The Structure of Social Personality in Young Horses

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A Master's thesis

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THE UNIVERSITY OF TURKU
The Department of Biology
RIIHONEN VEERA: The Structure of Social Personality in Young Horses
A Master's thesis, 37 p.
Ecology and Evolutionary Biology
July 2021
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In this study I aimed to understand the structure of young horses' social personality towards humans and conspecifics, respectively. The study population consisted of 19 horses under four years old. I tested their sociality towards humans and their general reactivity to novelty with six different personality tests. The tests were conducted twice with six months in-between. Additionally, I assessed their sociality towards other horses by focal observations. I found two repeatable and context independent factors from the personality test data in which the variable loadings presented some overlap. The first factor, Reluctance, informs about the motivation of the horses to co-operate with humans, and the second factor, Unfocusedness, informs about their general interest towards humans. While I did not formally test whether the observational variables comply with the personality criterion, the sociality towards other horses seems to form one clear factor, Sociability; more social horses seek and are sought by other horses more regularly and are less aggressive towards other horses. There was no connection between either Reluctance or Unfocusedness and Sociability or any of the observed social behaviour variables tested on their own. I conclude that horses do have social personality factors for both human and horse sociality, but these are separate from each other. This separation of sociality aspects sheds light on the effects of domestication on sociality overall. The results call for more studies on differences in animal personality towards humans and conspecifics both in horses and other species with different management systems and domestication histories.

Keywords: social personality, personality structure, horse personality, domestication

Contents

1. Introduction

1.1. Animal personality

Animal personality is defined as individual behavioural tendencies that vary across individuals within a population (Mehta and Gosling 2008; Cabrera et al. 2021). Personality traits are consistent within individuals over time and across different contexts: while the absolute individual values can vary with age or environmental conditions, the differences between individuals are still largely maintained (Réale et al. 2007). Historically animal personality has also been called temperament, behavioural syndromes and types, coping styles and disposition among other synonymously used terms (Réale et al. 2007; Mehta and Gosling 2008; Rankins and Wickens 2020).

Personality has been found in a wide variety of animal species from mammals, birds, fish reptiles and amphibians, and even some invertebrates (Cabrera et al. 2021). Typical traits studied in animals include aggression, boldness, activity, exploration and sociality, sociality receiving the least attention of these (Sih et al. 2004; Réale et al. 2007; Mehta and Gosling 2008). Since most studies concern very few traits regardless of the study organism used, other possibly important traits could be missed – the ecological validity of traits should be considered beforehand as Koski (2014) suggests. For example, in a social species the social interactions shaped by different social personalities within the population should be considered (Krause et al. 2010; Koski 2011, 2014).

1.2. Personality, evolution, and ecology

Different personality aspects affect the interactions of an individual with its environment in various ways, ranging from reactions to predators and food sources to its reproductive interactions with conspecifics (Réale et al. 2007). These interactions with the surrounding environment may cause significant fitness consequences for the individual (Dingemanse et al. 2004; McDougall et al. 2006; Réale et al. 2007). As personality is also known to be heritable, it is easy to see why personality, due to these fitness consequences, is a major

evolutionary factor that can potentially even lead to speciation (Sih et al. 2004; McDougall et al. 2006; Réale et al. 2007).

Since personality differences are known to have fitness consequences, the existence of these stable personality differences between individuals is an evolutionary puzzle. Current explanations of the evolutionary mechanisms include spatiotemporal variation and frequency dependent selection (Sih et al. 2004; Cote et al. 2008), and sexual selection (Cabrera et al. 2021) that can all maintain the personality variation within a population while still selecting for predictability in behaviour on the individual level. Additionally, behavioural traits are often linked with other traits as syndromes – for example, aggression and bold response to novelty tend to co-occur (Sih et al. 2004). These behavioural syndromes are often caused by a linkage at the proximate level, for example pleiotropy, and the connection is hard to sever, which explains the persistence of sometimes maladaptive personality traits in some cases (Sih et al. 2004).

In partner choice, parenting, social tolerance and co-operation, differences in social personality can have direct fitness consequences (Koski 2014; Sabol et al. 2020). For example, the sociality of a female baboon affects the survival of its offspring (Silk et al. 2003). The social personality composition of a population thus shapes the whole social environment of the individuals in the population – game-theoretical models traditionally assume a social structure based on random encounters, but this is rarely the case, and this can lead to different evolutionary consequences for different populations (Réale et al. 2007; Cote et al. 2008; Krause et al. 2010;). As personality is shaped by genes and the environment, the social environment at certain critical periods of development can also shape the personality of an individual (Réale et al. 2007; Rankins and Wickens 2020).

Animal personalities are also linked to several important ecological factors which can influence population and community ecology (Sih et al. 2004; Réale et al. 2007). For example, personality is known to affect the major factors governing population dynamics: births, deaths, and dispersal (Sih et al. 2004). Personality differences in boldness, exploration and sociality affect the individual differences in dispersal rates and thus the speed of range expansions and invasions (Fogarty et al. 2011; Cabrera et al. 2021). Social

personality should also be taken into consideration in conservation biology as habitat loss and fragmentation can favour certain personalities and thus lead to bottlenecks in behavioural phenotypes (Sih et al. 2004; Réale et al. 2007). Personality is also known to affect reintroduction success especially in the case of accidental domestication in captive-bred animals (McDougall et al. 2006; Cabrera et al. 2021).

1.3. The effects of domestication

Domestication is an evolutionary process where animals are (on purpose or inadvertently) selected for "tameness", which means fearless, non-aggressive, and pro-social behaviour towards humans (Hare et al. 2005; Trut et al. 2009; Wilkins et al. 2014; Wheat et al. 2018). At least in dogs this sociality towards humans has not come without a cost: there are signs there might be a trade-off between sociality towards humans and conspecifics. For example, dogs direct their play behaviour more towards humans than conspecifics (Wheat et al. 2018), and dogs do not show the same kind of reconciliation behaviours as wolves after a conflict with conspecifics (Cafazzo et al. 2018).

In all animals, selection for tameness also leads to a so called "domestication syndrome": predictable changes in animals' morphology and physiology – usually white markings and floppy ears, and changes in brain size and cognition (Trut et al. 2009; Wilkins et al. 2014). On the whole, animal domestication reshapes and alters the behaviour, morphology, and physiology of the animals in predictable ways (Larson and Fuller 2014; Kaiser et al. 2015; Ahmad et al. 2020).

Horses were domesticated over 5000 years ago (Orlando 2020). They have many of the markers of the domestication syndrome: white markings, smaller brain size, and more docile behaviour towards humans (Wilkins et al. 2014). Their social cognition has clearly been shaped so that they can aptly read human facial expressions and emotional cues (Nakamura et al. 2018; Baba et al. 2019; Schrimpf et al. 2020). They are also one of the very few animal species alongside dogs and goats that are known to understand human gestural signals (Maros et al. 2008; Proops et al. 2010). This is thought to be an effect of

domestication, as better social cognitive abilities towards humans have been connected to domestication: for example, foxes bred for tameness are better at understanding pointing than wild-type foxes (Hare et al. 2005).

