Basic colour terms in Modern Greek

Twelve terms including two blues

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We describe an investigation of Modern Greek colour terms intended to establish its set of basic colour terms (BCTs). Pilot work suggested that Greek had terms for each of the Berlin & Kay (1969) eleven 'universal categories'. These terms, plus [γalázjo] "light blue", were the most frequent terms in Greek texts. Four naming studies with varying stimuli (Munsell, Color-aid and NCS), lighting (daylight, illuminant C and fluorescent), instructions (no restriction on terms or only essential terms), and informants (bilingual Greek-English students and monolingual Greek speakers from Crete) were carried out. Measures of basicness included frequency, consistency and consensus of use, naming time and 'necessity'. The results supported the analysis of texts, suggesting that Greek has twelve BCTs, including two terms for blue. The ranges of the two blue terms differ mainly in lightness, and this division is similar to the equivalent divisions in Russian and Turkish. However, the positions of the best examples vary across the three languages presenting difficulties for a common account of the origins of the additional term. The use of BCTs was reasonably stable across variations in methods, stimuli, lighting and informants, suggesting that field studies with limited control over these variables may nevertheless be able to identify BCTs.

Keywords: Greek, basic colour terms, colour universals, field methods

1. Introduction

We report a series of studies of Greek colour terms carried out within the framework of Berlin & Kay's (1969) theory of universal colour categories. The main aims of the study were to establish the inventory of 'basic' colour terms (BCTs) in Greek, and to see if, like Russian (e.g. Corbett & Morgan 1988) and Turkish (Özgen & Davies 1998), it has two BCTs for blue, *μπλε* [blé] "blue" and *γαλάζιο*

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[γalázjo] "light blue". In addition, because the stimuli, lighting, instructions and informants varied across four naming studies, we were able to assess, to some extent, how important these variables are for determining and mapping BCTs. We first outline Berlin & Kay's (1969) theory, and then consider likely Greek BCTs. This suggests that Greek may have twelve BCTs, and we consider how this could be accommodated by the theory. We then outline our methods, emphasising how comparisons across the four naming studies can be used to test the theory, and in turn how these comparisons may be used to assess the importance of controlling variables such as lighting, instructions and stimuli in fieldwork.

1.1 The Berlin & Kay theory

Before Berlin and Kay (1969), the prevailing belief was that languages encoded colour without constraint (e.g. Ray 1952, Gleason 1961). In contrast, Berlin and Kay argued that all languages encode from two to eleven BCTs drawn from a universal inventory of just eleven colour categories as shown in Figure 1. According to the theory, languages fall into one of seven possible evolutionary stages as they acquire BCTs in the order illustrated by the hierarchy. Languages first encode BLACK and WHITE then RED, then either GREEN or YELLOW, and so on, up to the theoretical maximum of eleven BCTs (Berlin and Kay's stage 7).

The concept of basicness is central to the theory. Basic terms are the minimum set required to name all colours. Languages may have many additional non-basic terms, particularly sub-divisions of BCTs, but they are not essential, in that they can be replaced acceptably with the superordinate BCT. According to Berlin & Kay (1969), BCTs should be: (a) simple (thus not *greenish-blue*); (b) their meaning should not be included in another term's (thus not *scarlet*, which is wholly included in *red*); (c) general (thus not *blond*); (d) used frequently and with good agreement across speakers (thus not *taupe*). In practice these criteria converge and terms, which are used frequently and with good agreement across informants, also tend to meet the linguistic criteria for basicness.

BCTs are defined by their foci — the best examples of the terms. According to Berlin & Kay (1969) the positions of the BCT foci tend to occur in one of just eleven small 'privileged' regions of colour space, rather than being uniformly dis-

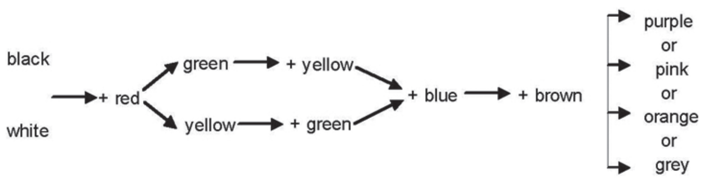

Figure 1. The Berlin and Kay hierarchy of basic colour terms.

tributed across the space. On the other hand, category boundaries vary considerably. This variation is most notable when comparing languages with relatively few terms with late-stage languages. The categories of the former tend to be larger than the latter, encompassing all colours, and thus the positions of the boundaries are almost necessarily different. One implication of the importance of focal colours is that there should be at least one colour that is consistently named by most speakers. Moreover, this colour should be close to one of the privileged regions.

The original monograph stimulated great interest and criticism, which led to extensive fieldwork to test the theory. The theory has been modified to accommodate new findings (Kay & McDaniel 1978, Kay, Berlin, Maffi & Merrifield 1997, Kay & Maffi 1997) and continues to be very influential (but, for criticisms of the theory, see, for instance, Lucy 1997, Ratner 1989, Saunders & van Brakel 1997). The changes mostly affect the early stages of the hierarchy, and as Greek is almost certainly a stage-7 language (at least), most post-1969 developments are not directly relevant to it with one important exception. Kay & McDaniel (1978) distinguished between 'primary' and 'derived' BCTs. Primary terms are the first six terms on the hierarchy and their best examples are 'perceptual primitives' underpinned by 'fundamental neural responses'.[1] Derived BCTs are fuzzy set intersections of pairs of primaries; best examples of derived terms seem to be perceptual blends of primaries. For instance, ORANGE is RED-YELLOW, and PURPLE is RED-BLUE. This development is pertinent to our current purposes because it provides a route for languages to acquire more than eleven BCTs. We will return to this in Section 1.3.

1.2 Greek Colour Terms

Modern Greek is the unique member of the Hellenic group within the Indo-European family of languages (Babiniotis 1998a). It has two dialectal groups: Northern and Southern Greek. One variation of the Southern dialectal group, generally referred to as 'Athenian', has become standard Modern Greek. One of the most 'marked' (differing from standard Greek) of the Southern dialectal group is spoken on the island of Crete (Kontosopoulos 1997).

As a preliminary exploration, some Greek students in England translated the eleven Berlin and Kay terms from English into Greek. The Greek terms matched those given in Greek handbooks of linguistics as Greek representatives of the Berlin & Kay terms (e.g. Tsitsipis 1998). They are (in Greek spelling and in the International Phonetic Alphabet): WHITE *άσπρο* [áspro], BLACK *μαύρο* [mávro], RED *κόκκινο* [kócino], GREEN *πράσινο* [prásino], YELLOW *κίτρινο* [cítrino], BLUE *μπλε* [blé], BROWN *καφέ* [kafé], ORANGE *πορτοκαλί* [portokalí], PINK *ροζ* [róz], PURPLE *μωβ* [móv] and GREY *γκρι* [grí].[2] Consultation of English-Greek dictionaries supported the above with the exception of PURPLE. The term *purple* is translated as *πορφυρό* [porfiró], which is etymologically equivalent to *purple*, but as we shall see, is not equivalent in usage. Compounding the problem, back translating [porfiró] into English gives *cerise* rather than *purple*. The probable Greek term for PURPLE is *μωβ* [móv], as given above. This has the same etymological root as *mauve*. Similar problems occur with both English-Russian (Davies & Corbett 1994) and English-Catalan (Davies, Corbett & Bayo 1995).

The term [áspro] "white" originates from the Latin, [lefkó] and [mávro] "black" from Ancient Greek. The terms [kócino] "red", [prásino] "green", [cítrino] "yellow" and [portokalí] "orange" are derived from plant names. All of the above are both nouns (i.e. the colour itself) and adjectives (when accompanying a noun as modifiers). As nouns, they have eight forms, two numbers (singular and plural) and four cases for each number (nominative, genitive, accusative, vocative). As adjectives, they have in addition three genders (masculine, feminine, neuter). The terms [blé] "blue", [kafé] "brown", [róz] "pink", [móv] "purple" and [grí] "grey" are from French and are not inflected. The term [grí] "grey" though, has the derivative [grízo], which is used as a noun and an adjective, with inflected forms for all genders, numbers and cases.

In addition to these representatives of the Berlin & Kay (1969) terms, γαλάζιο [γalázjo] or γαλανό [γalanó] "light blue" seemed to have claims to basic status. It is used commonly, for instance, to describe the colour of the sea, the sky, the Greek flag, and blue eyes; these are rarely called [blé] "blue". Greek dictionaries translate [γalázjo] "light blue" as "the colour of the clear sky and of the calm sea". The term originates from the Ancient Greek word "κάλαϊς", which is the name of a stone with a greenish-light blue colour, found in Iran. [Υalázjo] "light blue" is both a noun with two numbers and four cases and an adjective with three genders, two numbers and four cases. One of the main aims of the studies we report was to see if [γalázjo] "light blue" was a BCT. Measured against the linguistic criteria for basicness it is a simple term and seems to be used generally. However, its meaning may be included in the meaning of [blé] "blue". Thus, one of the aims of the tests we used was to assess its independence. In addition, we used various measures of salience, such as frequency in texts, frequency of use in naming tests, and naming times. We expect BCTs to be distinguished from non-BCTs by high scores on these measures. It is worth noting here that some terms, such as the second Turkish blue term, are clearly basic in terms of salience, but less clearly so in terms of inclusion (Özgen & Davies 1998).

1.3 Twelve basic colour terms?

Berlin and Kay (1969) considered the possibility of a language encoding more than eleven basic colour terms and Kay and McDaniel's (1978) theory allows this.

Derived terms are ‘combinations’ of two primary terms. There are 15 possible pairs of primaries, but only five derived terms on the hierarchy. No explanation is offered as to why those five terms often occur as BCTs rather than any of the remaining ten. BLUE combines with RED to give PURPLE, but with no other term, according to the theory. In principle, it could also combine with BLACK, WHITE, GREEN and YELLOW, although the latter makes no psychological sense, in that blue-yellow are mutually exclusive perceptually, according to Hering (1964 [1920]).

Adding another blue term appears to be the most common way that languages move beyond stage 7. Russian has *sinij* “dark blue” and *goluboj* “light blue” (Corbett & Morgan 1988; Moss 1988; Morgan & Corbett 1989; Moss, Davies, Corbett and Laws 1990; Davies & Corbett 1994; Laws, Davies & Andrews 1995; Paramei 2005); Turkish has *lacivert* “dark blue” and *mavi* “blue” (Özgen & Davies 1998). There are also indications that other languages, such as Italian (Kristol 1979), Guatemalan Spanish (Harkness 1973), Peruvian Spanish (Bolton 1978) and Nepali (Bolton, Curtis & Thomas 1980) may be close to having two blue terms.

