August 25, 1975

Mr. Rolf G. Kuehni
Verona Dyestuff Division
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Dear Mr. Kuehni: <u>Replying to your letter of August 19</u>

1. I believe we shall not have any really superior formula for measuring
small color differences until we have a superior uniform color space, and
know how to handle the weighting of the various visual attributes for differ-
ing situations, the effects of contrast and illumination, and any other
factors that affect the discrimination of small color differences. The stand-
ard by which I would judge the success of a formula is its degree of correla-
tion, over the entire range of color space, with the average of visual observa-
tions made (in sufficient numbers and by a sufficient number of color-normal
observers) on the same samples, under similar conditions of illumination and
viewing.

This approach is indicated in the 1944 Nickerson-Stultz paper by results in
Tables IV and VIII. The correlation of visual observations in terms of H/V/C
measurements (P^2) averaged 57. Compare this to $R^2 = 0.57$ for the average of
the 7 formulas applied to measurements of the same samples. Visual and instru-
mental results are about equally good - or poor - depending upon one's point
of view. In Table VIII, if you will compare results of the Munsell type form-
ulas with the Judd and Adams type, you will find that the Munsell type has a
consistent edge over the others. None are as good as we might wish, but at
least they provide results about as good as those based on visual performance!
So I left it, feeling that no substantial improvement would come until we know
a lot more about color space and color vision that we can apply to this work.
I have seen results of no work since then that has led me to change this view.
(The Japanese are the only ones I know of that include the original Munsell
type formulas in their small-difference studies.)

2. At the time the "Adams Chromatic-Value" formula was proposed it provided
the best approximation to the scaling of Munsell that I found for direct use of
CIE data. As the 1944 paper showed, this Adams space seemed to provide results
that gave a reasonable approximation to those based on the H/V/C formula.
Other workers came along and substituted a cube root formula for Munsell value -
because it was easier to handle on early computers - and the formula became
L,a,b, similar to the type proposed by Hunter,Judd and Scofield. Then came
adjustments to L*a*b*. All the time these formulas get farther and farther
away from a formula based on a suitable weighting of H/V/C differences.

3. I agree with you that improvement is desirable. But my belief is that it
will be many years before the required research will be done that will make
possible any significantly important improvement in a general formula. Perhaps
acceptance of the proposed formulas, which many of us clearly recognize as in-
adequate, will hasten the day when the needed research will be done - perhaps
by someone who sets out to prove those inadequacies!

                                   Yours very sincerely,

                                   Dorothy Nickerson

cc D.L.MacAdam