1.4. Horse personality

In their review of equine personality Rankins and Wickens (2020) summarize the previous horse personality research. From this review, it is clear that horse personality research mainly focuses on the horses' reactivity, fearfulness, sensitivity, and activity. Conversely, their sociality towards humans and conspecifics has been studied quite little. The existing research has focused on passive presence or absence of humans or other horses rather than focusing on interaction. For example, the differences in sociality towards other horses has most often been studied by isolating the horses from conspecifics and this reaction to isolation is referred to as gregariousness. In contrast, the differences in their sociality towards humans have been studied primarily by observing their reaction to passive human presence.

If horses have been tested in a socially interactive situation, the research has usually focused on the differences between demographic groups rather than trying to find out individual behavioural tendencies in a social situation, i.e., social personality (for example, Bouskila et al. 2015). Additionally, the social structure of horses living in herds has been studied by comparing the social structure of herds with or without a stallion (Sigurjonsdottir et al. 2003; Granquist et al. 2012) or domestic and feral populations (Christensen et al. 2002), but the individual differences have never been considered. Co-operation with humans has also been studied, but again the research has examined the phenomenon on the population level. For example, in their study Hockenhull and Birke (2015) compared the behaviour of the horses in a co-operative situation either with a familiar or an unfamiliar person.

The fact that the social personality of horses has not been studied more is particularly surprising, considering that horses are socially rather unique in the animal kingdom: both

sexes disperse from their natal group and form long-lasting individualized relationships with non-relatives (Seyfarth and Cheney 2012). These relationships between non-relatives give direct fitness benefits for groups of bachelors (Seyfarth and Cheney 2012), more social mares in a harem (Cameron et al. 2009), and stallions forming alliances with each other (Feh 1999). Thus, their unique sociality and strong influence of domestication make them a very intriguing model animal for social personality research. They could help shed light on a multitude of evolutionary processes creating sociality and co-operation in animals.

1.5. Aims of the study

As has been established, the personality types of individuals can affect the ecology of a population. Personality can also affect the population's evolutionary trajectory. Social personality is especially important in its many indirect ecological and direct fitness consequences. Animal personalities are shaped by natural, sexual, and artificial selection, and domestication has been especially influential at shaping the sociality of a handful of animal species. For their unique sociality horses are a great model species for social personality research. As thus far little is known about their social personality, my research aims to fill this gap.

In my thesis I investigate the structure of social personality in young domestic horses. I test their sociality towards an unfamiliar, neutral person by different personality test measures and assess their sociality towards other horses by focal observations. I conduct the personality tests twice with six months in between and test the variables for repeatability. While not formally testing the observational data for repeatability, I contrast the sociality towards humans and other horses with each other to see whether there is an association between these different aspects of sociality.

I predict that based on primate research (Neumann et al. 2013; Massen and Koski 2014), social traits form one or several syndromes independent of general reactivity. While a trade-off between sociality towards humans and conspecifics has never been formally

assessed in any animals, the studies on dogs (Cafazzo et al. 2018; Wheat et al. 2018), indicate that there could be one. Thus, I also predict that social personality traits expressed with conspecifics are negatively associated with those expressed with or towards humans.

2. Materials and Methods

2.1. Study population, location, and time

I conducted the study at the Kylämäki horse farm in Marttila, Southern Finland from March to November 2020. I did the first round of personality tests from March to April, collected the observational data from May to September, and repeated the personality tests from October to November.

Initially, 19 young, previously unhandled horses were included in the study to test their social personality with humans and conspecifics, respectively. Of those 19 horses, 11 were yearlings (born in 2019), six were two-year-olds (born in 2018), and two were three-year-olds (born in 2017). Nine of the horses were stallions, nine were mares, and one was a gelding. Most study horses were Finnhorses. Additionally, three American standardbreds and one Finnish warmblood were also included in the study.

One stallion dropped out of the study before the summer observations, and one stallion died before the second test round of the personality tests. Additionally, after the summer four stallions moved stables, so their remaining repeat personality tests had to be conducted in their new stables. There their living and testing conditions differed from the conditions at the Kylämäki horse farm, but all were tested in comparable conditions to the earlier tests.

All information on the horses can be found in an individualized form in Table 1.

Table 1. Individualized information on the horses included in the study.

ID	Age	Sex	Breed	Other
CE	1	mare	Finnhorse	
DE	3	mare	Finnhorse	
DU	3	gelding	Finnhorse	moved after summer
EE	2	stallion	Finnhorse	
EN	2	stallion	Finnhorse	
ER	2	mare	Finnhorse	
FF	1	mare	Finnhorse	
FI	1	mare	Finnhorse	
FM	1	stallion	American standardbred	dropped out
FP	1	stallion	Finnhorse	moved after summer
FR	1	stallion	Finnhorse	died in October
FU	1	stallion	Finnhorse	
FY	1	mare	Finnhorse	
FÖ	1	mare	Finnhorse	
GA	1	stallion	American standardbred	moved after summer
JH	2	stallion	Finnhorse	
LN	2	mare	Finnhorse	
MA	1	mare	American standardbred	
ZT	2	stallion	Finnish warmblood	moved after summer

During the personality tests in March-April and October-November the horses lived in groups in an open housing complex with free indoor-outdoor choice. From March to April the horses were separated by age into two groups. Additionally, while all yearlings lived together independent of sex, all older horses were further separated by sex into two groups. From October to November all horses were separated by sex only, independent of their age. All groups had visual, auditory, and olfactory contact to all other groups in the complex.

During the observations from May to September the horses were living freely on large mixed-habitat pastures. All pastures had varying terrain, forested areas for shelter, clearings with sufficient grass to feed them all, and natural streams or rivers for fresh water. The sexes were separated for the summer. All the fillies and young mares independent of age lived on one very large 20-acre pasture together for the whole summer. The stallions were further separated by age so that the yearling colts lived separately from the older stallions. The yearling stallions rotated between two 2-acre pastures and one 3-

acre pasture, and the older stallions and geldings rotated between one 3-acre pasture and one 5-acre pasture. The pastures were located so far from each other that the horses had no visual or auditory contact with the other groups during the summer.

The living situations during both test rounds and the observations have been further clarified in Table 2.

Table 2. The living situations and groups during the experiments and observations.

Period	Time	Group structure	Notes
Test 1	Mar – Apr	Yearlings: together regardless of sex Older: separated further by sex	Open housing with free indoor-outdoor choice
Obs.	May – Sep	Mares: together regardless of age Stallions: separated further by age	Large mixed-habitat pastures
Test 2	Oct – Nov	Mares: together regardless of age Stallions: together regardless of age	Open housing with free indoor-outdoor choice

2.2. Horse-human sociality: personality tests

2.2.1. General

I assessed the horse-human sociality by different behavioural experiments that investigate the horses' motivation to co-operate with an unfamiliar human. I conducted the experiments twice, first in spring and again six months later in autumn, to allow for repeatability calculations. I conducted the tests in a randomised order for each horse, except for the human orientation index test, which was always done first to ensure minimum familiarity of the tester.

