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Horses can learn to use symbols to communicate their preferences

Cecilie M. Mejdell[a,*], Turid Buvik[b], Grete H.M. Jørgensen[c], Knut E. Bøe[d]

[a] Norwegian Veterinary Institute, Department of Health Surveillance, P.O. Box 750 Sentrum, 0106 Oslo, Norway
[b] Trondheim Hundeskole, Norway
[c] Norwegian Institute of Bioeconomy Research, P.O. Box 34, 8860 Tjøtta, Norway
[d] Norwegian University of Life Sciences, Department of Animal and Aquacultural Sciences, 1432 Ås, Norway

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ABSTRACT

This paper describes a method in which horses learn to communicate by touching different neutral visual symbols, in order to tell the handler whether they want to have a blanket on or not. Horses were trained for 10–15 min per day, following a training program comprising ten steps in a strategic order. Reward based operant conditioning was used to teach horses to approach and touch a board, and to understand the meaning of three different symbols. Heat and cold challenges were performed to help learning and to check level of understanding. At certain stages, a learning criterion of correct responses for 8–14 successive trials had to be achieved before proceeding. After introducing the free choice situation, on average at training day 11, the horse could choose between a "no change" symbol and the symbol for either "blanket on" or "blanket off" depending on whether the horse already wore a blanket or not. A cut off point for performance or non-performance was set to day 14, and 23/23 horses successfully learned the task within this limit. Horses of warm-blood type needed fewer training days to reach criterion than cold-bloods ($P < 0.05$). Horses were then tested under differing weather conditions. Results show that choices made, i.e. the symbol touched, was not random but dependent on weather. Horses chose to stay without a blanket in nice weather, and they chose to have a blanket on when the weather was wet, windy and cold ($\chi^2 = 36.67$, $P < 0.005$). This indicates that horses both had an understanding of the consequence of their choice on own thermal comfort, and that they successfully had learned to communicate their preference by using the symbols. The method represents a novel tool for studying preferences in horses.
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1. Introduction

Horses have been utilised by humans for a variety of tasks, e.g. traction power in agriculture and forestry, sports and leisure. The behavioural flexibility of horses, their ability to cope with different uses and their ability to learn and obey signals given by humans have been crucial for this success in the domestic context (McGreevy, 2008). The training of utility skills is traditionally achieved by one way communication; from the human to the horse. The human gives the cue, most often a vocal or tactile signal, and the horse learns to respond. Principles of learning theory is increasingly being implemented in equitation (Murphy and Arkins, 2007; Baragli et al., 2015) and in a scientific context various training techniques have been used to explore cognitive abilities and preferences of horses. Examples are using Y-mazes (Kratzer et al., 1977; Heird et al., 1986; Murphy, 2009), and more complex labyrinths (Marinier and Alexander, 1994) to test learning ability and memory. Y-maze choice has been used to test acceptance or avoidance of the roll-kür riding style (von Borstel et al., 2009), preference for shorter or longer riding bouts (von Borstel and Keil, 2012), and stall or treadmill training (Lee et al., 2011). Animals may also be trained to perform a task, for example to operate a lever or push a button, in order to gain access to a resource or avoid something unpleasant (Skinner, 1953). The value of a resource as regarded by the animal, and thereby its motivation to work for it, can be measured as the number of times the animal is willing to repeat the task (i.e. pay a "price") before being rewarded (e.g. Dawkins, 1983). In horses, such operant techniques have been used to investigate the preference for a light source during night (Houpt and Houpt, 1992), the strength of horses' need for social contact (Sondergaard et al., 2011), and the motivation for release into a paddock (Lee et al., 2011).

The ability of horses to discriminate between visual cues and learn the relevance of one stimulus over another is well demonstrated in horses (see reviews by Nicol, 2002; Hanggi, 2005). This

* Corresponding author.
E-mail addresses: cecilie.mejdell@vetinst.no (C.M. Mejdell), kontakt@trondheimhundeskole.no (T. Buvik), grete.jorgensen@nibio.no (G.H.M. Jørgensen), knut.boe@nmbu.no (K.E. Bøe).

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ability comprises discrimination of stimuli of both two- and three-dimensional shape (Hanggi, 2003), also when rotated (Hanggi, 2010), and for some individuals recognising categories such as triangular shape as opposed to a variety of geometrical patterns (Sappington and Goldman, 1994). More arguably, horses may possess concepts formation such as relative size, i.e. picking the larger (or smaller) of different objects (Hanggi, 2003) and sameness, i.e. selecting two matching stimulus cards (Flannery, 1997). However, none of the four ponies in a study by Gabor and Gerken (2010) learnt a "matching to sample" visual discrimination task, and the four horses in a study by Leeson (2015) failed to learn to pick "the bigger".

