Do soothing vocal cues enhance horses' ability to learn a frightening task?

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abstract

When working with horses, it is frequently asserted that horses have an inherent understanding of harsh voice cues that would be used as reprimands versus soothing voice cues that may be used as positive reinforcers or calming modifiers. If horses are unable to understand this difference while their handlers assume they can, it may potentially lead to unfair or inappropriate training. A total of 107 horses from 2 different horse facilities in the United States and 7 different horse facilities in Europe were randomly assigned to either soothing voice treatment (SV; n ¼ 58) or harsh voice treatment (HV; n ¼ 49). The learning task involved horses of various breeds and ages learning to cross a tarpaulin. Methodology was standardized across locations. SV involved handlers saying "good horse" in a soft soothing manner whenever horses made forward progress toward the tarpaulin. HV involved saying "quit it" in a loud harsh manner whenever horses made forward progress toward the tarpaulin. Praat software was used to assess similarities in vocal spectrograms and acoustic parameters of different handlers and treatments. Mean pitch for SV and HV was 236.2 ± 2.2 Hz and 322.1 ± 8.9 Hz, respectively, both well within the equine hearing range and different at $P < 0.001$. Average intensity (loudness) for SV and HV was 51.2 ± 1.7 dB and 61.7 ± 1.2, respectively, different at $P < 0.001$. Contrary to our hypotheses, risk of failing the task (>10 minutes to cross the tarpaulin for the first time) was not different between treatments (22.4% failures on SV; 24.5% failures on HV; P ¼ 0.41). Also, for those horses who did cross the tarpaulin, the total time to achieve the calmness criterion (crossing with little or no obvious anxiety) did not differ between treatments (139.9 ± 50.4 for HV vs. 241.6 ± 40.3 for SV; P ¼ 0.25). There was no difference between the average heart rate (HR; n ¼ 70 horses) of horses that crossed (82.9 ± 7.0 beats/minute) versus those that failed (77.4 ± 6.7; P ¼ 0.43). Also, there was no difference between the average HR of HV horses (85.7 ± 3.9 beats/minute) versus SV horses (77.9 ± 3.7 beats/minute; P ¼ 0.16). Furthermore, there was no difference between the maximum HRs, with HV horses registering a mean of 143.4 ± 11.25 beats/minute and SV horses registering a mean of 166.1 ± 9.5 beats/minute; P ¼ 0.20. In the context of this study, soothing vocal cues did not enhance horses' ability to perform a novel potentially frightening task.

Introduction

There is a common belief among many animal trainers that animals have an intuitive understanding of humans' tone of voice. For instance, many riding theories recommend the use of soothing or harsh voice cues along with other cues, particularly when working with young horses (e.g., FN, 2012). It is assumed that long, low, soothing tones will quiet, calm, or slow an animal, whereas sharp harsh vocal cues are more likely to be used in reprimanding situa- tions (McConnell, 1990). Recent work by Merkies et al. (2013) found that draft horses at liberty in a round pen showed more favorable behavioral responses to tape recordings of pleasant voice and low tones than stern voice and low tones. Overall, however, the field of bioacoustics has received comparatively little attention in terms of its impact on horse-human interaction. Thus, there is surprisingly

Table 1
List of locations and other demographic data related to this study

Country	Facility type	Number of horses	Number of females	Number of males	Average age (years)	Number of HV	Number of SV	Behavior data	HR data	Handlers' vocal data
Germany	4 Locations, mixed	62	31	31	9.95	31	31	All	50	Yes
Italy	3 Riding stables	19	10	9	15.37	6	13	All	0	Yes
Michigan, USA	University farm	16	13	3	7.13	8	8	All	11	Yes
Delaware, USA	University farm	10	5	5	9.1	5	5	All	9	Yes

HR, heart rate; HV, harsh voice treatment; SV, soothing voice treatment.

