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The effect of ocular blinkers on the horses' reactions to four different visual and audible stimuli: results of a crossover trial

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Abstract

Objective To determine the effect of ocular blinkers on driving horses' reactions to visual and audible stimuli.
Design Balanced crossover trial with horses randomly assigned to either wear blinkers or not wear blinkers first or second, then subjected to repeated sequences of four distinct stimuli (chain rattle, cap gun, umbrella opening, and shaking of an aluminum can containing coins). Two weeks later, this process was repeated with the ordering of wearing blinkers reversed.
Animal studied Eight driving horses of various breeds.
Procedures Responses were recorded quantitatively as inter-beat times (the time between each heart beat in msec) and qualitatively via video recording. Statistical analysis of the first 10 s of inter-beat times poststimulus assessed the effect of the presence of blinkers, order of blinker application and stimulus type using a linear regression model with a random effect for horse.
Results Wearing blinkers is significantly associated with a decrease in the inter-beat times (increase in heart rate) when they are worn by horses experiencing an unfamiliar sound. However, wearing blinkers is significantly associated with an increase in the inter-beat times (decrease in heart rate) when worn by horses experiencing a primarily visual, familiar stimulus.
Conclusions and Clinical Relevance Trained driving horses, when they wear blinkers, have a decrease in inter-beat time (an increase in heart rate) when there is an unfamiliar sound. This may have relevance to horses who have limited vision caused by trauma or disease.

Key Words: behavior – equine, inter-beat time – equine, ophthalmology – equine

INTRODUCTION

The horse is an animal that uses its senses of sight and hearing to stay alive and flee enemies. Horses are prey animals and as such need these senses to escape their predators.[1] What, then, happens to the horse whose vision is decreased or altered in some way? Corneal opacities caused by injuries or infectious diseases can decrease field of view or visual acuity. Cataracts or retinal disease can also alter vision. Driven horses used for racing, pleasure, or driven competitions often wear blinkers which decrease their field of view. Thoroughbreds and Quarter Horses raced on the flat will also sometimes wear blinkers.

How do we determine what effect these losses of normal vision have on a horse? Anecdotal evidence abounds, either when the subject of using blinkers on a driven horse is discussed, or in making a prognosis as to whether a horse will return to functioning as an athlete after ocular trauma, infected ulcers, or uveitis. The purpose of this study was to quantify horses' responses to stimuli when their visual fields were decreased with blinkers compared to not wearing blinkers.

MATERIALS AND METHODS

Subjects

Eight privately owned adult horses, with ages between 6 and 30 years, four mares and four geldings; one was a warmblood horse, the others were mixed or pure-bred pony breeds. All had been driven with blinkers; they ranged in experience from novice to experienced and most had also been ridden. The study protocol was reviewed and approved by the Clinical Research Review Committee; College of Veterinary Medicine, Texas A&M University, and informed owner consent was obtained.

Experimental design

All horses were tested with blinkers on or with no blinkers. Two racing hoods were used: one with a half-cup blinker sewn in on both sides (the treatment) and the other with open orbital areas (the control). A half-cup blinker is a quarter of a sphere that covers the temporal part of each eye. The hood was worn under the halter. While these hoods are not identical to blinkers that are worn with a driving bridle, they obscure the area behind the horse in the same way driving bridles do. And because all driving bridles' blinkers fit differently, these hoods allowed for similarity between horses. The random variable was the animal's inter-beat time after a stimulus. For the first of the two replicates of the experiment (at day 0, sequence 1), four horses were randomly assigned to start first with blinkers (the treatment); the other four were started without blinkers (the control). Then the hoods were reversed and the sequence 2 was run. For the second replicate, conducted 2 weeks later, the blinker order was reversed so that horses starting with blinkers during the first replicate began the second replicate without blinkers. Each horse was located in a secure area using a lead line, facing forward and held loosely by one person, who handled all eight horses throughout the entire experiment which was conducted in a familiar location for the horses.

Four stimuli were used for each of the two sequences per replicate. The same order for these stimuli was used in all sequences: (i) a length of steel chain (33″ and 780 g) was dropped from waist height onto a piece of aluminum roofing material, (ii) a children's toy cap gun was fired, (iii) an umbrella was rapidly opened, kept opened to the count of five, and then closed, and (iv) an aluminum can containing coins was shaken to the count of five. The same person administered all the stimuli and stood about nine strides behind the horse; this person could not be seen by the horse when the horse was blinkered.