We wanted to explore whether the ability of horses to discriminate simple visual symbols could be extended with associations between specific symbols and corresponding outcomes, and furthermore the consequences for own comfort as perceived by the individual horse of these outcomes. If so, symbols could guide appropriate decision-making behaviour and be utilised as a communication tool in preference testing of horses. A very common but still disputed management routine in the Nordic countries is to equip horses with blankets (rugs). Our aim was thus to develop a tool to "ask" horses whether or not they prefer to wear a blanket under different weather conditions. In this paper, we describe the method by which horses are taught to touch visual symbols on a display board to communicate their preference to humans.

2. Materials and methods

2.1. Horses and daily management

Twenty-three horses kept on two neighbouring premises in mid Norway, one private stable (Nypan) and one stable at an agricultural high school (Skjetlein) were included in the training programme. Horses comprised 13 cold-blood horses (7 Norwegian trotters, 3 Norwegian dølehest, 2 Fjord horses, 1 Icelandic horse) and 10 warm-blood horses (6 Danish, German, or Swedish warmblood riding horses, 3 Arabian or Arabian crossbreds, and 1 Thoroughbred), whereof 18 were geldings and five were mares. Age varied from 3 to 16 years (average 9.8, median 10). All were kept as riding horses for leisure activities, dressage, or show jumping, and some were in addition used as carriage horses. All individuals were accustomed to wear a blanket, but the daily management routine regarding blanket use was decided by the owners and thus varied among horses. Some horses routinely wore a blanket when turned out in a paddock during the non-summer seasons, while others did only wear a blanket under extreme weather conditions (very cold, very wet, or very windy). At night, all horses were stabled in standard single boxes bedded with wood-shavings, allowing visual and nose contact with other horses. During daytime, they were kept in outdoor paddocks in groups of 2–3 except for one horse which was kept singly. Horses were fed roughage (hay or haylage) three times per day and concentrates twice daily, with the amount depending on individual workload.

All the horses which were kept on the two premises were included in the training program except for three; one due to advanced age (38 years), another due to a tendon injury, and the third for safety reasons as it was flighty and difficult to handle.

Horses were kept and handled according to the Norwegian Animal Welfare Act, the Horse Welfare Directive and the Use of Animals in Research regulation. Training methods included solely positive reinforcement, never putting animal welfare at stake. The owners of the 13 privately owned horses and the person responsible for the 10 school horses all gave permission to conduct the study.

Table 1
Training procedure with goals for the 10 hierarchical steps to achieve free choice learning.

Category	Step	Goal for the step
Operant reward based behaviour	1–4	
	1	Introduce display board. Horse touches the display board with muzzle
	2	Horse touches the display board independently of board position (plasticity)
	3	Horse moves towards the display board and touches it with muzzle
	4	Horse moves towards the display board and touches it with nose independently of board position (plasticity)
Symbol learning	5–8	
	5	Horse learns the difference between symbols "blanket on" and "blanket off"
	6	Assessment: Check that the horse understands of the difference between symbols "blanket on" and "blanket off" in repeated exposures, by touching the display board with relevant symbol with its muzzle
	7	Assessment: Check that the horse will touch the relevant symbol with muzzle after switching display board position
	8	Assessment: Check if horse understands the difference between "blanket on" and "blanket off" symbols independent of position of display boards and context (plasticity)
Introducing free choice	9–10	
	9	Introduce "no change" symbol. Couple "no change" symbol with relevant change symbol, i.e. "blanket on" or "blanket off" depending on initial blanket state in a free choice setting. The horse is rewarded regardless of choice of display board touched
	10	Assessment: Check the horse' understanding of choice

2.2. Trainer skills

Positive reinforcement training (e.g. Lindsay, 2000; Pryor, 2002) was performed by a highly skilled professional animal trainer and her two experienced assistants, working two in a team throughout the training period. These trainers had a broad knowledge of training animals and many years of practical experience with clicker training and the use of reward criteria. Their skills included knowing exactly which initial behaviours must be rewarded to develop the final behaviour, appropriate timing of reinforcer delivery, optimal frequency and quality of rewards, an understanding of the level of difficulty of each step in the learning process for the horse. The trainers also had the ability to tailor the training sessions to the individual horse.

