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The relational correspondence between category exemplars and names

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ABSTRACT *While recognizing the theoretical importance of context, current research has treated naming as though semantic meaning were invariant and the same mapping of category exemplars and names should exist across experimental contexts. An assumed symmetry or bidirectionality in naming behavior has been implicit in the interchangeable use of tasks that ask subjects to match names to stimuli and tasks that ask subjects to match stimuli to names. Examples from the literature are discussed together with several studies of color naming and basic emotion naming in which no such symmetry was found. A more complete model of naming is proposed to account for flexible mapping of names to items. Principles of naming are suggested to describe effects of stimulus sampling, differing access to terms, task demands, and other impacts on naming behavior.*

1. Introduction

Naming is the process of assigning lexical terms to referents. It occurs as the result of categorization processes that involve recognizing an object and assigning an appropriate name to it based on the fit between the item and the meanings of available words. While both acquisition of names and categorization behaviors have been widely studied, the process of flexible assignment or variable mapping of names to referents has received less attention. This paper explores the relational correspondence between category exemplars and names and proposes a model of naming behavior based on empirical research in two domains: color naming and emotion naming.

Two theory-based controversies, arising in different subfields of psychology, demonstrate the importance of developing a more complete model of naming behavior. Each illustrates a fundamental underlying assumption that the assignment of names to referents is invariant under different experimental conditions and ought to produce the same results. Unfortunately, such invariance has not been found, leading to conflicting results for different experiments. These conflicting results have been interpreted in terms of theory, leading to heated debate. The first controversy

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arises in the field of emotion research and concerns the dispute between Ekman (1994) and Russell (1994) over the existence of basic facial expressions of emotion. The second controversy arises in the field of color perception and concerns the dispute over whether certain basic hues and their associated names have special salience linked to underlying color neurophysiology (Berlin & Kay, 1969; Saunders & van Brakel, 1997). We suggest that both controversies hinge on an underlying incomplete understanding of the assignment of names to referents. Our goal is to highlight the need for a more complete understanding and propose an alternative model for explaining naming behavior.

2. Searching for basic emotional facial expressions

Ekman and Friesen (1971; see also Ekman, 1972; Ekman *et al.*, 1969) identified a set of six basic facial expressions of emotion using a series of cross-cultural studies that asked subjects to label photos by selecting the best descriptor from six multiple-choice emotion terms. In a variant of that task, Ekman and Friesen (1971) asked subjects to select the best photo from among three to exemplify a story in which affect might arise. High reliabilities for naming across cultures and across paradigms were found. Since those early studies, Ekman and Friesen's findings have been replicated many times in a wide range of cultures, usually with a paradigm asking subjects to label faces using emotion terms.

Decades later, Russell and colleagues initiated a series of experiments evaluating the methodology of Ekman and Friesen's earlier work. Russell (1980) presented Ekman's photos of basic emotions with multiple-choice options omitting Ekman's previously identified best names. Russell contended that subjects in this modified judgment situation chose names consistent with his own circumplex model of the emotional meaning space for facial expressions. Ekman contended that subjects were actually choosing a second best name, the label closest to the omitted best descriptor. Russell claimed that forced choice restricts the options available to subjects, forcing selection of a perhaps incorrect name if the best name does not happen to be presented by the experimenter. He argued that the initial selection of names for presentation by Ekman was theory-based, and thus biased the results. Russell and colleagues raise an important question about the need for empirical grounding of the selection of names for referents presented as stimuli in studies.

In follow-up studies, they (Carroll & Russell, 1996; Russell, 1991, 1993; Russell & Bullock, 1986; Russell & Fehr, 1987) showed that presentation of pairs of photos altered the labeling judgments of subjects, usually in contexts where Ekman's "best" label was again omitted. Further, subjects failed to freely list Ekman's identified best terms as highest frequency descriptors for the various basic expressions. On the basis of his conflicting results obtained with these changes in judgment context or task, Russell (1991) asserted that Ekman's basic expressions conveyed no stable meaning. In the face of conflicting evidence from a variety of sources, including his own work, Russell has now retreated from this extreme position and accepts that there are reliably interpreted basic facial expressions (Carroll & Russell, 1996, 1997), though he has not conceded that they occur in nature nor that they are

the result of experienced affect, and he has referred to them as illusory correlations of component facial movements only coincidentally co-occurring in the face. For example, Carroll and Russell (1996, pp. 215–216) state:

> First, observers often selected the emotion label predicted by Ekman and his colleagues for the face when seen alone. These high "recognition scores" for faces seen alone replicate a ubiquitous result (Ekman & Friesen, 1978; Matsumoto & Ekman, 1988). The interpretation rather than the reliability of this result is the question. We interpret high recognition scores as partly due to the pleasantness, arousal, and quasi-physical properties of the face (e.g., the nose wrinkle of the "disgust expression" conveys an unpleasant reaction to an odor; not all emotions terms are equally applicable to this reaction) and partly due to the method of gathering judgments. That is, the forced-choice response format, within-subject design, and other features of method used here and in previous studies help funnel the observers' judgment of the face into a single category (for a discussion of these issues, see Russell, 1994). As we saw, the recognition scores vary with small changes in the response format.

Despite recognition of the importance of judgment context in Ekman's studies, Russell did not interpret results of his own methodological manipulations as context effects, but rather asserted them as proofs of his own model, as criticisms of Ekman's theory of basic emotions, and later, as support for a cultural-relativistic or constructionist approach to emotional experience (Russell, 1997). Other emotion theorists struggling with these issues have similarly assumed that there is something about the nature of emotion—some fuzziness, cultural relativity or ultimate subjectivity that precludes reliable labeling of emotional experience (Ortony & Turner, 1990). If so, we would expect these context-related differences in results to be specific to the domain of emotion. They are not.

3. Searching for basic colors

Berlin and Kay (1969) theorize that color experience is cross-culturally labeled using 11 "basic color category" hue terms that universally evolve in a fixed order in linguistic cultures. Their theory assumes that color naming and cognitive processing of color appearances are linked to the "cognitive salience" of both colors and the terms used to label them, which in turn emerges from an underlying neurophysiology of color perception. This theory was supported initially by a US-based ethnography (Berlin & Kay, 1969), followed by the World Color Survey (WCS) (Kay & Maffi, 1999; Kay *et al.*, 1991, 1997). In these and other replicating studies, color region foci are elicited in the same manner. Berlin and Kay provided a small set of names to subjects and asked them to identify the best exemplar for each name from a set of 320 maximally saturated chips presented in an array that was the same for every subject.

Ongoing debate asserts that even the best work done in color naming remains fraught with methodological and theoretical shortcomings which muddle the absol-

ute determination of simple color naming relations (Lucy & Sweder, 1979; Saunders & van Brakel, 1997; van Brakel, 1993). For example, color appearances are perceived differently in different contexts. In Berlin and Kay's work, presentation of chips in a different array results in selection of different focal colors. Equally problematic, in Berlin and Kay's array, the same chips are selected as "best" even when the printed Munsell sets vary widely in their colorimetric properties and are seen under different levels of illumination. These difficulties suggest that any invariance of response is unlikely to be a property of the stimuli because the stimulus properties were not the same from study to study. Thus emergent salience must be related to some other aspect of the task.