little evidence-based literature on how horses respond to vocal cues of different volumes, tones, and intensities. There is slightly more research on the topic in dogs with respect to their responses to vocal commands. For example, when the same word cues are used, but with different than normal intensities or emphases, the compliance level of tested dogs dropped considerably (Fukuzawa, 2005a,b). Similarly, dogs were less likely to respond correctly to tape recorded rather than natural voice commands of their owners, although the context of their trainers' presence had not changed (Fukuzawa et al., 2000, 2005a, 2005b; Coutillier, 2006). According to Howard and Angus (1996), certain features such as frequency composition and resonance of human-generated speech differ from tape recorded speech, which may explain these differences. In practice, the situation is further complicated by the fact that cues are generally multimodal, that is, certain voice cues are accompanied by the handler's facial expression, body posture, or gestures (Partan and Marler, 1999; Partan, 2013), so that the handler intentionally or unintentionally conveys visual, as well as potentially olfactory or tactile, information via body language to the animal.

In horses, research has predominantly focused on tactile cues and on the effectiveness of different reinforcement schemes. For example, horses' responses to tactile cues diminished the farther the cue was moved from the originally trained location on the body (Dougherty and Lewis, 1993). Additionally, negative and positive reinforcement schemes (Innes and McBride, 2008; Heleski et al., 2008) have been compared, but vocal cues, if any, were used only in addition to other cues (Sankey et al., 2010; von Borstel and Euent, 2012). Based on experience from practice, and confirmed by both horses' hearing ability (Saslow, 2002) and learning theory (Voith, 1986; McGreevy, 2004), horses are well able to perceive and "learn" the meaning of certain words. However, although there is no doubt that horses can learn to perform certain actions in response to previously learned voice cues (e.g., a horse that stops at the word "whoa," ponies that learn to back up after reinforced verbal commands [Sankey et al., 2010]), it is not known whether horses intuitively understand the humans' tone of voice. If horses are unable to intuitively understand the difference between harsh and soothing voice cues, handlers may make poor assumptions that potentially lead to unfair or inappropriate training. Therefore, our objective was to see if horses performed better (when learning to cross a novel potentially frightening objectda tarpaulin) when soothing voice (SV) cues rather than harsh voice (HV) cues were used in place of a positive reinforcer after a correct response (i.e., moving toward the tarpaulin). We hypothesized that horses would perform better (e.g., cross more quickly, meet calmness criterion more quickly) and maintain a calmer demeanor (e.g., lower heart rate) when learning the task with SV cues as compared with HV cues.

Methods

Vocal cue collection and analysis methodology

Before testing, we recorded a minimum of 4 replicates of each of the 2 types of voice cues used for the 2 treatments (HV and SV; see the following text) from 5 of the handlers. Praat software (free acoustic analysis software; http://www.fon.hum.uva.nl/praat/, developed by P. Boersma & D. Weenink) was used to assess the acoustic qualities of the differing sets of vocal cues (n ¼ 26 samples of HV and 25 samples of SV). The analysis of the acoustic qualities included assessment of pitch (measured as frequency in Hertz), volume or intensity (measured in decibels), and number of pitch periods (1 per frequency), often used to show similarities or differences in vocal samples.

Horses and testing procedures

A total of 107 horses were tested during 2011 and 2012: 62 from 4 horse facilities in Germany, 19 from 3 horse facilities in Italy, 16 from the university facility in Michigan, and 10 from the university facility in Delaware (Table 1). Horses were balanced for age and gender and then randomly assigned to either the HV or the SV treatment. Average age of horses on the HV treatment was 10.7 years and 10.4 years for the SV treatment. Ages ranged from 3 years to 26 years. Fifty-eight horses were females; 47 horses were males, including 5 stallions. Horses were of various breeds and were grouped for analysis purposes into the following breed-groups: Hotbloods (n ¼ 22; Arabians, Thoroughbreds); Warmbloods (n ¼ 75; e.g., Italian Warmblood, Hanoverian, Trakehner); and other, which included Coldbloods and ponies (n ¼ 12; e.g., Gypsy horse, Haflinger, Fjord horse, and Shetland pony). For 2 horses, the breed was unknown, and thus, the breed-type information was set as missing for later analysis.