If Modern Greek has two basic terms for blue, the extra term [γalázjo] “light blue” could be the intersection of WHITE-BLUE, leaving [blé] “blue” as the token of the universal blue. Alternatively, [blé] “blue” could be the intersection of BLACK-BLUE, and [γalázjo] “light blue” the token of the universal blue. These alternatives may be resolved by comparing the best examples of the terms to the best example of the universal blue. Comparisons with the two blue terms in Russian and Turkish might also provide evidence as to whether the path to lexicalising additional terms is constrained by universal processes or is driven by local circumstance. If the former is the case, then the best examples of the light blue terms and those of the dark blue terms should be similar across languages.

1.4 The present study

The main aim of the present paper is to establish the BCTs of modern Greek with particular consideration of the status of the two blue terms, *μπλε* [blé] “blue” and *γαλάζιο* [γalázjo] “light blue”. By the end, we hope that it will become clear that eleven terms given earlier are Greek BCTs, and perhaps presumptuously, we will refer to them as such from now on to save space. This shorthand should be read as having an implicit qualifier, such as putative, or possible. Next, we outline briefly our methods, including measures of basicness, instructions to informants, stimuli and illuminants. (See also the Appendix for further technical explanation.)

1.4.1 *Measures*

We first analyse frequency in texts, which is associated with salience, as an indicator of basicness. BCTs should occur more often than non-BCTs, and primary terms more often than derived terms (Corbett & Davies 1995). We then describe a series of four naming studies from which we derive a range of measures of salience as further indicators of basicness. In all studies we report two measures for each term: frequency of use across informants; and frequency of use across colour samples. The latter measure is used to examine levels of agreement among informants. BCTs should be used frequently and with high levels of agreement, particularly for the best example of a term. In the first study, informants named the stimulus set twice and we report within-subject consistency of naming. This should be high for BCTs (Boynton & Olson 1987). In the second study we used naming times as an indicator of basicness. BCTs should be named faster than non-BCTs (Boynton & Olson 1987 and 1990).

We also use various operational measures to locate the foci of BCTs. In Study 2 (the first naming study, Section 3) we assumed that colours showing maximum within and across subject consensus were focals. In Study 3 (Section 4), tiles named quickly and with absolute agreement across informants were taken as focals. In Study 4 (Section 5), we assumed that tiles named with maximum agreement among subjects were focals. In Study 5 (Section 6) informants choose the 'best example' of each of the colour terms in the 330 Munsell stimulus array, and the most frequently chosen tile was deemed the category focus.

1.4.2 *Instructions*

We also varied the demand characteristics of our tasks, either explicitly, through instructions, or implicitly, by varying the range of stimuli. Instructions were to: use simple everyday terms (Studies 2–3); name the stimuli with no restrictions (Study 4); use simple necessary terms (Study 5). We expected that the use of BCTs would increase as the restrictions increased and that BCTs would occur in compound terms in the least restricted condition. The two restricted sets of instructions, particularly those requiring necessary terms, provide a way of testing the relationship between the two blue terms. If one was a subordinate of the other, then even if they were both used frequently when there were no restrictions, the use of the subordinate term should fall as restrictions increased.

The implicit instruction was implemented by using 40 stimuli from just the green-blue-purple region (Study 4). This was done to map the domain of the two blue terms more precisely, but also as a further check on their robustness. The context, as well as the specific stimulus, influences choice of names. Terms are used to distinguish among stimuli. Although the forty stimuli could be named correctly with just three (or four) terms — [prásino] "green", [blé] "blue" (and possibly [γalázjo] "light blue") and [móv] "purple" — there may be an implicit invitation to use more specific, subordinate terms, to make distinctions among the exemplars of the superordinate terms. If one blue term was subordinate to the other, the use of the subordinate term should increase with the restricted stimulus set. On the other hand, the use of both terms could decrease at the expense of more specific terms. The latter provides a further check on the robustness and the stability of the two terms.

1.4.3 *Colour stimuli*

Naming studies have used stimuli drawn from a number of commercial colour-order systems such as: the Natural Colour System (Appendix 1.1, e.g. Lin, Luo, MacDonald & Tarrant 2001a and 2001b), Color-Aid (Appendix 1.2, e.g. Özgen & Davies 1998, Turton 1980), Munsell (Appendix 1.3, e.g. Berlin & Kay 1969, MacLaury 1997, Sturges & Whitfield 1995), and the Optical Society of America (e.g. Boynton & Olson 1987). Provided colour-space is sampled adequately, it should make little difference which is used. Density of sampling has also varied considerably from samples of eleven (Senft 1987) to 1526 (Lin et al. 2001a, 2001b). The former may be enough to establish BCTs, but runs the risk of missing unusual terms. The denser the sampling, the greater the precision of mapping the range of each term and the lower the likelihood of missing rare terms should be. As a further check on the likely reliability of naming studies, we used stimuli from NCS, Munsell and Color-Aid, with dense sampling[3] and we compared naming patterns across the studies (Section 7).

1.4.4 *Illuminants and colour constancy*

BCTs are used in the everyday world across a range of illumination due to natural variations in sunlight and to the use of artificial lights (see Appendix 2.1). Changes in the illuminant will change the wavelength composition of light incident at the eye. To a reasonable extent, the perceptual system is able to partition out the illuminant variation, and colour perception is relatively constant (see Appendix 2.3). Even when perceptual constancy fails, naming constancy is robust (Troost & de Weert 1991). Variations in the illuminant might lead to naming changes for colours close to category boundaries, but they are unlikely to do so for category foci and their near neighbours.[4] Thus, stability across illuminants is likely to be a characteristic of basic terms, and we assess this in our studies.

There is a related reason for assessing stability of naming across illuminants. Most field studies of BCTs have used the prevailing illuminant (e.g. Berlin & Kay 1969, MacLaury 1997, Senft 1987, Turton 1980) usually with some care to avoid extremes, such as direct sunlight. The stimuli used are usually standardised under a prescribed illuminant (CIE illuminant C for Munsell and D65 for NCS) but this is rarely achieved in the field. Thus the usefulness of field studies relies (usually implicitly) on the effectiveness of perceptual and naming constancy. Laboratory studies, on the other hand, usually control the illuminant (e.g. Boynton & Olson

1987). We believe that provided they are done carefully, field studies that make the best of the available lighting are unlikely to be far wrong in their assessment of BCTs. Nevertheless, by comparing naming across illuminants, our premise can be checked (Section 7).

2. Frequency in texts

BCTs tend to have higher frequencies in texts than non-BCTs (Corbett & Davies 1995). Moreover, primary terms tend to have higher frequencies than derived terms. We searched the recently created Hellenic National Corpus for the frequencies of use of Greek colour terms. The Corpus consists of 20,600,984 entries, corresponding to 65,500 types, which produce 1,650,000 inflected tokens. The corpus is derived from written sources and is composed as follows: newspapers 69.10%, books 15.75%, magazines 6.97% and 8.27% from other sources, such as the Internet or leaflets. All of the entries are recent, starting in 1976, with most after 1990. The corpus has been tagged, but this is still under development, so the frequencies include colour terms functioning as adjectives, nouns or in set expressions. The only homograph, however, is the term [kafé], which, apart from "brown", can also be the singular genitive, accusative or vocative of the noun "coffee".

Table 1 shows the frequencies for the various terms with more than one entry. Likely BCTs are shown first, in the order of the hierarchy, followed by [γalázjo] "light blue", and then all probable non-BCTs with a frequency of ten or more. As expected, the primary basics have higher frequencies than the derived basics. However, [blé] "blue" with a score of 423 has the lowest score of the primary basics, with [cítrino] "yellow", the next lowest, having double the score (884). This may be due to the use of the additional blue terms, [γalázjo] + [γalanó] "light blue", which score 383. Combining the blue terms gives a score about equal to [cítrino] "yellow". This leaves the unusual feature of these data being the low scores for [portokalí] "orange" (85) and [móv] "purple" (61). Nevertheless, the latter terms still score more than all the remaining terms except [χakí] "khaki" with a score of 88. The next highest score is for [kastanó] "chestnut", which scores 53, and then there is a relatively sharp drop to [béz] "beige" (29). The score for "khaki" [χakí] overestimates its use as colour term, as it also means "army uniform". The term [kastanó] "chestnut" is used to denote eye, hair and skin colour, and its use is restricted in a similar way to *blond* in English.

In summary, frequencies in texts support the preliminary inventory of BCTs based on translation of English terms into Greek, and on dictionary analysis (with the exception of [móv] "purple"). In addition, [γalázjo] "light blue" (383) scores considerably more than [portokalí] "orange" (85), and [móv] "purple" (61) and

Table 1. Frequency in texts. Colour terms with more than one entry in the Hellenic National Corpus.

Term	IPA	Gloss	Entry
άσπρο	[áspro]	white	2592
μαύρο	[mávro]	black	3050
κόκκινο	[kócino]	red	1669
κράσινο	[prásino]	green	1986
κίτρινο	[cítrino]	yellow	884
μπλέ	[blé]	blue	423
καφέ	[kafé]	brown	591
πορτοκαλί	[portokalí]	orange	85
ροζ	[róz]	pink	304
μωβ	[móv]	purple	61
γκρί+γκρίζο	[grí]+[grízo]	grey	644
γαλάζιο	[γalázjo]+[γalanó]	light blue	383
χακί	[χakí]	khaki	88
καστανό	[kastanó]	chestnut	53
μπεζ	[béz]	beige	29
πορφυρό	[porfiró]	cerise	21
βυσσινί	[visiní]	berry	18
θαλασσί	[θalasí]	sea blue	16
ώχρα	[óxra]	ochre	14
χρυσό	[xrisó]	golden	12
ασημί	[asimí]	silver	9
λαδί	[laδí]	olive	7
κεραμιδί	[keramidí]	tile	6
μπορντώ	[bordó]	claret	6
καμηλό	[kamiló]	camel	5
τυρκουάζ	[tirkuáz]	turquoise	5
εκρού	[ekrú]	light beige	4
τρανταφυλλί	[triadafilí]	rose	4
κροκί	[krocí]	yolk	3
λιλά	[lilá]	lilac	3
μουσταρδί	[mustarδí]	mustard	3
φούξια	[fúksia]	fuchsia	3
βεραμάν	[veramán]	almond	2
λαχανί	[laxaní]	cabbage	2
μελιτζανί	[melidzaní]	aubergine	2
μολυβί	[moliví]	pencil	2

also more than [róz] "pink" (304). Thus on this measure, it merits consideration as a BCT.

