DEVELOPMENT OF A COLOR PALETTE DESIGNED TO IMPROVE USABILITY FOR INDIVIDUALS WITH COLOR-VISION DEFICIENCIES

Nelda J. Milburn, Ph.d., David L. Post*, Ph.D., and Kevin Gildea, Ph. D.

Federal Aviation Administration: Civil Aerospace Medical Institute

INTRODUCTION

Colors used to code information on air traffic control (ATC) displays must be legible, discriminable from one another, and recognizable. Designing a color palette that meets these criteria is especially challenging when the users include people with color-vision deficiencies (CVDs), as is the case for some controllers in the US.

PURPOSE

Develop a candidate color-coding palette, suitable for normal color normal (CN) and CVD ATC controllers, for testing in a subsequent formal experiment. The palette must contain foreground colors for coding symbols and alphanumerics, plus background colors for coding weather severity.

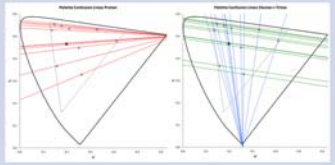
PHASE 1 METHOD

In Phase 1, 3 groups consisting of one CN, protan, deutan, and tritan examined an LCD showing 25 foreground-color swatches and matching character strings, initially. The participants provided verbal feedback. The original luminances and chromaticity coordinates matched ones Derefeldt and Swartling (1995) found that CNs recognized reliably.

The background colors consisted of black plus six others, ranging from a desaturated green to a desaturated red. They all had low luminances, chosen to provide adequate legibility for the foreground character strings.

All colors were calibrated to colorimetric tolerances of +/- 2.5% in luminance and 0.0025 on the CIE 1976 u'v'-chromaticity diagram, using a recently calibrated Photo Research PR-740 spectroradiometer and custom software.

Palette designer output



PHASE 1 RESULTS

Over the course of testing four groups, the experimenter adjusted some colors and eliminated others, based on the participants' feedback. We ended with a set of 11 foreground and 4 weather/background colors, which the participants deemed legible, discriminable, and recognizable in all foreground/background color combinations.

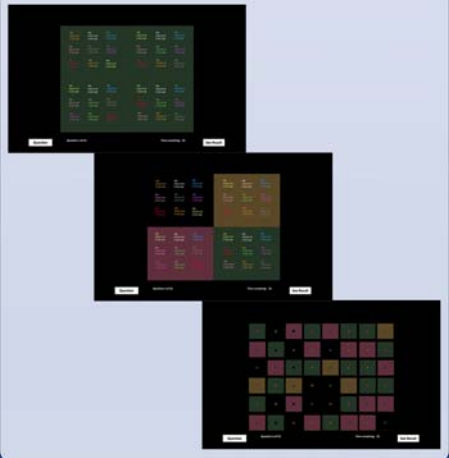
PHASE 2 METHOD

In Phase 2, legibility was tested with a search for a target three-character string among 48 three-character distractor strings. Discriminability and recognizability were tested with a search for strings having a target foreground color among an array of distractor strings having different foreground colors. All possible foreground/background color combinations were tested in both cases.

We tested the discriminability and recognizability of the seven background colors with a search for small solid squares in a specific target color among distractors having the other six background colors. Each small square was centered in a larger one having a different background color. The small squares' size equaled the smallest used to represent weather severity on contemporary ATC displays. Again, all possible foreground/background color combinations were tested.

PHASE 2 RESULTS

Results to date show that legibility for all foreground/background combinations is good, but some foreground and some background colors are confusable.



CONCLUSIONS

We have studied the colors' confusion lines and calculated color differences for CNs and adjusted the palette accordingly. We have also reduced the number of background colors to black plus a dark green, dark mustard, and dark pink. We will continue Phase 2 and perhaps make further improvements to the palette before proceeding to the formal experiment.

APPLICATION

The palette that results from this project will appear in a new FAA color standard for ATC displays (FAA HF-STD-010 ATC Display Color Standard). The palette provides the opportunity to accommodate color deficient controllers in the workforce. It may also be useful for other applications that have CVD users.

REFERENCES

Derefeldt, G., & Swartling, T. (1995). Colour concept retrieval by free colour naming. Identification of up to 30 colours without training. Displays, 16, 69-77.

ACKNOWLEDGMENT

Research reported in this presentation was conducted under the Flight Deck Program Directive / Level of Effort Agreement between the FAA NextGen Human Factors Research and Engineering Division (ANG-C1) and the Aerospace Human Factors Division (AAM-500) of the Civil Aerospace Medical Institute sponsored by the Office of Aerospace Medicine and supported through the FAA NextGen Human Factors Division.

*David L. Post: Wright State University

DISCLAIMER OF ENDORSEMENT

Reference herein to any specific commercial products, process, or service by trade name, trademark, manufacturer, or otherwise, does not constitute or imply its endorsement, recommendation, or favoring by the United States Government or the Federal Aviation Administration. The views and opinions of authors expressed herein do not state or reflect those of the United States Government or the Federal Aviation Administration, and shall not be used for advertising or product endorsement purposes.