completely dismiss notions of kin – and their relations to the society as a whole – any more than I think we get very far by dismissing the concept of color.

Finally, in their rejection of the four main tenets of current color theory, S&vB fail to suggest anything that even comes close to the explanatory power that the current standard models offer. It is true that the Berlin and Kay hypotheses have many internal inconsistencies as I myself have noted (Stanlaw 1997). Opponent process theories also have difficulties (see Boynton 1979 or Thompson 1995, in addition to those mentioned by S&vB). But is dismissing these powerful theories the right answer? And what should we do with the accumulated data that *does* support them? In section 1 they say "To avoid misunderstanding, we emphasize that we do not argue for . . . [the hypothesis that] relativism and unconstrained plasticity should prevail." They go on to say that "the right approach is hermeneutics and/or social constructivism." But what does this mean? No alternatives are ever offered and, thus, it seems that the implication of Saunders & van Brakel's claims is that color terminology *can* vary without linguistic, cultural, physiological, or psychological constraint. Is color naming random or totally arbitrary? I believe that eventually we will find that it is not.

Universal colour perception versus contingent colour naming: A paradox?

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Abstract: Confusion concerning the issue of universality of colour categorization would greatly diminish if context regains its fundamental status in psychological research and we give up on the reductionist notion that biological universality implies behavioral universality.

Although we are largely sympathetic to the four conclusions Saunders & van Brakel (S&vB) arrive at, we disagree with their general message, namely, that there are no nontrivial constraints on colour categorization. Nontrivial constraints on colour categorization must exist. Why? Because, if they do not, it becomes pretty difficult to explain why people within a society talk about and communicate by means of colour so easily. For example, apart from the colour blind, we have a common image about the colour green, and when necessary we use colour names for object identification. Thus, colours cannot get their names through completely arbitrary denotation. This may seem trivial, and surely it is not what the authors meant when they asked if there are nontrivial constraints on colour categorization. Yet, our goal is to show that this introduction illustrates the confusion from which this domain suffers.

1. Colour perception. General agreement exists about the universality of the biological colour-vision system in Homo Sapiens.[1] When linguistic responses are not required, colour (dis)similarity judgments, one way of categorizing colour, show amazing uniformity (Allen 1879; Berlin & Kay 1969; De Valois & Jacobs 1968). Thus, from this perspective, the general claim that colour categorization is not universal appears untenable. Moreover, it undermines the claim that psychophysics and neurophysiology fail to set nontrivial constraints on colour categorization.

2. Colour naming. No agreement exists about the existence of universal basic colour categories. S&vB supply ample, convincing linguistic evidence for the claim that there is no ground for the universality of basic colour terms. Note, colour naming is yet another means available to humans for categorizing colours.

An apparent paradox emerges: colour categorization without the involvement of linguistics (henceforth, perceptual categorization) shows that there are universal features, whereas colour categorization in which linguistics plays a fundamental role (henceforth, colour naming) shows that there are no universal features. The first step out of this inconsistency is to take seriously the *context* in which categorization takes place. In this particular case, an essential contextual constraint is whether or not linguistics is involved in the task. Thus, perceptual categorization is functionally different from colour naming, which is, perhaps unwillingly, shown by the example presented by S&vB in section 2.2. Dani people were worse than Americans in pointing out focal colours shown 30 seconds before in an array of 160 colours. S&vB do not invoke it as a potential explanation, but the difference between the two groups is that the Americans were probably able to use colour names to remember the presented colour chip, whereas the Dani people do not have this linguistic mnemonic at their disposal. This contextual difference is fundamental to the process of colour categorization, but it is not in any respect indicative of the absence of universality in colour perception.