2.3. Training

The aim of the training was that the horse, when later placed in a free choice situation, would be able to communicate whether it wanted a blanket put on or taken off or that it preferred to stay unchanged. A successfully trained free choice behaviour implies that the animal has learned and understands the options available and the consequences, and makes its choice based on own motivation, independent of the trainer. For communication, the horses had to learn to use symbols. Three different symbols presumed to be non-aversive and unambiguous to horses were used. They were presented on white wooden display boards, measuring 35 × 35 cm,

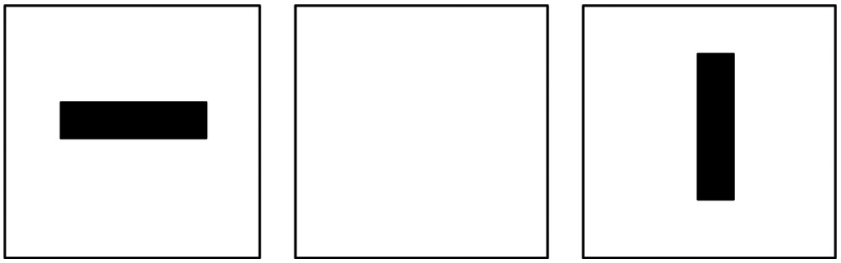

Fig. 1. Symbols were presented on white painted wooden display boards (35 × 35 cm). To the left, the horizontal bar meaning "put blanket on", in the middle the blank board meaning "no change", and to the right, the vertical bar meaning "take blanket off".

which could be hung up on a box wall or a fence. A board with a 5 cm wide vertical black bar meant "take blanket off" and a board with a similar but horizontal bar meant "put blanket on", and a white board without any markings meant "no change" (Fig. 1).

The training sessions started in January 2013 for 16 of the horses, and in late autumn 2013 for the remaining 7 horses. The first 6 steps were trained in the horses' home box, thereafter training took place both indoors and outdoors. Horses were free to move in the choice situation, i.e. were only kept on a lead rein before the start of a trial. A horse was trained for two or three sessions per day, for 5–7 days a week. Each session lasted around 5 min and comprised of two or three repetitions. There was a short (5 min) break between the sessions. The performance of the horse the particular day decided whether it got two or three repetitions per session and two or three sessions of training. When the horse performed a task unambiguously, the number of repetitions and sessions per training day was kept to two. Thus, the training was always adjusted to the individual horse.

The training schedule was built up as a sequence of 10 steps in a strategic order with a hierarchy of targets (Table 1). Before advancing to the next step, the goal of the previous one had to be reached. A training day typically started with a brief repetition of the previously learned task(s). If the horse failed to perform correctly or showed hesitation during this repetition, the previous step(s) were retrained. There is known to be individual differences among horses in learning abilities (e.g. Wolff and Hausberger, 1996). To avoid spending resources on training in vain, a cut off point for performance or non-performance was set. Based on the trainer's former experience, this was set to day 14.

During the first 4 steps, the horse was trained to approach and touch the display board with its muzzle. This was done in a shaping process, reinforcing each successive approximation of the desired response (e.g. Evans et al., 1990; Cooper, 1998). Thus, the training was built on the clicker training method (Pryor, 1995; Spector, 1999), although a sharp, short sound (ya!) was given as the secondary reinforcer instead of using a clicker. The clicker is difficult to operate precisely when using winter gloves, and the trainers had experienced that training is equally efficient with this sound. The treats used throughout the training were thin slices of carrot, presented in a bucket with an elevated bottom.

The horse was trained to touch the display board independent of board position, and also when the horse had to move up to 5 m to reach the board. The success criterion for this "show and tell" behaviour learning was that the horse had identified, approached, and touched the board firmly and without hesitation in eight consecutive trials, before advancing to step 5.

The aim of steps 5–8 was to teach the horse the difference between the "blanket on" and the "blanket off" symbols. First (i.e. step 5) only one display board was used at the time, always showing a relevant symbol, e.g. the "blanket off" symbol if the horse already had a blanket on, and vice versa. When the horse touched the display board, it got the food reward in the bucket, and the meaning of the symbol was carried out straight away, i.e. removing or putting on the blanket. All horses were trained both with and without a blanket, with consecutive repetitions. In this way, the horse learned to associate each of the two symbols with a definite outcome that is, blanket taken off or put on. When a specific symbol was presented, the horse thus learned to know what was going to happen. Before advancing to step 6 the horse had to perform eight successful repetitions where it identified, approached and touched the only (and relevant) board one time, firmly and without hesitation. At step 6, both the "blanket on" and the "blanket off" symbols were presented to the horse at the same time. Now, the horse was rewarded with the treat only when touching the board with the relevant (meaningful) symbol; that is the "blanket off" symbol if the horse already wore a blanket and the "blanket on" symbol if the horse was without a blanket. The first times the two change symbols were presented simultaneously, the display board with the relevant symbol was placed closer to and in front of the horse, increasing the chance of a "correct" touch. Later, the position of boards was varied.