3. Naming NCS stimuli

This first study used 685 stimuli from the NCS system (see Appendix 1.1). They were named by a Greek sample in Britain, using 'simple, every day' colour terms. The task was repeated at a second session. NCS stimuli are standardised under illuminant D65, but here we used a 'warmer' illuminant with a colour temperature of 5754° rather than 6500° (see Appendix 2.2). This lighting is yellowier than D65 and closer to the prevailing daylight in Greece than D65, which is more characteristic of northern Europe. We examine the data in terms of frequency of use per colour term, levels of agreement across informants and consistency of use across the two sessions.

3.1 Method

3.1.1 *Informants*

Eight native Greek speakers, six women and two men, aged 19–31 years took part. They were students at the University of Surrey, and they were fluent in English. They had normal colour vision, as assessed by the City University Colour Vision Test (Fletcher 1980).

3.1.2 *Stimuli*

Six hundred and eighty-five stimuli were selected from the 1750 samples of the NCS Index Second Edition. Every odd-numbered card was included except for those cards with only low chromaticity stimuli (values of 05 and 10).[5] Card 2 was added to the set so that achromatic stimuli were more adequately sampled and cards 48, 86 and 94 were added because of the low representation of red in the set. The stimuli were presented on the original cards, with all but the 50 × 19 mm target stimulus masked by a grey card (N-5000). The viewing distance was approximately 40 cm, projecting a visual angle of 2.9°. Illumination was from incandescent lamps mounted above the stimuli, filtered to a colour temperature of 5754°K (see Appendix 2.2) measured using a Minolta CS-100 colorimeter, providing 225–250 lux.

3.1.3 *Procedure*

The stimuli were presented one at a time in a different random order for each subject, until all the stimuli had been presented. This was repeated in a second session several days later, in which the stimuli on each card were presented in reverse order to the first session. The instructions were to name each sample using a simple, every-day colour term.

3.2 Results

3.2.1 Frequency of use per colour term

There were 10960 responses (8 informants × 685 stimuli × two sessions) distributed across thirty-four colour terms. Columns 3 and 4 of Table 2 show the percentage occurrences per term (F%) and the number of informants who used each term (N). The terms are ordered according to the hierarchy, followed by [γalázjo] "light blue" and then the remaining terms in order of frequency of use. The Greek chromatic BCTs plus [γalázjo] "light blue" were used with higher frequencies than the remaining terms, and they were also used by all eight subjects. The three achromatic terms, [mávro] "black", [áspro] "white" and [grí] "grey", had lower scores than many probable non-basic terms, but all informants used them. However, the incidence of achromatic colours in the sample, particularly black and white, was low, despite the inclusion of card 2 to boost their representation.

The distribution of frequencies seems to form a continuum, rather than sharply dividing the Greek chromatic BCTs from the remainder. The lowest chromatic BCT [kócino] "red" scores 495, followed by [laδí] "olive green" (440) and [béz] "beige" (279). Both latter terms were used by all informants, while none of the remaining terms were.

3.2.2 Consistency

As well as being used frequently, BCTs should be used 'consistently'. Following Boynton and Olson (1987), responses were deemed consistent if the same term was used for the same stimulus in both sessions; otherwise their use was 'inconsistent'. Figure 2 shows the ratios of consistent to inconsistent use for each term, summed across stimuli and informants. As can be seen, only 14 terms have ratios greater than one — greater consistent than inconsistent use. These are the eleven BCTs plus [γalázjo] "light blue", [somón] "salmon" and [lilá] "lilac". Note, however, that [somón] "salmon" only just achieved a ratio grater than one, and was only used by four people; similarly only two informants used [lilá] "lilac" and it was only used for 49 out of a possible 10960 judgements.

The two blue terms behave in a very similar way in terms of consistency. The relative frequencies of consistent to inconsistent use (and ratios) were 538:201 (2.67) and 558:196 (2.85) for [blé] "blue" and [γalázjo] "light blue" respectively.

3.2.3 Agreement among informants

Consistency is one measure of agreement, but it is independent of breadth of use. Combining consistency with frequency of use gives another measure of agreement, or consensus, the 'dominance index'. We say that a term is dominant for a given tile if the frequency of use across respondents and sessions (maximum: 16) exceeds a

Table 2. Greek colour terms used to describe the NCS stimuli in their I.P.A. transcription and their English glosses. Summary statistics shown are: percentage frequency of use (F%), the number of subjects using each term (N), and the dominance indices. The first eleven terms are in the Berlin and Kay order followed by [γalázjo] 'light blue' and the remainder in order of frequency.

I.P.A	Gloss	F%	N	Dominance Indices		
				D_{100}	D_{75}	D_{50}
[áspro]	white	0.17	8	0	1	1
[mávro]	black	0.37	8	0	2	3
[kócino]	red	4.52	8	3	18	31
[prásino]	green	22.77	8	37	118	165
[cítrino]	yellow	4.58	8	2	18	29
[blé]	blue	6.74	8	10	29	42
[kafé]	brown	11.07	8	6	43	79
[portokali]	orange	6.20	8	6	26	41
[róz]	pink	8.89	8	20	43	60
[móv]	purple	7.14	8	10	14	14
[grí]	grey	2.31	8	10	14	14
[γalázjo]	light blue	6.88	8	6	28	42
[laδi]	olive	4.01	8	0	2	19
[béz]	beige	2.55	8	0	0	5
[veramán]	almond	2.32	4	0	0	0
[ceramidí]	tile	1.81	6	0	0	0
[bordó]	claret	1.65	6	0	0	1
[somón]	salmon	1.20	4	0	0	0
[mustarδi]	mustard	0.78	5	0	0	0
[χaki]	khaki	0.78	3	0	0	0
[fúksia]	fuchsia	0.63	7	0	0	2
[lilá]	lilac	0.45	2	0	0	0
[θalasí]	sea blue	0.41	2	0	0	0
[tirkuáz]	turquoise	0.36	2	0	0	0
[ecru]	light beige	0.31	4	0	0	0
others		1.11				
Total		100		113	378	581

threshold value. The dominance index is then the number of tiles for which a term is dominant. We show three graded measures of dominance, D_{100}, $D_{75,}$ and D_{50} with decreasing thresholds or levels of agreement: 100%, 75% and 50%.

Table 2 column 5 shows the D_{100} index, and the column total (113) shows the number of stimuli that produced this maximum degree of consensus. The terms with D_{100} scores greater than one were: [kócino] "red", [prásino] "green", [cítrino] "yellow", [blé] "blue", [kafé] "brown", [portokalí] "orange", [róz] "pink", [móv] "purple", [grí] "grey" and [γalázjo] "light blue". Thus all the BCTs except [áspro] "white" and [mávro] "black" achieve the maximum consensus, and no other terms do so.

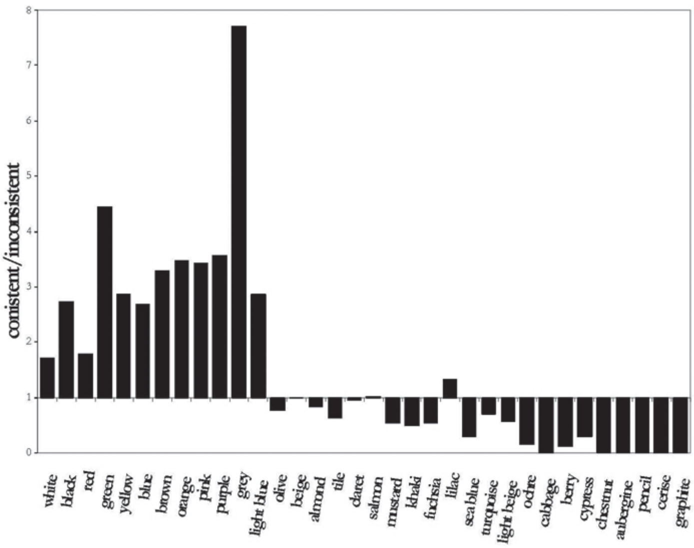

Figure 2. Ratio of consistent to inconsistent use of colour terms in naming NCS stimuli. Bars are labelled with English glosses; see Table 1 for the Greek Terms.

Column 6 shows the equivalent measure of dominance for 75% agreement (the same name 12–16 times). Three hundred and seventy-eight tiles produced this level of consensus. Three hundred and seventy-six of these were for the twelve terms listed above, and the remaining two tiles were called [laδí] "olive green". Column 7 shows the scores for D_{50} (the same name 8–16 times). There were 554 tiles for the BCTs plus [γalázjo] "light blue", while the remaining 27 tiles were named [laδí] "olive green" (19), [béz] "beige" (5), [bordó] "claret" (1) and [fúksia] "fuchsia" (2).

In Figures 3 and 4, all tiles that achieved D_{50} are plotted in CIE colour space together with the landmark colours (see Appendix 1.2). Figure 3 uses the (u*, v*) axes and Figure 4 the (u*, L*) axes. The size of the symbols indicates the three levels of consensus. The Figures also show the positions of the eleven universal foci as landmarks. The regions dominated by the BCTs are close to the appropriate universal focus in all cases, and those with 100% consensus tend to be closest to the landmarks, although mostly closer to the centre than the appropriate landmark. The latter is because NCS colours do not include very saturated examples.