Quantitative data were collected via heart rate monitor electrodes secured to the horse with a strap that fastened at the girth area. A transmitter in the strap sent the signal to a receiver in wrist monitor[a] worn by the experimenter who was administering the stimuli. The heart rate monitor was set to record the time, in milliseconds, at each beat of the horse's heart. Thus, the data from the heart rate monitor are recorded as inter-beat times: the number of millisecond between each heart beat. Data from the heart rate monitor are uploaded to a computer, and these numbers were used in the statistical analyses. These numbers can be converted to heart rate; which is done in real time on the wrist monitor and is used in Fig. 1 for ease of understanding. The experimenter stood nine strides directly behind the horse, and could not be seen by the horse when blinkers were on. The onset of each stimulus was recorded on the heart rate monitor manually. The first stimulus was given when the horse's heart rate was at a steady state (baseline) and the next stimulus was given when the horse's heart rate had returned to baseline. After the fourth stimulus the hood was exchanged and the stimuli repeated for the second sequence in the replicate, following a brief period of rest. Qualitative data were collected in two ways: the horse handler spoke into a hand-held voice recorder describing any behavioral changes when the stimulus was given, and a video camera mounted on a tripod filmed the horse's reaction to the stimuli. Video recordings were matched with heart rate data by time, when

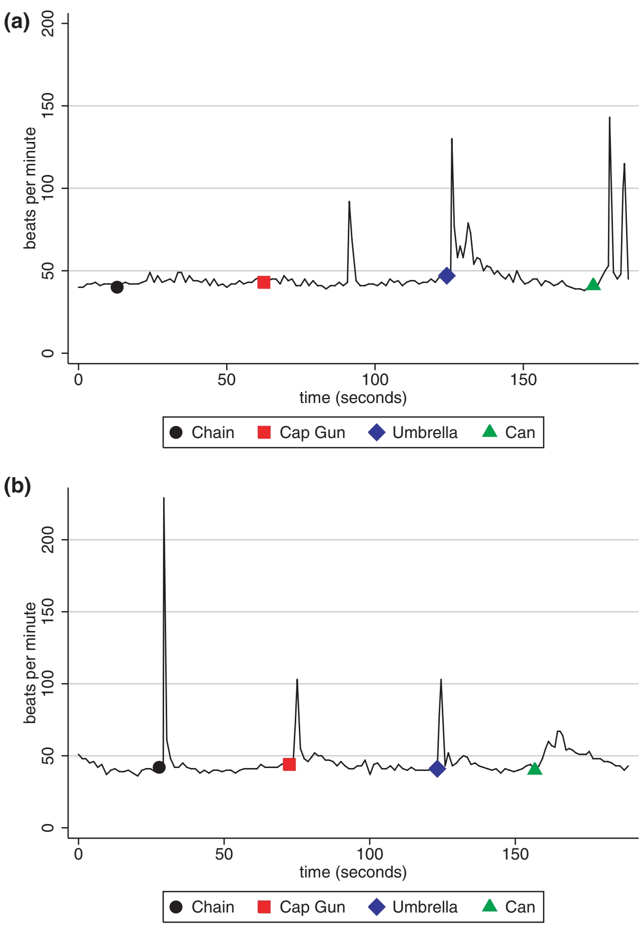

Figure 1. A plot of the heart rate for one horse, graphed as beats per minute, for two sequences in one replicate.

[a]Polar Horse Heart Monitor, with 200 foot transmission range telemetry kit, Polar S810, Woodbury, NY.

Table 1. Qualitative observations of horse reactions to stimuli

Stimulus	Maximum reaction	Minimum reaction
Blinkers		
Chain	Ear and head movement/flinch	Nothing
Cap gun	Ear movement, head up	Nothing
Umbrella	Flinch (only when the blinkers were on second)	Nothing
Aluminum can	Head and ear movement/feet moved	Nothing
No blinkers		
Chain	Movement of body	Nothing
Cap gun	Head and ear movement	Ear movement
Umbrella	Spook/jump forward	Nothing
Aluminum can	Head and ear movement	Nothing

they were watched. Qualitative data were recorded only on the first six horses.