Horses were handled by 5 different female handlers (maximum of 2 handlers per location) with a traditional pressure-release method using a halter or head collar and lead rope without a chain. Whenever the tested horse stepped forward, the pressure on the halter and lead rope was released (negative reinforcement). When SV horses stepped forward, they additionally received a verbal reinforcer of "good horse" said in a soft soothing manner. When HV horses stepped forward, they additionally received a verbal reinforcer of "quit it!" said in a loud sharp manner. The process was repeated until our pre-established criterion was met (i.e., horses needed to cross with little or no obvious anxiety, e.g., rushing to cross, tucking the tail, whites of eyes showing; Figure 1).

We used the same methodology as 3 previous studies (Heleski et al., 2008; Heleski and Bello, 2010; McLean et al., 2008). A tarp or tarpaulin (1 tarpaulin per country, with the following specifications: green or gray, 2.44 × 3.05-m, high-density polyethylene material) was set up in the middle of an arena, which was used for the testing area. Boards were laid along the 2 outer edges to help stabilize it. We then placed 2 cones 13 m back from either side of the tarpaulin. This formed a starting line for each horse and the point at which a research assistant began timing each trial. The testing sessions were video recorded for later review. One helper per country scored behavior, timed trials, and recorded the number of trials to reach the calmness criterion (crossing with little or no obvious anxiety; e.g., no rushing to cross, no snorting or blowing, no whites of eyes showing). The behavioral scoring system was on a

Figure 1. Sample picture of a horse that is about to step onto the tarpaulin while the handler is about to release pressure from the lead rope.

scale of 1-5, with 1 being "easy" (i.e., horse walks over the tarpaulin with little or no hesitation) and 5 being "very difficult" (i.e., horse appears very frightened or extremely resistant; Table 2). Video clips from a previous study (Heleski et al., 2008) were shared with the collaborators of each country to provide samples of each number of the scoring system. For horses that successfully completed the task, other measures recorded included time taken to the first crossing of the tarpaulin (in seconds) as well as time taken to subsequent crossings up through the achievement of calmness criterion or a maximum of 5 crossings; the number of attempts to reach calmness criterion; and the total time required to achieve calmness criterion. Those horses that did not complete the task (cross the tarpaulin) in the first attempt within 10 minutes (600 seconds) were considered failures, and their observations were considered censored for statistical analysis.

Heart rate data collection methodology

Before testing, horses were fitted with heart rate monitors (Polar, Kempele Oy, Finland). Owing to the unavailability of the heart rate equipment at the Italian locations and to occasional technical failures, heart rate measurements were only available from 70 horses. Mean and maximum heart rates were assessed for all these horses for each trial. Additionally, from 63 of these horses, the heart rate variability parameters, root mean square of successive differences and low-frequency and high-frequency spectral power (von Borell et al., 2007; König v. Borstel, et al., 2011), were calculated using the software Kubios developed by Biosignal Analysis and Medical Imaging Group, University of Eastern Finland (http://kubios.uef.fi/).

Table 2
Scoring scale for horses' behavior during tarpaulin task

Score	Rating	Description
1	Easy	The horse walks over the tarpaulin on the first attempt with minimal or no hesitation
2	Fairly easy	The horse hesitates but then proceeds with little difficulty or horse starts to cross readily but then spooks mildly during crossing
3	Average	The manner in which most horses approached the task
4	Somewhat difficult	The horse is either quite fearful or quite resistant
5	Very difficult	The horse appears very frightened or highly resistant; the horse demonstrates one or more behaviors that are somewhat dangerous to the handler

For the "average" horse description, this was based on video clips that were shared among collaborators from a previous tarpaulin task study (Heleski et al., 2008).