From Figure 4 it can be seen that many terms occupy restricted lightness regions marked by a lightness boundary at an L* value of about 63. The terms [γalázjo] "light blue", [róz] "pink", [portokalí] "orange" and [cítrino] "yellow" only occur above the boundary, while the terms [blé] "blue", [móv] "purple", [kafé] "brown", and [kócino] "red" only occur below the lightness boundary. [Prásino] "green" is the only term that spreads across this boundary. The marginal terms

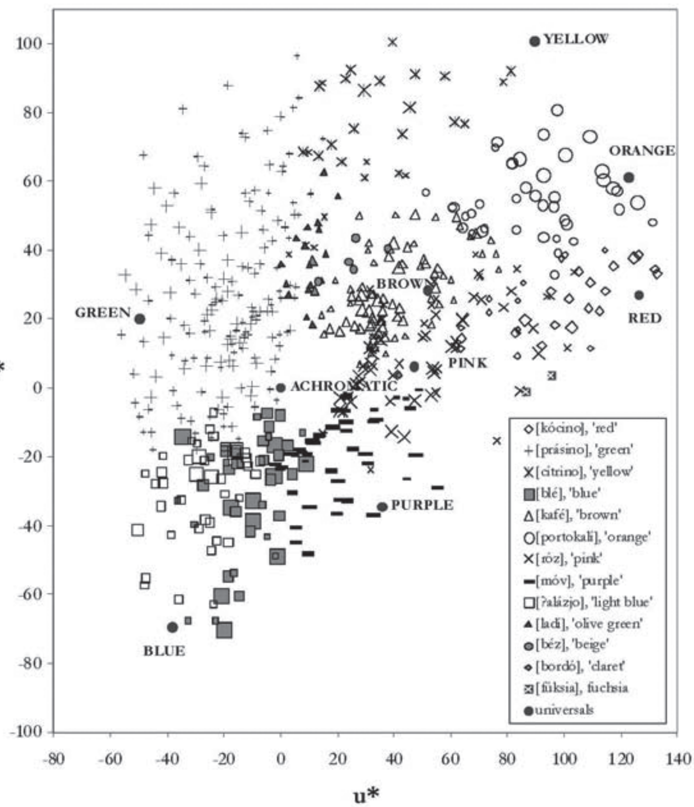

Figure 3. CIE coordinates (u* v*) of the NCS stimuli with a dominant name. Symbol size indicates dominance level: large = D_{100}, medium = D_{75}, small = D_{50}. Locations of the universal foci are shown as landmarks.

[laδí] "olive green", [béz] "beige", [bordó], "claret" and [fúksia] "fuchsia" also seem to be restricted by lightness. [Laδí] occurs between green and brown in terms of hue (see Figure 3) but, unlike [prásino] "green" only below the lightness boundary (see Figure 4), with lightness values similar to [kafé] "brown", whereas [béz] "beige" has similar hue, but is lighter than [laδí] or [kafé]. [Bordó], "claret" and [fúksia] "fuchsia" are close to PINK in Figure 3 but they are below PINK (darker) in Figure 4.

From Figure 4 it can be seen that the two blue terms are separated by an imagery horizontal axis, through the universal BLUE. They are also separated on v* with [γalázjo] "light blue" lying closer to GREEN and [blé] "blue" nearer to PURPLE (Figure 3).

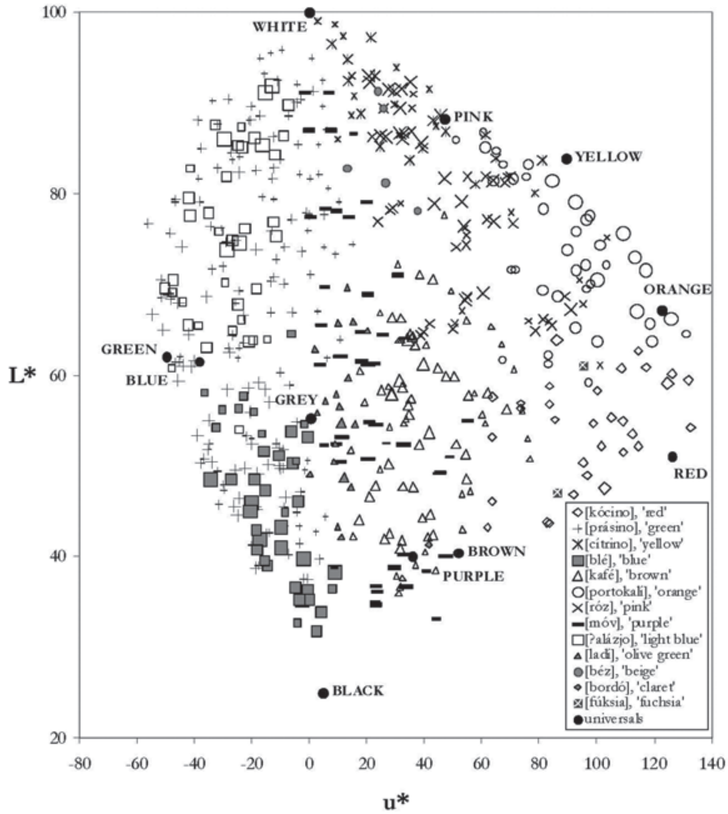

Figure 4. CIE coordinates (u* L*) of the NCS stimuli with a dominant name. Symbol size indicates dominance level: D_{100}, medium = D_{75}, small = D_{50}. Locations of the universal foci are shown as landmarks.

3.3 Summary

The results suggest that Modern Greek has twelve BCTs. These are the eleven terms first suggested in the introduction, plus the additional blue term [ɣalázjo] "light blue". These terms are: *άσπρο* [áspro] "white", *μαύρο* [mávro] "black", *κόκκινο* [kócino] "red", *πράσινο* [prásino] "green", *κίτρινο* [cítrino] "yellow", *μπλε* [blé] "blue", *καφέ* [kafé] "brown", *πορτοκαλί* [portokalí] "orange", *ροζ* [róz] "pink", *μωβ* [móv] "purple", *γκρι* [grí] "grey" and *γαλάζιο* [ɣalázjo] "light blue". The evidence is clearest for the chromatic terms. These had the nine highest frequencies of use (Table 2); they were used by all informants (Table 2); they were used with absolute consensus (Table 2); they were used with high consistency (Figure 2); and their best examples were close to the appropriate landmark colour (Figures 3 and 4). The latter also indicates that colour constancy is operating, but we defer discussing this until Section 7.

The two Greek blue terms, *μπλε* [γalázjo] "light blue" and *γαλάζιο* [γalázjo] "light blue", have similar scores on these measures; they have almost the same overall frequency of use, they are assigned to almost identical numbers of stimuli for three levels of dominance and produce similar ratios of consistent:inconsistent use. Their referents differ mainly in lightness (L* in Figure 4) but [γalázjo] "light blue" is also closer to GREEN than [γalázjo] "light blue", which in turn lies closer to PURPLE than [γalázjo] "light blue".

4. Naming computer emulated NCS by a monolingual sample from Crete

The informants in the previous study were bi-lingual Greek students. In the current study we sought to test the generality of the BCTs found in the previous study by using monolingual informants from Crete, who were speakers of a marked dialect. The stimuli were emulated NCS presented on a computer monitor in an otherwise dark room. The data were again examined in terms of frequency of use and agreement between subjects. Response times were used as an additional measure of 'psychological salience' (Boynton & Olson 1987).

4.1 Method

4.1.1 *Informants*

Six Greek villagers, 3 men and 3 women took part; their ages ranged from 21 to 30 years (mean: 24.5). They were all born and had lived all their lives in a remote village of around 150 people on the island of Crete, in southern Greece. Five were monolingual and one had some knowledge of English. All had normal colour vision, as assessed by the City Colour Vision Test.

4.1.2 *Stimuli and Apparatus*

The stimuli were presented on a Compaq Presario 1400 notebook with a 360 mm screen. The limited gamut of the monitor meant that just 584 of the 685 NCS stimuli used in the previous study could be produced. The set was now particularly short of good yellows. The 584 realisable stimuli had the same CIE co-ordinates as their NCS equivalents, as measured by a Minolta CS-100 colorimeter. The most luminant white the screen could produce was used to calculate L*. The stimuli were 40 × 40 mm squares centred in the middle of the screen projecting a visual angle of approximately 2.9° from the viewing distance of 600 mm normal to the screen. The experiment took place in a room that was dark, other than the light from the computer screen.

4.1.3 *Procedure*

The stimuli were presented in set blocks with about 100 stimuli assigned at random to each block. The blocks were presented in random order, and informants could rest between blocks. The full session lasted about three hours. The onset of each stimulus was signalled by a 'beep' and the stimulus was then presented for 10 seconds. The instructions were to name the colour using a simple, every day colour term. The next stimulus appeared five seconds after the offset of the previous one. Response times (RT) were recorded from the stimulus onset until the beginning of the subject's response using a stopwatch.

4.2 Results

4.2.1 *Frequency of use and levels of agreement*

Thirty-nine colour terms were used to describe the stimuli in 3447 naming assignments out of a possible 3504 responses (6 informants × 584 stimuli); 57 responses were treated as 'do not know' because no response was made before the next stimulus appeared. Twenty-eight of these terms were also used in the previous study. The new terms were: [triadafilí] "rose", [ámu] "sand", [χrisó] "golden", [anθrakí] "charcoal", [asimí] "silver", [verikocí] "apricot", [zahari] "sugar", [kamiló] "camel", [krém] "creme", [krocí] yolk" and [siél] "sky blue". Table 3 columns 3–4 shows the percentage of use per term (F%), and the number of informants who used each term (N) for all terms with scores at least equal to [mávro] "black". It can be seen that the chromatic BCTs plus [γalázjo] "light blue" have the highest scores, except [cítrino] "yellow", and they are used by all informants. The two blue terms have similar scores: [blé] "blue" 8.56% and [γalázjo] "light blue" 7.85%. The achromatic terms, particularly [áspro] "white" and [mávro] "black" have low scores, but [mávro] "black" and [grí] "grey" were used by all informants, and [áspro] "white" was used by all but one informant. The terms [laδí] "olive green" [béz] "beige" and [visiní] "berry" score more than several BCTs: [cítrino] "yellow", [áspro] "white" and [mávro] "black"; [laδí] "olive green" also scored more than [grí] "grey".

One hundred and thirteen stimuli met the D_{100} criterion. All of the BCTs except [áspro] and [cítrino] "yellow" produced absolute agreement for at least one stimulus (column 5). The highest agreement for the latter terms was five out of six. The additional blue term [γalázjo] "light blue" also produced absolute agreement for eight stimuli. No other terms produced absolute agreement.

Thirteen terms met the D_{75} criterion across 23 stimuli (column 6), the twelve terms that achieved D_{100} plus [laδí] "olive green", for two stimuli. The thirteen foregoing terms necessarily met the D_{50} criterion, plus [béz] "beige" for 5 stimuli and [visiní] "berry" for 8 stimuli (column 7).

Table 3. Terms used to describe the computer emulated NCS stimuli in their I.P.A. transcription and their English glosses. Summary statistics shown are: percentage frequency of use (F%), the number of subjects using each term (N), and the dominance indices. The first eleven terms are in the Berlin and Kay order followed by [γalázjo] 'light blue' and the remainder in order of frequency of use.