Rosch-Heider (1972; Heider, 1971, 1972) tested Berlin and Kay's theory cross-culturally using a series of judgment tasks in which color patches were presented individually and identification response times were measured. She proposed that cultures using fewer terms to name color categories would nevertheless have similar mental color representations; thus focal colors should be remembered and named more readily even in cultures where these focal colors were not individually named, as in the Dani culture. She also demonstrated that children pay more attention to focal colors, match them more accurately and choose them more frequently as best exemplars of category names (Heider, 1971).

Rosch-Heider's series of investigations of cognition and color salience (Heider, 1971, 1972; Rosch-Heider, 1972) have been criticized for inadequate stimulus control and could not be replicated by other researchers (van Brakel, 1993; Roberson *et al.*, 2000). Rosch-Heider herself notes that cognitive "salience" was equivalent to saturation in her results. She writes, "The most saturated colors were best examples of basic color names for both English and for speakers of the other 10 languages represented" (Heider, 1972, p. 13).

Boynton and colleagues expanded upon Rosch-Heider's ideas and gave the first rigorous results for cognitive salience of color appearances and color naming (Boynton & Olson, 1987, 1990; Boynton *et al.*, 1989). Using well-controlled stimuli, they demonstrated salience for a different set of basic or focal colors, which Boynton has termed "landmark hues." Boynton methodically assessed cognitive salience of all OSA colors using several different measures, including naming consistency, response time, and majority choice. Boynton's measures all converged on the finding that "landmark" hues (i.e. opponent-process colors: red, green, yellow and blue) were more salient than *some* composite hues, but that other composite hues (e.g. orange) demonstrated as much salience as the landmark colors. These results largely held up for limited tests of the Japanese color lexicon as well.

Thus, in the domain of color naming, different focal colors emerge under different conditions in different experimental paradigms. In Berlin and Kay's studies, names are provided by the experimenter and matched by subjects against an array of color samples of maximum saturation. In Rosch-Heider's studies, names were first taught to subjects by the experimenter, then supplied from memory by the subject in response to a series of individually presented color samples. In Boynton's work, subjects were presented with different color appearances in a speeded-response task that required them to supply monolexemic names, a task that privileges

the more familiar or more accessible names. Different basic colors emerge from Boynton's work than from that of Rosch-Heider and Berlin and Kay. Without stimulus control, it is unclear whether Rosch-Heider and Berlin and Kay identified the same focal colors either. Further, Berlin and Kay assert that different focal colors emerge in different linguistic cultures.

Most striking to us are the similarities between these conflicts over basic colors and the acrimonious debates in the field of emotion over basic emotions. In each field, naming is at the heart of the issue because inconsistencies of naming behavior across paradigms seem to fuel the debate.

4. Empirical studies of naming symmetry

Our interest in the contribution of naming to these theoretical debates led us to explicitly study naming asymmetries across different judgment contexts. These studies are briefly described here and in greater detail in Alvarado and Jameson (2002), Jameson and Alvarado (in press), Alvarado and Jameson (1996), and Alvarado (1996).

Shepard and Cooper (1992) developed a paradigm to compare the equivalence of meaning across two domains, such as the visual and verbal domains, without asking subjects to attach verbal labels to visual stimuli (or vice versa). Shepard and Cooper studied equivalence of visual and verbal color representations by presenting separate similarity judgment tasks, using color terms and color samples as stimuli, to groups of normally sighted, color-blind, and blind subjects (terms only). In each task, subjects were asked to rank order the stimuli in terms of similarity. The results were then input to multidimensional scaling. This method of gathering similarity data is similar to a triad task, in which subjects are presented with all combinations of three items drawn from the stimulus set and asked to select the item that is most different. An item-by-item similarity matrix is created from this data, which is then input to multidimensional scaling.

Shepard and Cooper's (1992) result for normal subjects was Newton's color circumplex in both domains (when judging color terms and when judging color samples), as shown in Figure 1. For color-blind subjects (dichromat deutans and protans), the scaling of color terms was closely similar to that of the normal subjects. The color circumplex emerged for both groups in the verbal domain. The deficiency of the color-blind subjects was evident only in their judgments of the color samples, where red and green were judged to be similar rather than opposite. Monochromat and blind subjects who had never experienced the colors were nevertheless able to produce a scaling solution for color terms that was somewhat similar to that of normal and color-blind subjects, presumably through their acquired understanding of the meanings of the color terms as used in language. Although the lexical color wheel collapsed, red and orange, violet and purple, green and turquoise, yellow and gold were correctly judged to be similar to each other. The monochromat subject was also able to determine which colors are opposites, but not the blind subjects.

Shepard and Cooper concluded that subjects drew upon the same mental representations to perform both tasks, despite the evidence that subjects in the

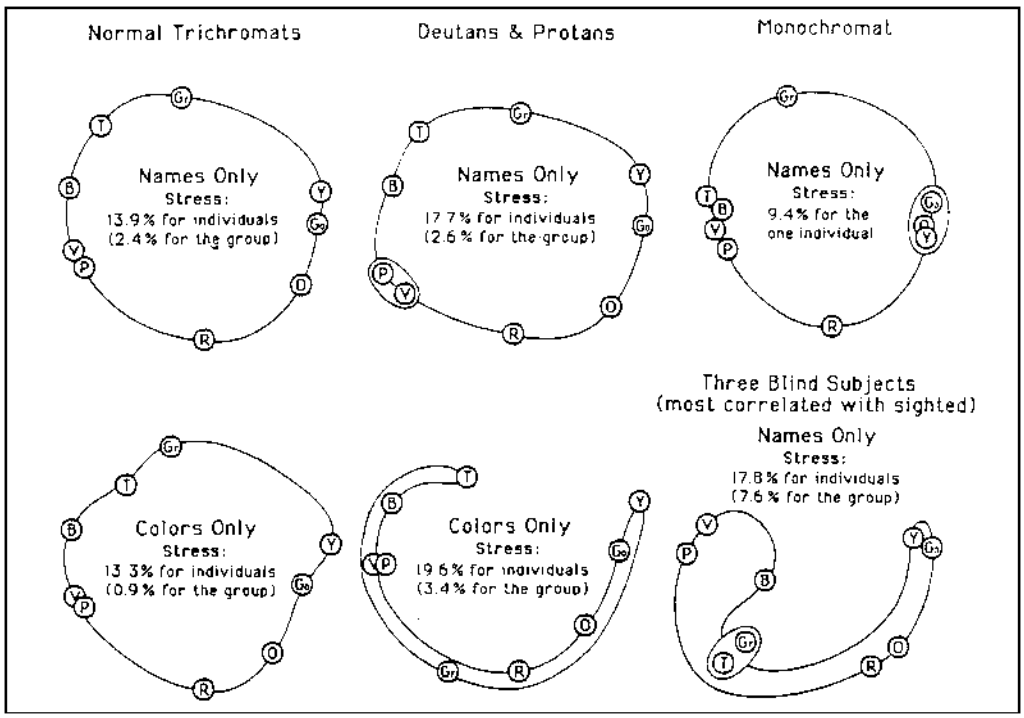

FIG. 1: Comparison of judgments for color terms and color appearances (from Shepard & Cooper, 1992).

color-blind group performed differently in the two tasks, drawing upon lexical knowledge in the verbal task that was unavailable to them in the visual task. The most interesting aspect of this study is that knowledge about the relationships among words within a meaning space can be acquired in the absence of direct experience with the referents to which those words have been linked, as occurred for the monochromat and blind subjects. We believe this study provides evidence of independent verbal and visual representations among dichromats (color-blind subjects) that may also exist among subjects with normal color vision.

