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COLOUR CATEGORIES AND CATEGORY ACQUISITION IN HIMBA AND ENGLISH

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For over fifty years, the domain of colour categorization has been used as a testing ground to investigate the degree to which culture (through language) might influence thought. While it has been known for many years that different cultures use different sets of linguistic categories to describe the visible range of colours, many researchers retain the view, first put forward by Berlin and Kay (1969) that there is a particular set of basic colour categories, shared between all humans, named in English by basic colour terms (BCTs) and deriving from the structure of the visual system (e.g. Guest & Van Laar 2002; Munnich & Landau 2003). These basic categories (named in English as: *red, green, blue, yellow, black, white, grey, pink, orange, purple* and *brown*) are considered distinct from other terms (for example, *turquoise* or *maroon*) because they are known to all members of a community, not subsumed within another category and generally named with mono-lexemic words (Kay, Berlin & Merrifield 1991). This view proposes that the organization of cognitive representations of colour (the set of possible categories) is tightly constrained by perception, even though the organization of linguistic categories for colour varies widely.

At the same time, there is a growing body of evidence, from a variety of other cognitive domains, that interactions between culture, language and thought are widespread and complex. Gumperz and Levinson (1997) found that variations in number systems were mirrored by differences in numerical reasoning, and both Levinson (1996), Levinson, Kita, Haun and Rasch (2002) and Choi, McDonough, Bowerman and Mandler (1999) found similar results for cultures whose categories for spatial relations differed. Malt and Johnson (1998) found that category judgments for artefact categories were made in line with semantic categories; a result also found for classification by material or shape by Lucy (1992), for time by Boroditsky (2001), and for modes of motion

by Gennari, Sloman, Malt and Fitch (2000). Roberson, Davidoff and Shapiro (2002) found that speakers of a language that does not distinguish basic shape categories (square, circle, and triangle) were unable to sort stimuli into these categories, whereas Sera and colleagues (Sera, Berge & Pintado 1994; Sera, Elieff, Forbes, Burch, Rodriguez & Dubois 2002) have reported differing effects of grammatical gender on classification across languages. Thus the weight of evidence in favour of tight links between culture, language, and thought would make colour a unique field of classification, if cognitive colour categories can truly be independent of the terms used to describe them.

A series of cross-cultural studies of adult colour categorization have found consistent differences in a range of perceptual and memory tasks, systematically linked to the colour categories in each culture (Davidoff, Davies & Roberson 1999; Roberson, Davies & Davidoff 2000). Most recently, Roberson, Davidoff, Davies & Shapiro (2005) have shown that, even though two coding systems may appear to be superficially very similar, speakers of the two languages encode, remember and discriminate colour stimuli in different ways. Himba, a language spoken by a semi-nomadic, cattle-herding people in South West Africa, shows similarity in its number of linguistic categories for colour to Berinmo, the Papua New Guinean language previously studied by Roberson et al. (2000). Both languages have five basic colour categories, according to the criteria of Kay et al. (1991). However, Himba participants showed categorical perception only for their own linguistic categories and not for either the supposed universal categories, as occurring in English, or to those of the Berinmo language.

These findings might be accounted for in several different ways. Firstly, it might be the case that all adults have a universal set of cognitive categories that may be innately determined and independent of the terms used to describe them. Despite this, they might always recruit a culture-specific naming system, even when making perceptual matching judgements for colour, so that two items that are called by the same name would always be judged more similar than two items that are given different names, as suggested by Munnich and Landau (2003). This seems unlikely, however, for three reasons. Firstly, there is no correspondence between BCTs and any processes yet found in the visual system (Boynton 1997; Webster, Miyahara, Malkoc & Raker 2000; Valberg, 2001) that would support such a universal categorization system. Secondly, nameability has been shown to be an important feature of colour sets, independent of any perceptual qualities of focality (Guest & Van Laar 2002), and thirdly, a number of recent cross-cultural studies have found no increased salience for the proposed universal ‘focal’ colours (Davidoff, Davies &

Roberson 1999; Jameson & Alvarado 2003; Özgen & Davies 1998; Roberson, Davidoff, Davies & Shapiro 2004; Roberson et al. 2005) around which it has been suggested such universal categories develop (Rosch Heider 1972).