I.P.A	Gloss	F%	N	Dominance Indices		
				D_{100}	D_{75}	D_{50}
[áspro]	white	1.03	5	0	2	4
[mávro]	black	0.34	6	1	1	1
[kócino]	red	5.82	6	4	12	35
[prásino]	green	20.63	6	51	86	131
[cítrino]	yellow	1.68	6	0	1	9
[blé]	blue	8.56	6	16	28	45
[kafé]	brown	6.54	6	6	13	38
[portokali]	orange	6.28	6	1	11	41
[róz]	pink	9.65	6	12	27	57
[móv]	purple	7.79	6	13	23	50
[grí]	grey	3.80	6	1	8	14
[γalázjo]	light blue	7.85	6	8	18	43
[laδi]	olive	3.88	5	0	2	16
[béz]	beige	2.80	4	0	0	5
[visiní]	berry	2.11	3	0	0	8
[ceramidí]	tile	1.03	2	0	0	0
[bordó]	claret	1.65	6	0	0	1
[somón]	salmon	0.97	3	0	0	0
[fúksia]	fuchsia	0.83	2	0	0	0
[triadafilí]	rose	0.57	1	0	0	0
[ámu]	sand	0.54	1	0	0	0
[veramán]	almond	0.49	1	0	0	0
[χrisó]	golden	0.49	2	0	0	0
[ecrú]	light beige	0.37	2	0	0	0
[anθrakí]	charcoal	0.37	1	0	0	0
[tirkuáz]	turquoise	0.34	1	0	0	0
[lilá]	lilac	0.34	1	0	0	0
others		2.23				
don't know		1.63				
Total		100		113	232	497

4.2.2 *Naming times (RT)*

On average, naming was faster for likely BCTs than for the probable secondary terms: 1850 ms compared to 2450 ms (excluding [γalázjo] "light blue" in both cases).[6] Table 4 column 3 shows the mean RT for each term that was dominant for at least one tile. It can be seen that although, on average, probable BCTs have faster RTs than probable secondary terms, RT does not segregate them perfectly. The term [laδí] "olive green" was used faster than [cítrino] "yellow", [kafé] "brown" and [áspro] "white". However, although some of the remaining terms have faster RTs than some probable BCTs, they are used by only a few informants. The two blue

Table 4. Mean RT (ms) for each term, and for each term at the various dominance levels. Overall means for each dominance level are given in the final row. The first eleven terms are in the Berlin and Kay order followed by [γalázjo] 'light blue' and the remainder in order of frequency of use.

I.P.A	Gloss	Mean RT			
		All	D_{100}	D_{75}	D_{50}
[áspro]	white	2470	0	1230	1710
[mávro]	black	1640	1180	0	0
[kócino]	red	1720	1500	1305	1613
[prásino]	green	1560	1340	1586	1848
[cítrino]	yellow	2320	0	2060	2589
[blé]	blue	1760	1330	1797	1901
[kafé]	brown	2390	2060	1874	2674
[portokali]	orange	1850	1370	1546	1844
[róz]	pink	1980	1540	1504	2014
[móv]	purple	1850	1740	1326	1867
[grí]	grey	2200	2240	1451	1783
[γalázjo]	light blue	1760	1350	1602	1748
[laδi]	olive	2280	0	2130	2016
[béz]	beige	2550	0	0	2140
[visiní]	berry	2260	0	0	2110
Mean			1457	1649	1962

terms, [blé] "blue" and [γalázjo] "light blue" both scored 1.76 seconds, which was faster than the probable BCTs [portokalí] "orange", [móv] "purple", [róz] "pink", [grí] "grey", [cítrino] "yellow", [kafé] "brown" and [áspro] "white".

Table 4 also presents the mean RT for each of three levels of dominance for each term (columns 4–6) and the means across terms are also shown in the final row. RTs tend to be inversely related to the level of dominance with means as follows: 1457 ms, 1649 ms and 1962 ms with decreasing dominance.

4.2.3 *Referents of terms in CIE colour space*

In order to save space, from now on we show just the chromaticity plane (u*, v) except when comparisons across studies are made (Section 7). The distribution of terms in L* showed essentially the same pattern in all studies.

The locations of all stimuli that met the D_{50} criterion are shown in Figure 5. Symbol size represents dominance level. The relative positions of the terms show a similar pattern to Figure 3 from the previous study, but overall the envelope bounding the stimuli has shrunk, due primarily to the limited gamut of the computer display. Within these constraints, the range of each term tends to be closest to the appropriate landmark. The marginal terms, [laδí] "olive green" and [béz]

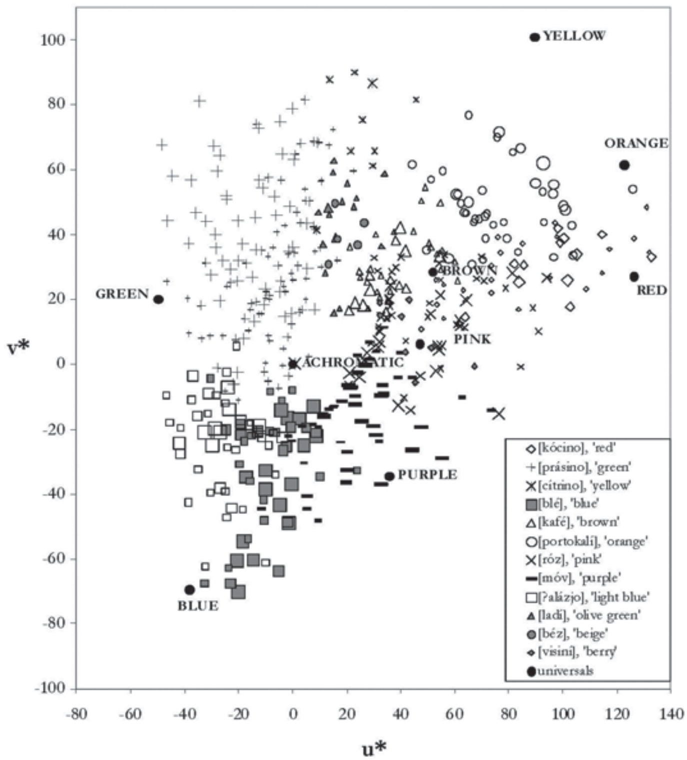

Figure 5. CIE coordinates (u* v*) of the computer generated NCS stimuli with a dominant name. Symbol size indicates dominance level: D_{100}, medium = D_{75}, small = D_{50}. Locations of the universal foci are shown as landmarks.

"beige", are in more or less the same position as in Figure 3, but [bordó], "claret" and [fúksia] "fuchsia" were not used dominantly being replaced by [visiní] "berry", which lies close to PINK.

4.3 Summary

In general, these data support the findings from the previous study. The converging measures of frequency of use, level of agreement, and the new measure of naming time suggest that [kócino] "red", [prásino] "green", [blé] "blue", [kafé] "brown", [portokalí] "orange", [róz] "pink", [móv] "purple", and [γalázjo] "light blue" have the strongest claim to basic status. The absence of [cítrino] "yellow" is an anomaly, but it is probably because there were few good yellows due to the limited gamut of the monitor. The low frequencies for [áspro] "white" and [mávro] "black" are partly due to their status as 'perceptual endpoints'. These terms tend to denote the lightest and darkest stimuli in a set, and colour contrast makes slightly different stimuli appear grey. RTs for [áspro] "white", [cítrino] "yellow", [kafé] "brown" and [grí] "grey" were particularly slow. This probably reflects their relatively low frequency of use in the experiment; RT is a function of both general influences such as availability in memory, and local influences, such as frequency of use. The term with the next highest claim to basic status is [laδí] "olive green". It was used 136 times and five out of six informants used it. It produced 75% agreement for two stimuli, and the mean weighted RT for its 136 occurrences was 2.28 secs. This was about the same as for the achromatic terms mentioned above. We defer judgement on its status until the general discussion.

5. Zooming in on Blue: The effect of local context

Choice of colour names is likely to be influenced by the overall context, including the stimulus range, as well as by the specific stimulus (see, e.g. Lin et al. 2001a and 2001b, Alvarado & Jameson 2002). If many stimuli are exemplars of the same BCT, this is likely to serve as an invitation to use subordinate terms or complex terms. Thus, the prevalence of BCTs should fall under these circumstances, particularly if, unlike the previous two studies, complex terms are allowed. Conversely, if they remain the dominant terms, this would be further evidence for their robustness and salience. On the other hand, if [γalázjo] "light blue" is a subordinate of [blé] "blue", its use might increase when faced with multiple exemplars of [blé] "blue".

These considerations were tested by using stimuli selected from just the blue region and its immediate surrounds and allowing informants to use complex terms. Thus the use of blue terms should be high, perhaps including subordinate and complex forms. The stimuli were chosen from the green-blue-purple region of Color-aid (see Appendix 1.2) and presented under daylight. Variations in daylight affect the spectral composition produced by the stimuli. Nevertheless, as argued in the introduction, BCTs need to be robust enough to survive variations in the illuminant. Therefore, if the two blue terms are both BCTs, there should be some stimuli that still elicit these terms by all, or at least by the majority of informants.

5.1 Method

5.1.1 *Informants*

Eighteen people took part, 10 men and 8 women, aged from 19–28 years (mean 24 years). All were native Greek speakers and students at the University of Surrey. They could all speak English, and they had normal colour vision.

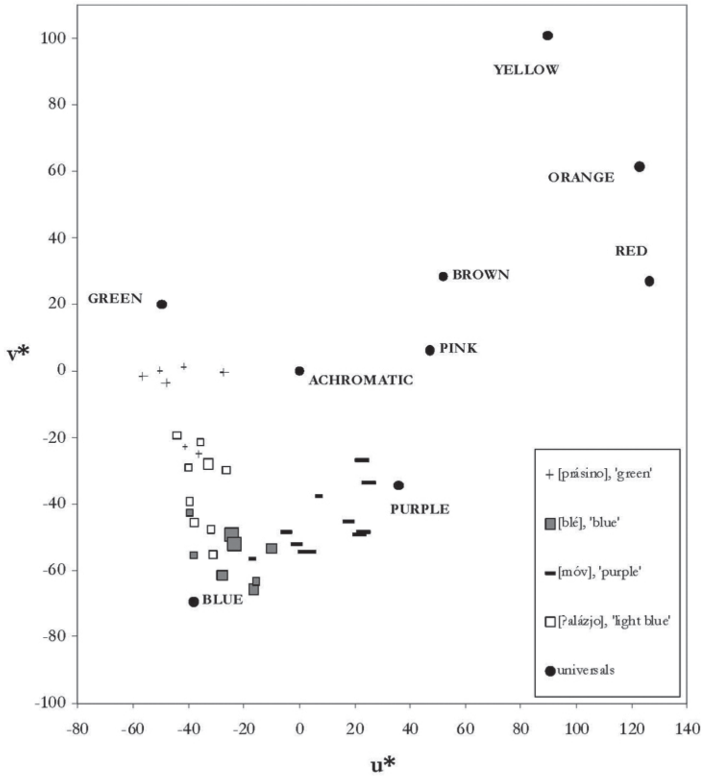

Figure 6. CIE coordinates (u* v*) of the Color-aid stimuli with a dominant name. Symbol size indicates dominance level: large = D_{100}, medium = D_{75}, small = D_{50}. Locations of the universal foci are shown as landmarks.