The pervasiveness of the confusion just discussed is succinctly expressed in the following statement by S&vB: "Although not the focus of concern, a central problem in reviewing evidence for the four assumptions is *the relation between language and vision*" (sect. 1, emphasis is ours). If a *central* problem in colour categorization is the relation between language and vision, why is *that* not the focus of their target article? We believe that the paradox expressed in our commentary title disappears, once we accept the fundamental interrelatedness between language (i.e., colour naming) and vision (i.e., colour perception) without assuming a reductionist view. The reductionist approach is expressed in the view that biological universals should imply automatically and isomorphically psychological universals, as stated in the S&vB's first sentence of section 4.3: "If four unique hues were a universal human perceptual grounding, cross-cultural research would confirm it." We do not adhere to this "effect equals structure" assumption, that is, to the idea that the presence of an experimental effect implies the presence of a mental structure. For further discussion of reductionism and the "effect equals structure" assumption, see Lakoff (1987), Putnam (1981), Van Orden et al. (1996), or Van Orden et al. (in press).

Finally, colour naming is functionally different from perceptual categorization, because the fundamental constraints on colour naming are different from those on perceptual categorization. In colour naming, the need to communicate puts major constraints on colour vocabularies. Idiosyncrasies at the cultural level (in effect, people with different languages) and at the level of the social-cultural environment within a language determine the way people divide the spectrum, both in number and type. Examples are provided abundantly by S&vB (see for example, sect. 6.2.) The Xhosa people distinguish among 26 cattle colours; this is probably very useful in their habitat. The colour terms of the people from Arawak correlate strongly with the level of ripeness of their fruit and vegetables, *imoroto* for unripe or green, *koreto* for ripe, red or orange, and *bunaroto* for overripe or brown. (For other examples, see van Kruysbergen & Bosman 1987).[2]

In summary, continuing to study psychological phenomena without providing a fundamental role for context (i.e., a linguistic or nonlinguistic one) gives rise to yet another stalemate (see also Van Orden et al. 1996) in the study of cognitive psychology (i.e., universal colour perception vs. contingent colour naming). Rejecting a reductionist view solves the apparent paradox. Invoking communicational constraints explains the absence of universal colour vocabularies, but does not contradict the biological universality of colour vision.

NOTES

1. This claim is not seriously challenged by the possibility of peripheral regional adaptations as suggested by Bornstein (1973a). He voices the opinion that people living in tropical climates developed a yellow filter

(so-called "built-in sunglasses") to reduce the level of ultraviolet light entering their eyes.

2. Trying to separate colour from cattle idiom or to decide whether a word refers to a colour or to an aspect of growth is yet another trap that information-processing theory has set for us. It is a chicken-egg problem for which there is no solution. Assuming interrelatedness (in these examples clear correlations exist) causes the question to be superfluous.

Ekphrasis in colour categorisation: Time for research, or time for revolution?

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Abstract: Saunders and van Brakel propose that we rethink or reject much of current colour theory. Many of the problems they cite appear to call for further research rather than a radical rethinking of colour theory. The controversy described in this target article appears to be itself a case of "ekphrasis," or something that does not exist.

In their interesting and controversial target article, Saunders & van Brakel (S&vB) put forward the thesis that much of the current wisdom about colour vision and colour categorisation is either wrong or built on very shaky foundations. They imply that we need to rethink much of current theory, or cast it away and start again. Despite the large amount of evidence marshalled to illustrate their points, much of what S&vB imply are fatal problems with current theories are either well known and being actively investigated in the hope of improving, not discounting the theories, or seem to be the result of methodological rather than substantive theoretical or evidential factors.

In their section on the evidence for the universality of colour experience (sect. 2), S&vB restate the well-known problems with Berlin and Kay's (1969) original work. When criticising this work, however, S&vB often seem to go further than the evidence suggests. For example, in considering perceptual universals, the methodological problems of Rosch's work with the Dani are given as evidence not of poor communication between the experimenter and participant, but of undermining "the universal salience of both focality and prototypicality" (sect. 2.2, para. 5). Developmental psychology in particular has recently needed to rethink findings based on misunderstandings between participants and experimenters, or "actors and observers" (Siegal & Peterson 1994, p. 427) and has tried to reappraise previous work in this light. For example, the problems described in the Berlin and Berlin (1975) study appear very similar to those encountered in studies with participants who do not understand experimental instructions (for developmental, linguistic, cultural, intellectual or situational reasons).