Statistical analyses

Mean, median, standard deviation and range were used for descriptive statistics of the inter-beat time. A linear regression model was fit with inter-beat time as the response, indicators for presence of blinkers, sequence, and stimuli, the interactions of blinkers with sequence, replicate and stimuli, and the interaction of sequence with replicate. The interaction terms allow the effect of one factor to differ depending on the level of the other factor. For example, having the interaction of blinkers with sequence in the model allows the effect of the blinkers to vary depending on whether they were on first or second. A random effect for horse was used to account for possible correlation of observations on the same horse. The normality of the residuals was gauged using normal probability plots and histograms. All hypothesis tests were conducted using a significance level of 5%. All statistical analyses were performed using STATA, version 11.[b]

RESULTS

The first six horses' visible reactions to all the stimuli were usually mild, consisting of no response, flinching, or moving their ears. Driving horses are typically not very reactive, usually by temperament, but always by training. These were no exception. Occasionally, the horse would shift or throw up its head. A summary of qualitative responses is given in Table 1. Behavioral changes were too subtle to help in evaluating differences between blinkers and no blinkers, and so the last two horses were not recorded in this way.

Figure 1a,b is the plot of the quantitative responses for one horse, graphed as beats per minute, for two sequences in one replicate (1 day's data). The quantitative data for all eight horses are summarized in Table 2. This consists of mean, standard deviation, median and range during the 10-s period poststimulus tabulated for treatment (blinker/no blinker), sequence (blinkers first/blinkers second) and stimulus type (chain, cap gun, umbrella, and aluminum can). Figure 2 is a box plot of inter-beat time for 10 s after each stimulus by the same categories.

The linear regression model was fit to the data, using the inter-beat time as the response variable. Since heart rate varies, there is a different number of beats for each 10-second period and thus number of observations totaled was 1026. The model estimated average inter-beat time, for the following factors: blinkers worn (0 = no, 1 = yes), sequence (0 = blinkers worn first, 1 = blinkers worn second), replicate (0 = first, 1 = second) and indicators for stimuli (chain is the reference group). A histogram and normal probability plot of the residuals show no apparent deviation from normality when a square-root transform was applied to the response. Table 3 is the results from this model.

There was no significant difference between the three primarily audible stimuli, so a second model was fit, collapsing the stimuli into two categories: primarily audible (chain, cap gun, and aluminum can) and primarily visual (umbrella). The reference category was audible, and again a square-root transform improved the normality of the residuals. The resulting coefficient table is shown in Table 4.

Predicted average inter-beat times, with 95% confidence intervals, are shown in Table 5 and Fig. 3. The nonoverlapping confidence intervals in the first row of Table 5 indicate that wearing blinkers is significantly associated with a decrease in the time between heartbeats (increased heart rate) when they are worn by horses experiencing a noise for the first time. The same effect is seen when blinkers were worn second on the first replicate, and when blinkers were worn first on the second replicate. On the other hand, nonoverlapping confidence intervals in the last row of Table 4 indicate that wearing blinkers is significantly associated with an increase in the time between heartbeats (decrease in heart rate) when worn by horses experiencing a primarily visual stimulus.

[b]StataCorp LP, 4905 Lakeway Drive, College Station, TX 77845; StataCorp LP. (2009). *User's Guide.*

Table 2. Quantitative descriptive statistics of horse heart inter-beat time (×10^3 ms) during the 10-s period poststimulus

			Blinkers first			Blinkers second		
		Stimulus	*N*	Mean (SD)	Median (range)	*N*	Mean (SD)	Median (range)
Rep 1	Baseline		57	1.39 (0.38)	1.28 (0.26–2.21)			
	Blinkers	Chain	45	0.91 (0.44)	0.81 (0.26–1.85)	26	1.53 (0.29)	1.42 (1.18–2.08)
		Cap gun	35	1.09 (0.58)	0.92 (0.61–3.78)	27	1.54 (0.42)	1.36 (0.63–2.48)
		Umbrella	38	1.08 (0.45)	1.00 (0.38–2.10)	31	1.24 (0.57)	1.33 (0.26–2.68)
		Aluminum can	34	1.16 (0.37)	1.11 (0.35–2.01)	28	1.38 (0.49)	1.37 (0.53–3.33)
	No blinkers	Chain	29	1.38 (0.38)	1.28 (0.25–2.31)	30	1.37 (0.43)	1.35 (0.25–2.86)
		Cap gun	33	1.24 (0.59)	1.16 (0.25–3.00)	30	1.31 (0.45)	1.22 (0.56–2.27)
		Umbrella	42	0.96 (0.40)	0.99 (0.26–1.64)	37	1.11 (0.55)	0.94 (0.28–2.27)
		Aluminum can	30	1.35 (0.40)	1.39 (0.33–1.98)	31	1.28 (0.42)	1.28 (0.35–2.49)
Rep 2	Baseline		53	1.38 (0.43)	1.41 (0.26–2.35)			
	Blinkers	Chain	30	1.35 (0.32)	1.22 (0.82–2.13)	37	1.12 (0.52)	1.16 (0.26–2.35)
		Cap gun	30	1.27 (0.38)	1.14 (0.57–1.87)	33	0.92 (0.28)	0.81 (0.29–1.36)
		Umbrella	33	1.19 (0.50)	1.20 (0.33–2.35)	29	1.03 (0.56)	0.71 (0.58–2.29)
		Aluminum can	38	1.03 (0.39)	1.05 (0.28–1.94)	33	1.22 (0.42)	1.14 (0.25–2.18)
	No blinkers	Chain	27	1.49 (0.30)	1.33 (1.17–2.07)	28	1.45 (0.40)	1.27 (1.07–2.31)
		Cap gun	26	1.54 (0.52)	1.34 (1.06–3.52)	29	1.41 (0.55)	1.34 (0.47–3.59)
		Umbrella	31	1.35 (0.44)	1.20 (0.31–2.34)	38	1.05 (0.54)	0.93 (0.30–2.54)
		Aluminum can	29	1.39 (0.36)	1.27 (0.40–2.15)	29	1.40 (0.41)	1.32 (0.39–2.18)