This paradigm was adapted by Alvarado (1996) to explore similarities in meaning between the mental representations of Ekman and Friesen's (1978; Ekman, 1992) basic facial expressions of emotion and basic emotion terms, as shown in Figure 2a. A closely similar mapping among the items appeared in both domains, just as occurred in Shepard and Cooper's (1992) study of color naming, suggesting a similarity of visual and verbal meaning conveyed by the stimuli. In a second triad task where multiple exemplars of basic emotional expressions were used, an emotion circumplex emerged. This circular arrangement of the basic expressions centered on dimensions of arousal and valence, also called hedonic tone, pleasure, or evaluation by various theorists (Schlosberg, 1952, 1954). This sort of circular arrangement implies that while two dimensions are relevant, categories of items are equidistant from the centroid with respect to one of the dimensions and only vary on the other dimension. Color appearances used by Shepard and Cooper were maximally satu-

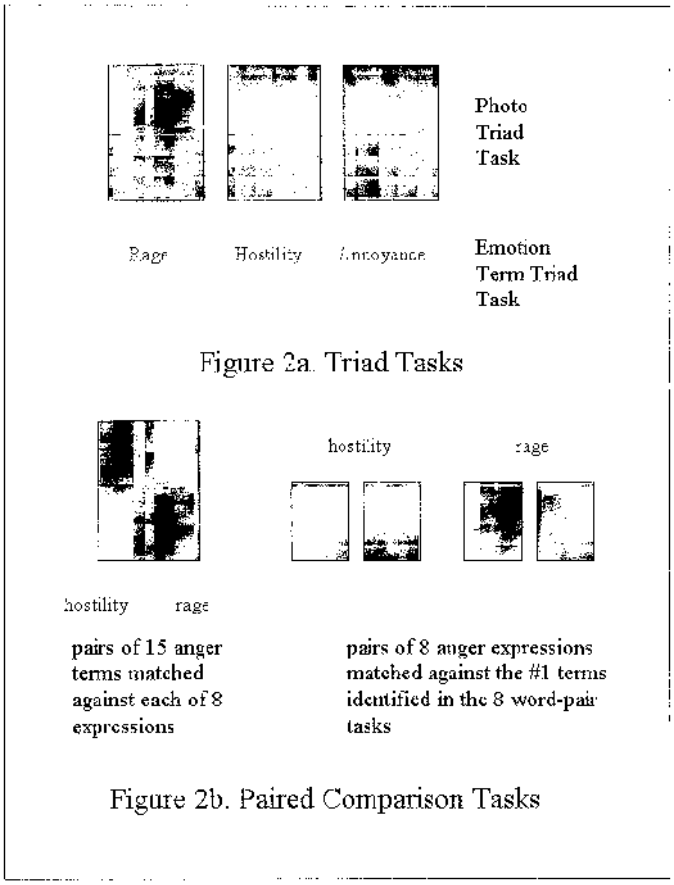

FIG. 2: Experimental tasks used to test naming relations.

rated. Facial expressions used by Alvarado were created by Ekman and Friesen to portray maximum intensity of feeling, reducing the variance in the arousal dimension. The somewhat equal circular spacing in these circumplex solutions suggests that basic level names and basic expressions or best exemplar colors are considered maximally distinct from each other, varying on only one, perhaps integral, dimension. It may be that this property of maximal differentiability is what makes them "basic" in the various studies where they have emerged as salient. Emergence of a circumplex is dependent on stimulus sampling (Alvarado, 1996).

We developed a different paradigm to test for symmetrical meaning (called reciprocal meaning in previous studies), as shown in Figure 2b. This paradigm was first applied in a study of the differentiation of the disgust and contempt facial expressions and their verbal labels "disgust," "contempt," and various synonyms widely considered to name the same emotional state (e.g. revulsion, loathing, scorn, disdain; Alvarado & Jameson, 1996). In addition to testing the similarity of meanings using the triad tasks described above (see Figure 2a), multiple paired comparison tasks were used to identify the "best" facial expression exemplar of the terms

"disgust" and "contempt" or the "best" descriptor for eight different facial expressions (four of disgust and four of contempt, as classified by Matsumoto, 1992). All possible pairs of stimuli were presented. The results were analyzed using a numerical rating model that produces an interval scale of the "goodness" of each item judged in that context by subjects (Jameson, 1996).

Results showed reciprocal or symmetrical meaning for disgust but not for contempt. Subjects chose disgust photos to exemplify the word "disgust" and selected the term "disgust" as the best descriptor for all four disgust expressions. No symmetrical meaning was found for the contempt expression. Subjects disagreed about whether disgust expressions or contempt expressions best exemplified "contempt," though they were consistent in differentiating both sets of photos and also consistent in attributing a set of photos to a term. They also tended to rank "disgust" and "contempt" as equally poor descriptors for the contempt expression (both terms appear together near the bottom of the ranked terms), preferring the term "annoyance." On this basis we concluded that subjects disagreed about the meaning of the term "contempt" and that perhaps the facial expression had been mislabeled, because subjects ranked "contempt" very low as a descriptor for that expression. From this study it was clear that the paradigm revealed a problem in the naming relation between the so-called contempt expression and its hypothesized verbal label, "contempt." This was asserted as an alternative explanation for the lower reliabilities obtained in cross-cultural studies when translations of "contempt" were provided as one of the multiple-choice alternatives for naming that expression. The low reliabilities for contempt judgments have been a cornerstone of the criticism of theories of universality of basic emotions (Fridlund, 1994).

Symmetrical meaning within a single category, anger terms and anger expressions, was tested using this same paradigm by Alvarado and Jameson (2002). First, separate triad tasks were used to scale the similarity of 21 anger facial expressions (previously normed by Ekman & Friesen, 1978), and 21 anger terms (selected from the sorting task and hierarchical cluster analysis of Shaver *et al.*, 1987). Next, eight facial expressions were presented, each photo to a different group of subjects, and a paired comparison task matching all possible combinations of 15 anger terms was presented. As in previous studies, subjects were asked to select the term that best described the expression shown in the photo, which remained the same for all pairs of terms judged. The numerical rating system was used to determine the "best" term to describe each of the eight facial expressions. Then those eight best terms were presented individually to separate groups of subjects and the eight facial expressions of anger previously used were presented in a paired comparison task. Subjects were asked to select the photo that best exemplified the meaning of the term presented. Again, if symmetry of naming existed, subjects were expected to select the same photo as was presented originally to obtain each "best" anger term. Results are shown in Table 1 (see also Alvarado & Jameson, 2002).