I video recorded all the tests for later analysis. After data collection I coded the obtained video material from the personality tests using Boris (Friard and Gamba 2016) and extracted the data from there into Excel files using R (R Core Team 2020). The focus was

on the reactions, reluctance, and changing emotional states of the horses in the tests. I quantified the data as latencies, durations, and frequencies in each experiment.

I was always the tester as I was previously unfamiliar to the horses. To maintain unfamiliarity and to remain equally familiar and neutral to all the horses, I avoided touching or communicating in any way with the horses outside of the testing situations. There were always 1 – 3 assistants present and helping me conduct the experiments. One assistant brought the horses in and out of the tests so that I only handled or interacted with them during the tests. All people handling the horses before, during, and after the experiments wore helmets, long sleeves and trousers, sturdy shoes, and gloves with a solid grip for safety reasons. The horses had standard nylon halters and were led either by a 2-metre leading rope or by a 10-metre lunging rope depending on the test.

I conducted all the tests, except for the human orientation index test, in a riding hall. I built a small enclosure of 10x10 metres out of pole holders, fence posts, and a 50-metre rope inside the riding hall for the two tests where the horses had to be let loose for a time. There was always one of the farm's two donkeys in the riding hall as a companion for the test horses so that they would not be alone and would feel more at ease in an unfamiliar place. The donkeys were previously known to the horses, as they lived with them in the open housing complex and on the pastures during summer.

2.2.2. The Human Orientation Index (HOI)

The Human Orientation Index (HOI; Lansade and Simon 2010; Górecka-Bruzda et al. 2011) measures the horse's reaction to a human stranger and its acceptance of gentle touching. The test was modified from Lansade and Simon (2010). I put the older horses into standard box stalls, and the yearlings (as they had never been in the stable before) into a separate 2x2 metre corner of the open housing complex, so that during the test they had no visual contact to the other horses.

First, the assistant put the horse to the box stall, or the separated corner, and left it there to settle down for a few minutes. After the horse had settled into its new surroundings, I entered and stood facing the middle of the stall in a neutral body position and eyes downward. If the horse came to touch me within five minutes of me entering, I moved immediately to the next part of the test. If the horse did not touch me within the five minutes, I moved on to the next part regardless. If the horse touched me immediately as I was entering the stall, I waited for one minute, or until the next touch, before commencing to the next part. In the second part I tried to gently touch the horse's muzzle, shoulder, and forehead in this order with the palm of my hand. I did not force the touches if the horse's reaction was to refuse it.

I coded the following behaviours from the videos:

1. The horse's latency to touch the tester.
2. The time the horse was turned away from the tester, later turned into a percentage of the total testing time.
3. The horse's reaction to the forehead touch (affective – neutral – avoidant).

2.2.3. Object choice test

The test was identical to Proops et al. (2010). I tested the horses by pointing with a finger and body orientation, respectively, to a reward. In this study, I was not interested in whether the horse's interpretation of the pointing gesture was correct or not, since whether the horse understands the pointing gesture or not tells more about the cognitive capabilities of the horse than its personality. The experiment was included, however, because the willingness and motivation to participate in an active and cognitively challenging situation with an unfamiliar human is indicative of the horses' human orientation. The correct or incorrect choices will, however, be used later in another study.

I did the test in the 10x10 metre testing arena within the riding hall. During the test, I stood at one side facing the centre of the arena with carrot pieces or dried bread, depending on the horse's predetermined preference, in my pockets. The assistant brought

the horse in and led it to the other side of the arena so that it was facing me three metres away. The assistant then unclasped the leading rope from the horse's halter and stayed still. The horse was expected to approach me and the buckets voluntarily.

For the habituation rounds I put the two buckets directly in front of me on top of each other, and for the test rounds I placed one bucket on each side, equidistant from me and from each other. The assistant caught the horse again after it had clearly made its choice of buckets by lowering its head so that its nose was 20 centimetres from the bucket. The assistant then led it back to the starting place and let the horse loose again for the next round. The assistant led the horse away from the buckets alternating between right and left in a randomized order. The test arena and the position of all participants are depicted in Figure 1.

I did six habituation rounds first to teach the horse that there were treats in the buckets. If the horse came forward and put its nose close to the bucket in front of me, I dropped a treat in the bucket. If the horse was initially not interested or was afraid of the buckets, I sometimes crouched next to the bucket or threw some treats closer to the horse to increase its interest. The horse was always caught only after it had got the treats from the buckets. Six habituation rounds were generally enough to get the horses interested in the buckets.

After the habituation, I moved the buckets to my sides. I then pointed first five times with a finger and then five times with body orientation to one of the buckets at a time. I randomised the pointing direction of each round for each horse. After the horse had clearly made its choice and lowered its nose close to the bucket, I rewarded the horse immediately by dropping a treat into the bucket. If the horse chose the wrong bucket, it was not rewarded in any way. After the horse had made its choice on each pointing round, the assistant caught the horse again and led it to the starting point, regardless of the horse's success. I always did two pointing rounds back-to-back followed by one habituation round where I brought the buckets again to the middle and the horse always got a treat from the bucket to maintain the horse's participation motivation.

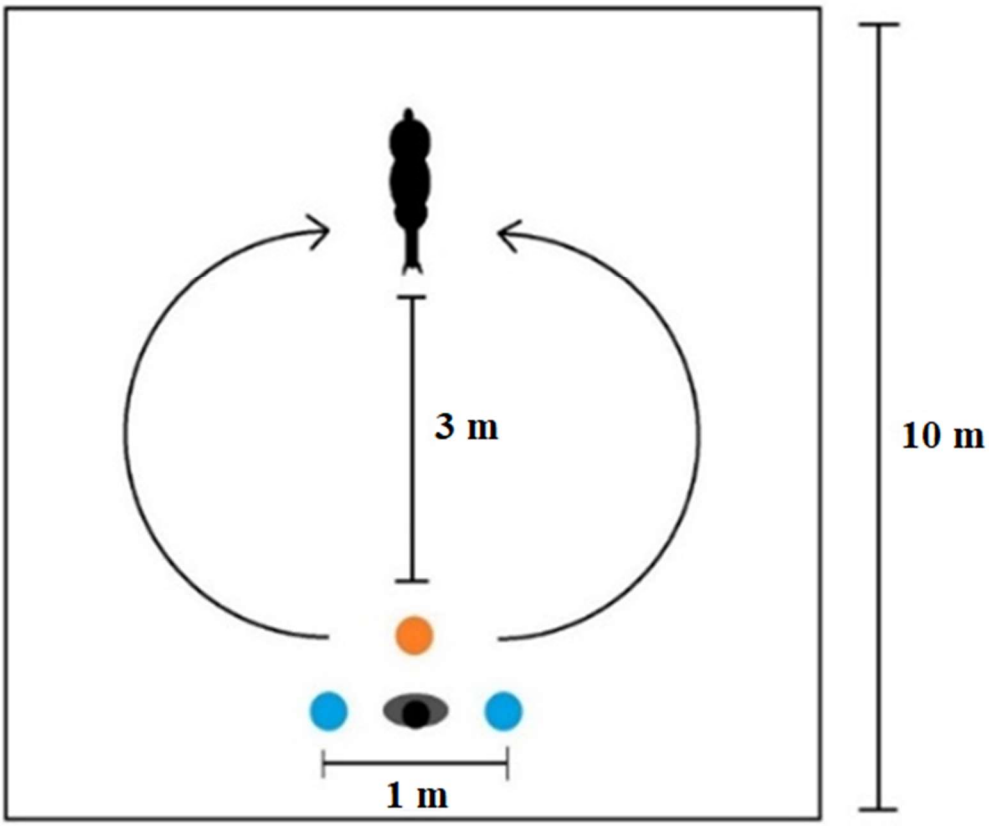

Figure 1. The positions of the tester, the horse, and the buckets during the object choice test within the 10x10 metre arena. The yellow circle represents the position of the bucket during the habituation rounds and the blue circles represent the position of the buckets during the experimental rounds. The arrows represent the route the assistant walked the horse back to the starting point after every round. The picture is not to scale.

