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DisplayMatch: Browser-Based Perceptual Colour Calibration for Consumer Displays

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Abstract

Visual content is reviewed on heterogeneous consumer displays whose uncalibrated colours cause inconsistent judgments, while hardware calibration remains confined to specialist workflows. We ask whether a simple browser-based perceptual procedure can give ordinary users useful colour corrections. We present DisplayMatch, a web application that, given a reference and target display, guides users through matching a grayscale ramp, neutral greys and a small set of colour patches, from which we derive per-display corrections for tone response, white point and chromatic balance. In a pilot study involving non-expert observers across projectors, monitors, and TVs, the inferred corrections exhibit consistent patterns within device types, with larger deviations observed for projectors, indicating that users can recover systematic differences between displays. This suggests that lightweight perceptual calibration in the browser can reduce cross-display colour differences without specialised hardware.

1 Introduction

Consumer displays vary widely in terms of colour gamut, white point, and tone response, so the same visual content can look noticeably different from one device to another. In collaborative workflows for photography, design and film, such colour inconsistencies can lead to miscommunication, rework and mistrust in what others see. Professional studios manage this with hardware-based calibration and device profiling, but the necessary instruments are expensive and rarely available to ordinary users.

Perceptual calibration offers a more accessible alternative. Observers view a calibrated reference display alongside a target display and adjust the target until corresponding colour patches appear identical. From these matches, one can estimate correction functions that bring the target closer to the reference, and two-display matching experiments have shown that such procedures can be reliable under controlled lab conditions [1]. However, these studies typically rely on specialised setups, leaving open the question of whether a short, browser-based workflow is usable for non-expert users on everyday hardware.

We therefore explore whether a simple web application can enable ordinary users to capture systematic colour differences between their devices. Our system, DisplayMatch, runs entirely in the browser and guides users through three phases of visual matching between a reference and a target display. The gamma phase adjusts tone response, the white-point phase neutralises greys, and the colour phase refines hues and saturation for a subset of patches. The final slider settings define per-display correction parameters that can be applied to images or analysed across device types.

In a pilot study, non-expert observers use DisplayMatch to calibrate several consumer displays, including monitors, a projector and a TV, allowing us to assess the consistency of inferred corrections within and across device types. Our findings suggest that even this lightweight procedure can recover meaningful structure in the space of consumer displays.

2 Related work

Foundational works in colour science, such as Colour Appearance Models [2], introduce metamers as colours that appear the same to a human observer but are not physically identical. Observer metamerism may result in an apparent colour match for some individuals but not others. To study and correct such effects, some calibration routines employ precise monochromatic light sources and carefully selected coloursensitive individuals, for example, Bodner et al. [3]. Other work, such as Sarkar et al. [4], defines colourimetric observer categories for industrial applications. In our work, we do not attempt detailed observer modelling. Instead, we assume typical observers and allow each participant to tune their own observer–display pair via a small set of perceptual matches, without explicit observer classification.

Work by Stone [5] provides a framework for colour-matching calibration of experimental projection displays by matching them to a reference monitor. Sony Corporation later formalised colour matching between OLED and CRT reference monitors, including the adoption of Judd-modified colour matching functions [6]. A framework for using gamma curves and sRGB values to set perceptual calibrations is presented in Mantiuk [7]. Long and Fairchild discuss how the spectral range of different display technologies affects observer metamerism in wide-gamut multiprimary systems [8].

The specification of individual colourimetric observer functions is studied by Asano, Fairchild and Blondé [9], where physiological metrics such as age, cone density and macular pigment concentration are used to model variation between observers. These models characterise plausible variability in human colour matching but require detailed measurements. Our study treats observers as typical and focuses on device-level differences, as captured by our browser-based matching procedure. The X-Rite ColorChecker documentation provides a standard set of colour patches that we use as calibration stimuli [10].

3 Method

DisplayMatch is implemented as a browser-based two-display calibration tool, allowing the same code to run on laptops, phones, projectors, and TVs. We assume the browser's standard

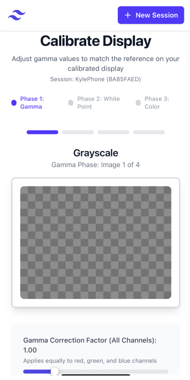

Figure 1: Calibration interface on the slider-controlled device.

SDR pipeline and specify all test patches in sRGB. Two browser clients join a shared session: one on a reference display and one on the device being calibrated. Both show the same patch, but only the calibrated display exposes sliders. Observers adjust these until the two patches appear identical, yielding a set of perceptual matches between devices.

The calibration is performed in four phases chosen to separate tone response, white point and chromatic errors:

1. **Grayscale gamma calibration.** A single gamma slider is adjusted until a mid-grey patch matches between displays, aligning overall brightness and contrast before any colour-specific corrections.
2. **Per-channel gamma calibration.** Three sliders $\gamma_R, \gamma_G, \gamma_B$ are then tuned on pure red, green and blue patches to refine channel-dependent brightness differences.
3. **White-point correction.** With gamma fixed, RGB gain sliders acting on neutral grey patches are adjusted until the greys appear neutral. This applies simple per-channel multipliers to remove global colour casts and match white points in RGB space.
4. **Colour palette tuning.** Finally, we

present the patches from the X-Rite ColorChecker chart [10], a standard target covering foliage, saturated primaries and neutrals. For each patch, observers adjust hue, saturation and value (HSV) sliders, chosen because they separate hue from intensity.

For each calibration run, we record the final gamma exponents, RGB gains and per-patch HSV offsets as per-display parameters. In our analysis, we average these parameters across observers for each display. The web tool can then apply the resulting mean corrections to arbitrary images by cascading the three stages to visualise how the calibrated device would render corrected content. In the user study described in the next Section, four non-expert observers follow this four-phase procedure once for each of the consumer displays we evaluate. This app can be accessed at **https://display-match.vercel.app/**. Demo images are included in the appendix.

4 Evaluation

The full calibration routine was completed by four non-expert observers on four displays: two Dell 27 Inch Plus monitors in Founders Room 9 and 10 [11], an Epson projector with an ELPLP88 lamp [12], and a Dell C5519Q TV in a basement meeting room [13]. For all runs we used the same Mac Retina notebook display at full brightness as the reference screen, kept room lighting fixed for each room, and disabled dynamic picture adjustments on the calibration devices.