Up till now, the aim was that horses associated each symbol with a corresponding action. The next aim was to ensure that horses would be able to associate blanket status with own thermal comfort. All horses were accustomed to wear a blanket at least under certain conditions, so they probably had experienced the effect of blankets. Nevertheless, to help horses to understand the consequences, challenge tests were carried out; first a heat test and then a cold test. The heat test was performed by putting on a thick blanket so the horse became obviously hot and then checking that it would touch the display board with the "blanket off" symbol. The cold test was done on a separate day, with challenging weather. It was performed by keeping the horse outdoors in rain or chilly weather, without a blanket, until it began to show signs of thermal discomfort (e.g. tense body posture, tail tucked), and thereafter check that the horse chose the "blanket on" symbol. However, at this stage, it cannot be ruled out that horses just acted by touching the symbol signalling a change to its present status. Before introducing the third, "no change", symbol (step 9), it was important to check that the horse understood the meaning of both the "change" symbols. The success criterion set to meet the learning goal of step 8 was that the horse had touched the board with the relevant symbol without any error in the last 12 trials. At step 9, all horses showed interest for and touched the novel symbol, the white board, after it was introduced. A touch was rewarded with carrot slices, but did not result in any change of blanket status.

During subsequent sessions, horses were presented with two of the three symbol boards simultaneously, in varying combinations and at a random order and positions. The horses' blanket status in the training situation was also varied. The trainers rewarded only relevant choices, i.e. touching the "blanket on" or "no change" symbol if the horse was not equipped with a blanket and the "blanket off" or "no change" symbol if the horse already wore a blanket. Thus, touching the irrelevant change symbol board was ignored, whereas

touching the "no change" board always was rewarded. To avoid a bias towards the "no change" symbol from horses disliking the procedure of putting on or removing a blanket, for instance because of ticklishness, a sham handling was always added when "no change" was chosen; the horse was touched on the body as if a blanket was put on or taken off.

When a horse was judged to have understood the meaning of all 3 symbols, the criterion being that it actively looked for, approached and touched a display board with a relevant symbol without error in the last 14 trials, the free choice situation was introduced. This was the most critical step in the training process, since the horse from now on would be rewarded for any choice made. There would no longer be any "wrong" response. From this stage on, the horse was always presented with two display boards with relevant symbols, that is the "no change" symbol and the relevant of the two "change" symbols, depending on the horse' status regarding blanketing. The transition to the free choice situation was started by a heat test followed by a cold test, performed as described above. By repeated choice testing and retesting under various conditions (step 10), the level of understanding by the horse of the consequences of its choice on its own thermal comfort was enhanced. The food reward and handling (sham or real handling of blanket) was the same regardless of choice, the only difference being the blanket status afterwards. It was important that the horses had time to experience the consequences of wearing/not wearing blankets on own thermal comfort. Thus, during the heat and cold tests and throughout step 10 there were only one session per day (without repetitions) or two sessions allowing retesting, then with a longer pause (1/2–1 h) in between, long enough for the horse to feel the consequence of wearing/not wearing blanket.

Plasticity was a key factor throughout the learning process, meaning that the horse had to respond independently of board position and site. Some degree of variation in the training situation is known to enhance learning in animals (Spector, 1999), and without this plasticity, contextual factors may otherwise disturb later performance. Horses appear to use spatial cues more easily than other stimulus features (Nicol, 2002; Martin et al., 2006) and some may spontaneously show side preferences (Murphy and Arkins, 2007; Gabor and Gerken, 2010). Therefore the display boards were hung up on different walls or fences, were placed close to each other or wide apart, placement of specific symbol were varied between the left or right hand side of the horse, with varying distance to the trainers, and indoors as well as outdoors. The signal for the horse to make a choice was that the trainers stepped 2–3 m aside. They were standing passive avoiding to give the horse any cues, until the horse had made its touch.