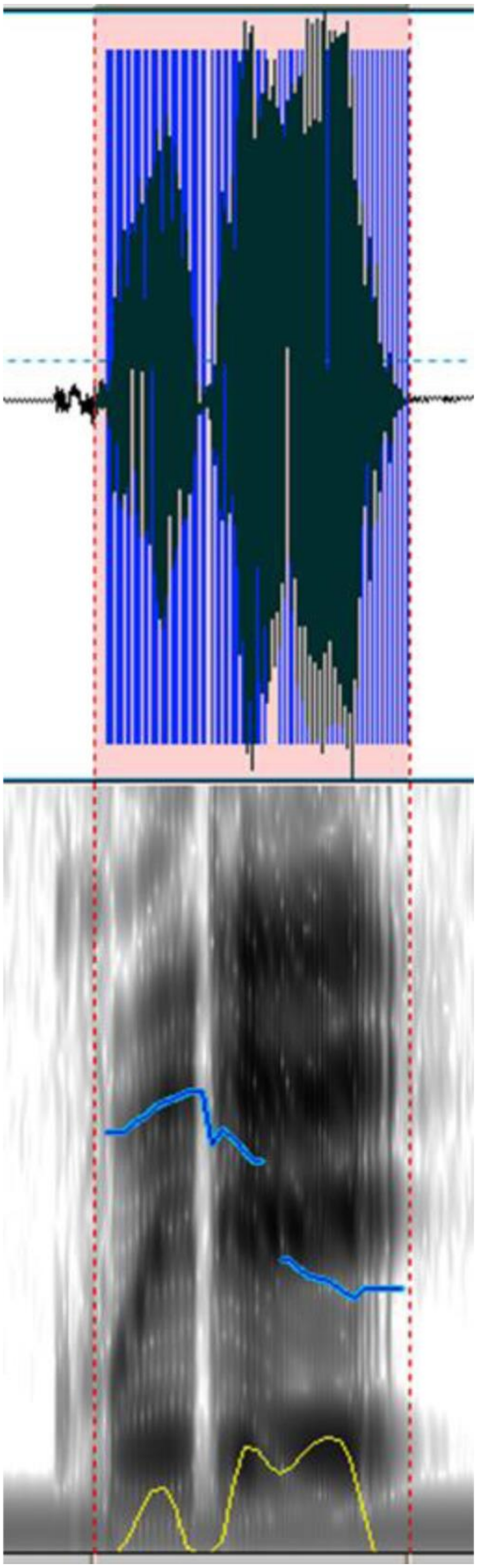

Figure 2. Sample spectrogram generated by Praat software for the harsh voice cue of "Quit it!"