We first analyse the gamma parameters inferred from the grayscale and RGB phases (Figure 2). The projector requires substantially larger gamma adjustments, especially in the red channel, and shows the greatest spread across observers, consistent with the less stable tone response of lamp-based projection systems [5]. By contrast, the two desktop monitors cluster tightly around $\gamma \approx 1$ for all channels, while the TV lies between these extremes with moderate blue-channel corrections.

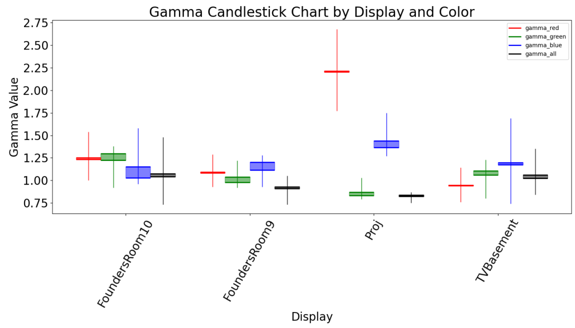

Figure 2: Gamma distributions across observers and displays.

White-point gains show a similar pattern (Figure 3). The projector needs noticeably stronger red and blue gain corrections than the monitors and TV, indicating a cooler native white that observers compensate towards the reference. Both Dell 27 Inch monitors require only small, consistent changes near unity, whereas the C5519Q TV, used in a dark environment with a vivid preset, shows slightly elevated gains across channels.

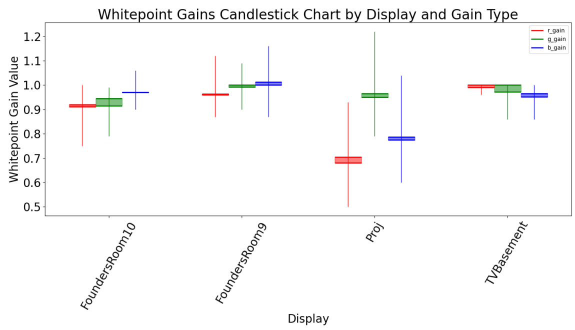

Figure 3: White-point gain distributions for each display.

The HSV adjustments, applied after gamma and white-point correction, exhibit the largest variability across observers (Figures 4 and 5). Different users adopt different matching strategies with the hue, saturation and value sliders, and some colours, such as foliage green, show systematic hue shifts whose direction differs between projector and TV, consistent with reports that projectors and multiprimary systems can have different green spectral coverage [8]. Overall, the HSV plots highlight which colours are hardest to align perceptually on each device.

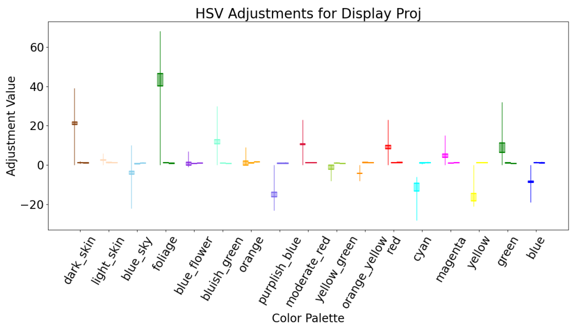

Figure 4: HSV adjustments for the projector across ColorChecker patches.

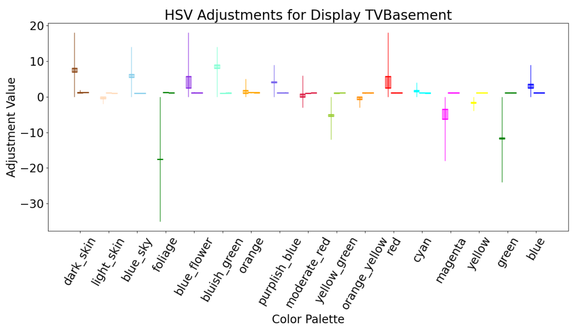

Figure 5: HSV adjustments for the basement TV across ColorChecker patches.

Finally, we plot the average projector corrections on a CIE chromaticity diagram (Figure 6) to visualise the transformation in gamut: the corrected ColorChecker patch chromaticities move from a compressed subset of the sRGB locus towards the corresponding reference positions, indicating that our simple procedure compensates part of the projector's gamut compression.

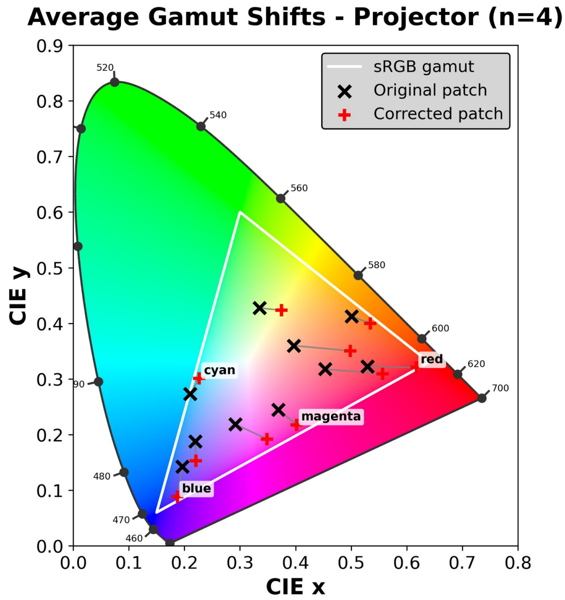

Figure 6: Average projector gamut shift before and after applying the inferred corrections.

5 Conclusions

We cannot expect a general browser-based procedure to match the accuracy of dedicated calibration hardware, but our results indicate that, given a reasonably configured reference display, a simple slider-driven matching workflow can expose useful per-display correction parameters for projectors, monitors and TVs at essentially no additional equipment cost, and thereby improve cross-display consistency in everyday settings.

Future work should extend this study to more observers and devices, compare the inferred parameters directly against hardware-based calibration, and investigate how repeated HSV adjustments could be aggregated into personalised or group-specific calibrations for shared hardware, for example, in families or small offices, and whether such calibrations improve agreement in real collaborative image and video review tasks.

