MISS DOROTHY NICKERSON
2039 NEW HAMPSHIRE AVENUE N. W.
WASHINGTON, D. C. 20009

July 7, 1975

Mr. Rolf Kuehni
Verona Div. of Baychem Corp.
P.O.Box 385
Union, N.J. 07083   Re: Small color difference formulas

Dear Mr. Kuehni:

This will refer to previous correspondence - a letter to you of November 30, 1973, my letter of February 10, 1975 to Dave MacAdam, and our brief conversation in New York concerning color-difference work prior to 1952 - and enclose a copy of my letter of today to Dave MacAdam as chairman of the USNC-CIE TC 1.3 committee which must be ready to report in London to the CIE committee of the same number.

In New York we spoke of work prior to 1952 which seems quite overlooked today, and you suggested that I might prepare a bibliography of such material. At the time I had forgotten that I had done just that back in 1952 in preparation for publication of the E-12, ASTM Symposium on Color Difference Specification. I enclose a copy, as part of Xerox copies of three papers prior to 1952 that I consider important early reports of which you may not already have copies. They include copies of Balinkin's 1941 paper which I think was the first ISCC paper that called attention to the many facets of this work, copies of the title pages of the 1944 ISCC symposium and the ASTM E-12 symposium of 1952, with full copies of my own papers on these programs. I think you may find the Judd discussion of my paper, p. 11 of the 1944 symposium, of interest; it may explain something of the reasoning that both he and I had regarding the usefulness of the Munsell parameters over those of other systems that might seem easier to handle because they could more easily be related to CIE standards.

In addition to this material I enclose copies of a list of my own papers that relate to color-difference work, and a list of ISCC symposia held 1939 to 1952 in which the subject was discussed.

You will find my present-day thinking on the subject set forth in my letter of today to Dr. MacAdam.

I hope this material may be useful to you in your own current work on this subject, and in connection with both the CIE and ISCC committee work.

Yours very sincerely,

Dorothy Nickerson

Encls.

February 10, 1975

Dr. David L. MacAdam
Kodak Research Laboratories
Rochester, N.Y. 14650

Dear Dave:

This will acknowledge receipt of your letter of January 7 to members of CIE 13. [USNC-]
Many other matters have kept me from answering you before this.

It has been many years since I have done any intensive work on color-difference specification, so many of the points raised in Mr. Kuehni's report I shall have to leave to others to study and reply. However, there are a few comments and observations that I wish to make.

In the first place, I still believe that analysis in terms of three perceptual scales is necessary for any good measure of color difference. The footnote on page 514 of my 1936 Textile Research J. paper still holds - "the layman, or commercial or industrial man, always asks for results in a single figure ...but by the time he can have it, a total/single figure for color change .... he will probably know enough more about color to realize that for most problems he needs to know the hue/value/chroma differences that make up this total...." (On this last point I may be expecting too much even today!)

Second, in my 1936 papers (1936 ASTM Standards paper, as well as the 1936 paper in Textile Research) the difference between acceptability and perceptibility data determined under similar conditions was clearly faced, for the H/V/C differences for 19 pairs of samples accepted as a match averaged 1.5/0.18/0.4 when cotton was involved, but 0.7/0.09/0.2 for 22 pair of wool samples, the acceptability being twice as large for cotton samples as for wool. These were based on samples measured by R.D.Nutting (Textile Research 1935).

Another comment: My first color difference formula 1935-36 (Index of Fading, so-called, but actually a color-difference formula) was based on adding together the H/V/C differences for any small-difference pair of samples. But after CIE data came into more use, and before easy computer conversions to Munsell were available, I found that Munsell computations took too long for most people - they wanted a color difference unit directly convertible from CIE. So when I found that by using the "Chromatic Value" concept proposed by E.Q.Adams I could get a reasonably good plot of Munsell spacing, with chromas staying fairly constant for high to low values, I suggested its use. The chromatic value concept, as proposed by Dr. Adams in his 1942 JOSA paper, is based on the Adams theory of color vision. He states, p. 171 of his paper, that the (V_x-V_y) and (V_z-V_y) subtractions of his chromatic value concept "are the mathematical representation of the inhibitory nerve connections (synapses) in the retina, postulated on the author's theory of color vision (Psych.Rev. 36, 56-76,1923, especially Fig. 1, p.59)." The next few paragraphs of his paper go on to explain how this "chromatic value" concept fits his theory, with Figure 6 of his paper illustrating the I.C.I. colorimetric magnitudes as related to nerve elements postulated in the Adams theory. I think it is about time that workers in this field go back to the literature preceding 1952!

Many changes have been introduced into the color-difference formula that I first used and called "Chromatic Value," but essentially the ANLAB, and the present CIE L*A*B* formulas are based on the Adams theory of color vision. I wish more people would go back and study his 1942 and 1923 papers. He was a remarkable man in the color field - this is only one of his many basic contributions. (He - along with Judd - should have been among the first to receive the Godlove Award!)

About the size of units: I quote from my 1936 ASTM paper: ...."it would be convenient to have it arranged so that one unit would represent the amount of fading which the AATC&C and the ASTM decide to call "just barely faded." "Subcommittee 7 in a report dated July 12, 1934 has suggested 1/3rd chroma step in the definition of the term 'Fast to Washing' as applied to silk and rayon piece goods." This was the reason that I made the unit in that 1936 formula equal to 1/3rd of a Munsell chroma step.

Judd's definition for his unit - described in his 1939 Textile Research paper - was: ..."the size of the unit of color difference ....a unit color difference of such size that smaller differences can be neglected in the average commercial transaction involving a color match but larger differences cannot." (Based on observations of fairly large samples - say 10 cm^2 at a distance of 25cm - tentative.)

In the Nickerson-Stultz 1944 JOSA paper, 10 observers and 7 formulas were used in calculating differences that involved 187 chromatic samples for which detailed data are provided. Table VII of that paper proved a factor for each of the 7 formulas used by which the units of each could be adjusted to a common level for comparison of average results. My 1935/36 formula based on Munsell required a factor of 1.164, Judd's formula required 0.907; the Hunter-Scofield revision of Judd's formula required 1.104; the formula based on Adams Chromatic Value required 41.854. This is where the 42 or 40 - or even 41.8 - multiplying numbers came from that were later used in various forms of the Chromatic Value formula. Dr. Godlove published a lot on this.   My feeling was that 40 was sufficiently close to provide a number about on a par with the average results of either Judd's formula, or my 1936 "Index of Fading" that was based on Munsell.

I hope the foregoing comments may be useful to those who are today making studies in the field of color-difference specification.   There was quite as much work on this subject in the 1930s and 40s - witness the several symposia sponsored by the ISCC and its member bodies - in 1939 with APA on Color Tolerances, in 1940 with TAPPI and IES, in 1941 with ASTM, in 1944 on Small Color Differences with AATC&C and FPVPC. These 1944 papers were published in the American Dyestuff Reporter, with bound reprints supplied to all ISCC members.

Until we know more about uniform color spacing I do not believe we shall have any completely successful formula for assessing color differences. That should not deter us from adopting a formula that can be useful, one that can be applied in an efficient manner.

Yours very sincerely,

Dorothy Nickerson

cc RKuehni
   GWyszecki