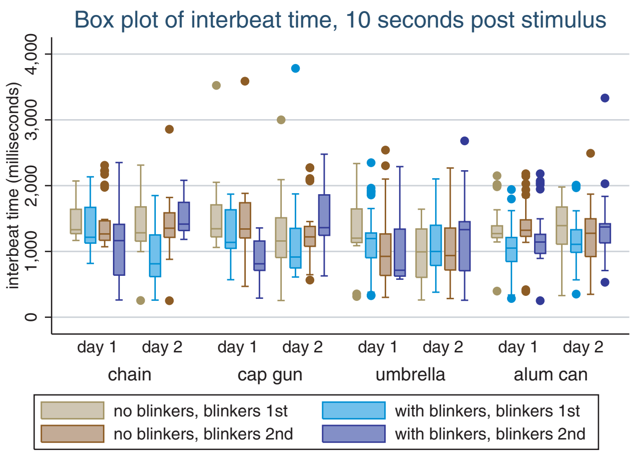

Figure 2. A box plot of the inter-beat time for 10 s after each stimulus tabulated for treatment (blinker/no blinker), sequence (blinkers first/blinkers second) and stimulus type (chain, cap gun, umbrella, and aluminum can).

Table 3. Linear regression result table, using four stimuli

Variable	Coefficient	*P*-value
Blinkers	−6.3948	<0.0001
Sequence	−3.213588	<0.0001
Replicate	−4.62682	<0.0001
Cap gun	−1.000189	0.253
Umbrella	−4.867414	<0.0001
Can	−1.034797	0.236
Blinkers × sequence	2.383747	0.004
Blinkers × replicate	3.299867	<0.0001
Blinkers × cap gun	1.148146	0.339
Blinkers × umbrella	3.927901	0.001
Blinkers × can	1.198096	0.314
Sequence × replicate	5.103545	<0.0001

Table 4. Linear regression result table, using two category stimuli: audible and visual

Variable	Coefficient	*P*-value
Blinkers	−3.216783	<0.0001
Sequence	−3.216783	<0.0001
Replicate	−4.636843	<0.0001
Visual	−4.18008	<0.0001
Blinkers × sequence	2.381033	0.004
Blinkers × replicate	3.299793	<0.0001
Blinkers × visual	3.138886	0.001
Sequence × replicate	5.117251	<0.0001

Table 5. Estimated average horse heart inter-beat time (×10^3 ms) and 95% confidence interval during the 10-s period poststimulus

		Stimulus	Blinkers	No blinkers
Rep 1	Blinkers 1st	Audible	1.14 [1.06, 1.21]	1.55 [1.45, 1.64]
		Visual	1.07 [0.98, 1.17]	1.24 [1.14, 1.34]
	Blinkers 2nd	Audible	1.08 [1.01, 1.16]	1.30 [1.22, 1.39]
		Visual	1.01 [0.92, 1.11]	1.02 [0.93, 1.11]
Rep 2	Blinkers 1st	Audible	1.05 [0.98, 1.12]	1.20 [1.13, 1.28]
		Visual	0.98 [0.90, 1.07]	0.93 [0.85, 1.02]
	Blinkers 2nd	Audible	1.34 [1.26, 1.43]	1.34 [1.26, 1.42]
		Visual	1.27 [1.17, 1.38]	1.05 [0.96, 1.14]