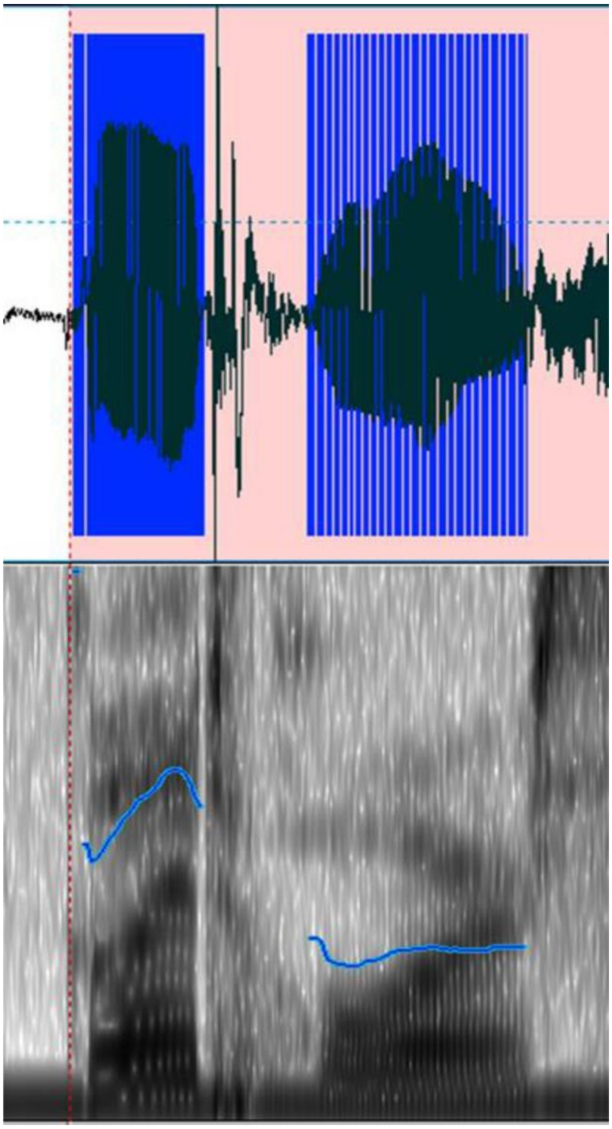

Figure 3. Sample spectrogram generated by Praat software for the soothing voice cue of “Good horse.”

Statistical analysis

All statistical analyses of behavioral measures and heart rate measures were conducted using SAS 9.3 (SAS Institute Inc., Cary, NC, USA).

All behavioral and heart rate data were tested for normality (PROC UNIVARIATE) and subsequently log transformed to achieve an approximate normal distribution, if necessary (e.g., all heart rate variability parameters). Mean (Anderson-Darling; *P* ¼ 0.0573) and maximum heart rate did not differ significantly from a normal distribution and were thus not transformed. Heart rate and heart rate variability parameters were then analyzed using a mixed model accounting for horse age and behavior score as potential covariables and the fixed effects of treatment, location, breed type, crossing of the tarpaulin (yes or no), and horse sex, as well as their 2-way interactions. Factors were removed from the model if they were not significant ($P > 0.1$). Behavioral measures were assessed using the PROC MEANS and PROC UNIVARIATE procedures; also, survival analysis (Kaplan-Meier method) via the LIFETEST procedure was used to consider the censored data. Comparison of means for acoustic measure data were conducted with SPSS 11.5 (IBM SPSS Statistics for Windows, Armonk, NY, USA). Significance was set at *P* S 0.05.

Table 3
Acoustic measures of human handler voice cue samples

Acoustic measures of voice	Harsh voice treatment (n ¼ 25), mean ± SEM	Soothing voice treatment (n ¼ 26), mean ± SEM	Significance
Pitch/tone/frequency	322.1 ± 8.9 Hz	236.2 ± 2.2 Hz	<0.001
Intensity/loudness	61.7 ± 1.2 dB	51.2 ± 1.7 dB	<0.001
Pitch periods (1/frequency)	67.7 ± 3.8	172.1 ± 5.0	<0.001

SEM, standard error of mean.

Table 4
Behavioral measures of the horses involved in this study

Behavioral measures considered in this study	HV	SV	Significance
Failures for completing task (:::10 minutes to cross the first time) (%)	24.5	22.4	NSD (*P* ¼ 0.41)
Total time to reach calmness criterion (horse crosses with little/no obvious anxiety), seconds, mean ± SD	139.9 ± 50.4	241.6 ± 40.3	NSD (*P* ¼ 0.25)
Number of attempts to reach calmness (maximum of 5 allowed), mean ± SD	2.2 ± 0.1	3.1 ± 0.2	*P* ¼ 0.001[a]
Time to first crossing of the tarpaulin, seconds, mean ± SD	63.6 ± 9.5	125.7 ± 12.2	NSD (*P* ¼ 0.11)[b]
Average behavior score, mean ± SD (see Table 1)	2.9 ± 0.2	3.2 ± 0.2	NSD (*P* ¼ 0.37)

HV, harsh voice treatment; NSD, no significant difference; SD, standard deviation; SV, soothing voice treatment.
[a] Difference is significant, but in the opposite direction from the hypothesis; that is, HV horses performed better.
[b] Difference only at the trend level, but in the opposite direction from the hypothesis; that is HV horses tended to perform better.