Alternatively, all humans might be born with a universal set of cognitive categories, that are later distorted by learning the appropriate set of categories for their language (Bornstein, Kessen & Weiskopf 1976; Franklin & Davies 2004). Such distortions might arise if learned colour categories were mentally represented by prototypes and these stored representations acted as perceptual magnets, distorting the perceived colour space. Some recent studies of languages having eleven basic categories (Sturges & Whitfield 1997; Guest & Van Laar 2000; Lin, Luo, MacDonald & Tarrant 2001) have provided some support for the pre-eminence of category centres, or 'foci'. Moreover, recent training studies have shown that new categories can be induced for brightness (Goldstone 1994) and for hue (Özgen & Davies 2002). However, many recent studies have suggested that cognitive organization changes in these cases, because there is a shift in attention to differences at category boundaries that causes enhanced discrimination of boundary items, relative to category centres (Özgen & Davies 2002; Roberson & Davidoff 2000; Pilling, Wiggett, Özgen & Davies 2003; Goldstone 1998). Such a mechanism for category acquisition would imply less, rather than more attention to category centres, over time.

Finally, it might be the case that there is no single set of categories that is universal and independent of culture and language, and that all divisions of the perceived continuum of colour must be learned. In that case, individuals who have yet to learn the set of categories appropriate to their own culture and language might still group colours in a principled way, such as by similarity, but fail to categorize along the lines of the proposed universal set. The tendency to group by similarity is pervasive, both across cultures and across cognitive domains. Colour cognition is no exception to this and no culture / language has yet been reported that violates this principle by grouping together two areas of colour space (for example, yellow and blue) in a category that excludes the intermediate area (for example, green).[1] Roberson, Davidoff and Braisby (1999)

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[1] However, McNeill (1972) documents a number of instances of languages in which a term comes, over time, to be used for either one of opposing colours (red / green or blue / yellow) in different derivative languages. In the case of Slavonic languages, the same term, *plav*, at different times has meant 'pale yellow / blonde' in some East Slavonic languages, but 'pale blue' in some South and West Slavonic languages. Fasske, Jentsch and Michalk (1972) suggest that the original meaning of the term in Proto-Indo-European was 'pale' or 'grey' and that the 'yellow / blonde' meaning came from the 'pale' sense, while the 'pale blue' meaning came from the 'grey' sense.

found that an adult patient with colour anomia, who had lost the ability to categorize colours, explicitly grouped colours on the basis of perceptual similarity. If categories are initially formed based on the relative similarity of stimuli, as Dedrick (1996) and Roberson et al. (2000) have argued, then both the range of available stimuli in the environment and variability in the need to communicate about colour should affect the eventual set that a community arrives at.

A further set of studies examined this question by turning to a new source of evidence: the acquisition of colour terms by children. Estimates of the age at which children acquire a minimum colour vocabulary (four basic terms) have dropped from the 7-8 years of age estimated by Binet and Simon (1916) to 2-3 years (Shatz, Behrend, Gelman & Ebeling 1996; Andrick & Tager-Flusberg 1986), but competent use of a full set of BCTs is acquired relatively late, compared to other dimensional terms (Bornstein 1985; Mervis, Bertrand & Pani 1995; Soja 1994; Sandhoffer & Smith 1999) even by English-speaking children for whom the set of basic terms to be acquired would be just those that are presumed to be universally present before the correct terminology is acquired. With constant intensive training, children as young as 1.5 years can produce and use some colour terms accurately (Cruse 1977; Mervis, Catlin & Rosch 1975), but hundreds of training trials are required to reach such early competence (Rice 1980), compared to the single presentation learning demonstrated for object terms (Carey 1978). With choices restricted to only two widely separated colours (for example, red and green), young children may show the same degree of success as for dimensions such as size or form (Pitchford & Mullen 2001) but, without intensive input, estimates of the age at which children acquire a full set of colour terms fall between two and six years, depending on the number of terms examined and the measures of knowledge taken. Our studies examined naming and comprehension systematically over a three-year period in order to establish a reliable measure of children's colour term acquisition.