Since there were six initial habituation rounds and ten testing rounds plus a habituation round every time after two testing rounds, there were 21 rounds in total. If the horse was uninterested and did not even try to get close to the buckets for over 60 seconds and/or started to get restless during any part of the test, the test was terminated. The test had to be terminated early due to restlessness or uninterest for four horses on both testing rounds and for nine horses on only one of the testing rounds. The testing was also terminated if the horse escaped the testing arena; in the end two horses escaped on one of the testing rounds.

I coded the following behaviours from the videos:

1. The horse's latency to start moving towards the buckets on the first and the sixth habituation rounds and every trial round thereafter.
2. Time the horse was turned away or doing something else, later turned into a percentage of the total testing time.
3. The number of trial rounds the horse completed before the experiment was terminated (out of ten).
4. Whether the horse's choice of the buckets was correct or not. The choices were not taken into consideration in the personality analysis, but they will be used later in another study.
5. Whether and when the horse escaped the testing arena. The time of the possible escape was used to calculate the percentages for the time the horse was turned away or unfocused.

2.2.4. Motivation to co-operate with an unfamiliar human

I tested the horse's motivation to co-operate with an unfamiliar human with two separate tests: first, an obstacle course consisting of walking over a pole and trotting when led, and second, crossing over a novel surface when led. For both tests the assistant brought the horse to a predetermined spot 10 metres away from the pole or the novel surface where I fetched the horse for the tests. For both tests I led the horse by a 10-metre lunging rope for safety reasons.

Obstacle course

This test was not modelled after any previously done studies. For the obstacle course I placed a standard show jumping pole on the ground. First, I led the horse to the pole and tried to walk it over it. The horse was given three trials; the test proceeded to the second part either after the horse had walked over the pole for the first time or after the horse had refused three times.

In the second part, I led the horse to a circle with a 20-metre radius. I asked it to trot by starting to run myself and by putting light pressure on the lunging rope in a predetermined spot on the circle. I gave no auditory or other signs of encouragement to the horse. If the horse refused to trot, I released the pressure and stopped running after a few seconds. If the horse started to trot, I slowed the horse down to a walk after trotting for a quarter of the circle. I repeated the trotting trial three times independent of whether the horse trotted or not on the previous rounds.

I coded the following behaviours from the videos:

1. How many attempts it took for the horse to go over the pole (out of three).
2. Whether and how the horse explored the pole (no exploring – only sniffing – or manipulating with mouth and/or foot).
3. The horse's reluctance to go over the pole (no reluctance – some pulling back or away – heavy pulling, rearing, or bolting).
4. How many times the horse trotted (out of three).
5. The latency from the tester asking the horse to trot to the first trot step of the horse on the first successful run.
6. Tightness of the rope during the trotting test (all the time loose – initial pressure – all the time tight).

Novel surface

This test was modified after Lansade et al. (2016). In contrast to their test, I did not use food reward as a motivator. I used two different 2x3 metre cotton sheets for the novel surface test. For the first test round the sheet was pure white and for the second test round the sheet had blue stripes on a white background. This was done to keep the test surface truly novel to the horses, but similar enough to be comparable with each other. I led the horse to the novel surface and tried to walk it over it. The horses were given three trials in total, and the test was terminated immediately after either the horse walked successfully over the novel surface, or it had refused three times.

I coded the following behaviours from the videos:

1. How many attempts it took for the horse to walk over the novel surface (out of three).
2. Whether and how the horse explored the novel surface (no exploring – only sniffing – manipulating with mouth and/or foot).
3. The horse's reluctance to go over the novel surface (no reluctance – some pulling back or away – heavy pulling, rearing, or bolting).
4. How many seconds the horse spent standing before the novel surface.
5. Did the horse cross the whole novel surface, only a part of it, or none of it on the last try.

2.2.5. Reactivity to novelty

I tested the horses' reactivity to novelty in a well-known novel object paradigm (Górecka-Bruzda et al. 2011; Bulens et al. 2015; Dai et al. 2015; Lansade et al. 2016) as a reference point for the other personality tests. I used two different novel objects during the first and the second testing round, respectively, to ensure the novelty of the object to the horses. The novel object was a black-and-white chequered rally flag on the first testing round, and three rainbow-coloured narwhal stuffed toys placed on a pedestal on the second testing round.

First, the assistant led the horse into the 10x10 metre enclosure and gave the lead rope to me. Then the assistant revealed the novel object five metres away from the horses head, and I released the horse at the same time. Both the assistant and I then exited the enclosure and left the horse alone in the arena to explore the novel object by itself. The testing was terminated after three minutes of solitary exploring or if the horse escaped the testing arena before the three minutes were up. In the end four horses escaped the testing arena on both testing rounds, and two horses escaped on one of the testing rounds only.

I coded the following behaviours from the videos:

1. Latency until the horse was two metres away from the object.
2. Latency until the horse touched the object.
3. Time the horse was focused on the object (looking directly at it). This was later turned into a percentage of the total test time.
4. Time the horse was examining the object (sniffing or touching with the muzzle). This was later turned into a percentage of the total test time.
5. Several behaviours from the horse that could indicate stress as frequencies: startles when approaching or touching the novel object, snorting, and whinnying, rolling, rearing or bucking, urinating or defecating, pawing, and trotting restlessly. For the analyses, the startles were analysed on their own as a clear indicator of a stress response caused by the novel object. The rest were summed up and grouped into two groups: vocalisations (snorting and whinnying) and other (rolling, rearing, or bucking, urinating or defecating, pawing, and trotting restlessly).
6. Whether and when the horse escaped the testing arena. The time of the possible escape was used to calculate the percentages from the time the horse was focused on the novel object or examining it.

2.3. Horse-horse sociality: observational data

2.3.1. Conditions during the observations

The horses were checked once a day by the farm staff but had no further human contact during the months they lived on the pastures. All horses included in the study were always on the pastures, except for one mare who was removed from the herd in September before the last observation day. The herds varied in size between observation days as additional horses not included in the study left the herd or came back: the mare herd size varied between ten and fourteen individuals (nine of which were in the study), the yearling stallion herd varied from six to eleven individuals (four of which were in the study), and the older stallion herd varied between seven and twelve individuals (five of which were

in the study). There was one donkey living in the mare herd and one in the yearling stallion herd – the donkeys are included in the previous numbers.

