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Final Report: Analysis of EasyFix Jump Sample

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Overall Summary

A sample of a horse jump was sent for analysis from Michael Earls, managing Director EasyFix for analysis to horse vision. The aim was to take digital images of the jump and convert them to horse vision, followed by analysing the visibility of the jump (with white and orange toe boards) against natural backgrounds. The results show that the different colours on the jump are generally of low visibility to natural vegetation to horse vision, but also that there is wide variation. The orange colours and white toe boards can be visible against certain backgrounds, but this is not substantial. Other colours are likely to provide greater visibility to horse vision. There are also differences in brightness, with the white toe boards offering high visibility in this regard, and to a lesser extent some good visibility provided by the orange jump colours and green components. Overall, a combination of high brightness visibility and strong colour contrast (using different colours to those currently present) would likely be optimal.

Methods

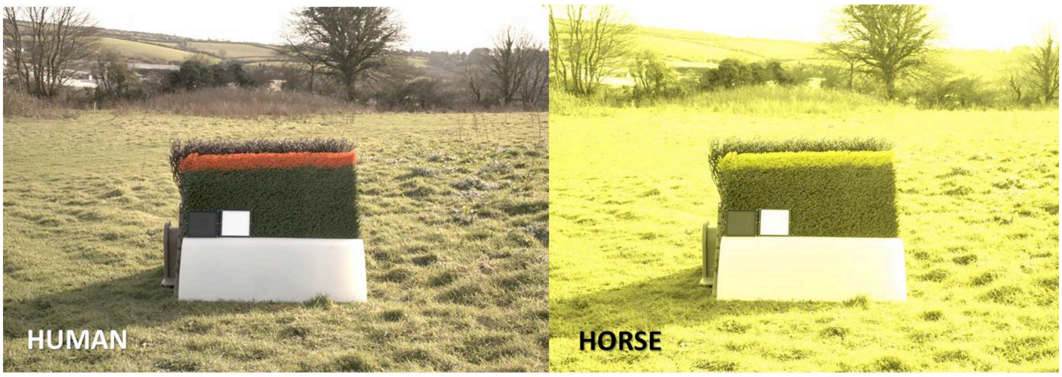
A sample of a jump was placed in a natural setting for analysis. Photographs were taken of the fence with each of the two different coloured toe boards, on a clear day in a field with a range of vegetation types around and in the background. Vegetation included grass, brown scrub, and darker green foliage from trees. Photographs included reflectance standards (black and white squares) to control for variation in natural light levels, and were taken with a camera of known spectral sensitivity to different wavelengths of light. Following image capture, images were converted to correspond to the relative stimulation of a horse's shortwave and longwave cone types. In horses, there are two cone types used in colour vision, sensitive to short (428 nm peak) and medium/longer wavelengths (539 nm peak), which equates to dichromatic colour vision (Carroll et al. 2001. J Vision. 1: 80-87). Brightness likely stems from the medium/longer cone type.

Images can be seen in Figure 1 to human and horse vision of the jump and backgrounds. The process involves a mathematical transformation, whereby through knowing the sensitivity of our camera to different wavelengths of light, and that of the horse's cone types, we transform the images from camera sensitivity to that of horse vision. This is based on a range of previously published methods in our lab (e.g. Stevens et al. 2007. Biol J Linn Soc. 90: 211-237; Troscianko & Stevens. 2015. Meth Ecol Evol. 6: 1320–1331). The resulting images correspond to how stimulated / activated the horse's cone types would be when viewing a given object under a given set of light conditions. This process of converting from camera to animal colour space is highly accurate and with very low error rates compared to modelling of cone stimulation data with other methods, such spectrometry. In fact, images here much more accurately account for illuminating conditions and angles, and measure larger areas of the focal object or scene, than is possible with spectrometry, meaning that using image analysis is even more accurate than purely based on its high correspondence with spectrometry data. The R^2 values of the models converting from image values to horse cone stimulation values were all ≥0.99, illustrating the accuracy of this approach.

Figure 1: Easyfix jump with orange (top) and white (bottom) toe board. Images on the left represent the scene as it would appear to a human (with "normal" trichromatic colour vision), and images on the right as it would appear to a horse (dichromatic vision). Note – the horse images look brighter than they would naturally be because the images have been square-root transformed for display purposes only.