Results

Vocal cue assessment

The acoustic spectrograms of the cues “Quit it!” (HV) and “Good horse” (SV) were consistently different from each other yet highly similar across handlers within tone category (see Figures 2 and 3 for examples of each treatment).

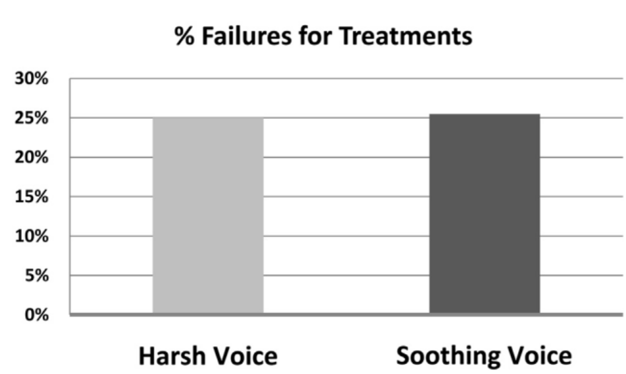

Figure 4. Comparison between the 2 vocal cue treatments in terms of what percentage of horses “failed” the task of learning to cross the tarpaulin within a 10-minute cutoff point.

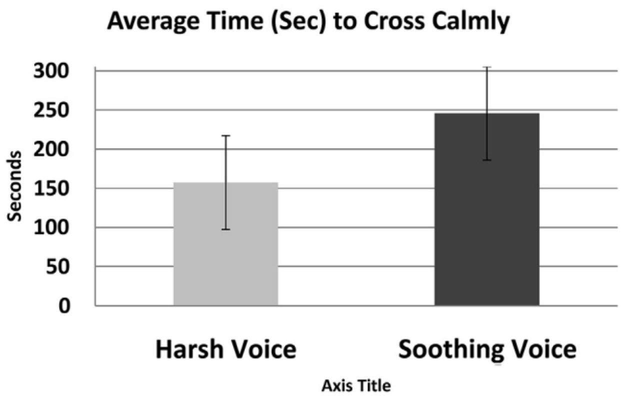

Figure 5. Means ± standard errors of mean for the 2 vocal cue treatments in terms of the total time required to reach calmness criterion (crossing the tarpaulin with little or no obvious anxiety).

Mean pitch for SV was 236.2± 2.2 Hz and 322.1± 8.9 Hz for HV (different at P < 0.001). Average intensity for SV was 51.2 ± 1.7 dB and 61.7 1.2± dB for HV (different at P < 0.001). The mean numbers of pitch periods (1 per frequency and an acoustic measure of similarity or difference of tones) were 172.1± 5.0 for SV and 67.7 3.8± for HV, respectively, different at P < 0.001 (Table 3).

Behavioral results

We examined the percentage of failures per treatment, time to first crossing of the tarpaulin, total time to calmness criterion, and behavioral scores and found no significant difference between treatments for any of those measures (PROC MIXED, PROC MEANS, PROC UNIVARIATE, and LIFETEST; SAS 9.3). There was no significant sex effect (P ¼ 0.38) or age effect (P ¼ 0.33). However, when failure rates were compared for 3- and 4-year-olds (36% failures for this age group; n ¼ 25) and for horses ≥20 years (7.6% failures for this age group; n ¼ 13), the difference was significant (P ¼ 0.001). When all ages were considered, there was a small but significant correlation with older horses being more likely to cross the tarpaulin in the allotted of 10 minutes (r ¼ −0.32; P ¼ 0.001).