References

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List of Figures

6 Appendix

We have also plotted various colour gamuts for other experiments. Here is the average of all users' colour gamut representation for the basement TV. You can clearly see in comparison to the projector, fewer corrections are necessary:

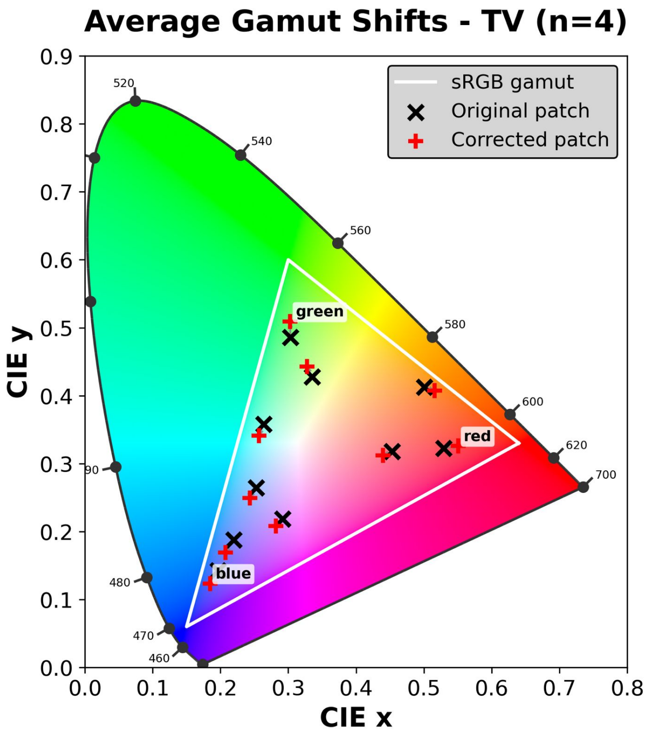

Figure 7: Average TV Gamut Shift

Here is another user's gamut shift, averaged across all hardware. This is primarily useful if multiple runs of the calibration are done in a consistent set up.

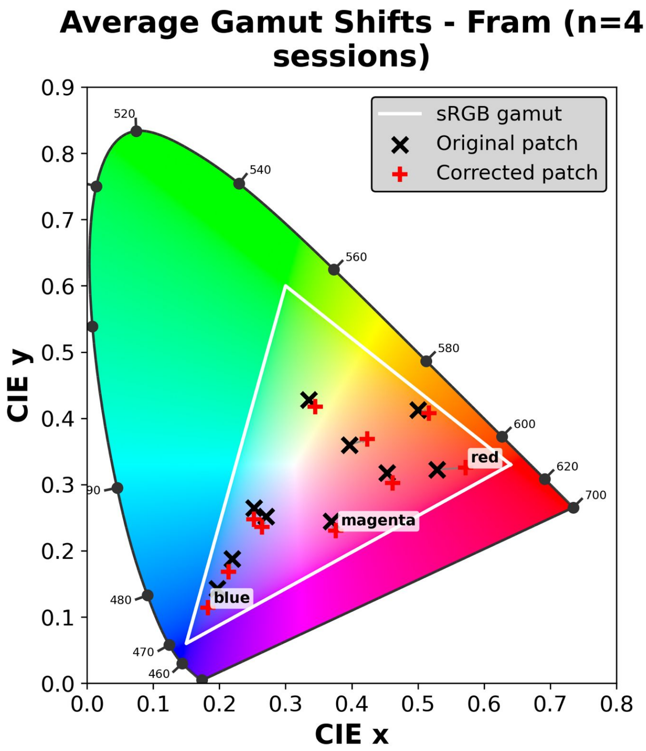

Figure 8: Single User's Projector Gamut Shift

We designed our calibration methodology for a range of environmental luminances. For example, projectors generally see poor performance in daylight environments [5], but we left the lights on in the projector setup and were able to achieve near metamerism. We have photos of the capture environment here:

