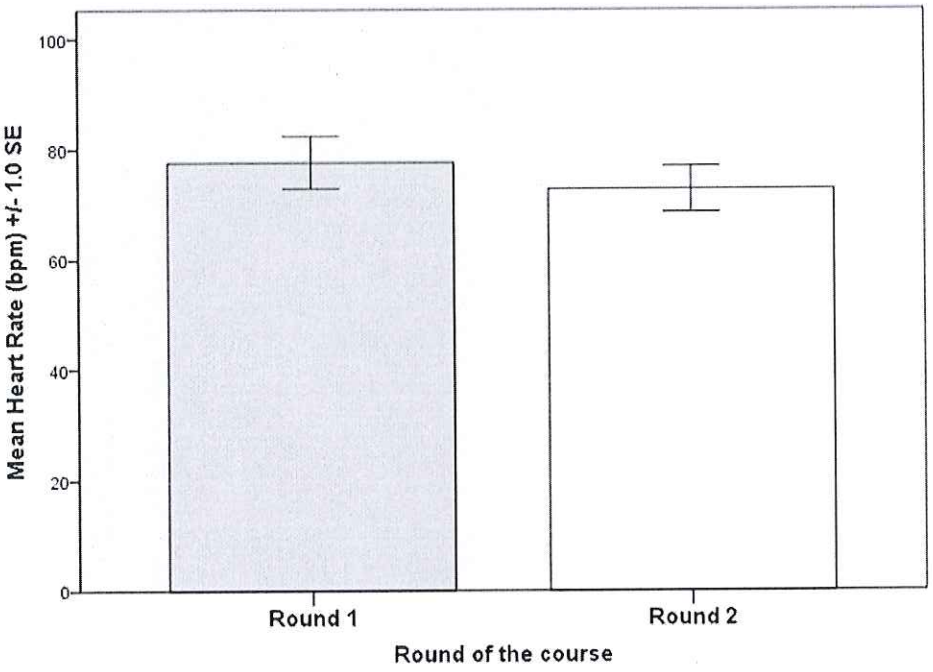
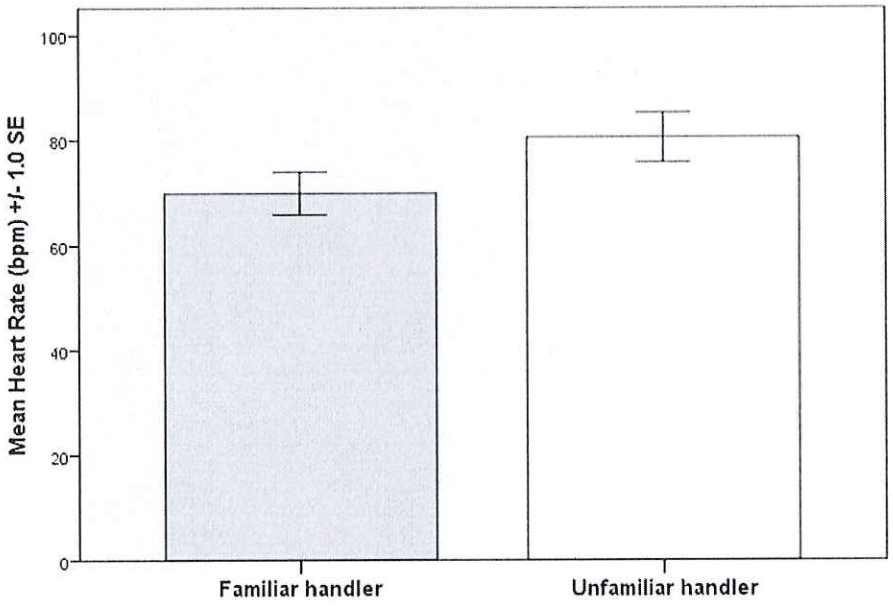


Figure 3. There was a significant difference in mean heart rate (bpm) of horses when led by a familiar and an unfamiliar handler, regardless of whether this was their first or second round of the course.



660 Figure 4. Mean heart rate (bpm) of the handlers was significantly different
661 when leading a familiar or an unfamiliar horse.
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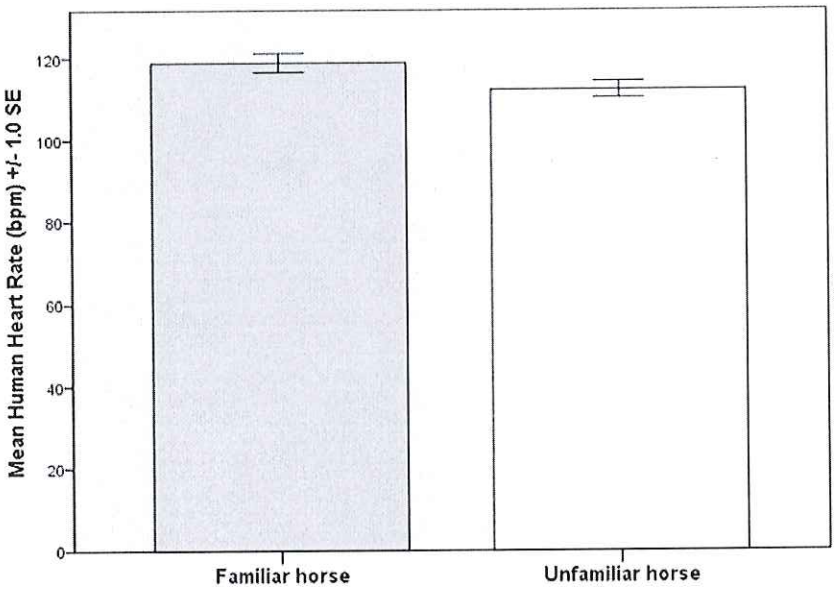

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