Subjects apparently made fine discriminations among the facial expressions and they assigned different terms to each photo, presumably on the basis of those fine discriminations. However, when a single term was presented and photos were matched against it, subjects tended to select the same photo as the best exemplar

TABLE 1. Failure of reciprocal naming for facial expressions of anger

Facial expression photo ID (Ekman & Friesen, 1978)	Best descriptor selected to match each photo	Photo selected to best exemplify that descriptor
3	Contempt	3
18	Frustration	53
25	Annoyance	53
44	Resentment	96
53	Rage	53
80	Anger	53
96	Hostility	53
105	Disgust	53

(photo 53), regardless of the term presented. Photo 53 was selected as best exemplar for six of the eight photos, and was second and third in the ratings for the remaining two conditions. The only two photos producing reciprocity of meaning across these two judgment tasks were the extremes—the worst and the best exemplars of anger, matched with the worst and the best anger terms ("rage" and "contempt"). These findings demonstrate that naming behavior differs substantially across two judgment contexts.

The facial expression cues considered meaningful in the first judgment context were disregarded in the second context in favor of resemblance to a prototype or strongest anger expression. The subtleties of meaning of the various anger terms appeared not to influence the selection of facial expression to match them. We believe that different behavior occurs in these two different judgment contexts because naming is not invariant, but is responsive to the demands of the task and the characteristics of the judgment context.

A third example of naming flexibility was found in the domain of color naming (Jameson & Alvarado, in press). We compared color naming behavior across three language groups: monolingual English speakers, monolingual Vietnamese speakers, and bilingual Vietnamese speakers tested in Vietnamese. We attempted to replicate findings of greater salience for certain basic or landmark hues using color stimuli that systematically sampled OSA space. Equivalence to previous color samples used by Berlin and Kay (1969) or Boynton and colleagues (Boynton, 1997; Boynton & Olson, 1987, 1990; Boynton *et al.*, 1989) was demonstrated using both colorimetry and empirical testing. Two simple modifications to a free listing task were made: (a) subjects were permitted to list terms at their own pace; and (b) subjects were permitted to use modifiers and multiple-word terms, not constrained to monolexemic or basic terms. With these two simple changes, no greater salience for the basic or landmark hues could be demonstrated using measures of frequency or confidence, even after reduction of the names to single terms specifying Berlin and Kay's or Boynton's categories. The purported basicness or salience of certain colors disappeared with a change in the naming procedure.

We believe our result occurred because the constraints present in previous research had the effect of forcing naming to rely more strongly upon category

structure. These constraints include: (a) speeded response and (b) restricted access to names imposed by monolexemic naming. With these constraints removed in our study, naming behavior was able to vary with other factors that also influence naming, including the extent of the stimulus space sampled and variable access to names (as was most evident comparing the bilingual and monolingual Vietnamese subjects).

Taken together, these findings imply that basic level terms or most salient exemplars emerge under some conditions and not others. Assertions that some colors are focal or that some facial expressions are basic are not invalidated by our findings. Rather, such findings are limited by the factors that encourage the emergence of salience in some studies but not in others. Identifying these factors is an important step toward developing a more complete model of naming behavior, as well as a better understanding of the domains in which naming occurs.

Experimental approaches that examine naming behavior from a single perspective have typically looked at only one side of the naming relation. Some have looked at mapping of names to objects. Others have looked at mapping of objects to names. Neither, by itself, captures the full process of naming. Thus, we consider these emergent asymmetries to be an incompleteness in the modeling of naming behavior, not a context effect. The solution is to develop a more complete model that maps naming relationships fully, not just for one task. While it may be impossible to do this exhaustively, exploration of more complete models is not only important to categorization theory but may shed light on other existing controversies across subfields, especially those debating existence of prototypes or basic levels of language use.

5. Invariance across contexts

While researchers have overlooked the contribution of naming behavior to their substantive findings, theorists in linguistics and in reference philosophy have been grappling directly with the problem of invariance of meaning across contexts. For experimenters, the problem has been to eliminate or control context effects and thereby accomplish invariance of meaning across contexts, individuals, time, and tasks that all seem to influence meaning. Viewing shifting meaning as a "context effect" overlooks the importance of linguistic flexibility. While invariance of meaning is essential to both communication and reasoning, flexibility of mapping is also important because without it no recognition of the similarity of varying items can occur. We suggest that the same cognitive mechanism that produces invariance also mediates flexibility. Invariance of meaning emerges from the process of mapping names to referents, not from the meanings of items in either domain. We propose that a rule-governed naming function accomplishes this by producing useful mappings that vary under different constraints. In the following paragraphs, we describe how such a naming function model might address problems of categorization.

6. Holism versus feature-based accounts

Mapping of names to referents depends upon the meanings of available names, but those meanings change. As several early theorists (e.g. Brown, 1958; Garner, 1974; Jacoby & Craik, 1979; Olson, 1970) have noted, "The meaning of a word in a given context depends on distinctions that are to be conveyed by that word in that context" (Jacoby & Craik, 1979, p. 2). These distinctions arise through processes of comparison that take into account relationships among items, especially contrasts between them (Tversky, 1977). Jacoby and Craik characterize *meaning* as "a set of contrasts resulting from distinctions required when interpreting the item in the context of some task." (p. 3). These early theorists used terms such as "distinctiveness," "diagnosticity," and "salience," not simple presence or absence of features, to describe relational attributes of stimuli captured by the names assigned to them in specific contexts. Inherent to this view is the idea that an object does not have a single name or description, but that the name may change with the need to emphasize important distinctions arising through comparison of items in a specific context.

The role of selective attention to aspects of stimuli as needed to accomplish a categorization task has been noted (Nosofsky, 1986). Traditionally, a distinction has been made between holistic processes such as similarity comparisons involving prototypes or previously stored exemplars as opposed to a decisional evaluation with respect to category boundaries specified for scalable stimulus properties (Estes, 1994). Garner (1974) described the contribution of stimulus features and context to classification processes as follows. Classification processes may potentially strive for maximum interclass difference together with maximum intraclass similarity. However, these sorting criteria change depending upon the nature of the stimuli to be differentiated, the relevant dimensions for classifying items, and whether those dimensions are integral or separable in the stimuli. The concept of overall similarity as a sorting criterion is most relevant when stimuli have integral dimensions. Similarity becomes relatively unimportant when dimensions are separable (that is, when dimensions can be selectively attended during a task). A scalable dimension becomes more salient as stimuli become more discriminable with respect to that dimension. The dimension showing the largest differences among stimuli will dominate during a sorting task. Thus, task demands, stimulus characteristics, and perceptual processing all interact during classification of items into categories. We do not know how the assignment of names to referents changes as the salience of dimensions and sorting criteria change. We do not know the extent to which the use of language provides invariance when dimensional relationships among classes of items change. These aspects of the mapping of names to referents have yet to be explored, but our studies of naming symmetry across contexts suggest strongly that the mapping of names to referents does change.

Despite criticisms of similarity as a basis for categorization (see Goldstone, 1994; Roberson *et al.*, 1999), we believe that categories and concepts are formed on the basis of both similarities and differences among exemplars. According to some theorists, category prototypes or best exemplars may emerge as an average across a

pool of exemplars (Hintzman, 1986; Nosofsky *et al.*, 1992) and thus may represent that which is common to or most representative of members of that category. However, some theorists suggest that categories may be distinguished from each other by their differences. For example, color category names are best learned through contrast with members of different categories (Au & Laframboise, 1990; Soja, 1994).