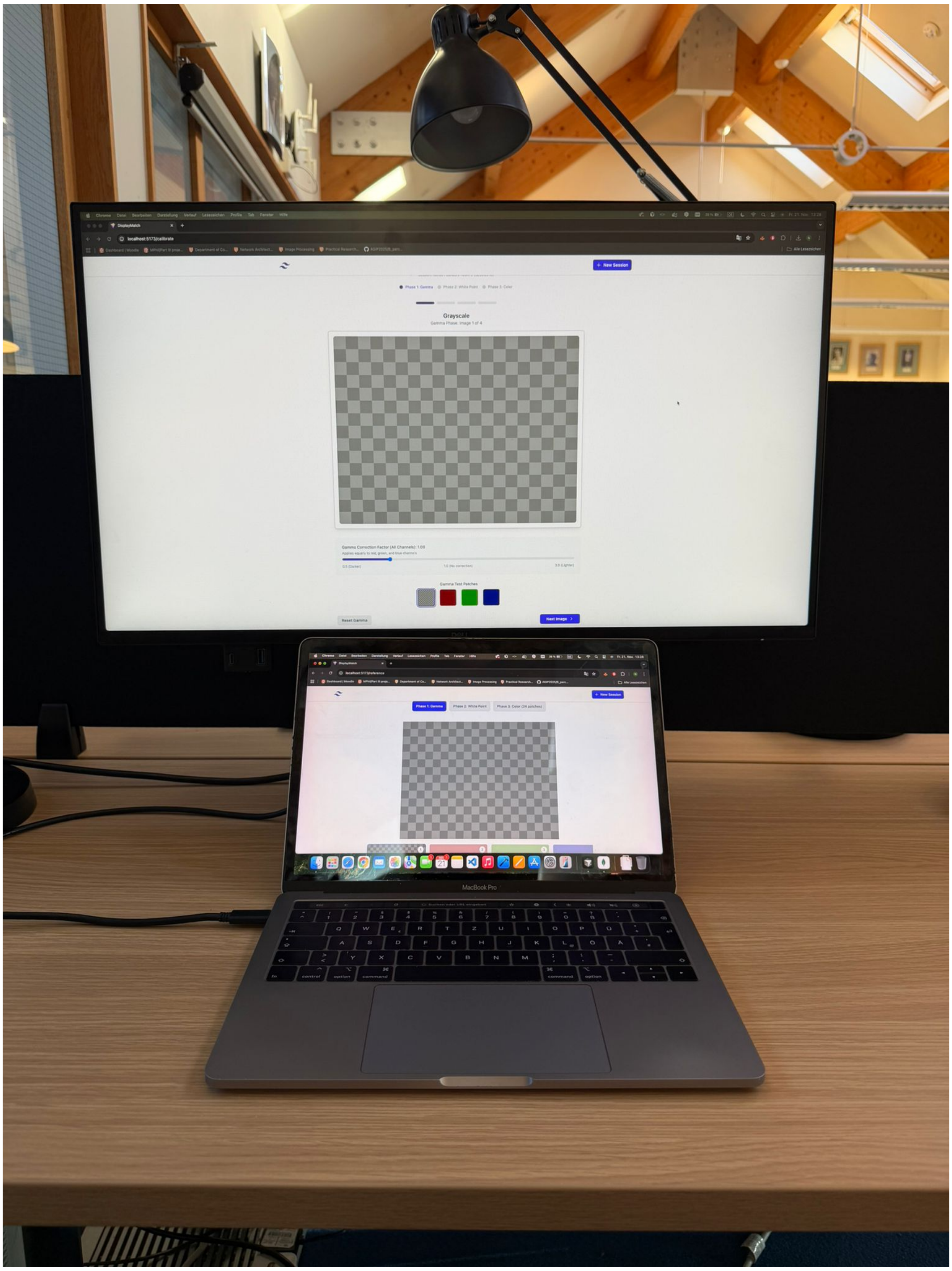

Figure 9: Founders Room 9 and 10

This projector setup was in a darkened room, and all users proceeded to perform their calibration on the monitor.

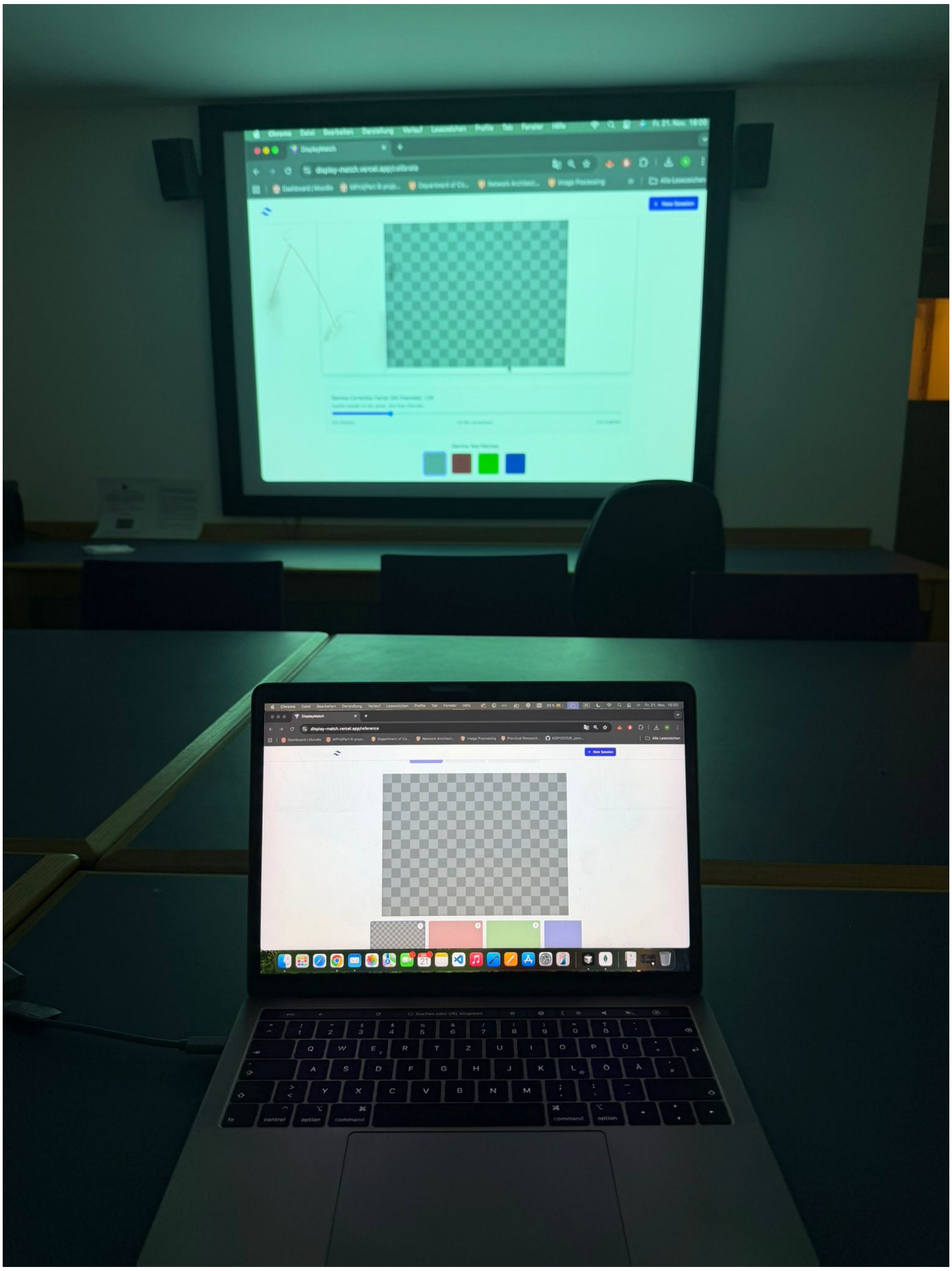

Figure 10: Projector

Similarly, the TV was in a darkened room.