5.1.2 *Stimuli*

Forty chromatic chips were selected from the Color-aid Corporation green-blue-purple region (see Figure 6). The chips measured 13 mm × 19 mm and were of eight different hues (Gc, BG, C, Bc, B, Bw, BV and V) and five degrees of lightness (Hue, T1, T2, T3 and T4). The experiment took place indoors, under natural daylight from a northern window. The illuminance was between 290–340 lux and the colour temperature was between 5000–8000°K.

5.1.3 *Procedure*

Informants were told (in Greek) to name each tile however they liked; tiles were then presented to them singly and in random order.

5.2 Results

5.2.1 *Frequency of use per colour term*

There were 714 responses (18 informants × 40 stimuli, less six 'don't know' responses), distributed across fourteen colour terms. Terms were sometimes used as part of a compound response. The latter consisted of a colour term plus one of six modifiers, or one of nine combinations of two colour terms. The distribution of kinds of term was approximately: single terms 68%, modified terms 26%, and combinations 5%. The simple forms of [prásino] "green", [blé] "blue", [móv] "purple" plus [γalázjo] "light blue" total to about 55% of all responses, and about 81% of just simple term responses.

The modifiers, used by fourteen out of eighteen informants, and their frequencies were [anihtó] "light" 117, [skúro] "dark" 34, [vathí] "deep" 18, [apaló] "soft" 7, [hlomó] "pale" 8 and [éntono] "vivid" 3. The two blue terms differed in the modifiers they were paired with. Both blue terms accept the modifier [anihtó] "light", but [γalázjo] "light blue", unlike [blé] "blue", occurred rarely with [skúro] "dark". On the other hand, [apaló] "soft" and [hlomó] "pale" occurred with [γalázjo] "light blue", but not with [blé] "blue". There was reasonable agreement in the use of modifiers, particularly for [anihtó] "light" and [skúro] "dark". The use of the former increased as the level of Tint increased; about half of the usage was for T4 stimuli. The use of [skúro] "dark" showed the reverse pattern; it was used almost exclusively to name the various Hues (the darkest colour for constant hue).

Table 5 shows the percentage frequency of use of simple terms plus their compound forms. For these purposes, modifier-colour term compounds were collapsed onto the appropriate simple term and combined colour terms were counted as instances of the first term. Over 80% of responses in this form were [prásino] "green", [blé] "blue", [móv] "purple" or [γalázjo] "light blue". The two blue terms were used with similar frequencies. However, [γalázjo] "light blue" was not used by three of the 18 informants. These three used [θalasí] "sea blue" or [uraní] "sky blue", for stimuli the other informants called [γalázjo] "light blue". The former had the highest score after the four main terms of about 5%.

5.2.2 *Agreement between informants*

Table 5 columns 5–7 shows the three levels of dominance and Figure 6 shows the location of each colour with a dominant name. Since not all informants used [prásino] "green" and [γalázjo] "light blue", these terms could not achieve absolute agreement. This was achieved by [móv] "purple" for five stimuli and [blé] "blue" for two stimuli. All of the four terms achieve the 75% level for at least one stimulus and they all achieve the 50% level for at least seven stimuli. This leaves just five

Table 5. Terms used to describe the Color-aid stimuli in their I.P.A. transcription and their English glosses. Summary statistics shown are: percentage frequency of use (F%), the number of subjects using each term (N), and the dominance indices. The first four terms are in the Berlin and Kay order followed by [ɣalázjo] 'light blue' and the remainder in order of frequency of use.

I.P.A	Gloss	F%	N	Dominance Indices		
				D_{100}	D_{75}	D_{50}
[prásino]	green	14.72	17	0	3	7
[blé]	blue	21.94	18	2	5	8
[móv]	purple	26.39	18	5	9	11
[grí]	grey	0.83	2	0	0	0
[ɣalázjo]	light blue	21.53	15	0	1	9
[θalasí]	sea blue	5.14	9	0	0	0
[tirkuáz]	turquoise	1.94	5	0	0	0
[inopnevmatí]	methylated spirits	1.94	2	0	0	0
[siél]	sky blue	1.25	2	0	0	0
[lilá]	lilac	1.25	4	0	0	0
[veramán]	almond	0.69	2	0	0	0
[ciparisí]	cypress	0.56	3	0	0	0
[uraní]	sky blue	0.42	2	0	0	0
[fisticí]	peanut	0.56	1	0	0	0
don't know		0.83				
Total		100.00		7	18	35

stimuli that did not produce 50% agreement. No other term achieved the lowest dominance threshold.

5.3 Summary and Discussion

As expected, with stimuli concentrated in a limited area of colour space and no restrictions on permitted terms, over 30% of responses were compound terms. Most consisted of a simple term plus modifier. Of the simple terms, the great majority (81%) were one of the BCTs [prásino] "green", [blé] "blue", [móv] "purple" or [ɣalázjo] "light blue". This score is very similar to those for the eleven BCTs plus [ɣalázjo] "light blue" in the two previous naming studies (~82% in Study 1 and ~80% in Study 2). Collapsing compound terms onto the root term (Table 5) give a score of about 85% for the four terms. Thus, despite the relaxing of the naming-restrictions, and the concentrated stimuli, the frequency of use of these four terms is consistent with them being BCTs.

The two blue terms were used with about equal frequency (about 20%, Table 5), however, the level of agreement for [γalázjo] "light blue" was lower than in previous studies. It did not achieve the D_{100} criterion and did so for D_{75} for only one tile. The corresponding scores for [blé] "blue" were two and five. This reduction in agreement scores for [γalázjo] "light blue" is largely due to three of the 18 informants not using the term. However, even for the fifteen who did use the term, no tile evoked complete agreement. Thus, there is no evidence for [γalázjo] "light blue" replacing [blé] "blue", which might have happened if the former is a subordinate of the latter. Rather, [θalasí] "sea blue" and [siél] "sky blue" seem to be used instead of [γalázjo] "light blue". Recall that [γalázjo] "light blue" is "the colour of the clear sky and of the calm sea" (Babiniotis 1998b). Thus, the apparent replacement terms ([θalasí] "sea blue" and [siél] "sky blue") are more restricted than [γalázjo] "light blue" and could be subordinate to it.[7] The two blue terms differed in the modifiers they commonly occurred with. The modifier [skúro] "dark" does not occur frequently with [γalázjo] "light blue". On the other hand, [anihtó] "light" occurs with both terms, while [apaló] "soft" and [hlomó] "pale" occur with [γalázjo] "light blue", but not with [blé] "blue".

These data have equivocal implications for the status of [γalázjo] "light blue". On the one hand, agreement over its use was lower than in the previous two studies. On the other hand, its replacement by the more specific terms [θalasí] "sea blue" and [siél] "sky blue" may imply that [γalázjo] "light blue" is a BCT. This interpretation would be strengthened if it was clear that the more specific terms were subordinates of [γalázjo] "light blue", and that the latter could replace them if necessary. However, this was not investigated. If [γalázjo] "light blue" had been chosen rather than [blé] "blue" as a replacement, this would have been consistent with [γalázjo] "light blue" being a BCT. We include this step in the method of the next study.

Finally, we must add a caveat. The stimuli were selected objectively by taking the main blue region plus surrounds from Color-aid. We assumed that this procedure would necessarily yield stimuli from the appropriate regions of colour space. This was a mistake. Comparisons of Figures 3 and 5 with Figure 6 show that the Color-aid stimuli under represent the [γalázjo] "light blue" region. This lies between $u^* = -40$, $v^* = -30$ and $u^* = -20$, $v^* = -10$ for both previous studies. While the u^* values sample this region adequately, the corresponding v^* values leave gaps between about −45 to −33 and above −20. These missing regions included good examples of [γalázjo] "light blue". If these regions had been included, [γalázjo] "light blue" would probably have been used more frequently and, perhaps, without modifiers.

6. Naming Munsell Stimuli

In this study we used Berlin and Kay's (1969) original set of 320 Munsell colours. This has since been used extensively by the World Colour Survey (Kay & Maffi 1999) and MacLaury (1997). The set includes the Munsell chips judged to be the foci of the eleven Berlin and Kay universal categories (Heider 1971). The Munsell set includes more saturated colours than the NCS set, but there are also about 100 stimuli that have exactly matching stimuli in NCS. The stimuli were presented under fluorescent light, with a colour temperature of 4200°K. This light was yellowier and less blue than in studies 1 and 3, but more typical of daylight in Greece (see Appendix 2.2). Comparing naming in this study with that from the earlier studies, particularly for the 100 stimuli with direct NCS matches, allows us to see to what extent colour naming is influenced by variations in the illuminant. The instructions required responses to be simple and 'necessary'; that is, not replaceable by a superordinate term. In addition, we asked informants for the 'best example' of each term. Potentially, this provides a more direct estimate of the foci than frequency of use. The new stimuli and lighting provide a further test of the robustness of likely BCTs. The restricted instructions provide a test of the possibility that [γalázjo] "light blue" is included (perhaps partially) in [blé] "blue". If it is, then its incidence should be considerably lower than in the previous naming studies. They may also clarify the relationship(s) among [θalasí] "sea blue" and [siél] "sky blue" and their possible superordinate terms [blé] "blue" or [γalázjo] "light blue".

6.1 Method

6.1.1 *Informants*

Twelve native Greek speakers took part, seven women and five men, aged between 19 to 28 years (mean 24 years). Five were students at Plymouth University and seven were university graduates from Thessaloniki, in Northern Greece. They could all speak English and two of them also spoke some German. All informants reported normal colour vision.

6.1.2 *Stimuli*

The stimuli were 320 chromatic chips detached from the Munsell Book of Colour, Glossy Finish (1976). These consisted of every other Hue at each of eight lightness levels (Values: 2–9) at the highest available Chroma plus ten achromatic chips of varying lightness (Values 0.5–9.5; corresponding L*: ~10–100 (see Berlin & Kay 1991 or MacLaury 1997 for illustrations of the array). Their size was 20 × 16 mm giving a visual angle of ~1° from a viewing distance of ~ 500 mm. They were illuminated by a Philips cool white fluorescent tube producing an illuminance of 375 lux with a colour temperature of 4200°K.