Jacoby and Craik (1979) suggested that formation of categories and concepts facilitates identification and subsequent recall of items in the absence of distinctive encoding. Assumption of invariant characteristics for categories also aids reasoning using categories or concepts. Setting aside disputes about how categories are mentally represented (e.g. as abstractions such as prototypes, as instances, or as theories), invariance of meaning across contexts enhances the usefulness of concepts and categories in cognitive processing. In both classification and naming, the problem is not with determining meaning, but with determining an invariant meaning. Meanings of both stimuli and names can change as needed if there is a method for flexibly mapping names to referents that meets the needs of the individual in a given situation. Typically, those needs are related to communication, not to any desire to maintain invariance of usage across contexts.

A popular notion is that basic level terms exist which are invariantly linked to best exemplars or most-typical exemplars within categories. For example, Berlin and Kay suggest that "basic" color terms have the same processing salience as the "best exemplar" color appearances they describe. Some studies have successfully demonstrated special properties of basic colors (Heider, 1972), while others have not (Roberson *et al.*, 2000), leading to criticism of prototype and best exemplar theories (Estes, 1994; Nosofsky, 1992). Roberson *et al.* (2000, p. 394) assert that language use distorts perceptual distances at category boundaries, resulting in categorical perception. They suggest "the internal color space is not static." An additional difficulty is that the same basic level names may be used to denote exemplars encountered in different contexts, including both situations where variance of attributes is large and situations where it is not. This flexible assignment of the same set of names in different contexts introduces confusion about category boundaries and the meanings of names and suggests the importance of examining how names are assigned to exemplars.

The same tension between holistic interpretation and feature-based analysis exists when evaluating meanings of names (as opposed to properties of their referents). For example, Russell and Fehr (1994), applying the ideas of Quine and Wittgenstein, note the logical impossibility of defining emotion terms. They conclude, as did Ortony and Turner (1990), that the deficiency is with the nature of emotion, not the nature of language. They assert, based on divergence of results across a variety of different tasks, that the emotion lexicon has no clear structure but rather consists of fuzzy categories organized around prototypes. Ortony and Turner (1990) assert that no consensual definition of emotion exists and that emotion should therefore be conceptualized using variable assemblies of components. This approach sounds similar to the method of scripts offered by Russell and Fehr (1994) or the analysis of lexical contents suggested by Wierzbicka (1992). In each case, a

definition is approximated by permitting the mix-and-match of constituent items of appraisal, context, action tendency, physiological response, or phenomenology. This varying combination might be labeled using a specific emotion term, depending upon some determination of whether an instance to be classified contains a sufficient number or amount of the constituent elements. These approaches provide only a partial solution to the problem of diversity of definition and fuzzy boundaries. They do not specify how to judge synonymity or determine category inclusion. As Clore and Ortony (1991) noted, one must still decide how many features of a script or which components are needed in order to label an emotion using a given term.

A more recent approach links categories and concepts to theories that provide the coherence needed to account for a wider range of naming behaviors. Keil (1996) reviews the development of theories and their application to both nominal and natural kinds. An appeal to causality and a higher level of abstraction resolves some but not all of the theoretical difficulties arising from observed language use. One limitation is that they explain naming at the individual level without considering that individuals must interface with a world that operates with different theories, concepts, and names.

7. Putnam's solution

These dilemmas can be resolved by applying the ideas proposed in reference philosophy by Putnam (1988). Putnam proposes four principles important to meaning: (1) definition depends on "meaning holism"; (2) as a result, most terms cannot be defined; (3) reference is socially fixed and distributed in a linguistic "division of labor"; and (4) interpretation of meaning depends upon charity. These principles apply to all cases of reference, including natural-kind categories. Thus, emotion is not a special fuzzy case, but is difficult to define for the same reasons that all things are difficult to define. For justification of these principles, see Putnam (1988).

Meaning holism, to summarize Putnam (1988), suggests that if a collection of objects is described using the same term, then we assume that all such objects have something in common. This need not be a physical property or feature, but can be a disposition. As Putnam explains, for the color red it is the disposition to be perceived as red (under "normal" viewing conditions) that red objects have in common, not any specific wavelength of light or unvarying feature or property of the object. The myriad combinations of light, texture, context and physiology contributing to the perception of red cannot be enumerated or specified by rule. Red objects are simply those perceived as red upon viewing. Extending Putnam's example to emotion, it is the disposition to feel angry that unites all instances of anger. The disposition to be experienced as anger is what instances of anger have in common, not the context leading to that anger, the appraisal, the physiological state, or the other endlessly variable circumstances leading to an experience of anger (see Putnam, 1988, for an explanation of the difference between disposition and essence).

The concept of "meaning holism" comes from Quine's argument that theories

consist of a body of statements that "meet the test of experience 'as a corporate body' and not one by one (hence the term 'holism')" (pp. 8–9). Putnam (1988, p. 9) extends this to language: "If I say 'Hawks fly,' I do not intend my hearer to deduce that a hawk with a broken wing will fly. What we expect depends on the whole network of beliefs. If language describes experience, it does so as a network, not sentence by sentence." This implies that the presence of anomalous cases, discrepant features or disagreement among judges does not change the meaning of anger, which must be judged as a whole.

Putnam agrees that definition is impossible. If most terms take their meaning not from physical properties but from dispositions, and not from single defining statements but from a body of statements, then the possibility of a single, fixed definition is not possible. As Putnam (1988, p. 9) says, "… when an entire body of beliefs runs up against recalcitrant experiences, 'revision can strike anywhere,' as Quine has put it." Any of the statements in a definition can be altered over time and circumstances, while the meaning and the capacity for reference remain the same. Thus definitions evolve over time, or may be different for different people, while still denoting the same object of reference. The key idea here is that the word continues to reference the same object, whatever the definition offered.

Putnam (1988) asserts that a further consequence of meaning holism is that the meaning of a term resides in society, not in any given individual. Further, experts may know different parts of the whole than do novices, yet we consider the totality to be the meaning. As Putnam notes, an individual might be unable to provide a satisfactory definition for an object, yet feel strongly that he or she knows what the word referencing it means. Thus, Putnam (1988, p. 25) says, "Language is a form of cooperative activity, not an essentially individualistic activity … reference is socially fixed and not determined by conditions or objects in individual brains/minds." For emotion research, this suggests that lay definitions and expert definitions need not be the same, and that experts need not share the same definition nor apply the same test to decide whether an instance is anger. To use Putnam's example, just as a chemist and a jeweler might apply different tests to decide whether an element is gold, emotion researchers need not agree as long as their divergent definitions and tests identify the same instances as anger.