The risk of failing the task (>10 minutes to cross the tarpaulin for the first time) was not different between treatments, with 22.4% failures in the SV treatment and 24.5% failures in the HV treatment (P ¼ 0.41). For those horses that did complete the task, total time to achieve calmness criterion (crossing with little or no obvious anxiety) did not differ between treatments (139.9± 50.4 for HV vs. 241.6 ±40.3 seconds SV; P ¼ 0.25; Table 4; Figures 4 and 5). The number of attempts required to achieve calmness was significantly different but in the opposite direction of the original hypothesis; that is, less attempts were required by horses in the HV treatment (2.2 ± 0.1 attempts [HV]; 3.1 ± 0.2 attempts [SV]; P ¼ 0.001). The average behavior score for those horses that crossed was 2.9 ± 0.2 (HV) and 3.2 ± 0.2 (SV; P ¼ 0.37).

Table 5
Heart rate measures: data obtained from 70 horses (based on availability of equipment per site)

HR measures considered	HR (beats/minute)	Significance
Average HR for those completing task	82.9 ± 7.0	P ¼ 0.43; NSD
Average HR for failures of task	77.4 ± 6.7	
Average HR for all HV horses	85.7 ± 3.9	P ¼ 0.16; NSD
Average HR for all SV horses	77.9 ± 3.7	
Maximum HR for all HV horses	143.4 ± 11.3	P ¼ 0.20; NSD
Maximum HR for all SV horses	166.1 ± 9.5	

HR, heart rate.

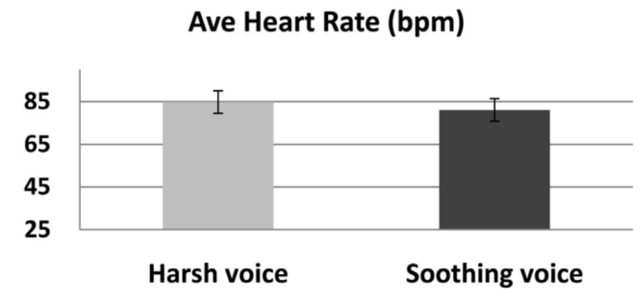

Figure 6. Means ± standard errors of mean. A comparison of the average heart rate (beats/minute [bpm]) of horses in the 2 treatments. Heart rate data were collected for 70 horses.

Heart rate data

There was no difference between average heart rate (n ¼ 70 horses) of horses that completed the task (82.9± 7.0 beats/minute) versus those that failed (77.4± 6.7 beats/minute; P ¼ 0.43). Also, there was no difference between average heart rate of HV horses (85.7 ± 3.9 beats/minute) versus SV horses (77.9 ± 3.7 beats/minute; P ¼ 0.16). Furthermore, there was no difference between the maximum heart rates, with HV horses registering a mean of 143.4 ± 11.25 beats/minute and SV horses registering a mean of 166.1 ± 9.5 beats/minute (P ¼ 0.20; Table 5; Figures 6 and 7).

Discussion

Our results were not what we had expected. We had hypothesized that the horses in the SV treatment group would more likely cross the tarpaulin, would cross in less time, and would reach calmness criterion more quickly. Furthermore, we had expected that their average heart rates and maximum heart rates would be lower if they found the soothing vocal cues to be at least somewhat calming. None of these proved to be true. After testing over 100 horses and using these multiple measures, we accept that our hypotheses were not substantiated in the context of this study.

We believe there are several alternative explanations for our findings. The most straightforward conclusion to draw is that horses are either not able to distinguish between harsh voices and soothing voices, or they do not rely on the differences for this type of training task. Another possibility is that these horses were not familiar enough with this set of handlers to differentiate between the 2 vocal cues; perhaps, the anecdotal observations of horses differentiating between different types of vocal cues are only

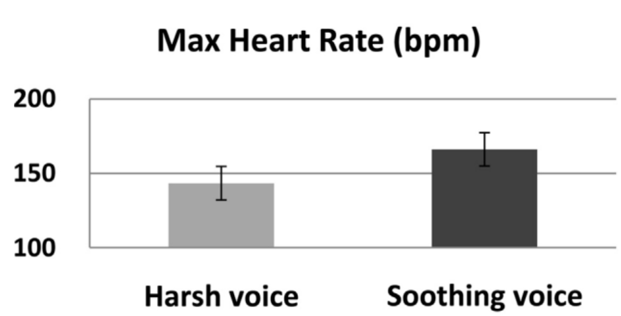

Figure 7. Means ± standard errors of mean. A comparison of the average maximum heart rate (beats/minute [bpm]) for the horses in the 2 treatments. Heart rate data were collected for 70 horses.