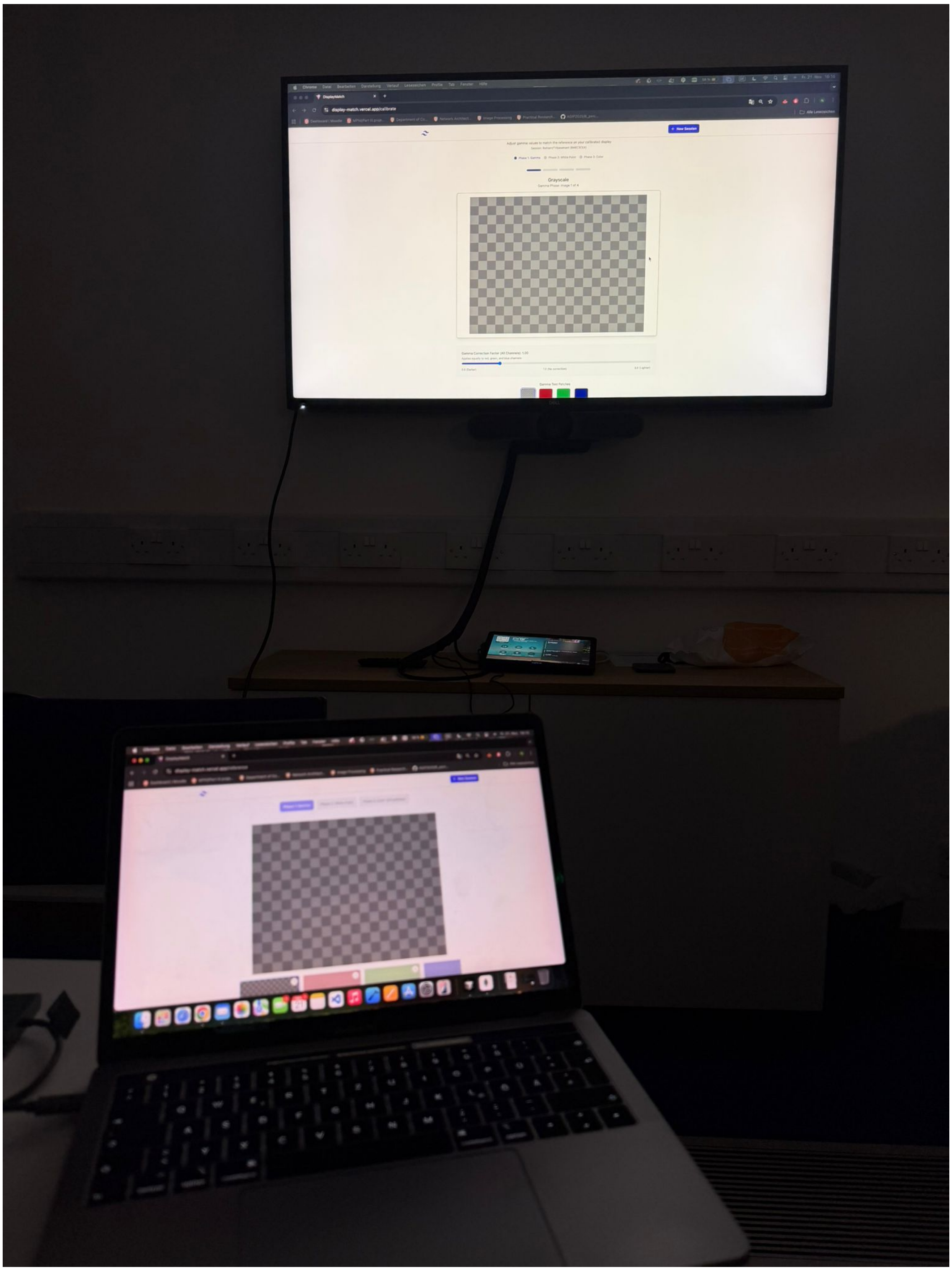

Figure 11: Basement TV

We also provide a few images of the calibration website. This is the home page, one can select the render, calibration, or target.

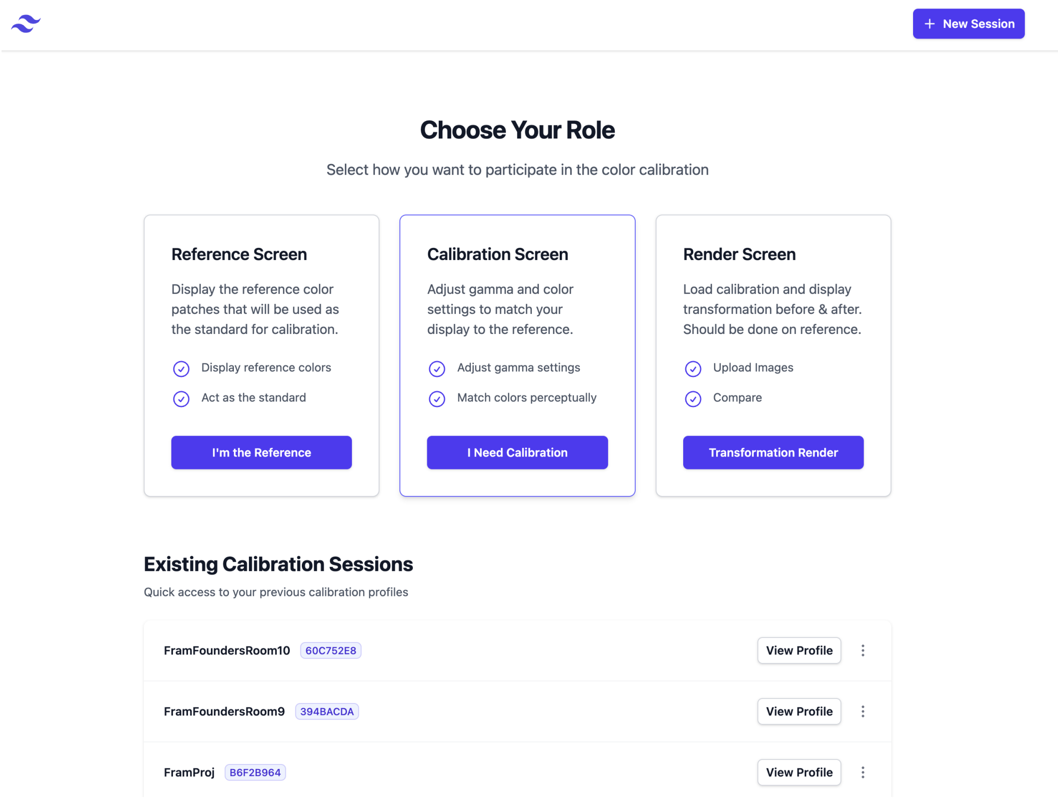

Figure 12: Home Screen

Here is the reference screen, the user selects a session which may sync with calibration.