Because of the differences in the partial definitions held by different members of the same culture, the changing nature of definitions over time and circumstance, all interpretation of meaning depends on charity. Putnam (1988, p. 13) says, "… we always have to discount at least some differences in belief when we interpret … suppose we are reading a novel written 200 years ago in English, and we encounter the noun 'plant' … we do not hesitate to identify this 'plant' with our present English 'plant'; yet in so doing, we are ignoring a host of differences in [biological] belief … we treat the concept plant as having an identity through time but no essence." Obviously, minor differences are routinely overlooked in everyday conversation to facilitate communication. Further, ambiguous words are routinely interpreted to preserve the sense or meaning within a larger context. The operation of such principles within the judgments made by subjects should be taken into account. Whenever language is involved, the exactitude demanded by Russell and

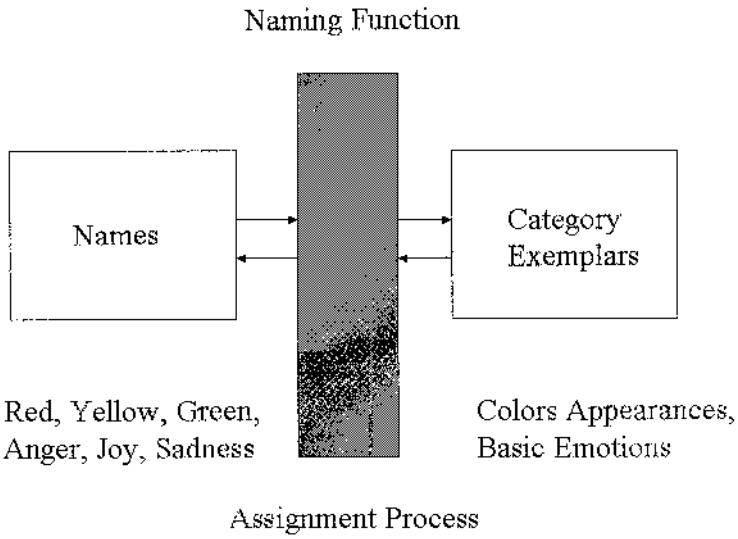

FIG. 3: The basic naming function.

Fehr (1994) and similar critics will not be found because subjects are willing to give their experimenters charity of interpretation when presented with deliberately or inadvertently misclassified items.

These principles assume that meaning is not equivalent to mental representation, a point Putnam (1988) argues strenuously. The observed flexibility in our use of language to convey meaning requires this dissociation. We believe that for purposes of referencing objects in the world, referents and linguistic representation are flexibly linked through a cognitive process we call the naming function. The naming function assigns names to referents as needed to accomplish a performance-related goal (see Figure 3). This process is dynamic, rule-governed, and guided by information from the lexicon, category structure (concepts, theories), as well as other cognitive processes. It is the naming function that is responsive to fluctuations in meaning, not definitions of words nor even theories. Communication about emotion, or color for that matter, using words would be impossible among people in their day-to-day lives if the extreme fuzziness asserted by Russell and Fehr (1994) or Ortony and Turner (1990) existed. The need for some congruence between the message sent and the message received necessarily constrains the meanings of the words used to communicate. Language provides that constraint or invariance, but it does so through flexible mapping, not through variable definition or increasing abstraction. The names used are those that meet the need to communicate, the task demands, not those that best describe the items named.

How does this differ from existing theories? In much research, including the disputes described earlier, observed differences in naming behavior have been assumed to derive from differences in underlying processes of classification and categorization, differences in the stimuli (e.g. natural kind versus abstract categories, perceptual versus conceptual categories), or from differences in descriptive contents of the lexicon (e.g. linguistic relativity). For example, in a series of color naming and

judgment tasks, Roberson *et al.* (2000) interpreted the observed lack of invariance across linguistic and memory paradigms in two cultures (Papua New Guinea and Great Britain) as the influence of linguistic relativity on perception. They claim that neurophysiological universality cannot exist because greater invariance of response was found among language-mediated tasks than among similarity judgment tasks. We believe that the contribution of context, contrast, and task demands in the various experiments may provide an alternative explanation for lack of invariance, albeit one that does not exclude their conclusions.

The preference for such theory-relevant explanations is understandable. Context effects frequently have been dismissed because they are widely observed and thus seen as irrelevant to substantive issues. However, they are worth examining in their own right because they have the potential to explain some of the perplexing inconsistencies in categorization research. By better understanding naming relations, we can separate the contribution of naming from that of linguistic and categorization processes and thereby shed more light on these controversies. In addition to categorization and lexical choice processes, naming behavior appears to depend upon the relationships among items in a category, the extent of the stimulus space sampled, salience of relevant dimensions, extent of access to a variety of lexical terms and modifiers for making finer distinctions among those items, and task demands, including the need to make speeded responses and other constraints imposed by the experimenter.

8. Mapping phenomena

As Estes (1994, p. 9) notes: "… Jacoby & Brooks (1984) have [now] marshaled a substantial amount of empirical evidence in support of the idea that many phenomena of perception, recognition, and categorization depend on memory for instances rather than on stored abstractions." Regardless of whether this contextual influence occurs through comparison with stored instances or with a stored abstraction (habitual encoding or prototype as Estes calls it), recognition of items as members of categories and consequent naming is modified by context and task demands. A naming function that maps names to referents would accomplish this second step and provide the flexibility needed to implement Putnam's concept of meaning holism and linguistic charity, as shown in Figure 3. It may permit us to extend linguistic charity to others when their definitions differ from ours due to experience and culture. It may enable us to be precise when needed and less precise when speed or fluency is more important than accuracy.

This naming function may be important to several other kinds of mental mapping phenomena. If we assume that the naming function can map lexical terms onto entities that are internal (e.g. mental representations or states), not just those that are external (e.g. things in the world), then it may be the mechanism for figurative speech such as slang and metaphor. It may enable us to acquire additional languages by linking new vocabulary to existing terms. Each of these uses is inherent in the idea of a naming function that permits flexibility in the assignment of lexical

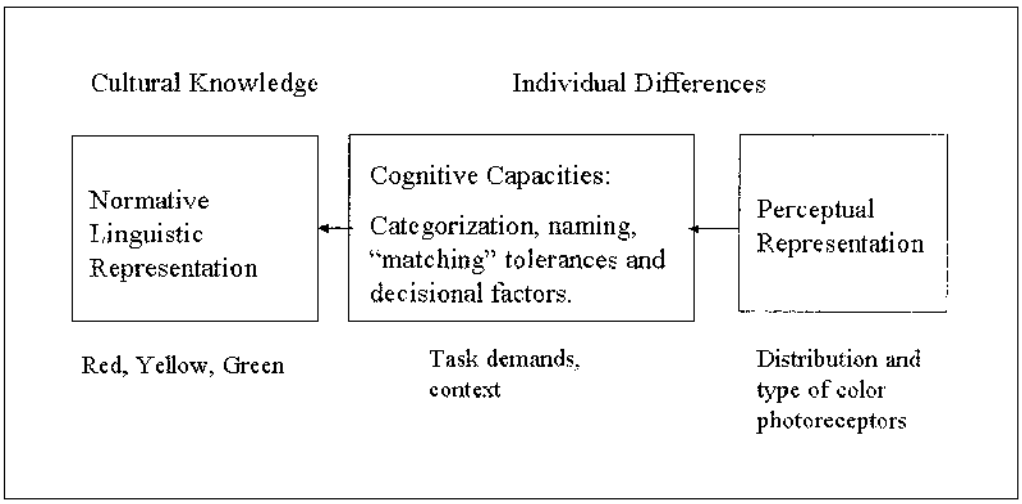

FIG. 4: Hypothesized mapping of names to color representations.

terms to representations, both over time and place and over different cognitive functions.