2.4. Testing choices

After training was deemed completed, we continued with preference testing under varying weather conditions. This was the ultimate test on whether the horses had learned to use the communication method. If horses understood the meaning of the symbol boards and were aware of the consequences, we predicted that choices made by the horses would be different under different weather conditions, i.e. challenging or not challenging regarding their thermal comfort. Testing was done from February to May 2013 and from late August to December 2013. The horses were tested outdoors with or without a blanket on, following owners' routine management. Type of blanket was individual for each horse and would vary with weather conditions and hair coat status. Horses were let out in their usual paddocks for two hours before testing, so that they would be fully aware of the weather situation, and were tested one by one. The target horse was haltered and led to the test arena, separated from the paddock area. Here, the horse was turned so its head was facing the paddock area. Two display boards, the "no change" and the relevant one of the two change symbols, were hung up on the fence in front of the horse so that the distance from the horse to each board was equal and approximately 3 m (Fig. 2). The horse was released and the two trainers stepped aside, standing passive, while the horse approached the chosen board and made one touch with the muzzle.

Board position, i.e. which symbol was presented on the left and right hand side of the horse, was varied from test to test in a systematic but not predictable way. Any choice made was rewarded with a treat, which was put by the handler in a bucket placed in front of the horse. After changing blanket status or performing the sham blanketing procedure, the handler returned the horse to its home paddock designated for daily turnout. One person scored all responses of all horses.

2.5. Statistics

Breed differences in learning speed was analysed using a *t*-test.

A Chi-square test was used to analyse whether choices made by horses, when tested under bad (rainy, windy) or good (warm, sunny) weather conditions were different from random.

3. Results

3.1. Training

All the 23 horses (100%) successfully learned the task within 14 training days, meaning that all horses were able to distinguish the three symbols and that they understood the consequence of touching a specific symbol on their blanket status.

The different steps in the learning hierarchy were reached by individual horses at different training days (Table 2). Twenty of the 23 horses (87.0%) learned to touch a display board during the first day, two (8.7%) needed two days and one horse (4.3%) three training days to accomplish the task. By day 4, all horses (100%) approached and touched the board unsolicited and without undue hesitation. Two display boards (step 5) were introduced at day 3 for 14 horses (60.9%), at day 4 for seven horses (30.4%) and at day 5 for two horses (8.7%), and it took 2–4 training days for the horses to learn to separate these two symbols.

Horses were ready for the free choice phase of training (steps 9–10), starting by introducing the third symbol, at training day 11–13 (average 11.4, median 11). Horses of warm-blood type needed slightly, but significantly, fewer training days than horses of cold-blood type (11.1 ± 0.1 vs 11.6 ± 0.2 training days, $F = 5.27$, $P < 0.05$). The main reason for this relatively small difference in training days needed was that some of the horses which learned quickly in the beginning (e.g. Poltergeist and Runa) began to explore other possibilities and solutions to earn more carrot slices, like "wood-pecking" or nibbling the symbol board, and hence needed time to be convinced that there were none. Further, the 3-year old horse Blue seemed to enjoy the event of blankets taken on and off as he always touched the "change" symbol and therefore needed additional temperature challenge tests to understand the consequences of his choice for own thermal comfort. In contrast, the more slow learners (e.g. Sølvjan and Loke) made a steady progression without time-consuming explorative activities.

3.2. Testing

As could be predicted if horses signalled according to their expected preferences, they preferred to wear a blanket during bad weather and stay without during nice weather (Fig. 3). When 22 horses were tested on either of two sunny days with a relatively high ambient temperature (20–23 °C), all the 10 horses wearing a blanket that day (following owners' routine management) signalled

Fig. 2. The horses Romano, Katug and Poltergeist photographed in choice situations. All horses had a blanket on and had to choose between "blanket off" or "no change". In the two winter situations (left and middle picture) both horses touch the blank "no change" display board, whereas Poltergeist (right picture) touches the board with the "blanket off" symbol.

Table 2
Training progress of the individual 23 horses identified by name, sex (G = gelding, M = mare), breed type (W = warm-blood, C = cold-blood), and age (years). For each of the ten steps in the training hierarchy (for description, see Table 1) the corresponding days (training day no. 1–14) the step was trained are indicated in the cells.