2.3.2. The observations

I did focal observations in 15-minute increments with each horse as the focal individual at one time. Each horse was the focal individual 16 times on different days, except for the one mare who was removed from the herd before the last observation day and was then observed only on 15 times. I randomised the individual observation order on each day to ensure that each horse was observed in as different weather conditions and times of day as possible.

I recorded several behavioural observations continuously within the 15-minute observation window, with a 5-second error marginal:

1. How many horses were within the focal horse's personal space (i.e., at the most two horse's lengths away) at the beginning of every observational minute. These horses close to the focal individual were also identified.
2. Individuals approaching or leaving the focal individual, and individuals the focal individual approached or left.
3. Any aggression by or directed towards the focal individual.
4. Play behaviour: who initiated and who terminated, and the duration of the bout.
5. Allo-grooming: who initiated and who terminated, and the duration of the bout.

The data was turned into an Excel file where social behaviour frequencies were marked between all horse dyads. The obtained data was then corrected by group size and its variations so that the results from the three groups could be compared with each other. First, the horses were considered dyadically, and the dyadic numbers were divided by the observation times they could have potentially interacted with each other (i.e., living on

the same pasture). For example, for a horse dyad with both horses in the study, this number was 32, as they were both the focal individual on 16 different occasions. Contrastingly, for a dyad with only one horse in the study and the other horse only present for 13 observation days, this number was 13. Lastly, the obtained numbers were divided with the maximum group size for each herd to get numbers that were comparable between the different herds.

2.4. Statistical methods

I did the statistical analyses using SPSS 27.0.1.0, in addition to R (R Core Team 2020).

I tested the variables coded from the personality test videos for repeatability, to see whether they comply with the personality criterion. First, I z-scored the values from the personality tests to avoid biases in the data due to a skewed distribution. Then, I assessed the z-scored values for repeatability using Intra-class Correlation Coefficient (3,1; McGraw and Wong 1996) using SPSS. I used a two-way mixed effects model with test scores as fixed effects and individual effects as random. The test assesses the proportion of variance in the data due to variance among individuals. Higher scores mean that the variance is due to inter-individual differences, and vice versa: low scores imply that the variance is due to within-individual fluctuations. The test also takes into account the measurement error, for example the variance due to conditions or experimenter behaviour.

Only the truly repeatable values with an ICC score over 0.4 ($p < 0.05$) were allowed into the next part of the analysis: a factor analysis in SPSS. This test groups the variables that variate in tandem together into factors, that can be seen as indicative of personality traits, that in this case tell about the horses' sociality towards humans. The number of extracted factors was justified by a parallel analysis (Hayton et al. 2004). For factor analysis it is best if the sample size is ten times bigger than the amount of variables tested, but the test can give accurate results even with smaller sample sizes, provided that the measurements are reliable and the communalities are good (Budaev 2010). After I had done the factor

analysis, I then calculated individual factor scores for later analysis. I assessed differences in these individualized factor scores between sexes and age-groups with a t-test.

From the observational data, I assessed the horses' sociality towards conspecifics. For this, I calculated the mean number of neighbours and the mean frequencies of approaching/leaving, aggression, grooming, and playing for all individuals. I did not formally test for repeatability in the social data, because I only had 16 observations per horse – splitting those into two observational blocks and comparing them with each other would not result in a meaningful test of repeatability. To achieve a meaningful assessment of repeatability of behaviour in a group, ideally, I would have needed to repeat the observations in similar conditions a year later. However, I did analyse the obtained individual means by factor analysis, again in SPSS, and calculated individual factor scores for later analysis. By doing this, I aimed to get a concentrated social score for all individuals from the factor analysis. I used the factor score, and the social variable means as such in the next part of the analysis.

In the end, the individual factor scores from the personality tests, factor score from the social observations, and the isolated social behaviours were brought together using R, to see whether and how horse-human sociality and horse-horse sociality are connected to each other. First, I assessed the normality of the response variables by a Shapiro-Wilk test. I assessed associations between the personality test factors and the observational factor with a linear mixed model using the living group during the summer as a random factor and the social observation factor and isolated social behaviours (aggression, approaching, grooming, and playing) as fixed effects using R packages lme4 (Bates et al. 2015) and lmerTest (Kuznetsova et al. 2017). Considering the small sample size of just 19 individuals I made models with just one dependent variable to avoid over-parametrisation of the models. The details of each model are given in the corresponding section of the results.

3. Results

3.1. Repeatability of the personality tests

Several variables were found repeatable with a testing interval of six months from all but one of the personality tests (Table 3). The repeatable values could thus be seen as indicative of social personality directed towards humans.

Table 3. The ICC scores and their p-values for all variables coded from the test videos. The significantly repeatable values have been bolded.

		ICC	p-value
HOI	Latency to touch	0.078	0.371
	% turned away	**0.541**	**0.007**
	Reaction to touch	**0.499**	**0.013**
Object choice	**Trials completed**	**0.409**	**0.037**
	% unfocused	**0.524**	**0.009**
	Latency 1st habituation	<0	
	Latency 6th habituation	**0.695**	**0.003**
	Latency 1st trial	<0	
Obstacle course	**Latency to trot**	**0.423**	**0.032**
	Number of trots	0.368	0.055
	Tightness of the rope	**0.404**	**0.039**
	Exploring the pole	**0.484**	**0.015**
	Attempts at the pole	0.299	0.1
	Reluctance at the pole	0.305	0.096
Novel surface	Standing	0.038	0.437
	Attempts	**0.483**	**0.016**
	Portion crossed	**0.52**	**0.009**
	Exploring	0.276	0.119
	Reluctance	**0.513**	**0.01**
Novel object	% focused on object	0.21	0.187
	% examining object	<0	
	Latency to touch	0.325	0.081
	Latency to 2 metres	0.076	0.375
	Vocalising	<0	
	Startles	0.173	0.233
	Stress behaviour	0.271	0.124

In the Human Orientation Index, the mean latency to the horses touching the human was 51 seconds, and the mean percentage of the testing time turned away from the human was 38 %. Four horses always reacted affectively to the forehead touch, eight horses were always neutral, and for six horses the reaction was mixed between affective and neutral on the first and second test round, respectively. Only one horse did not allow the forehead touch on either test round.

In the end, in the Human Orientation Index the horses' reaction to an unfamiliar human touching their forehead and time turned away from the human were repeatable, whilst latency to touch the human was not.

In the object choice test the N was variable as some of the horses were not interested in the test and it had to be prematurely terminated for them – on average the horses completed 4.7 trials before termination. The mean percentage of the testing time being unfocused was 36 %, the percentages ranging from 1 % to 100 %. The average latency to start moving on all the habituation rounds and trial rounds was 5,6 seconds.

In the end, the trials completed and the percentage of time unfocused were both found repeatable (N = 19) in the object choice test. The latency to start moving on the sixth habituation round was also found to be repeatable (N = 13). The latency to move on the first habituation round (N = 19) and the first trial round (N = 12) were not repeatable.

In the first part of the obstacle course test, five horses never explored the pole, ten horses always explored the pole somehow, and four horses explored the pole on one of the test rounds, but not on the other. On average it took 2.2 attempts to go over the pole. In 53 % of the tests the horses showed no reluctance to go over the pole, in 39 % of the tests they showed some reluctance, and only 8 % of the time there was heavy pulling back, rearing, or bolting.