The study also examined whether colour term acquisition might differ in speakers of different languages. In the framework of a presumed innate, universal fixed set of colour categories, Bornstein (1985) predicted that acquiring colour terms would be even more difficult for children learning a language in which the innate universal set must be over-written by a new set, even if there were fewer terms to be learnt. They might have to assimilate their existing hue-based universal categories into a new and orthogonal set of semantic categories based on another dimension, such as lightness in the case of the Dani reported by Rosch Heider (1972). Similarly, Bowerman and Choi

(2003) suggest that, the more robust and pre-potent the pre-linguistic organization of the perceived world is, the greater the resistance that language acquisition would have to overcome, in order to re-structure mental life. Thus, the acquisition of a set of named categories that are different to the presumed set of innate, universal categories might show a different developmental pattern to that of English-speaking children.

Roberson et al. (2004) addressed these questions in a study that included a group of young English children, who were tested initially before they entered pre-school and, subsequently, through three years of formal education, and a group of Himba children from northern Namibia, few of whom received any formal education during the period of the study. Himba has five BCTs according to the criteria of Kay et al. (1991). Children's colour term knowledge and memory for colours were tested at six-month intervals over three years. At the first test, 32 English three-year-olds and 36 four-year-olds were tested, along with 42 Himba three-year-olds and 27 Himba four-year-olds. In the longitudinal sample, 28 of the English three-year-olds and 63 of the Himba children completed all six tests. All had normal colour vision. Color Aid matte stimuli were used (best examples of black, white, grey, red, orange, yellow, green, blue, pink, purple and brown, together with eleven intermediate colours). The children completed a colour term listing task ("tell me all the colours that you know"), colour naming ("what colour is this?"), colour term comprehension ("can you find a red one?") and a recognition memory task in each of the six testing sessions. Full details of the methodology can be found in Roberson et al. (2004).

Despite the considerable environmental, linguistic and educational differences between the two groups, there were some noticeable similarities in our data. Considering the order in which colour terms were learned, the order of acquisition observed over time differed according to the measure used and showed great individual variation. However, no measure showed the pattern, predicted by universalist theory, in which primary colour terms (in English: *red, blue, green* and *yellow*) are learned before non-primary terms, a finding consistent with other recent studies. Over the course of the longitudinal study, neither population showed a predictable order of acquisition, and there were considerable individual differences in term acquisition, such that terms for brown and grey were acquired very early by some children, although the English group, as a whole, acquired the terms *brown* and *grey* later than other terms (consistent with Pitchford & Mullen 2002). The present study supported previous findings of the lack of a predictable order of term acquisition in both languages (e.g. Macario 1991; Mervis et al. 1975; Pitchford & Mullen 2002;

Shatz et al. 1996).

Considering the trajectory of colour term acquisition in the two cultures, the longitudinal results suggested that children continue to refine their conceptual colour categories for some years after they first show evidence of term knowledge for 'focal' colours. Previous cross-sectional studies have found conflicting evidence about the age at which children reliably produce and use colour terms appropriately. This could be due to the wide range of methodologies used, the number of colour terms assessed, or to increased developmental variability introduced by the use of chronological, rather than language age as a measure, as suggested by Pitchford and Mullen (2003). A further possibility, uncovered by repeated testing in the present study, is the tendency of children to subsequently fail either to name or to comprehend a BCT that they had previously used correctly (the mean subsequent failure rate was 8% for both groups). Such error-prone performance may help to explain the inconsistency of previous estimates based on a single test of knowledge.