S&vB point out a number of problems caused by taking a simplistic view of basic opponency theory. However, much of the evidence cited is consistent with a maturing theory, rather than one approaching an imminent demise. For example, although Mervis and Roth (1980) do indeed show how Kay and McDaniel's (1978) fuzzy sets cannot differentiate basic from nonbasic colour categories, it could be that an improved methodology using both fuzzy sets and reaction times to basic and nonbasic colours will be able to distinguish reliably between them. A further example is the apparent claim that opponency cannot work, because researchers do not agree on the exact weightings of cone contributions to the individual opponency channels. Surely this is a call for new, refined research rather than a new theory.

Work in our laboratory at Portsmouth into "colour nameability," which combines the observed effects of the consistency of free colour naming, naming confidence, and reaction times has shown repeatedly that an opponent relationship exists between colour names for coloured patches, and that such colour nameability is predicted by opponency appearance models such as Hunt's (1991) model (Guest & Van Laar 1995). This model does not depend on experimentally flawed expectations of predefined colour categories or any underlying theories of opponency, but is derived directly from the 32,000 data points collected.

The section regarding hue, brightness, and saturation appears confused. For example, lightness and brightness are often confounded and used as synonyms. Saturation is also confused with chroma and colourfulness. For example: "It is generally assumed that colour has three independent psychological dimensions: hue, brightness, and saturation (Munsell's *hue, value,* and *chroma.*)" (sect. 5.1, para. 1). Value is a measure of lightness, not brightness, and chroma is a measure of the combined effects of lightness and saturation, not just saturation (Hunt 1991). With this in mind, most of the problems voiced in this section are answered.

S&vB's conclusions are couched in less controversial terms than most of the rest of their text, and there is much to agree with here. That neither neurophysiology nor psychophysiology confirm that there are exactly two opponent hues or three pairs of opponent colours is not surprising; research is still ongoing, but the balance of the available evidence seems to support this theory rather than any other combination. It is not a new finding that many cultures, when examined by current research methods, do not show 4 primitive hues or 11 basic colour categories. However, this is by far the general rule for most Stage VII languages. Hue, brightness, and saturation are well known not to be independent, and there are also well understood links between brightness and luminance (Hunt 1991; Yaguchi et al. 1993).

In conclusion, there does indeed appear to be a sense of "ekphrasis" (sect. 1, para. 1) or something that does not exist about this debate, but not in S&vB's sense of lack of agreement about generally held theories, but rather in their idea of controversy where none exists. The scientific method is used to increment knowledge through the dialectic process of theory and antitheory, the fitter theory at any point being the one that best accounts for the most evidence at any given time. Although many theories are known to be flawed, they are generally only rejected when a better theory with more explanatory power is offered in its place. In this target article, Saunders & van Brakel appear to criticise and discredit theories that may be flawed, but they fail in their scientific endeavour when they do not propose a better alternative.

Hue opponency: A constraint on colour categorization known from experience and experiment

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Abstract: The terms red, green, yellow, and blue are both necessary and sufficient to describe our chromatic experience. Their uniqueness and opponent nature is supported by evidence obtained under suprathreshold conditions, especially hue cancellation. These constraints are nontrivial. How some electrophysiologically identified mechanisms contribute to colour appearance is not known, but their complexities do not refute our experience of elemental hues.

True, if one examines the hues of the spectrum, one could easily divide them into the seven categories of Newton, or some arbitrarily larger number. This exercise places no constraints on colour categorization. More interesting and informative is to ask not how *many* terms one might use to categorize the hues of the spectrum, but how *few* terms are required for a complete account of colour appearance. There is a substantial body of evidence to support Hering's (1920b) contention that only four hue terms – red, green,