6.1.3 *Procedure*

Informants were tested singly and communication was in Greek. They were asked to name each chip, by using a single monolexemic term, whose meaning was not included in another term's, and overall to use the smallest possible number of colour terms. The stimuli were placed randomly on the table with the coloured side facing up and informants were asked to pick up one and name its colour. After a response was given, they were asked if they could use another colour term with a broader meaning. If they changed their response, only the new term was recorded. Each named tile was then put in a different pile, according to the colour term used. When naming was complete, informants were asked to point to the best example of each of the piles created.

6.2 Results

6.2.1 *Frequency of use per colour term and levels of agreement*

Fourteen colour terms were used to describe the stimulus set, in 3864 responses (12 informants × 330 stimuli less 96 "don't know" responses). The terms were the eleven universal basic terms plus [γalázjo] "light blue", [laδí] "olive green" and [visiní] "berry". Table 6 column 3 shows the percentage of use of each term out of the total responses. The chromatic BCTs, with the addition of [γalázjo] "light blue" have higher scores than the other two chromatic terms ([laδí] "olive green" and [visiní] "berry"). The two blue terms have similar frequencies, [blé] "blue" 10.20% and [γalázjo] "light blue" 10.38%. From Table 6 column 4 it can be seen that the eleven BCTs were used by all participants, while [γalázjo] "light blue", despite its high frequency, was used by ten out of twelve participants. The two who did not use the term did use it at first, but changed it to [blé] "blue" when asked if a more general term would do. The term [laδí] "olive green" was used by eight informants and [visiní] "berry" by one.

One hundred and thirty stimuli achieved the D_{100} criterion, distributed across the eleven BCTs (see Table 6, column 5). The same eleven terms, plus [γalázjo] "light blue" for 25 stimuli, met the D_{75} criterion for a total of 263 stimuli. At the D_{50} level, the term [laδí] "olive green" is added for ten stimuli. At this level, [blé] "blue" was dominant for 29 stimuli, while [γalázjo] "light blue" was dominant for 40. All of Heider's (1971) universal exemplars achieved the D_{100} criterion except for her focal blue, which was called [blé] "blue" by nine informants and [γalázjo] "light blue" by three informants.

Table 6. Terms used to describe the Munsell stimuli in their I.P.A. transcription and their English glosses. Summary statistics shown are: percentage frequency of use (F%), the number of subjects using each term (N), and the dominance indices. The first eleven terms are in the Berlin and Kay order followed by [γalázjo] 'light blue' and the remainder in order of frequency of use.

I.P.A	Gloss	F%	N	Dominance Indices		
				D_{100}	D_{75}	D_{50}
[áspro]	white	2.30	12	2	2	4
[mávro]	black	1.11	12	2	2	3
[kócino]	red	4.39	12	3	8	13
[prásino]	green	25.40	12	48	70	79
[cítrino]	yellow	3.26	12	1	7	11
[blé]	blue	10.20	12	14	24	29
[kafé]	brown	6.97	12	11	17	24
[portokali]	orange	3.69	12	3	8	12
[róz]	pink	11.94	12	21	31	41
[móv]	purple	12.98	12	22	37	45
[grí]	grey	1.54	12	3	5	5
[γalázjo]	light blue	10.38	10	0	25	40
[laδi]	olive	3.21	8	0	0	10
[visiní]	berry	0.20	1	0	0	0
don't know		2.42				
Total		100		130	236	316

6.2.2 *Referents of terms in CIE colour space*

In Figure 7 all of the 316 stimuli that met the D_{50} criterion are plotted in the CIE chromaticity plane (u*, v*), with three symbol sizes, representing the D_{100}, D_{75} and the D_{50} levels of agreement. As can be seen, exemplars of the Greek BCTs tend to cluster around the appropriate focal colour, and there is at least one colour with maximum consensus close to the landmark colour. There are several instances of [blé] "blue" with maximum consensus close to BLUE. In general, agreement between subjects increases as stimuli approach the landmark colours. The instances of [laδí] "olive green" that met the D_{50} criterion lie between [prásino] "green" and [cítrino] "yellow".

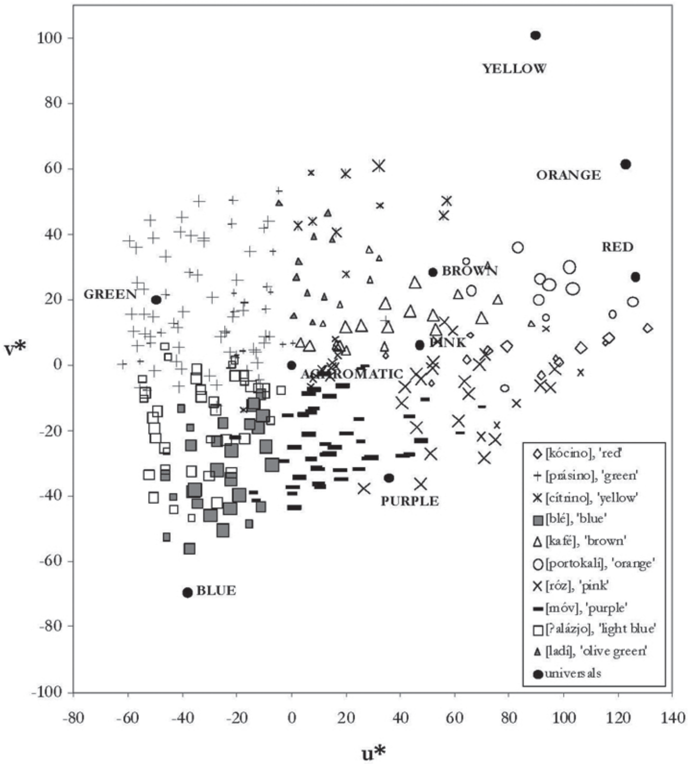

Figure 7. CIE coordinates (u* v*) of the Munsell stimuli with a dominant name. Symbol size indicates dominance level: large = D_{100}, medium = D_{75}, small = D_{50}. Locations of the universal foci are shown as landmarks.

6.2.3 *The 'best example'*

Tiles selected as the best example of one of the eleven BCTs were usually D_{100} tiles (123 out of 132 responses). Out of the 96 choices for the eight chromatic BCTs, 21 were of one of Heider's (1971) universal tiles. All of the tiles selected as best examples of [γalázjo] "light blue" were D_{75} and all of the ones selected for [laδí] "olive green" were D_{50}. (The location of the best examples in CIE colour space is described in the Section 7.)

The mean Munsell values (lightness) for the best examples of [blé] "blue" and [γalázjo] "light blue" were 3.00 (L*:~30) and 7.10 (L*:~75) respectively. The mean values for the remaining terms were, in descending order; [áspro] "white" 9.50, [cítrino] "yellow" 8.00, [róz] "pink" 7.25, [γalázjo] "light blue" 7.10, [portokalí] "orange" 6.00, [grí] "grey" 5.58, [prásino] "green" 4.58, [laδí] "olive green" 4.33, [kócino] "red" 3.92, [móv] "purple" 3.33, [kafé] "brown" 3.25, [mávro] "black" 0.50.

6.3 Summary

The general pattern is consistent with that found in the earlier studies of naming the NCS stimuli. The terms: *άσπρο* [áspro] "white", *μαύρο* [mávro] "black", *κόκκινο* [kócino] "red", *πράσινο* [prásino] "green", *κίτρινο* [cítrino] "yellow", *μπλε* [blé] "blue", *καφέ* [kafé] "brown", *πορτοκαλί* [portokalí] "orange", *ροζ* [róz] "pink", *μωβ* [móv] "purple" and *γκρι* [grí] "grey" were used by all subjects, with high frequencies in most cases and with high consensus (at least one D_{100}). In addition, *γαλάζιο* [γalázjo] "light blue" was used frequently and by all informants. However, two informants replaced it with [blé] "blue" when asked if it was a necessary term. Among those who persisted in using [γalázjo] "light blue" there was good agreement over its referents: there were 25 tiles that at least informants denoted [γalázjo] "light blue" (D_{75} in Table 6). [Laδí] "olive green" was used for about 3% of all responses, but just eight of the twelve informants used it. However, among those that did use it, agreement was high, with at least six of the eight using it for the same ten tiles (D_{50} in Table 6).

7. Comparing the Naming Studies

7.1 Candidates for BCTs

By and large, the same terms emerge as likely BCTs across the studies. For the three studies sampling all of colour space, the eleven BCTs plus [γalázjo] "light blue" followed by [laδí] "olive green" had the highest scores on most of the indicators of basicness. In the study using the blue region and its immediate surrounds, four of the above terms — [prásino], "green", [blé] "blue", [móv] "purple", [γalázjo] "light blue", [laδí] "olive green" — had the highest scores on most measures. Furthermore, by comparing Figures 3, 5, 6 and 7 it can be seen that the regions denoted by the various terms correspond reasonably well with each other, and with the appropriate landmark colour.

7.2 Best Examples

The latter claim can be evaluated more directly by comparing the various estimates of the best examples of the terms, with each other and with the universal foci. Figure 8 shows these data in CIE (u*, v*) and Figure 9 in CIE (u*, L*). These estimates of the best examples were derived as follows: For studies 2 (NCS) and 4 (Color-aid), the spatial mean of the stimuli evoking the highest agreement are shown; for Study 3 (NCS computer emulation), the stimulus with the fastest mean

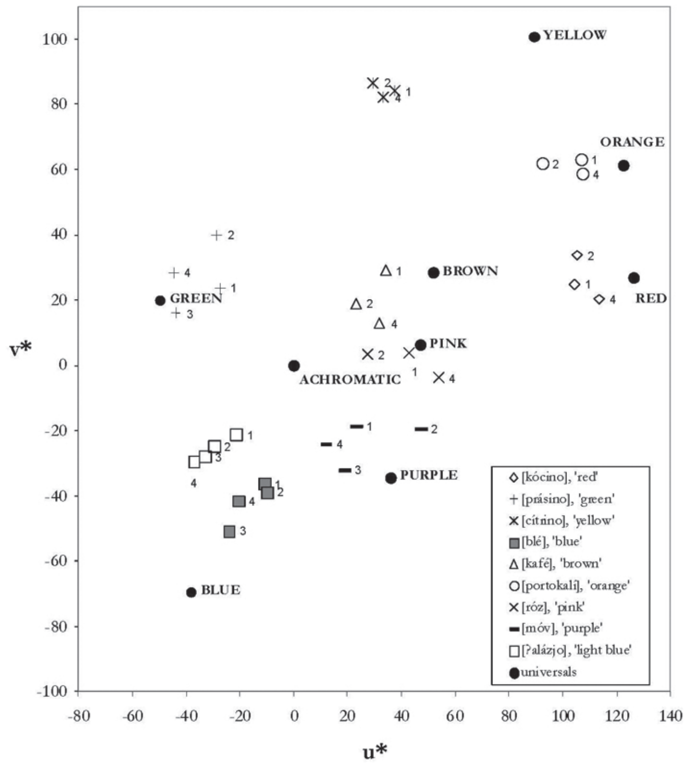

Figure 8. CIE coordinates (u* v*) of the estimates of the best examples of each main term for each naming study. 1 = paper NCS, 2 = computer generated NCS, 3 = Color-aid, 4 = Munsell.