In the second part of the obstacle course test, eleven horses never trotted, four horses trotted at least once on each test round, and four horses did not trot even once on one test

round but did so on the other. The average latency to start trotting on the successful runs was 1.7 seconds. The rope tightness reflected the willingness to trot: the rope was all the time tight only on the times the horses refused to trot, and either all the time loose (in 79 % of the cases) or just initially tight (in 21 % of the cases) on the successful runs.

In the end, the latency to trot on the first successful run, the tightness of the rope during the trotting trials, and exploring the pole were repeatable in the obstacle course test. The number of successful runs, the attempts needed to go over the pole, and the reluctance at the pole were not repeatable.

In the novel surface test, the horses spent on average 5.9 seconds standing in front of the novel surface. In 55 % of the tests the horses did not cross the novel surface at all during the three attempts they were given. If the horses did cross the novel surface, they needed on average 1.9 attempts to go over, and crossed the whole sheet in 64 % of the tests and only a part of it in 36 % of the tests. Thirteen horses always explored the sheet somehow, three horses never explored the sheet in any way, and three horses explored the sheet on one of the test rounds but not the other. The horses showed at least some reluctance to go over the sheet in 75 % of the tests, with only three horses showing no reluctance on either of the test rounds.

In the end, the reluctance to go over the novel surface, the portion of the novel surface crossed, and the attempts needed to go over were repeatable in the novel surface test. The time spent standing before the novel surface and the extent of exploration were not repeatable.

In the novel object test it took the horses on average 35.6 seconds to be two metres away from the novel object, and on average 31 seconds to touch it – if they touched it at all, since in 33 % of the tests the horse never touched the object at all. The horses were on average focused on the object 22 % of the testing time and exploring it 13 % of the testing time. In 25 % of the tests the horses startled, usually when touching the object for the first

time. Additionally, they either snorted or whinnied in 61 % of the tests and showed some other possible signs of stress in 30 % of the tests.

In the end, only the latency to touch the object was marginally repeatable in the novel object test, but even it failed to reach statistical significance. All other variables – percentage of time focused on the novel object, percentage of time examining the novel object, latency until two metres from the object, vocalisations, startles, and other stress behaviours – were not repeatable.

3.2. Factor analyses

3.2.1. Horse-human sociality factors

Only truly repeatable personality test values (ICC > 0.4 and $p < 0.05$) were included in the factor analysis aimed to concentrate all the behaviours into a few personality factors indicating their sociality towards humans. After an exploratory analysis, some variables were removed based on their poor communality and loading values. Additionally, the latency to move on the sixth habituation round in the object choice test was left out as it is likely that it tells more about the horses' food motivation and cognitive capabilities rather than their willingness to co-operate. Additionally, not all individuals finished even the initial six habituation rounds, so the N would have been smaller than for the other variables.

In the end, a total of nine behavioural measures were included in the factor analysis of the personality test variables. The diagnostics implied sufficient adequacy (KMO = 0.69 and Bartlett's test $p < 0.001$). The parallel analysis (Hayton et al. 2004) following the 95th percentile rule, indicated that a two-factor solution is the most reliable based on a comparison of the real data and randomized data.

Table 4. Results of the factor analysis from the personality test values. Variables that correlate with each other in each factor have been bolded. Variables loading also highly, but less so than in the other factor have been underlined. Abbreviations used: OBS = obstacle course test, NS = novel surface test, OC = object choice test, HOI = Human Orientation Index test.

	Reluctance	Unfocusedness
OBS latency to trot	**0.812**	-0.154
NS attempts	**0.790**	0.457
NS proportion crossed	**0.762**	0.481
OBS tightness of rope	**0.667**	-0.173
NS reluctance	**0.619**	0.283
OC trials completed	0.196	**-0.949**
OC % unfocused	0.026	**0.830**
OBS reluctance at the pole	0.481	**0.677**
HOI % turned away	0.494	**0.610**

The Varimax-rotated factor analysis solution can be seen in Table 4. The two factors explained 75.18 % of the total variance. The first factor (50.22 % of variance, eigenvalue = 4.52) consists of high loadings from both co-operation tests (the novel surface and obstacle course tests) and was named Reluctance. The second factor (24.96 % of variance, eigenvalue = 2.25) consists of high loadings of different measures from the object choice test, the obstacle course test, and the Human Orientation Index test, and was named Unfocusedness.

Although the loadings showed some overlap, i.e., some variables loaded strongly (>0.40) on both factors, the factors were statistically independent from one another (Oblimin-rotation correlation coefficient = -0.059). Therefore horse-human sociality seems to consist of two separate but somewhat overlapping personality factors that are indicative of the horses' motivation to co-operate with humans, and general interest towards humans.

Age was a significant contributor in Reluctance ($t = 4.315$, $df = 17$, $p < 0.001$; Figure 2) and Unfocusedness ($t = 2.215$, $df = 17$, $p = 0.041$; Figure 3), with younger horses scoring higher on both factors. No sex differences were found for Reluctance ($t = 1.246$, $df = 17$, $p = 0.230$) or Unfocusedness ($t = -1.144$, $df = 17$, $p = 0.269$), nor was the interaction of age and sex significant for either of the factors ($t = 1.218$, $df = 1$, $p = 0.287$).

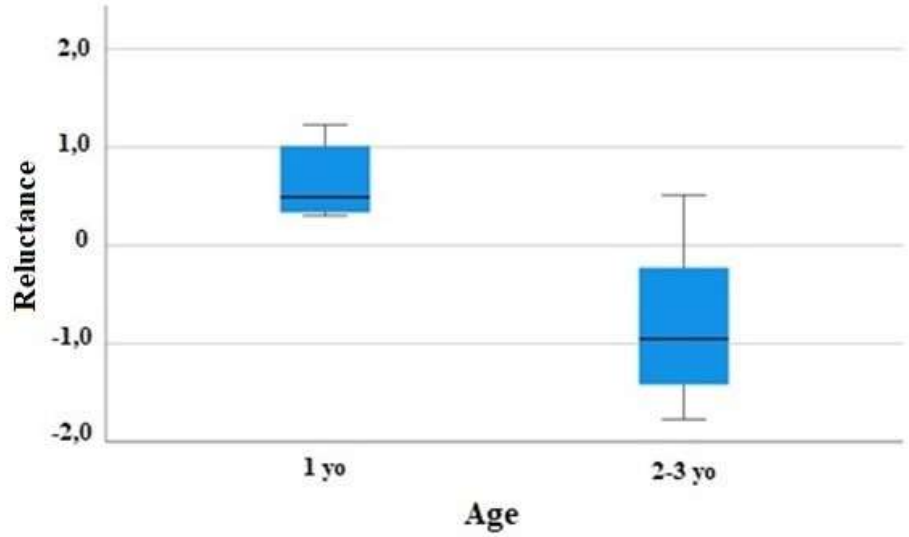

Figure 2. The association between the horse's age and the Reluctance score from the factor analysis of the personality test variables. The box and whiskers plot represents the median Reluctance score with the upper and lower quartiles and minimum and maximum scores from the t-test for one-year-olds (N = 11), and two- and three-year-olds (N = 8), respectively.