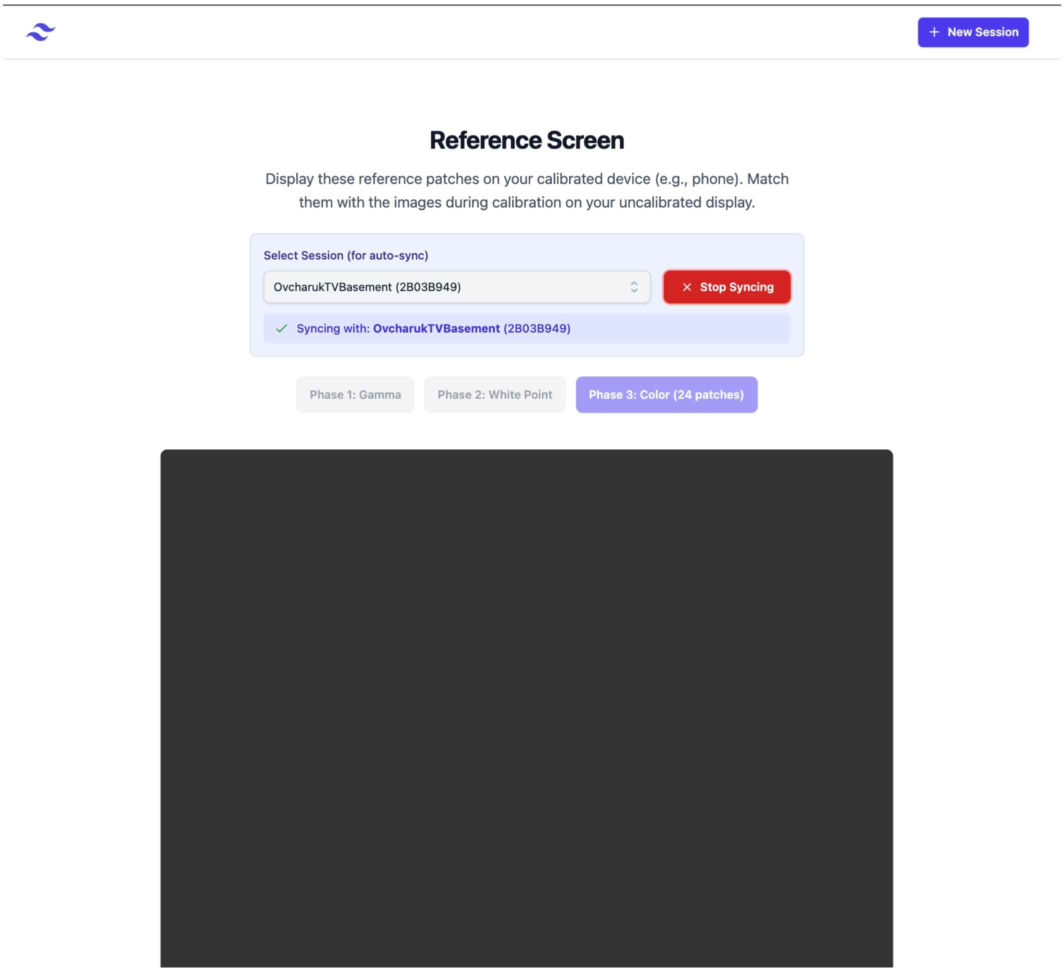

Figure 13: Reference Screen

The calibration screens have sliders for each relevant value. Once the screen matches, we proceed to the next image.