Orange toe board

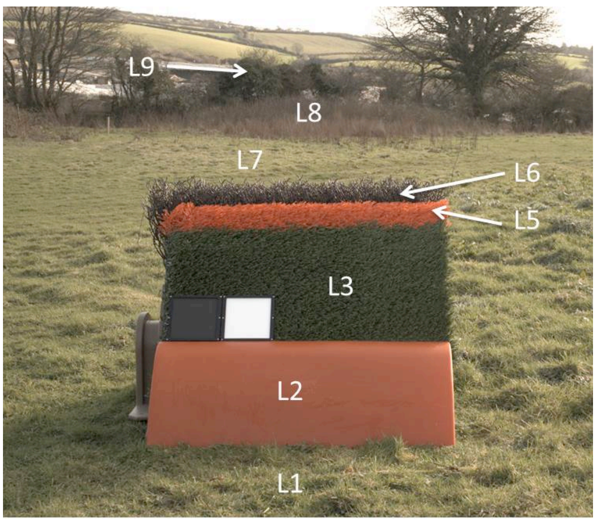
White toe board



Analysis of visibility

Once the images had been converted to horse vision, we then measured a number of focal areas of the jump and the background (Figure 2).

Figure 2: Easyfix jump showing all sections and background types measured in the analysis of the fence. Each code matches codes in the results table below.



Once these sections were measured, we analyzed two aspects of visibility (contrast in colour and in brightness) of each jump component against a near-by region of the background. In animal vision, colour information is processed separately from that of perceived brightness (called 'luminance'). Both can be used in detection and play a role in visibility, though brightness tends to fluctuate more over time and with weather conditions and so can be less consistent. To analyze visibility, we implemented a widely used model of animal vision in colour science.

Colour

For colour, the model can predict when two objects should look different to a given animal (e.g. a horse), and if so, how different they look. The model produces values called 'just noticeable differences' or JNDs. Small values, especially those below 3.00, indicate that an animal is unlikely to be able to see the difference between two objects in colour, even under very good light conditions. Higher values indicate an increasing probability that an animal will be able to tell the difference between two objects or detect one object against another.

Brightness (luminance)

For brightness, the model uses information from the horse medium/longwave cone type. It also provides a measure of detectability in the form of a JND, but the values are more speculative because detection rates for brightness are less well understood and more affected by current conditions. Therefore, a JND of less or more than 3.00 does not necessarily equate to something being undetectable or detectable. In contrast, the values give a good general indication of how observed brightness differs between the different components of a scene when viewed by a horse on a more continuous scale – larger values mean that something is more likely to be visible.

Analysis and Results

Figure 1 above, showing the sections of the jump and background to horse vision, illustrates how horses cannot distinguish between colours that are red, yellow, and green types (but probably can for differences in brightness). As can be seen, the orange jump colours and the different shades of brown and green vegetation all look a very similar yellow colour and are difficult to distinguish.

Table 1 below shows the full analysis of visibility for colour. In summary, no colour contrasts are high (JNDs are all <10), and for a range of values the JND contrast values are very low (< 3). This means that many of the colours and components of the jump will be difficult to see for a horse based on colour. However, the visibility of each component varied and some components were more visible to horse vision than others. Specifically, the orange and white toe boards were both likely to be detectable against the foreground green grass (although note these values are still not high). In contrast, the dark green plastic grass, the orange plastic grass strip, and the 3D plastic twigs of the jump were all hard to distinguish from brown scrub and often against the dark green background foliage.

Table 1. The visibility to horse vision of different jump components against foreground and background foliage focusing on colour. The contrast between the different plastic toe board colours and the dark green plastic grass of the fence (internal fence contrast) is also included. JNDs below 3 indicate that colours are indistinguishable, whereas higher values equate to greater likelihood of detection.