A straightforward case of mapping occurs when the visual representation of an object is associated with the verbal representation for that same object. Naming processes can also link verbal representations to other verbal representations. This occurs in: (a) judgments of synonymity, (b) acquisition of new vocabulary defined using existing terms, (c) when concrete terms acquire added abstract meaning, and (d) when figurative language is used, such as metaphor or metonymy.

Because the naming process can link different types of mental representations, there is the potential that different types of representations will map to the same lexical terms in a different manner. Use of different types of representations in different tasks or even different types of representations by different subjects within the same task is highly likely (Santa, 1977). For example, Jameson (submitted) describes three possible types of representations for color: (1) an idiosyncratic perceptual representation; (2) an idiosyncratic cognitive representation; and (3) a normative linguistic representation. These are shown in Figure 4. The first, perceptual representation, depends on an individual's perceptual capabilities (e.g. whether someone is a dichromat or a trichromat, or the distribution of color photoreceptors on the retina). The second, cognitive representation, depends on an individual's cognitive capacities operating upon the perceptual representation, such as discrimination tolerances when matching samples, resulting in greater or lesser willingness to consider two samples identical. The third, linguistic representation, maximizes communication within a society by emphasizing those attributes of stimuli most relevant to that culture, as when a cattle-raising society creates specific color terms for distinguishing the colors of hides. As Jameson describes, personal mental representations may map to linguistic representations differently in different individuals or differently in the same individual in different contexts. These different

mappings may be interconnected in naming behavior and thus may be quite difficult to disentangle experimentally.

Despite the idiosyncratic color experiences of individuals, societies may map culturally constrained linguistic terms onto those varying color experiences in roughly similar ways, forcing an emergent universality such as that reported by Berlin and Kay (1969). Existence of underlying cognitive naming processes might facilitate that universality. Thus shared color neurophysiology may not be the only explanation for observed regularities in the emergence of color terms cross-culturally. Similarly, the problems introduced when mapping from the idiosyncratic to the cultural do not necessarily negate the existence of underlying similarities in cognitive processing, whether in color neurophysiology or color cognition. However, comparisons across tasks eliciting different types of representations, both mapped to language, may obscure such similarities.

9. Judging synonymity

Names are not unique specifiers. Two different names can apply to the same entity or referent, or the same name can apply to several different entities or referents. For example, the substance NaCl can be called either "sodium chloride" or "table salt." The term "red" can apply to several different shades of color or even be used figuratively, as in "I saw red" to refer to anger. Because there is no invariant one-to-one mapping between lexical terms and referents, an evaluative process is needed to determine the meaning. The context in which a term appears is used to limit the possible meanings and guides the flexible mapping of terms to referents.

Synonymity is a problem for those attempting translations between two languages, or attempting to determine similarity of meanings between terms. Substitution has been used as a test of synonymity. Again, context is crucial to meaning. Putnam (1988) has proposed that equivalence of referents can be determined by substituting each referent into the same real-world context. Those that behave similarly in the same context can be considered to be equivalent. To use Putnam's example, we can determine whether two substances are both table salt by seeing whether they taste the same, both dissolve in water, both have the same chemical composition, and so on. As has been done in stimulus-equivalence studies, we can judge equivalence of perceptual representations by training an organism to respond to a given stimulus (e.g. a circle), then gradually changing the shape of that stimulus until the organism no longer responds. Substitution of names into lexical contexts does not fully establish synonymity or equivalence because flexibility in the mapping of names to referents permits linguistic charity, even within the same culture and language. A term that doesn't do a particularly good job of naming an item can be made to fit by treating that word more metaphorically, changing the category boundaries designated by the term, or similarly adjusting the criteria used to decide what to call a given referent. So, we have subjects willing to use the word "disgust" to refer to physical revulsion but also willing to use it to describe a state of anger (e.g. "I am disgusted that we had to wait so long"). An apparent category boundary

violation occurs because subjects will substitute the word "disgust" into sentence frames generated to describe anger situations (Russell & Fehr, 1994).

One implication of this is that cross-cultural divergence in emotion term usage can shed little light on the universality of the subjective experience of emotion, color, or whatever referent is being named differently in those cultures. Variation in naming cannot prove variation in experience unless the naming contexts and the naming processes are held constant. In the case of our study of Vietnamese-speaking subjects who named color samples, their use of modifiers and access to terms varied across languages (English versus Vietnamese) and across acculturation levels (bilingual versus monolingual speakers). The result was a language-related difference in naming behavior that may have nothing to do with cultural relativity, underlying perceptual experiences, or color cognition.

10. The Interpoint Distance Model

One way of characterizing naming behavior is the Interpoint Distance Model (IDM) proposed by Jameson and D'Andrade (1997) to explain Berlin and Kay's color naming results (see also Jameson, in submission). The extended form of the model proposed here consists of the following axioms: (1) in addition to category structure and lexical content, assignment of names depends upon both the number of names available and the extent of the stimulus space to be named; (2) names will be assigned to items in order to maximize their information content; (3) best exemplars of names will be located at points that equalize the distances between them with each new point maximally distant from existing points; (4) when the number of names available increases over time, the location of the first names applied to a space will partially determine the location of subsequent names; (5) confidence judgments depend on the mappings produced by the naming function, not the salience of items nor their characteristics; and (6) changing the stimulus space or the number of names available will change the locations of focal exemplars and category boundaries.

Our previous research suggests that names are chosen to optimize information content across a set of items to be named. It also suggests that when naming occurs under speeded response or cognitive load, it relies more heavily on category structure. The speed–accuracy tradeoff is reflected in lessened precision of meaning in the use of language as well as in the use of more global visual processing or other heuristics that permit one to function under cognitive load. This account suggests that the focal or basic item will be the item that is most salient. The properties defining its salience make it most readily detected. Thus, it is the most saturated color or the facial expression with the most distinctive movement cues. We believe theories describing the emergence of basic or prototypical exemplars are describing the elements that make such exemplars most salient in a context.