Children know that a set of terms refer to 'colour' and can select colour as a property on which to match objects as early as two years of age (Soja 1994). In the present study, three-year-olds in both cultures listed only colour terms when asked, demonstrating their understanding of colour as a dimension. However, even at the end of the study, some children from both language groups could not correctly apply all their BCTs (even though the English children had had three years of specific instruction). Despite the similarities in learning trajectory across the two populations, English children acquired their first colour words earlier than the Himba. Greater exposure to coloured objects and the increased cultural salience of colour in Western society may contribute to an earlier conceptual understanding of colour as a separable dimension. However, from then on, the differences between the groups are less marked than the similarities, which are clearly seen in their performance on the recognition memory tasks.

At the first time of testing, for both Himba and English children who knew no colour terms, the pattern of memory errors was very similar, and, crucially, neither pattern resembled that derived from the eleven basic categories of English. Both appeared to be based on perceptual distance rather than a particular set of predetermined categories. Additionally, for this group of children, there was no advantage in memory for the stimuli that were central (focal) to the BCTs in either language. This finding supports the hypothesis that the eleven basic categories that exist in English are not cognitive universals, and conflicts with the findings of some studies of infant colour categories (Bornstein, Kessen & Weiskopf 1976; Franklin & Davies 2004). We return to

this issue later in the discussion.

In our longitudinal study, from an initial reliance on perceptual similarity, an advantage for the (language appropriate) set of focal colours became evident as soon as children acquired colour terms. Of those children knowing one or more colour terms at the first time of testing, English children showed superior memory performance for the items that are focal to English, but not to Himba categories, while Himba children showed the reverse pattern. Such rapid divergence in the cognitive organization of colour for the two groups, from the time that the first terms are learnt, suggests that cognitive colour categories are learned rather than innate. Thus, these data, like those for adult Himba and Berinmo speakers, argue against an innate origin for the eleven basic colour terms in English.

For both populations, once colour terms were acquired, memory performance was determined by the number of terms known. Children made more correct identifications of focal items for terms that they knew than for terms that they did not, regardless of the absolute number of terms known. Thus, the effect of term knowledge on memory cannot be an artefact of superior memory, and language skills of children with higher general intelligence; children who knew more terms got the same proportion of the items they knew correct as those who knew few. Knowledge of even one colour term appears to change the cognitive organization of colour, and from this point on there are language-dependent differences between the two groups. Once knowledge is acquired, it appears to restructure the cognitive organization of colour in a reliable way, and this restructuring relates to term acquisition per se, not to maturation or educational input. Additionally, the type of recognition errors made changed over time. The perceptual distance of memory errors decreased as children learned more BCTs and, in most cases, more within-category than across-category errors were made at later tests.

Acquisition of term knowledge caused a reduction of memory errors, and these changed in nature over time. The effects of naming were particularly evident in the case of two items that were called by the same name in one language and by different names in another, such as navy blue, or dark orange. By the time children were six years old, the few errors that were made to these tiles were to within- rather than cross-category items, regardless of perceptual distance. It was not simply the case that improving memory allowed children to make fewer and less distant errors. There were two cases, however, in which perceptual and categorical errors could be directly contrasted. One was the navy blue tile, which lies perceptually between English focal blue and black. For English speakers, this tile is in the same category as the focal blue tile. For

Himba speakers, however, it is in the same category as the black tile (and both are equally focal). Within the test set, there was also a closer perceptual alternative than either of these; the English focal purple tile. If choices were only influenced by perceptual similarity, the purple tile should have been a more frequent erroneous choice than either the lighter blue or the black tile for both populations. A similar comparison was carried out for children's performance on the dark orange tile, which lies perceptually between English focal red and focal orange. For English speakers, this tile is in the orange category. For Himba speakers, however, it is in the same category as the red tile (and also focal). The red tile is also the closest perceptual alternative within the set. If choices were only influenced by perceptual similarity the most frequent erroneous choice for both populations would be the red tile. In both cases, errors in early tests were very varied, for both groups of children. In later tests, although there were fewer errors, these diverged and, within each language group, were significantly more likely to be made in connection with the best example of the category into which the tile fell. For example, by the sixth test, the only errors made by English children for the navy blue tile were to the focal blue tile. Over the same period, Himba children's errors narrowed until the only errors made were to the (within-category) black tile

