Kimberly A. Jameson

Assistant Professor

Department of Psychology

University of California, San Diego

9500 Gilman Drive

La Jolla, CA 92093-0109

kjameson@ucsd.edu

What Saunders and van Brakel chose to ignore in Color and Cognition Research.

ABSTRACT:

Saunders and van Brakel set out to review color science research and to topple the belief that color-vision neurophysiology sets strong deterministic constraints on the cognitive processing of color. Although their skeptism and mission are worthwhile, they fail to give proper treatment to (1.) findings that dramatically support some positions they aim to tear down, (2.) existing research which anticipates criticisms presented in their target article, and (3.) the progress made in the area towards understanding the phenomenon. At the very minimum these oversights weaken the credibility of their arguments and leave the reader to wonder why their discussion ignores what is clearly omitted.

Saunders and van Brakel (hereafter S&vB) are perplexed that there is no simple linkage between color vision neurophysiology and color sensation, and they propose the literature unjustly puts forth a simple explanation of that linkage. The view they present is unbalanced, often citing work superceeded by later research, and using extreme claims from the literature. While they correctly deem incomplete the present understanding of color neurophysiology as it relates to color sensations, they mistakenly imply that the enterprise has made no progress. Below I focus on some issues S&vB chose to overlook to demonstrate how their analysis is wrong.

S&vB Ignore Color-Appearance Similarity Judgments:

There is a body of similarity scaling research, ignored by S&vB, indicating that Hue, Saturation, and Brightness (hereafter H,S&B) are real psychological constructs. The work suggests that the polar structure of dimensions H,S&B has psychological reality in color-appearance similarity judgments. H,S&B account for much of the variance found in judgments of similarities among visible color space appearances, implying that these are psychologically "natural", cognitively relevant, dimensions. This is typically found even when no similarity criteria are explicitly suggested by an experimenter. These data from color-appearance similarity judgments also conform systematically to the relational structure of H,S&B.

Research by Indow and colleagues (cited in Indow, 1988) shows that while there are no logical reasons that colors be embedded in a metric space according to their mutual relationships, similarities of surface colors (Munsell colors) can nevertheless be embedded in a 3-D manifold with locally Euclidean metric. These Multidimensional Scaling (MDS) results suggest that individual subjects exhibit a "sweet spot"embedded in the 3-D solid of their similarity judgment scaling (Indow, 1983 and personal communication). That is, for colors in a hollow cylindricalsolid region (corresponding approximately to Munsell Value 3-8 and Chroma 4-6) similarity judgments for stimuli are highly consistent resulting in a very uniform metric, whereas judgments for stimuli on the extremum of the dimensions tend to be less regular and yield a weaker metric. While the observed cognitive metric is not uniform over the entire visible color-space, this core region of high regularity suggests an appropriateness of the dimensional constructs H,S&B

Moreover, Indow and colleagues' (1991,1992) assessment of discrimination thresholds for surface vs. aperture color appearances found remarkably similar ellipsoid tolerances for the two stimulus formats, similar to those estimated by MacAdam (1942). Again implying that the 3 dimensions of H,S&B appropriately model individual color-appearance matches.

With respect to these MDS studies of hue, saturation and brightness dimensions Indow concludes "the global system is perceptually real" (1980, p. 6).

These similarity judgments, analogous to color judgments made in everyday settings, are obtained under a variety of empirical tasks, stimulus modes, and scaling methods, and over numerous tests converge upon the conclusions presented above.

Indow's findings are corroborated by less systematic works of Shepard (1978, 1994) and others. Dunn (1983) reviews the scaling literature and concludes that the *only* dimensions that yield dissimilarity in terms of a Euclidean metric are H,S&B. Furthermore, Pruzansky et al. (1982) found that surface color space is one of the few cognitive domains which can be appropriate represented in a 3-dimensional Euclidean space.

While the discussion remains open on some parameters of the metric space (Chang and Carroll, 1980) and whether H,S&B are integral or separable, the fact remains that these "dimensional interaction(s) are mirrored in the patterns of scaling data ... " (Burns and Shepp, 1988, p.505). S&VB mention none of this, yet clearly this counts towards a validation of the psychological importance of H,S&B.

S&vB should put aside the attribution of H,S&B to only color-ordered systems. Even if Munsell never put ink to paper-swatches we could still obtain similarity distances using colors in the world and the resulting scalings would still reflect the relational structure of H,S&B described above.

S&vB Ignore H,S,&B as Practical Cognitive Constructs:

If one chose to ignore the above empirical work one would still need to account for the uses of H,S&B in everyday practice. Designers of user-interfaces make use of hue and brightness cues (and to lesser extent saturation explicitly) to convey information to display operators. Instances range from some air traffic control systems to naval tactical data symbologies. Systems based on the general principle that there is a systematic relationship between the intensity of a signal light and the perceived brightness of that signal have been in operation since the introduction of automated information representation, and are "to a first approximation ... valid" (Travis, 1991, p. 55). The fact that financial considerations largely determine whether a system is maintained or discarded underscores the practical value of this principle.

Jameson, Kaiwi and Bamber (Manuscript) show observers can utilize both a luminance/brightness code and a gradient hue code effectively. Moreover, when those two dimensions are combined into a single code which simultaneously varies along one dimension of brightness (ranging dark to light) and another color dimension (a gradient of green-yellow-red), then naive subjects can efficiently parse this code on the two described dimensions independently (making both correct detections of signals and correct classifications of the information content conveyed by the chromatic code).

Gegenfurtner and Kiper (1992) provide psychophysical evidence for two independent and equally efficient mechanisms tuned to a luminance axis or a chromatic axis, and imply detection performance is limited by putative luminance and chromatic mechanisms but involves mechanisms that combine luminance and chromatic information (p. 1885).

This speaks to the psychophysical relevance of said dimensions, and the robustness of the dimensions in practical domains suggests a psychological "naturalness" contradicting S&vB's Conclusion 3.

S&vB Ignore Certain Experts:

S&vB's Abstract (iii) and Conclusions (1.), (3.), (5.) posit the nonexistence of linking propositions and neurophysiological opponent mechanisms tuned to the Hering fundamentals. Neurophysiologists and psychophysicists have indicated frequently in print that these linking propositions are yet to be completely understood (see Lennie and D'Zmura, 1988; Krauskopf, Williams and Heeley, 1982; Burns, Elsner, Porkorny and Smith, 1984; Krantz, 1989, 1975, all cited Jameson and D'Andrade, in press). And Mollon (1995) states again: "... there is no physiological evidence in the visual system for cells that secrete the sensations of yellowness and blueness or redness and greenness. The two subsystems found in the retina and visual pathway simply do not correspond to Hering's two axes," p. 144. One could cite additional examples.

Thus, on this issue S&vB say nothing new. Moreover, while they acknowledge a few dissenting voices, they fail to give proper consideration to experts who are critical of the dominant theories and who recognize much needs to be done before there is a "correct" theory. As in all active areas of science the field is still incrementally evolving. In particular, S&vB overlook the fact that constructs, like hue and brightness, are still understood as works-in-progress by almost everyone in the area.

Although only one facet of their analysis is considered here, similar and, in some cases, more damaging arguments can be made against their remaining critique.

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