For example, Jameson and D'Andrade (1997) propose that irregularities in the shape of the perceptual color space and interactions between hue, saturation, and lightness result in "bumps" in the color space at the points identified as focal yellow and focal red. They suggest that the memory and other performance advantages

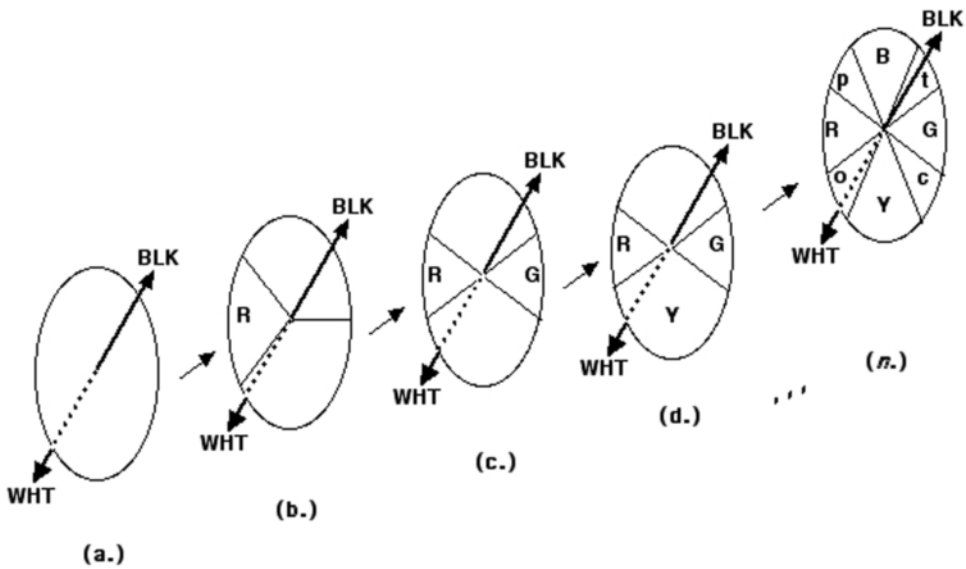

FIG. 5: Schematic of the IDM's dynamic partitioning of color categories in perceptual color space. The first partition (a.) divides a lightness axis that is perpendicular to the hue circle depicted. Subsequent partitions, (b.)–(*n*.), occur on hue or saturation dimensions.

found for focal colors in some studies result not from underlying opponent-process neurophysiology, but because people have access to the perceptual structure of the stimulus space in which those colors are maximally distant from each other. When the task is less constrained, finer discriminations among stimuli can be made and reliance upon salience or the perceptual structure of the stimulus space is replaced by attention to whichever aspects of stimuli are needed to perform the task. In the latter situation, experience with the extent of the stimulus space and the extent of the names available for use (either in memory or provided by the experimenter) permits the subject to infer the level of specificity required and select a suitable name. Thus, the idea of a naming function is not inconsistent with proposed theories of basic or universal color or emotion recognition, nor the special status accorded certain natural kinds (Keil, 1996), but rather, such phenomena may be considered a subcase of naming behavior that occurs under constraints. These subcases can be encompassed by general principles that also describe what happens when subjects are not under such constraints.

Jameson and D'Andrade (1997) applied the IDM to describe the locations of best exemplars of colors in perceptual color space, as shown in Figure 5.

The partitioning of the space depends upon the number of names available to designate items. If only two names are available to describe all exemplars, then the space is divided so that regions are balanced in size, cover the entire space to be named, and focal exemplars are both central to their categories and maximally distant from each other. Division of the space into dark/cool versus light/warm, as suggested by Berlin and Kay, accomplishes this. If a third term is added to that space, the location of the third focal exemplar will be at a point in space maximally

distant from the first two and the positions of all three will shift accordingly. The area called "red" is the position in color space most distant from the original division into two regions, consistent with Berlin and Kay's finding that "red" is usually the third color term acquired. The next split depends on the placement of the first three focals. As Jameson and D'Andrade (1997, p. 312) explain, "After these three terms are in place, it becomes more difficult to determine which is the next most distant region because the differences in distances are smaller and depend in part on how the focal areas are determined." Based on the distances between centroids in the OSA space computed by Boynton and Olson (1987), Jameson and D'Andrade predicted that either yellow or blue would be the next split, followed by green, purple, pink, orange, brown, and grey. This is consistent with the results found by the World Color Survey. Jameson (2001) further notes that if the light mixture color space is considered instead of the surface color space described by OSA coordinates, then yellow or green is predicted as the next color after red. Yellow is predicted when the dimension of saturation is most salient. Yellow, the least saturated color under maximal brightness, balances red, which is the most saturated color. Green is predicted when the dimension of lightness (brightness) is most salient, because it is chromatically opposite to red (for a more complete explanation of why different predictions emerge with shifts in attention to dimensions, see Jameson, 2001). As Kay and Maffi (1999) note, the sequence of emergence of color names after "red" differs in different cultures. The color appearing fifth depends upon what emerged fourth, and so on. This different schedule of emergence also depends upon differences in the need to make contrasts among items in the world. A word doesn't emerge unless it is needed to differentiate among items that vary by color.

Segmentation of the stimulus space need not be solely by division into equal-sized regions with equidistant focals. Garner's (1974) discussion of feature redundancy and pattern goodness can be applied to understanding categorization of other stimuli. A stimulus space can thus be partitioned in a multitude of ways depending upon the characteristics of items to be classified. Further, different partitions may occur in different dimensions. It is also conceivable that basic and more specific terms might be applied to nested subsets of items, forming confidence regions for names mapped to "sweet spots" in the stimulus space. For example, Indow (1988) has identified "sweet spots" in the perceptual color space for the dimension of color saturation. This nested subset partitioning makes sense for the dimension of saturation while mutually exclusive subsets make sense for hue. Formal applications of topology to concept structure as revealed in meaning spaces are beginning to be made.

Numerous studies have considered the dimensionality of emotion term and facial expression stimulus spaces, typically faltering with the interpretation of third and subsequent dimensions because no descriptive term fully captures the differentiations among items in the third and higher dimensions. This suggests that dimensions might define the extent of a stimulus space, but location of items within that space may depend more upon interrelations among items. Thus it may be more suitable to create models that describe emotions in terms of clusters defined by both their similarities and differences. Different sets of redundancies among features may

define different clusters within that stimulus space for different purposes, and names may reflect that considerable complexity. By definition, the first two dimensions of a stimulus space account for most of the variance and thus describe what items in that space have in common. That overall commonality may be uninteresting compared to the finer differences that are named when distinguishing stimulus clusters or nested subsets. Whether emotion or emotional facial expressions are better described in terms of dimensions or basic categories (clusters, mutually exclusive subsets) depends ultimately upon the purpose at hand, just as selection of names during communication depends upon task demands.

We propose that mapping of names to items is not a one-time event, but occurs repeatedly and flexibly as needed to communicate and accomplish other cognitive tasks. Thus the stimulus space can shrink or expand, can change its members, and names can shift accordingly. An apple can be grouped with fruits and vegetables during one sorting task, grouped with red items in another, called an "apple" at one moment and a "fruit" later on, depending upon context. Unless constrained to a particular stimulus set by task instructions, an individual can consider just the set of items presented by a task, or the entire set of possible items existing in the world or in imagination. While people attempt to infer the intended bounded stimulus space, they do not always make the same assumptions about it. Hence different subjects may assign names differently within a single naming task. A consequence of the large impact of these factors upon naming behavior is that if universality is expected to emerge, it must be given a fair chance to do so.

11. Conclusion

The IDM is only one of numerous possible explanations of observed naming behavior. It is obviously premature to advance it as a final explanation of naming. Our concern here is that naming behavior be explored in its own right, because of its strong impact on other theoretical questions and because it is a likely foundation for other interesting aspects of cognition, including metaphor and figurative language. In the meantime, theorists considering universality of such phenomena as color cognition or emotional experience must take a closer look at the contribution of naming behavior to their debates.

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