The advantage for items central (focal) to children's native language categories also increased throughout the longitudinal study. Thus, the importance that Rosch gave to focality in establishing categories seems justified from the present data; nevertheless, it is important to stress that the focality is not universal but, as shown both at first testing and longitudinally, it is language dependent. For English children, this effect may be unsurprising since these are just the colours that are taught from the earliest age, and most readily available in their playthings. For Himba children, focality was determined on the basis of adult naming agreement. Those targets deemed focal were those for which over 90% of adults agreed on the name. Other targets received little adult naming agreement. Himba children do not encounter constant presentation, through printing, dyeing and screen images of best example, highly saturated colours. In their environment only muted, natural colours are encountered, for which adult naming might often disagree. Children should then learn more quickly those colours that adults reliably call by the same name, hence the more accurate results for 'focal' colours.

Himba, like many other traditional cultures, has fewer than eleven basic categories, each containing a wide range of exemplars, each extending to very desaturated colours, and with little inter-individual agreement among adults on where the best examples of categories are located (Roberson et al. 2000;

MacLaury 1987; Rosch Heider & Olivier 1972). Without the full range of saturated stimuli that can be artificially produced, traditional communities may have no need of the finer categorical distinctions required when a wider variety is available, and thus lack the motivation to refine their colour lexicon further.

However, a large proportion of the world's major languages have the same number of colour categories, and one may ask why. It is possible that the eleven-colour organization yields the optimal combination of discriminability and cognitive economy for recognition and representation of large numbers of colours. If so, languages with fewer terms would gain by introducing / borrowing new terms, when increasing technological advances or contact with other cultures introduced a greater need to communicate more precisely about colour. Nevertheless, even if the eleven-term organization were found to be optimal, and eventually adopted by all cultures, it need not be innate.

Early studies by Bornstein and colleagues (Bornstein, Kessen & Weiskopf 1976; Sandell, Gross & Bornstein 1979) suggested that categorical divisions between red, green, blue and yellow might be innate and perceived categorically by both infants and other primates. However, there were methodological issues with these studies (Banks & Salapatek 1981; Werner & Wooten 1985) and, under controlled conditions, Davidoff, Goldstein and Fagot (2004) found qualitatively different colour categorization in humans and primates. Franklin and Davies (2004), using a preferential looking technique, found that 4-month-old infants showed categorical novelty preferences for a wide range of colour categories, both across hue boundaries (such as that between blue and green) and across brightness boundaries (such as that between pink and red), but there are reasons to be cautious of interpreting infant 'categorization' as resembling that acquired later in life.

Infants show remarkable abilities to form short-term dynamic 'on line' categories, within a preferential looking paradigm, for a wide range of stimuli such as cats and lions (Quinn & Eimas 1997), but these categorizations are labile and can change when the perceptual features of the input are changed (Rakison & Butterworth 1998a, 1998b). Moreover, recent work by Bremner and others (Bremner & Bryant 2001; Bremner & Mareschal 2004) suggests that colour and location information are processed separately in infants, and that dorsal and ventral streams of visual processing are not integrated until much later in development. This has been proposed as an explanation as to why children of 2-3 years of age often fail on other categorization tasks that infants appear to have passed, since it is around this age that children begin to try to integrate information about colour, shape, texture and location of stimuli. Xu and Carey (1996; Xu, Carey & Quint 2004) have also shown that, even at 12

months of age, infants fail to represent perceptual features of objects such as colour, size or pattern and they suggested that infants' representational systems only begin to distinguish kinds and properties of objects towards the end of the first year of life.

Given the difficulty in interpreting infant performance on preferential looking tasks, Roberson et al.'s (2004) study set out to examine when and how children acquire a set of colour categories appropriate to their own language and culture. The results suggest that children gradually acquire the organization of such categories, and progress gradually from an uncategorized organization of colour based on perceptual similarity (where dimensions are viewed as continua) to a structured organization of categories that varies across languages and cultures. The increase in the influence of linguistic categorization on memory for colours is progressive and cumulative in both groups. Moreover, without intensive adult input, colour category acquisition is universally slow and effortful.

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