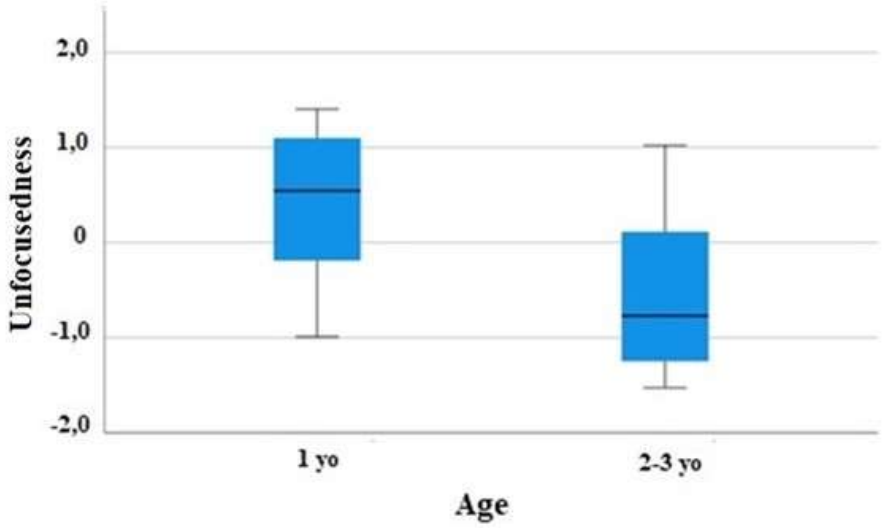

Figure 3. The association between the horse's age and the Unfocusedness score from the factor analysis of the personality test variables. The box and whiskers plot represents the median Unfocusedness score with the upper and lower quartiles and minimum and maximum scores from the t-test for one-year-olds (N = 11), and two- and three-year-olds (N = 8), respectively.

3.2.2. Horse-horse sociality factors

I also did a factor analysis for the observational data to get a concentrated social score for the horses' sociality towards other horses. After an exploratory analysis, some variables were removed based on their poor communality and loading values. Additionally, all play behaviour was excluded from the analysis, as only the stallions showed any play behaviour, and the obvious bias could skew the results.

In the end, four behavioural measures were included in the factor analysis, to get concentrated social scores for each horse. The diagnostics implied sufficient adequacy (KMO = 0.60 and Bartlett's test $p < 0.034$). The parallel analysis (Hayton et al. 2004) following the 95th percentile rule, indicated that a one-factor solution is the most reliable based on a comparison of the real data and randomized data.

The Varimax-rotated factor analysis solution can be seen in Table 5. The one factor explained 40.33 % of the total variance. The factor consists of high loadings of approaching, being approached, and being together with other horses more often, and low scores of being aggressive towards other horses. It was named Sociability and it is indicative of the horses' sociality towards conspecifics.

Table 5. Results of the factor analysis from the observational test values. All four variables left into the last analysis were loading well with each other.

	Loading	H2
Approached	0.767	0.256
Together	0.688	0.295
Seeker	0.543	0.588
Aggressor	-0.506	0.474

3.3. Associations between sociality factors

In trying to find whether horse-horse and horse-human sociality were connected to each other in any way, I found that Reluctance or Unfocusedness were not predicted by Sociability, or by any of the social behaviour variables tested separately (Table 6). There were only slight, statistically non-significant trends between the Reluctance and aggression towards other horses in the herd ($t = -1.934$, $df = 25.44$, $p = 0.072$), with more aggressive horses scoring lower on the Reluctance factor, and Reluctance and initiating play with other horses in the herd ($t = -1.795$, $df = 16$, $p = 0.093$), with more playful horses also scoring lower on the Reluctance factor.

Table 6. The results from the general linear model on how Reluctance and Unfocusedness are predicted by Sociability and all the independent social variables calculated from the observational data independently. Bolded values are almost significant.

Response variable	Fixed effect	t	df	p	R2
Reluctance	Sociability	-0.413	5.30	0.696	0.013
	Victim	1.221	15.30	0.241	0.064
	Aggressor	**-1.934**	**25.44**	**0.072**	**0.139**
	Groom initiator	1.454	15.90	0.165	0.107
	Groom receiver	-1.073	15.45	0.300	0.060
	Play initiator	**-1.795**	**16.00**	**0.093**	**0.159**
	Play receiver	0.643	14.85	0.530	0.024
	Seeker	0.159	25.67	0.876	0.002
	Approached	-0.531	10.74	0.606	0.018
	Together	-1.655	4.29	0.268	0.143
Unfocusedness	Sociability	0.676	7.24	0.520	0.035
	Victim	-0.501	15.44	0.623	0.012
	Aggressor	-1.520	15.99	0.148	0.111
	Groom initiator	0.468	15.27	0.647	0.010
	Groom receiver	-0.059	14.66	0.954	0.000
	Play initiator	0.702	15.78	0.493	0.023
	Play receiver	-1.062	14.57	0.306	0.065
	Seeker	-0.820	15.74	0.424	0.030
	Approached	0.040	15.03	0.969	0.000
	Together	1.203	13.67	0.249	0.087

4. Discussion

4.1. Overview of the results

In this study I aimed to find out young horses' social personality structure towards humans and other horses, respectively. As both a socially intelligent and domesticated animal, my main interest was the human orientation of the horses. However, I also wanted to study the possible connection between the horse-horse and horse-human sociality, as this has not been studied before with horses or any other animal species. I wanted to investigate the social personality in as young horses as possible to avoid most of the influence of experiences working with humans would have on the developing personalities.

My first prediction was that social traits would form one or several syndromes independent of general reactivity. While I failed to find a repeatable reaction to the novel object test assessing general reactivity, the repeatability of the personality tests showed that even at a young age, horses have consistent differences in their reactions to tests requiring co-operation with an unfamiliar human. This means that for the repeatable variables from the personality tests, the ranking order of the different horses stayed the same between the two testing rounds, even if the absolute values varied. The responses stayed relatively consistent over six months, which is a long time in a developing horse's life.

The trait structure analysis of the repeatable variables revealed that the motivation to work with a human correlates throughout different tests. My analysis revealed two somewhat overlapping, but separate personality factors dubbed Reluctance and Unfocusedness. Reluctance included different measures of the horses' reluctance to co-operate with an unfamiliar human in active tasks, and Unfocusedness consisted mostly of horses not being interested in or focused on an unfamiliar human in a passive or active social situation. Thus, they tell about different sides of sociality: active participation and general interest.

The partial separation of the two factors could indicate that they might tie in with other personality aspects I did not measure – or neophobia or curiosity towards novelty that I failed to find repeatable in these horses at this time. Overall, all the tasks requiring co-operation with a human are connected to each other in some way, indicating that horses' human-oriented personality traits are contextually stable, which is in line with my first prediction.

My second prediction was that social personality traits expressed with conspecifics are negatively associated with those expressed with or towards humans. The trait factor analysis of the observational data revealed one single sociality factor towards other horses, dubbed here Sociability. While I did not formally test whether the observed variables comply with the personality criterion (i.e., repeatable over time in different contexts), this indicates that horses have individually different tendencies to behave with their herd mates.