Horse name	Sex	Breed type	Age (yrs)	Steps									
				1	2	3	4	5	6	7	8	9	10
Katug	G	W	10	1	1	1–2	2	3–4	4–6	6–8	8–10	11	11–14
Runa	M	C	13	1	1	1–2	2	3–4	5–6	6–7	7–10	11	11–14
Sessen	G	C	11	1	1	1–2	2–3	4–6	7–8	8–9	10–11	12	12–14
Blue	G	W	3	1	1	1–2	2	3–4	4–5	6–7	7–10	11	11–14
Poltergeist	G	W	7	1	1	1–2	2	3–4	4–5	6–7	7–10	11	11–14
Romano	G	W	11	1	1	1–2	2	3–4	3–6	7–8	8–10	11	11–14
Virvelvind	G	C	10	1–3	3	3–4	3–4	4–5	4–7	8–10	10–11	12	12–14
Mario	G	C	5	1	1	2–3	2–3	4–5	5–7	8–10	10–11	12	12–14
Alto	G	W	13	1	1–2	1–2	2	3–4	4–6	7–9	8–10	11	11–14
Friska	M	C	13	1	1	1–2	2	3–4	4–6	7–9	8–10	11	11–14
Remosa	M	W	12	1–2	2	2–3	2–3	4–6	6–7	8–9	9–10	11	11–14
Sølvjan	G	C	13	1–3	3–4	3–4	4	5–8	7–8	9–10	11–12	13	13–14
Fenrik	G	C	6	1	1	1–2	2	3–4	4–5	6–7	6–10	11	11–14
Loke	G	C	10	1	1–2	2	2–4	5–6	6–7	8–9	8–11	12	12–14
Maibrun	G	C	6	1	1	1–2	2	3–4	4–5	6–7	6–10	11	11–14
Espen	G	C	8	1	1	1–2	2–3	4–6	5–7	8–9	10–11	12	12–14
Marion	M	W	9	1	1	1–2	2	3–4	5–6	6–7	7–10	11	11–14
Bruno	G	C	16	1	1	1–2	2	3–4	3–6	7–8	8–10	11	11–14
Ebonee	M	W	11	1	1	1–2	2	3–4	3–6	7–8	8–10	11	11–14
Hrafn	G	C	8	1	1	1–2	2	3–4	3–6	7–8	8–10	11	11–14
Zacco	G	W	12	1	1	1–2	2–3	4–6	7–8	8–9	10–11	12	12–14
Rauen	G	C	13	1	1	1–2	2–3	4–6	7–8	8–9	10–11	12	12–14
Anderz	G	W	5	1	1	1–2	2	3–4	4–5	6–7	7–10	11	11–14

that they wanted it taken off, and all the 12 horses not wearing a blanket signalled that they wanted to stay unchanged, i.e. continue to be without a blanket. When the same 22 horses were tested on either of two days with continuous rain (ambient temperature 5 and 9 °C, respectively) all the 10 horses wearing a blanket signalled that they did not want any change. Among the 12 horses not wearing a blanket, 10 asked for a blanket to be put on, whereas 2 horses signalled that they wanted to stay unchanged (both tested on the day with 9 °C). However, the same 2 horses touched the "blanket on" symbol on two other test days with perhaps even more challenging weather conditions (−12 °C, and 1 °C with sleet, respectively). The 23rd horse (Katug) was euthanized shortly after the training was completed and we therefore lack test days with extreme weather conditions for this individual. The fact that 22 of 22 horses signalled that they preferred to be without a blanket on summer days without rain and that 20 of the same 22 horses signalled that they wanted the blanket on when it was continuous rain, windy and chilly, strongly supports our prediction that if the horses understood the symbols, their choices would vary with weather ($\chi 2 = 36.67$, $P < 0.005$). In total, these results strongly indicate that the horses had learnt to communicate their preferences using symbols.

4. Discussion

The results indicate that the horses had no difficulties learning to discriminate between the three simple visual symbols. This is in accordance with other studies, in which horses show ability to distinguish between visual cues (Nicol, 2002; Hanggi, 2005). The described method is novel as it combines the operant task by which horses learn to touch boards and to discriminate three different neutral, visual symbols including the association with three corresponding interventions (i.e. blanket taken off, blanket put on, or no change), with the extension and generalisation of this learning into a free choice situation. The performance of horses in our study adds to the knowledge on horse cognition and learning abilities.