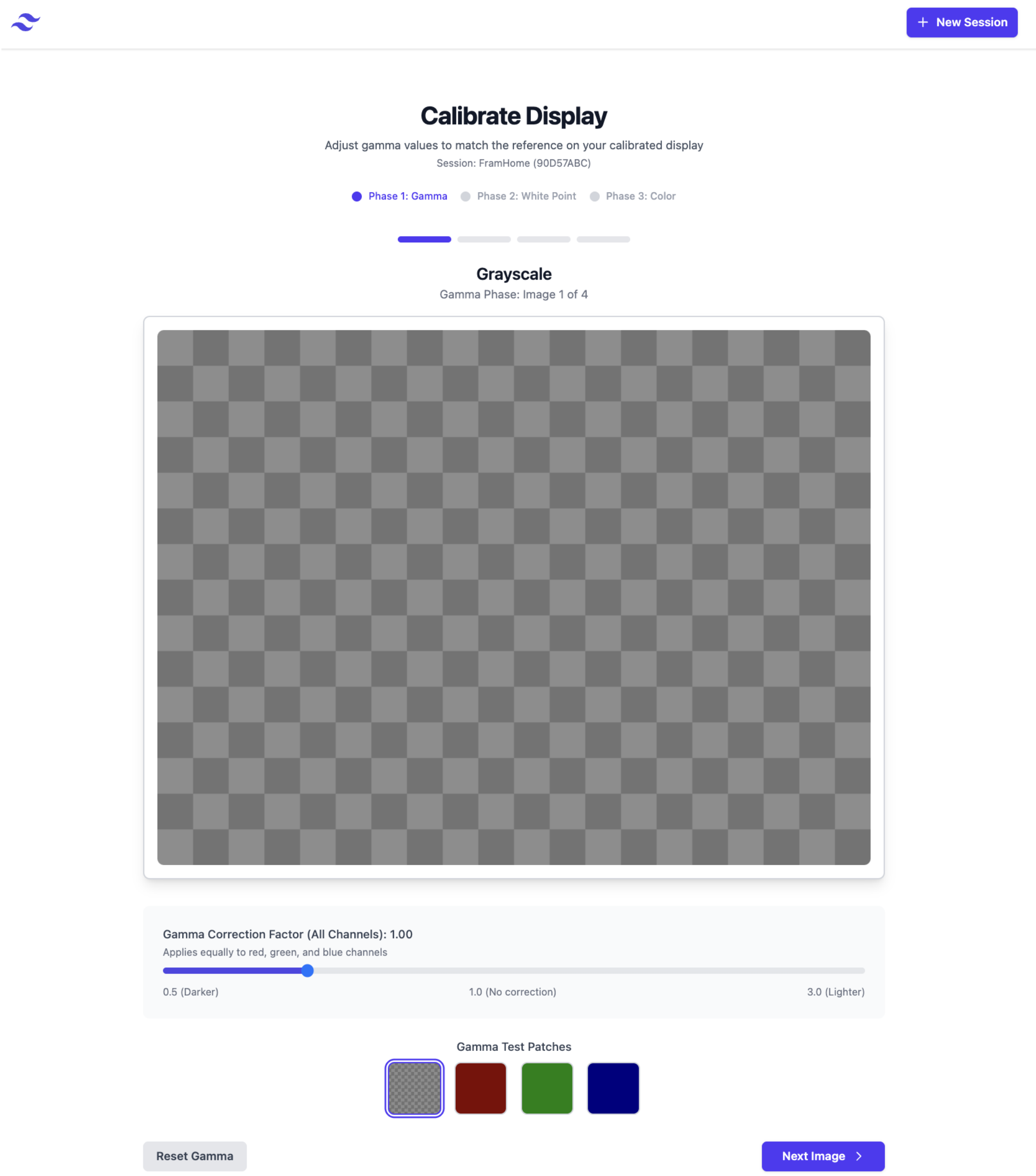

Figure 14: Gamma Calibration Screen

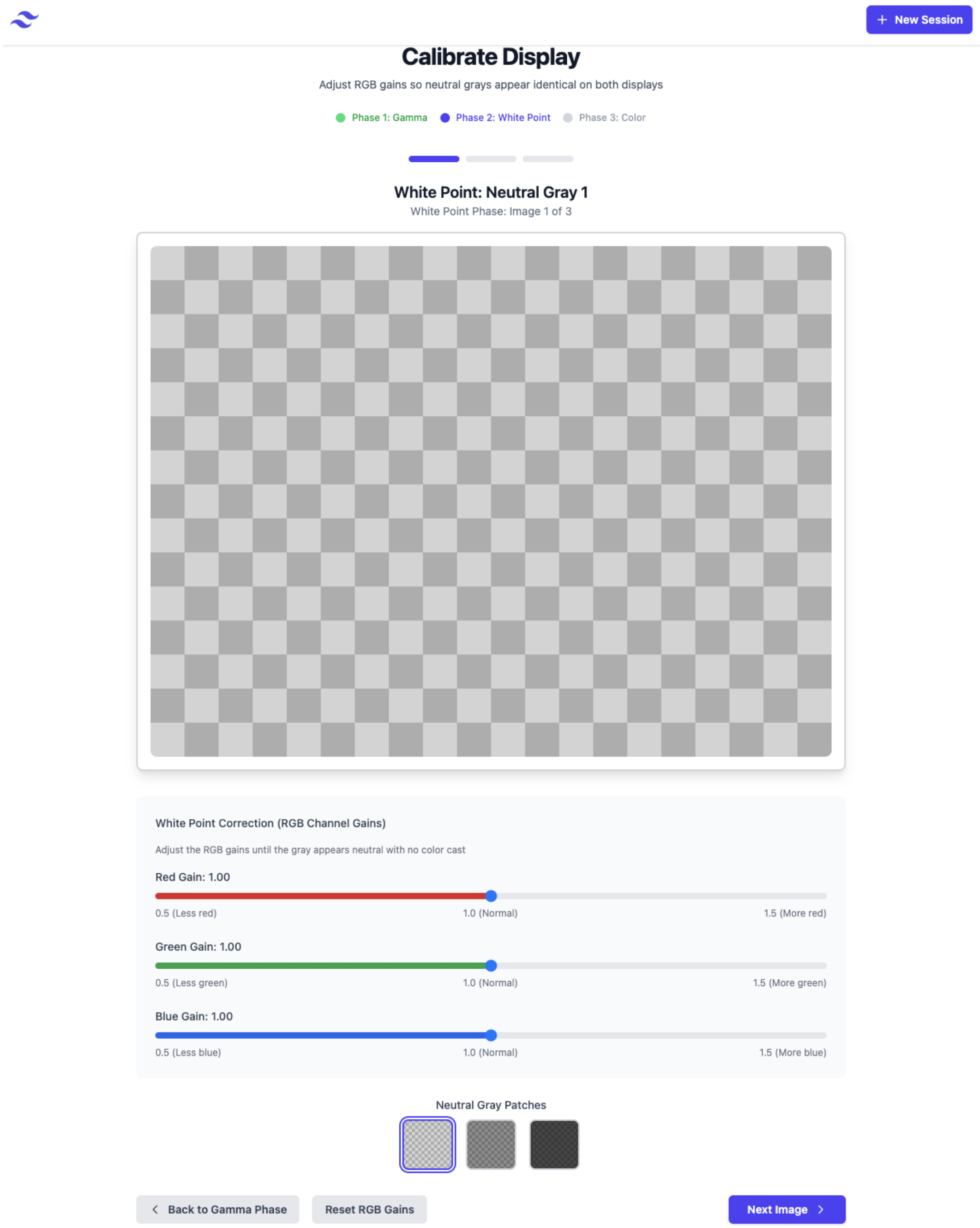

Figure 15: Whitepoint Calibration Screen

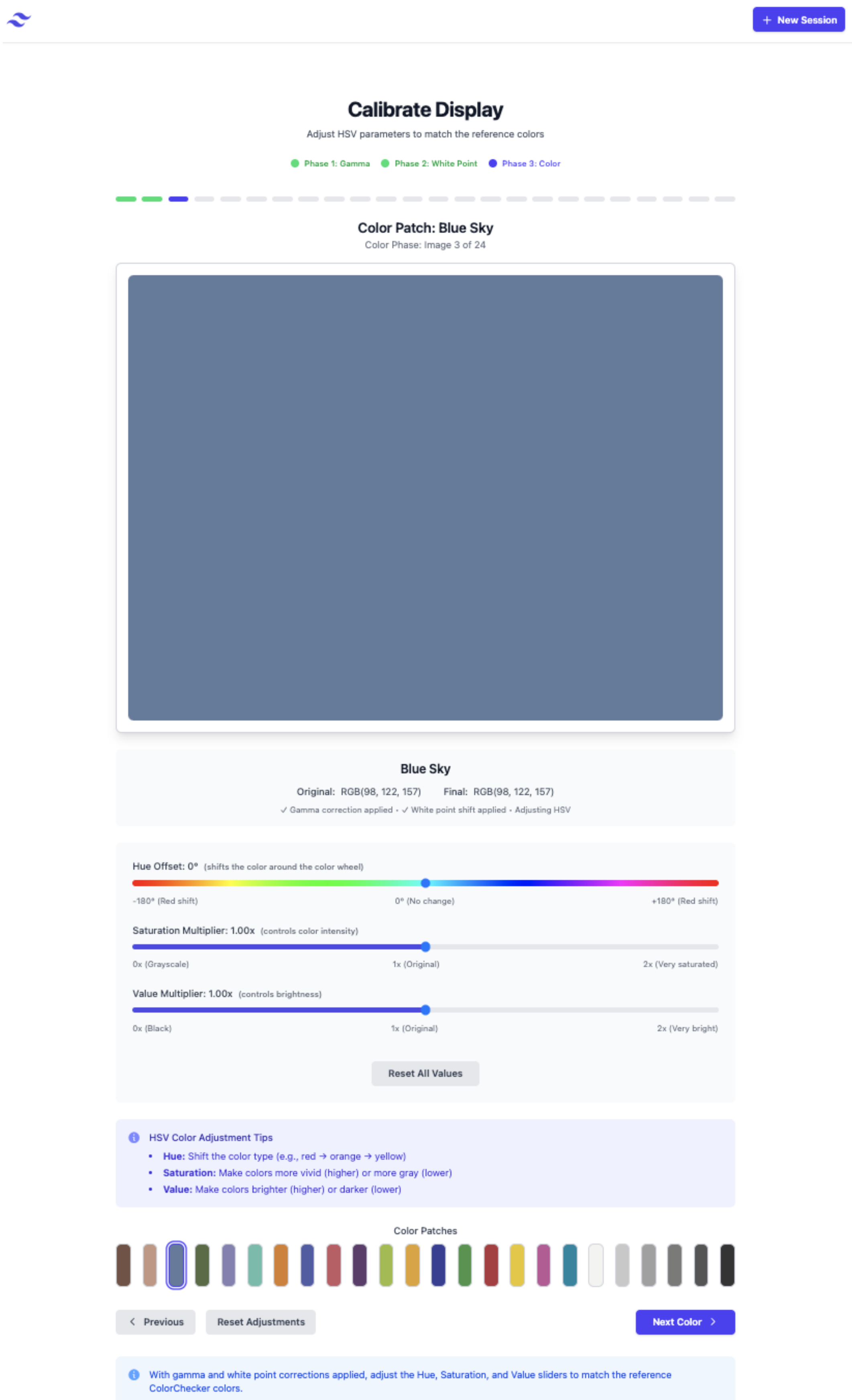

Figure 16: Colour Calibration Screen

This render screen shows the effect of the calibration on any uploaded image.