In the end, the factor scores from the personality tests, Reluctance and Unfocusedness, were not associated with Sociability, nor with the different individual social variables from the observational data, in opposition to my second prediction. It is unexpected that there was no dependence whatsoever be it positive or negative. Based on my data it now seems that the sociality towards humans is completely separate from the sociality towards conspecifics as an aspect of social personality.

4.2. Critical aspects and connection to other research

My study was ambitious overall, as social personality of horses has not been studied before as thoroughly as in this study and social personality tests on horses have not focused on interactive social situations. This is not surprising, as social personality has previously received scientific interest mainly in primate research (for example, Koski 2011; Šlipogor et al. 2016; Kulahci et al. 2018). Furthermore, the relationship between the sociality towards humans and conspecifics has not been researched in any animal species before.

The behaviour of young horses has been studied before using some of the tests that I used: their reaction to human presence, a novel surface, and a novel object. Reactions to human presence and walking over a novel surface have been found to be repeatable after one month, but not after one year (Visser et al. 2001). I found most of the behaviours I coded from the HOI and novel surface test were repeatable after six months, but it is possible that after a year the reactions in these tests would not be consistent with the earlier measurements anymore.

Conversely, in this study the novel object scores were not repeatable with the relatively long, six-month interval in testing. While I did use relatively different novel objects during the first and the second testing round, the horses' reactions should have stayed similar in relation to each other if the test was truly measuring novelty response as a personality trait. As it is, it appears neophobia and/or curiosity towards novel things are so unstable in my study population that I cannot assume that personality is set in these aspects. It follows that I could not conclusively show whether the human orientation of the horse has any connection to their general reactivity.

Previously, reaction to novelty and fear response has been found to be repeatable even in young horses (Lansade et al. 2008), and it has been suggested to be unstable only in the earliest months of their life to then stabilise fairly early on in development (Lansade et al. 2007; Christensen et al. 2020). However, there have also been some contrasting results. Visser et al. (2001) found that the reaction to novelty was repeatable after one month, but only half of the recorded behaviours were consistent in a comparison made one year later, and Lansade et al. (2007) could not find consistency in the reactions to the novel object paradigm following the same individuals in a longitudinal part of their study.

The novel object test is one of the most used personality tests across all animal species, but it is not without its critics: for example, Forkman et al. (2007) state in their critical review on different fear tests that the inconsistency of methods used, especially variability of the intervals between repeat measures are problematic. In the end, according to them, the results are not comparable with each other, and the scientific message becomes

unclear. From this, it seems clear that more research with more consistent methods is needed to understand the development and stability of fear reactions in horses.

The age differences in both personality factors, Reluctance and Unfocusedness, indicate that one-year-olds were more reluctant and unfocused in the tasks than older horses of two and three years of age. This may be explained by the older horses having more experience with humans (see also Visser et al. 2002). This could mean that I did not measure a stable, core temperament of the horses, but rather a personality aspect that is influenced by experience. However, it is also known that temperament traits overall have a relatively high plasticity in horses; while the behavioural tendencies are regulated by genetic and in-utero effects, these traits are under modifying influences from early age (Hausberger et al. 2008). The high repeatability over six months combined with the age difference supports this interpretation.

In recent years there have been more studies on the human-horse relationship. These studies have showed that horses treat humans as a safe haven in worrying situations (Lundberg et al. 2020), that the presence of a familiar trainer diminishes their fear reactions (Hartmann et al. 2021), and that horses behave differently in the novel object test if the human leading them has a happy or an angry expression (Schrimpf et al. 2020). While interesting, these studies did not consider the individual personality differences that shape how different horses orient towards humans and interact with them, which was my main focus.

It is especially interesting that based on my data it seems as though the horse-horse sociality and the horse-human sociality are completely separate from each other. There was only a slight negative association between aggression towards other horses and the Reluctance score. This could be because older horses were more willing to co-operate in the personality tests, due to the possible experience effect and were also more aggressive towards other horses in the herd, probably because a horse's rank in the herd is affected by its age (Komárková et al. 2014).There was also an even more tentative association between initiating play and the Reluctance score, but it is impossible to draw any

conclusions from this, as only the stallions played at all. Based on this, the sociality towards humans and horses seem completely separate from each other.

If I assume that domestication has shaped horse sociality, it seems that, based on my data, domestication has created completely new sociality factors in horses and has not expanded upon already existing sociality to be expressed also towards humans. If similar separation is found in further studies with bigger study populations in horses as well as in dogs and other animals, it reveals something completely new about the domestication process and the structure of social personality on the whole. The previous studies with dogs (Cafazzo et al. 2018; Wheat et al. 2018), however, point towards the possibility of a trade-off between different sociality aspects – this might be because of the longer domestication history of dogs, or it could indicate differences in the domestication processes in different animals. However, the relationship between sociality towards humans and other dogs has never been formally tested.

4.3. Future aspects and conclusions

As my thesis was only a pilot study on the matter, the obtained results should be confirmed with a much larger study population. It would be particularly interesting to see whether the reactivity to novelty would be repeatable or still volatile in young horses with a bigger sample size. Furthermore, it would be important to see whether the various social behaviours I collected from the observational data would be repeatable and thus indicative of personality aspects – and whether the Sociability factor extracted from these variables would be a reliable personality trait in horses.

Ideally, there could be a longitudinal study following the same horse individuals for a few years from foals to adults to see how their sociality in respect to humans and other horses would develop. In addition, to ascertain how the early experiences shape the horses' developing personality at an early age it would be important to see how semi-feral horses, with even less experience with humans than the young horses in this study, would compare to their fully domestic counterparts. To shed even more light on the

domestication process, it would be paramount to study other animals, for example dogs, with similar methods.

In conclusion, it can be said that there are several social personality traits in horses when studied in interaction with humans and other horses. Horse-human sociality can be roughly separated into two traits semi-independent from each other, which represent either their motivation to co-operate with humans or their general interest towards them. Horse-horse sociality seems to form one clear factor: more social horses seek and are sought by other horses more regularly and are less aggressive towards other horses.

The social traits expressed with humans and horses, respectively, appear to be completely separate from each other – how social a horse is towards humans does not predict how social they are towards other horses. The separation of sociality towards humans and conspecifics sheds light on the effects of domestication on sociality overall. These results are not conclusive, however, and more work needs to be done with horses young and old and other animal species as well.

5. Acknowledgements

First and foremost, I would like to thank Kylämäki horse farm for permitting such an intensive use of their horses and facilities for such a long time. Special thanks are in order to Kylämäki's Elina, Roosa, and Reetta for all their help during the study, and for the owners of the privately owned horses for trusting their horses in our hands. Additionally, I would like to thank all my assistants, Taru, Charlotta, Raakel, and Mariia, for their invaluable help during the experiments, and Océane for her continuing help both in the field and with the analyses. Kuisma's, Maaria's, and Annastiina's help was invaluable in the final editing and reviewing phase of the text. Lastly, I need to thank both of my supervisors, Sonja and Virpi, for all their advice and support during this year.

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