when the horses have been conditioned to the different vocal cues of people they are familiar with. Probably, the alternative hypothesis that these authors are most comfortable with is that given the horse's inherent nature, and the fact that most training relies heavily on negative reinforcement (McCall, 1990; McLean, 2005), the pressure-release paradigm simply carried more immediate relevance for these horses. The timing of the pressure release for learning the task was in keeping with how most of these horses had been halter trained, and thus, predictability for them came from responding to the halter pressure more so than the corresponding vocal reinforcements. If this was the case, the vocal cues simply became "noise" that the horses appeared to not find meaningful. Another way to state this would be that the reinforcement pattern of pressure release "overshadowed" (McGreevy and McLean, 2010) any information provided to the horses via vocal cues. Previously, Heffner (1998) stated that when an animal is presented with 2 stimuli in a learning situation, it will often attend to 1 stimulus and ignore the other. It may indeed be that the horses in this study attended to the stimuli of pressure release as being more salient than sound.

Interestingly, if anything, there was a tendency of the horses in the HV treatment group to perform more quickly than their SV group counterparts. Although we did not see heart rate evidence to strongly support this, some of the horse handlers suspected that the horses in the HV treatment group thought they were "in trouble" and thus performed more quickly.

In terms of whether the vocal cues used in this study were within the range of horses' hearing, the work by Heffner (1998) would strongly support the answer of yes, showing the lower limit to be 55 Hz and the upper limit to be 33,500 Hz.

Even if we consider, for example, that perhaps our harsh vocal cues were not as harsh as one might use in a "real" situation, it should have at least qualified as a neutral stimuli and our hypothesis would still have been that soothing tones help encourage a horse. Each of the horse handlers admitted that it was hard to give a "harsh as possible" vocal cue when the horse was actually moving forward as was desired. But each horse handler also said it was easy to give a soothing cue when the horse moved forward, if that was the appropriate treatment. Again, it was perceived by all handlers and the remaining research members that at the very least, it would have been perceived as harsh ¼ neutral and soothing ¼ positive.

Conclusion/Industry application

Anecdotally, most horsemen seem to believe that horses understand harsh tones mean they are misbehaving (e.g., yelling at a stallion that is pawing at his stall door) and soothing tones will assist horses in accomplishing frightening or novel tasks (e.g., cajoling a horse into a horse trailer or to walk past a frightening object). However, the evidence to support this belief is lacking.

Based on this study, most horses did not appear to inherently distinguish between harsh vocal cues and soothing vocal cues; or if they did, it did not influence their performance of learning and performing a frightening task. Based on every measure analyzed, horses did not appear to recognize the difference between harsh voice tones and soothing voice tones in learning the task of crossing a novel object. Trainers and handlers should recognize that horses may have no inherent understanding of voice cue differences and this may not be a highly relevant cue in the horse's world, at least without additional conditioning or training.

Acknowledgments

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The idea for the study was conceived originally by C. Heleski, but with additional input from C. Wickens, M. Minero, and U. Köenig von Borstel once the authors decided to expand to multiple locations. The experimental design was based on an earlier study by C. Heleski et al, but with additional input from Wickens, Minero, and Köenig von Borstel. The experiments were performed by Heleski, Minero, E. DallaCosta, E. Czeszak, and Köenig von Borstel with additional help from students who are mentioned previously in this section. The data were analyzed by C. Wu, Köenig von Borstel, Heleski, Wickens, and Minero. The article was written by C. Heleski with input and editing from each of the other coauthors.

Ethical considerations

Each university was responsible for submitting their respective ethical animal use forms. All universities received approval before collecting any data.

Conflict of interest

The authors have no conflicts of interest to disclose related to this article.

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