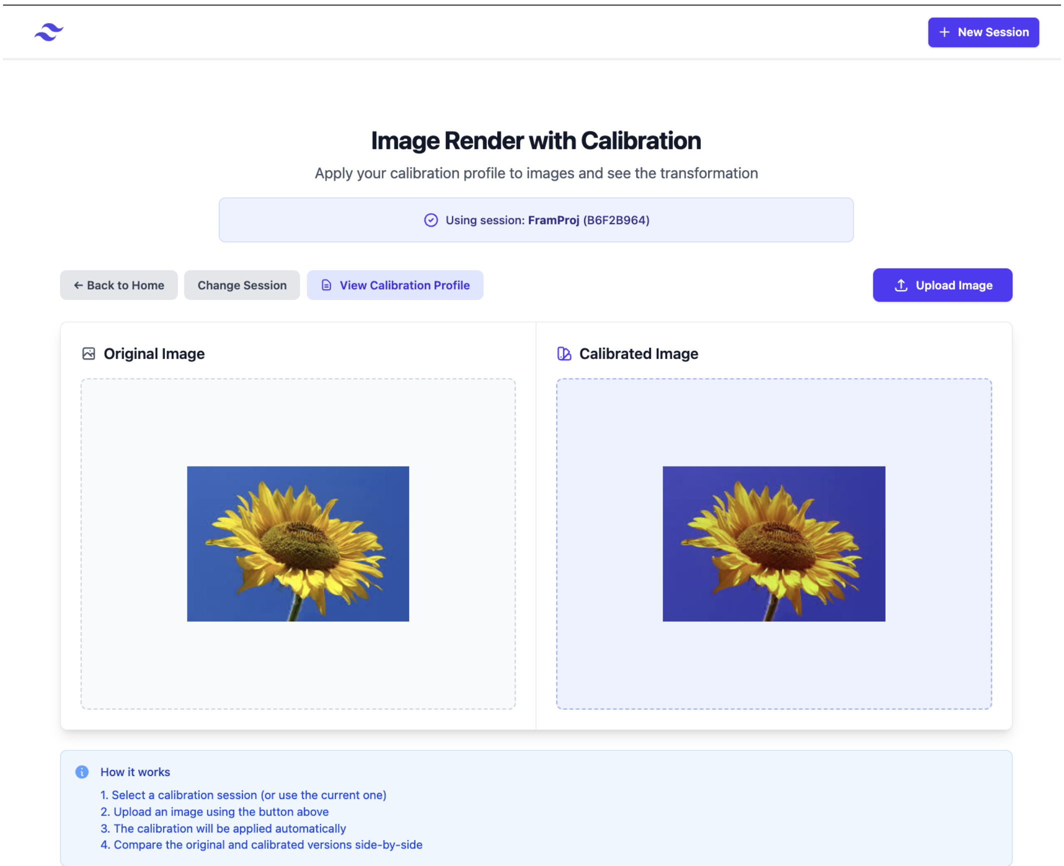

Figure 17: Render Screen

The calibration profile screen, as shown in the screenshot below, provides a summary of all calibration values entered by the user. It has the possibility to export the data as JSON for further usage.

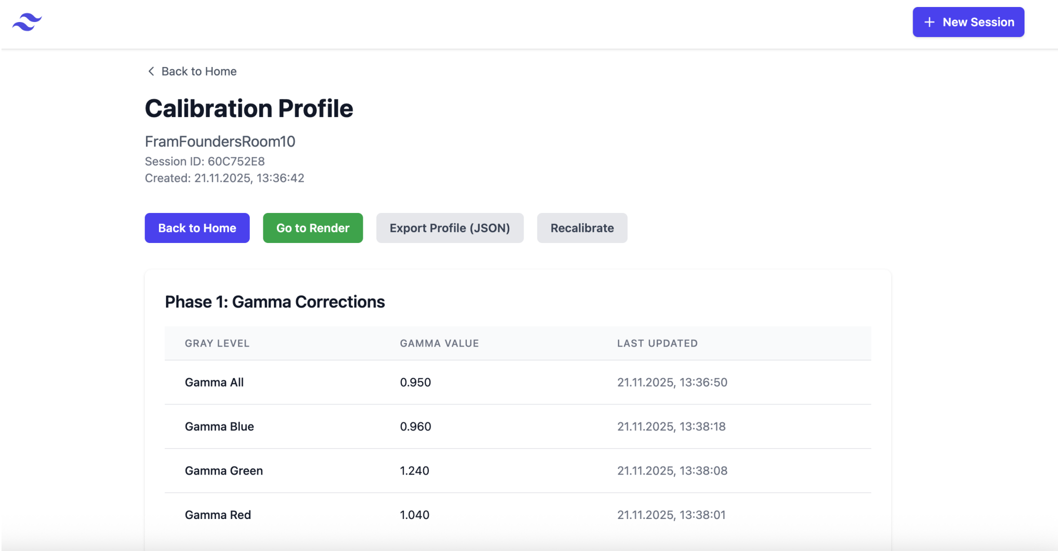

Figure 18: Calibration Profile Screen