The horses used their new insight to communicate their preference regarding blanketing in order to obtain or maintain thermal comfort, based on their individual perception of weather including ambient temperature, wind and precipitation. The "Clever Hans effect" is a potential challenge in test situations where humans are present (e.g. Sebeok and Rosenthal, 1981). The horse Clever Hans became famous for performing mathematics, but was actually using small cues given involuntary by the audience to find the right answer (Pfungst, 1911). Although such an effect cannot be ruled out, there are factors making it less likely to have biased our results:

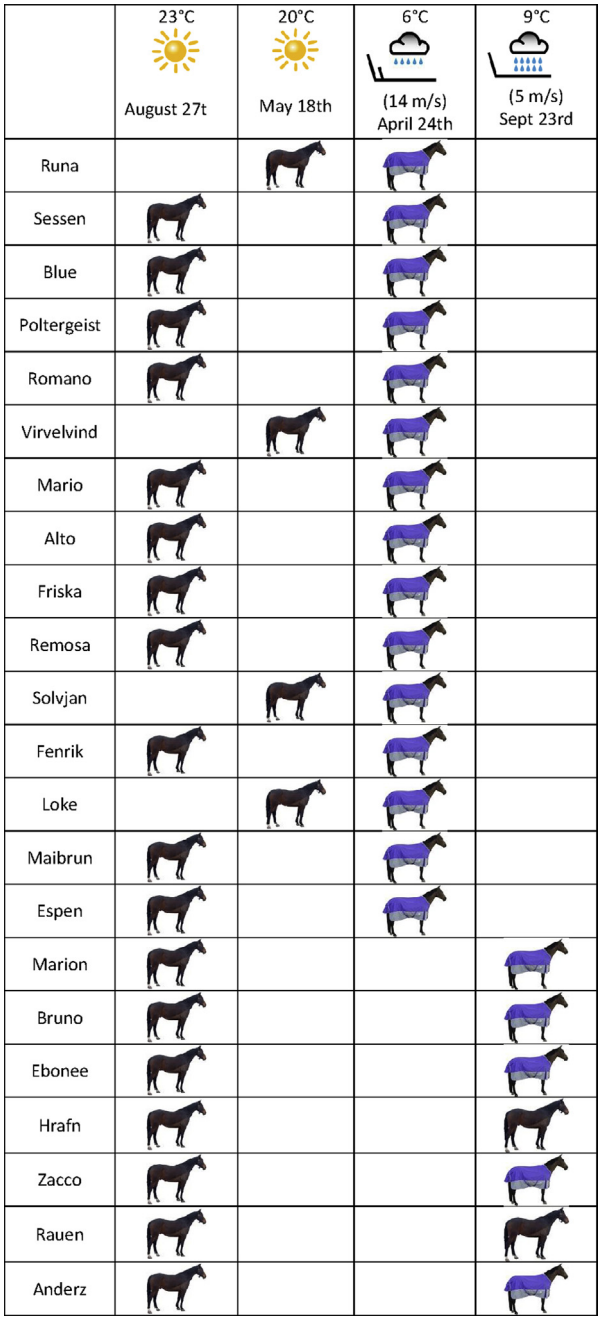

Fig. 3. Choice made by horses for blanket status is illustrated at days with very different weather conditions. All 22 horses were never tested at the same date, so two test days are used for each weather type. The horse Maibrun was neither available at April 24th nor September 23rd, therefore test results from April 20th, a day with similar bad weather (5 °C, heavy rain, wind speed 8 m/s), is shown instead.

Most important, there was no right or wrong response in the free choice situation and the horses were rewarded for any choice they made. Also, the horses' attention was clearly focused, having head and ears directed towards the symbols in front, and the touch was done without hesitation. The touch was easily recorded and not prone to interpretation bias.

The training method used was highly successful in that 100% of the 23 included horses achieved the training goal and became performers within the set limit of 14 training days. In many published studies on learning in horses, the performance rate is variable (Nicol, 2002). Individual differences in learning are often reported and may be influenced by several factors, including type of task and training method used, as well as horse characteristics such as breed, age, gender and temperament (LeScolan et al., 1997; Nicol, 2002; Visser et al., 2003; Murphy and Arkins, 2007; Lansade and Simon, 2010; Hendriksen et al., 2011). For example, in the study by Sappington and Goldman (1994) only one of 4 horses was able to learn the most complex discrimination task, and none of 4 horses learned the visual discrimination task in the studies by Martin et al. (2006) and Leeson (2015). The application of clicker training methodology might have added to our success, due to the very precise reinforcement possible with this method. Further, the ability of the trainers to tailor the training to the individual horse, i.e. knowing when to proceed, when to take a pause and when to repeat previous steps has probably been important. For the horse to be able to make a free choice (i.e. not aided by the trainer but related to the animal's internal motivation) it is necessary that it feels confident in the situation and is not afraid of making errors. Thus, using a reward based training program is very important, and previous punishment or aversive stimuli during training might counteract the training until the horse becomes confident. Furthermore, all horses used were already accustomed to wear blankets and therefore knew well what blankets do. Such an experience is important for making an informed choice. Other factors which might have contributed to the success are discussed later on.