DISCUSSION

Most carriage horses in the USA are driven with blinkers. When drivers are asked why they use blinkers, they give a variety of answers: Blinkers help direct a horse's concentration so that he is less stimulated by his surroundings and more amenable to the driver's requests. Horses with blinkers are not distracted by unfamiliar objects and cutting off many visual disturbances allows

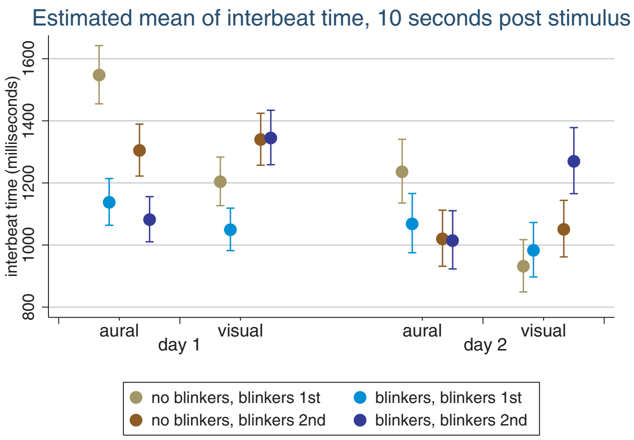

Figure 3. Predicted average inter-beat times for 10 s after each stimulus, with 95% confidence intervals.

them to concentrate on the driver. The horse cannot see the vehicle 'chase' them, and since they are prey animals having something 'chasing' them all the time can be stressful. A whip is used to direct a horse's movement both forward as well as lateral, and to direct the speed of the horse; horses that cannot see the whip will not anticipate the driver's directions before it touches them. This is especially important when driving multiple horses, since the whip will only be meant for one horse. If the horse cannot see the vehicle, the driver can switch vehicles without desensitizing for each vehicle. Horses with blinkers are not distracted by movements of the driver, or especially, of the passengers. Horses with blinkers can concentrate on the driver in a panic situation. Blinkers allow the horse to stay focused and concentrate on its job, which is the work ahead of them.

A change in heart rate is used as a measure of stress, excitement, and reaction to new stimuli.[2–4] Visser *et al.*,[5] showed an increase in heart rate when horses were exposed to a novel object, and Minero *et al.*,[6] used a heart rate monitor to examine responses to the application of a twitch and the sudden inflation of a meteorological balloon; both raised heart rate. Momozawa *et al.*,[7] correlated an increase in heart rate during a balloon reactivity test to personality traits in horses, finding 'anxious' horses had a higher heart rate than did nonanxious horses. Visser *et al.*,[8] showed an increase in heart rate when an umbrella was lowered from a ceiling, and when a horse was led over an unfamiliar bridge. This increase in heart rate was less in trained horses compared to untrained horses; and decreased as the horses got older. Reaction to novel stimuli can also be measured by various behavioral tests – recording behavior when the horse is exposed to a new situation, object, or environment; but as seen in this paper, horses can stand still and still be reacting as seen in changes in their heart rate. Heart rate and heart rate variability measurements, with the addition of behavioral changes, have been used to define personalities, and to look at breed differences in horses. For instance when put into isolation, Arabian horses were found to have higher heart rates than Standardbreds.[9]

Unfortunately, there are few purely visual stimuli, as seen by the fact that at least in one replicate, horses who had seen the umbrella first, reacted much more strongly to the small noise of the opening umbrella when they had blinkers on second, presumably because they knew what this noise signified. From a veterinary point of view, we are often cavalier in discussing partial vision in horses. If there is a part of the visual axis which is clear, we congratulate ourselves and tell the owner that the horse is visual on that side. This begs the question of how a partially visual horse will react to various stimuli.

It would seem obvious that wearing blinkers would be advantageous when a visual distraction is hidden by the blinkers. Because the horse cannot see the object, he has no reaction to this object which is potentially frightening. However, sounds are different. This paper shows that horses wearing blinkers react more when they are exposed to unexpected noises. This reaction is not necessarily seen by an observer, because many of the horses showed little or no reaction when they heard the noise, despite the fact that their heart rates increased dramatically. It was also surprising that we were able to get significant difference using only eight horses, and horses that had already been trained with blinkers.

Further work that could be performed with this model include using horses unused to blinkers and the use of different cups in the hood, including the simulation of the refractive changes seen in horses without lenses (postcataract surgery), and full cups to simulate blindness.

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