	Section of fence		Foreground/Background		Mean Just Noticeable Difference (JND)	Visible difference?
Bottom of jump	White plastic toe board	L1	Green grass foreground	L1	7.79	Yes
	White plastic toe board	L1	Dark green plastic grass	L3	3.34	Yes
	Orange plastic toe board	L2	Green grass foreground	L1	9.08	Yes
	Orange plastic toe board	L2	Dark green plastic grass	L3	2.81	Low
	Dark green plastic grass	L3	Green grass foreground	L1	5.48	Yes
	Dark green plastic grass	L3	Green grass background	L7	5.10	Yes
	Dark green plastic grass	L3	Brown scrub background	L8	1.99	Low
	Dark green plastic grass	L3	Dark foliage background	L9	5.47	Yes
	Orange plastic grass	L5	Green grass foreground	L1	9.27	Yes
	Orange plastic grass	L5	Green grass background	L7	7.30	Yes
	Orange plastic grass	L5	Brown scrub background	L8	1.78	Low
	Orange plastic grass	L5	Dark foliage background	L9	2.02	Low
	Brown 3D plastic twigs	L6	Green grass background	L7	8.14	Yes
	Brown 3D plastic twigs	L6	Brown scrub background	L8	2.53	Low
Top of jump	Brown 3D plastic twigs	L6	Dark foliage background	L9	2.02	Low

Table 2 below shows visibility data for brightness. Here, many values are comparatively small (less than or around 10.00) but with some values well beyond this, and most values should be visible to some degree. Most of the orange components of the jump have low to intermediate brightness contrast, except between the orange toe board and the green plastic grass and for the orange grass against the dark foliage background, where the contrast is high. Otherwise, the highest brightness contrast is of the white toe board against the green grass – here, contrast is considerably higher than for other comparisons.

Table 2. The visibility to horse vision of different jump components against foreground and background foliage focusing on brightness (luminance). The contrast between the brightness of the different coloured plastic toe boards and the dark green plastic grass of the fence (internal fence contrast) is also included.

	Section of fence		Foreground/Background		Mean Just Noticeable Difference (JND)	Visible difference?
Bottom of jump	White plastic toe board	L1	Dark green plastic grass	L1	55.55	Yes
	White plastic toe board	L1	Green grass foreground	L3	52.63	Yes
	Orange plastic toe board	L2	Dark green plastic grass	L1	23.01	Yes
	Orange plastic toe board	L2	Green grass foreground	L3	9.81	Yes
	Dark green plastic grass	L3	Green grass foreground	L1	10.01	Yes
	Dark green plastic grass	L3	Green grass background	L7	28.72	Yes
	Dark green plastic grass	L3	Brown scrub background	L8	22.47	Yes
	Dark green plastic grass	L3	Dark foliage background	L9	15.12	Yes
	Orange plastic grass	L5	Green grass foreground	L1	12.28	Yes
	Orange plastic grass	L5	Green grass background	L7	7.11	Yes
	Orange plastic grass	L5	Brown scrub background	L8	7.77	Yes
	Orange plastic grass	L5	Dark foliage background	L9	22.66	Yes
	Brown 3D plastic twigs	L6	Green grass background	L7	8.24	Yes
	Brown 3D plastic twigs	L6	Brown scrub background	L8	10.01	Yes
Top of jump	Brown 3D plastic twigs	L6	Dark foliage background	L9	11.94	Yes

Discussion and Recommendations

Horse vision differs from humans in a number of ways, including visual acuity and field of view around the body. However, one of the most notable differences concerns colour perception.

Humans are trichromatic and see different colours based on three cone types in the eye, sensitive to short, medium, and longer wavelengths of light (‘red’, ‘green’, and ‘blue’). Horses, however, have just two cone types used in colour vision, sensitive to short (428 nm peak) and medium wavelengths (539 nm peak), which equates to dichromatic colour vision. Horses can see the difference between colours that we see as blue and yellow, but they cannot discriminate between red, green, and yellow colours (unless they differ in brightness). The above analysis indicates that for colour some components of the jump, specifically the toe boards, can likely be seen by horses against green grass. However, the visibility is still quite low, and many components are likely to be indistinguishable to a horse against a range of background vegetation types. For brightness differences, the white toe board offers by far the highest contrast and is likely to be most visible. Some orange jump components are also likely to be visible against some background and other jump features, but to a lesser extent.

It should be emphasised that this is a provisional test. Further work could consider the effect of weather conditions (which can in particular affect brightness measurements), a wider range of samples and vegetation types, and perhaps most notably, more colour types. Given the properties of horse vision, it is likely that other colour types placed on a jump would offer greater visibility and detection to horse vision, and the optimal solution is likely to be a feature that offers both high colour and brightness contrast.

Please do let me know if you have further questions.

Yours Sincerely,

Martin Stevens