We found that horses of warm-blood breed type learned somewhat sooner than horses of cold-blood type. This is in contrast to Lindberg et al. (1999) who found that non-warm-bloods learnt an operant task, to open a bin with concentrates, sooner than did warm-bloods. The authors suggested that reduced reactivity among non-warm-blood horses or their higher motivation to feed might explain this difference. Also, Heird et al. (1986) found that less emotional horses tended to score better in a discrimination task, and temperamental dimensions may be more important for learning performance than breed per se (Lansade and Simon, 2010). Previous training history may also influence training success, as Dorey et al. (2014) reported that 4 out of 10 traditionally trained horses but 9 of 10 horses previously trained by the Pirelli method reached the learning criterion after 60 trials. It has been suggested that horses "learn to learn" (Nicol, 2002), and at one of the farms (Nypan) some of the horses, and mainly the warm-bloods, had previously been trained using positive reinforcement. Together with the fact that we used slices of carrots as reward, which is highly attractive also for the warm-bloods, previous experience with positive reinforcement training may explain why warm-bloods learned the task sooner.

Stress at the time of learning has been shown to reduce learning ability in horses (Valenchon et al., 2013). One warm-blood horse (Remosa) was anxious in the beginning, but she advanced successfully when she eventually relaxed and started to show initiative.

Positive reinforcement training has been shown to increase horses' general interest in humans (Sankey et al., 2010) and their motivation to participate in training (Innes and McBride, 2008). Actually, such a change in behaviour was observed among our horses. When horses realized that they were able to communicate with the trainers, i.e. to signal their wishes regarding blanketing, many became very eager in the training or testing situation. Some even tried to attract the attention of the trainers prior to the test situation, by vocalizing and running towards the trainers, and follow their movements. On a number of such occasions the horses were taken out and allowed to make a choice before its regular turn, and signalled that they wanted the blanket to be removed. It turned out that the horses were sweaty underneath the blanket.

The operant training methodology is based on the principle of learning by trial and failure; in this setting being positively reinforced when trying the "right" solution and ignored when wrong. Reward based operant methods are more easily trained in horses which trust the situation to be positive regardless of "wrong"

behaviour, since they are not afraid of making mistakes. Trainers who are able to read horse body language and recognize even small responses from the horse during training, and deliver rewards immediately and consistently, are crucial for success (Evans et al., 1990). However, the insight the horse gets from not being rewarded when trying the "wrong" solution is important and should not be disregarded. The use of short daily training sessions is shown to be favourable for learning compared to longer sessions (McCall, 1990).

The horses which had a slower learning progression performed just as well as the others once they had learned the task. Marinier and Alexander (1994), who tested memory in horses using mazes, also found that learning ability varied but once a horse had learned a maze, it later remembered it perfectly. Actually, Hanggi and Ingersoll (2009) demonstrated memory of categories and concepts in horses 10 and 7 years later, respectively.

After introduction of the free choice situation (steps 9–10 in the training programme), and throughout the later testing, rewards were given for any choice made (i.e. any display board touched). This was done to motivate the horse to make its choice without delay also when the horse preferred to stay unchanged. These horses might otherwise have lacked an incentive to make a choice. It could be argued that being returned to the home paddock with companions would be an ultimate motivation for making a choice. However, to be able to test a number of horses within a restricted time span, we needed all of them to be readily motivated for making a choice.

By comparing choices made by the horses at days with nice weather to days with definitely adverse weather conditions shows that their display board touching was far from random. Results strongly indicate that touches represented actual preferences. Choices made by the horses could largely be explained from the level of thermoregulatory challenge experienced by them due to climatic factors as ambient temperature, wind and precipitation on the test days. This suggests that the horses not only became able to discriminate the 3 symbols and associate each of them with a specific outcome, but that they also were able to understand the effect a change in blanketing status would have on their thermal well-being.

In conclusion, horses can learn to use symbols to communicate their preference regarding blanketing. The fact that every horse which was included in the training programme, being virtually all horses (23 of 26) on the two premises and comprising "ordinary" horses of various breeds and ages, completed successfully and became performers, shows the potential of the method. It may be used in further research into horse preferences regarding management or training routines and may as such be an alternative to Y-maze choice tests. The performance of horses in our study adds to knowledge on horse cognition and learning abilities.

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Appendix A. Supplementary data

Supplementary data (video) associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.applanim.2016.07.014.

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