RT is given; and for Study 5 (Munsell) the spatial averages across informants of the chosen best examples is shown.

The location of the centroids could vary for several reasons. First, the range of stimuli differed: there were less saturated stimuli available for computer emulated NCS than for standard NCS; and there were less saturated stimuli available for standard NCS than for Munsell. Second, the informants differed. And finally, the illuminants differed. The effect of reduced saturation would be to shift the best examples towards the centre somewhat. The effect of illuminant variation, unless compensated for by colour constancy, would be for the locations to shift towards blue for lower colour temperatures. There is some evidence consistent with both of these. The locations of the best examples of Munsell are a small amount towards the periphery compared to the NCS stimuli, and also a small amount towards blue. Nevertheless, the estimates of the best examples tend to cluster together, and to be close to the appropriate landmark colour.

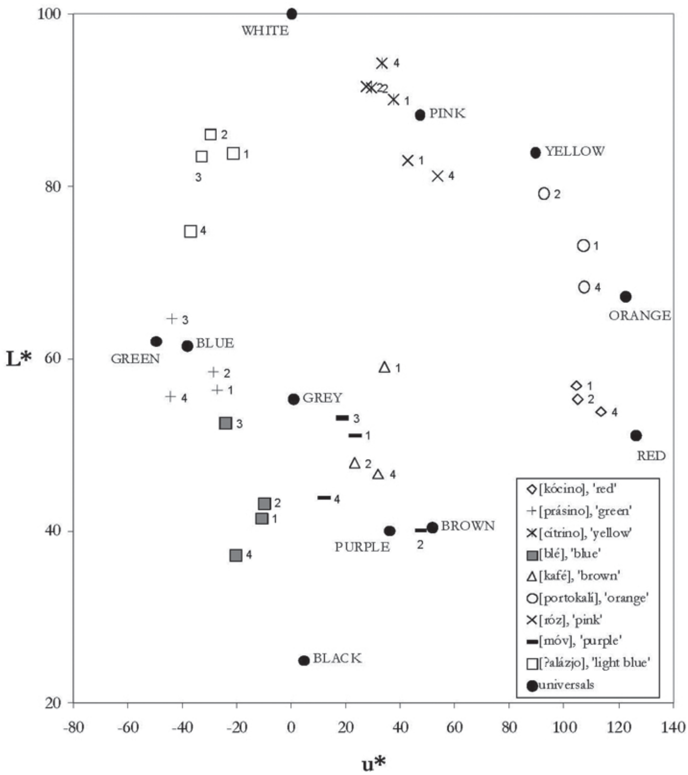

Figure 9. CIE coordinates (u* L*) of the estimates of the best examples of each main term for each naming study. 1 = paper NCS, 2 = computer generated NCS, 3 = Color-aid, 4 = Munsell.

7.3 Instructions

Comparing Table 2 (naming NCS) with Table 6 (naming Munsell) gives some indication of the effect of the different instructions. In the NCS study the scores are based on the subjects' first response, whereas in the Munsell study, they were always asked whether their first response could be replaced with a more general term. Allowing for the different numbers of stimuli in the two studies (685 for NCS and 320 for Munsell) it appears that the level of consensus was driven up by the 'necessity requirement'. There were more D_{100} tiles in the Munsell study (130) than in the NCS study (113) despite there being less than half as many Munsell stimuli as NCS. Some of this difference could be due to the differing characteristics of the two sets, but this is very unlikely to account for all of such a large difference. The effect of the necessity requirement was to reduce the number of terms used and to increase the usage of the surviving terms. This increase in usage and agreement strengthens the case for the eleven terms that throughout we have designated as the Greek BCTs. Moreover, even though using [γalázjo] "light blue" was replaced with [blé] "blue" by two informants there is some evidence that usage of [γalázjo] "light blue" was greater for the Munsell stimuli than for NCS. First, the percentage frequency of use was greater for Munsell than NCS (10.3% and 6.9%), and second, allowing for the different numbers of tiles, the level of agreement for Munsell was probably higher than for NCS (about the same D_{75} and D_{50} scores). In contrast, usage of [laδí] "olive green" was lower for Munsell than NCS (3.2% compared to 4.0%) and level of agreement was not higher for Munsell than NCS (e.g. 19 and 10 D_{50} tiles for NCS and Munsell, respectively). Taken together, this suggests that at minimum, [γalázjo] "light blue" has a stronger claim on basicness than [laδí] "olive green". Moreover, if it were not for two informants replacing [γalázjo] "light blue" with [blé] "blue", the case for it being a BCT would be very strong.

7.4 Stability across illuminants

One of the aims of these experiments was to see if the same terms emerged as candidate BCTs as in earlier studies, despite using a different illuminant. From the foregoing it is clear that the same likely BCTs do emerge. However, it is possible that the specific referents of the terms vary with the illuminants. If naming was driven entirely by the reflectance spectra incident at the eye, then the domain of each colour term should shift towards blue as colour temperature fell. Falling colour temperature indicates that the proportion of blue light is falling, entailing a shift towards bluer regions to maintain this proportion. On the other hand if it is the characteristics of the stimulus surface driving naming, then the same colour chips should evoke the same name despite varying illumination. We have seen that there is some evidence of a small effect of the illuminant (7.2), but here we make a further comparison of naming patterns across stimulus sets and illuminants. There are 101 stimuli used in the NCS 'paper' (Section 3) that have exact matches among the Munsell stimuli used in the last naming study (Section 6), in that they have the same CIE coordinates measured under illuminant C. Eighty seven of the matching pairs were given the same dominant name in the two experiments. Of the mismatches, ten were due to no name being dominant for the NCS stimuli, whereas there was a dominant name for the Munsell equivalents. There were four pairs with different dominant names; three of these were stimuli named yellow or orange in NCS, but named brown in Munsell. Thus, there was marked naming constancy despite illuminant variation and different informant groups.

7.5 Comparison with Russian and Turkish blues

We compared the domains of the Russian terms *sinij* "dark blue" and *goluboj* "light blue" (Moss et al. 1990) and the Turkish terms *lacivert* "dark blue" and *mavi* "light blue" (Özgen & Davies 1998) with those for [blé] "blue" and [γalázjo] "light blue". The stimulus sampling in the latter studies was not as dense or as uniform as in the current ones and most importantly, there are gaps in the data around the probable lightness boundaries: L*, 40–50 for Russian, and 27–35 for Turkish. Even so, it is clear that the major colorimetric difference between the two blue terms in the three languages is lightness, with a smaller difference in the chromatic plane. The dark blue terms lie closer to PURPLE than the light blue terms, and conversely, the light blue terms lie closer to GREEN than the light blue terms. Despite these similarities in the partitioning of the blue terms in the three languages, it is also clear that there are differences. The lightness boundary is somewhere below about 37, and possibly as low as 30 for Turkish. The Russian boundary is probably at about 45. There are five stimuli named *mavi* "light blue" in Turkish that are named *sinij* dark blue in Russian. Both Russian and Turkish differ from Greek, where the boundary is at about 60.

8. General Discussion

The main purpose of this series studies was to establish the basic colour terms of Modern Greek. In the introduction we suggested that the Greek BCTs were: *άσπρο* [áspro] "white", *μαύρο* [mávro] "black", *κόκκινο* [kócino] "red", *πράσινο* [prásino] "green", *κίτρινο* [cítrino] "yellow", *μπλε* [blé] "blue", *καφέ* [kafé] "brown", *πορτοκαλί* [portokalí] "orange", *ροζ* [róz] "pink", *μωβ* [móv] "purple" and *γκρι* [grí] "grey". We also raised questions about an additional term for blue, *γαλάζιο* [γalázjo] "light blue". Our data support the basic status of all the twelve terms given above, including [γalázjo] "light blue".

The twelve terms, particularly the chromatic ones, had high frequencies in texts in Study 1; high frequency of use, consistency of use and consensus in Study 2 (naming NCS); high frequency of use, consensus and naming times in Study 3 (naming computer emulated NCS); and high frequency of use and consensus in Study 5 (naming Munsell chips). The core repertoire of terms did not vary across the stimuli (NCS, emulated NCS and Munsell), illuminants (5700°K in Studies 2 and 3, and 4200°K in Study 5), and was reasonably stable across instructions (simple every-day terms in Studies 2 and 3, 'necessary' terms in Study 5). Instructions did have an impact, particularly on the relative use of the two blue terms [γalázjo] "light blue" and [blé] "blue", and we discuss this below. The stability of the core repertoire indicates one kind of naming constancy. However, despite the stability of the terms, their referents could have changed, particularly with the illuminant. There was some evidence that the illuminant did have an impact. The estimates of best examples shifted towards the blue region, probably to compensate for relatively low levels of short wavelength light in Study 5 (cool white daylight at 4200°K). But, this effect was small, and comparing the 101 stimuli from NCS and Munsell with identical CIE coordinates under illuminant C (metamerically equivalent reflectance spectra) showed that most of the pairs were given the same name, despite the illuminant difference. This probably reflects a reasonable degree of perceptual as well as naming colour constancy. The core repertoire of terms did not vary much across the samples of informants, despite variations in degrees of bilingualism and dialect (bilingual 'Athenian' speakers in Studies 2 and 5, monolingual 'Cretan' speakers in Study 2).

There were also a small number of 'marginal' terms, most notably [laδí] "olive green" and [béz] "beige" with high scores on many of the indices of basicness. Often there was no sharp cut off between one or both of these and the twelve terms that we claim are basic. We are happy to regard basicness as a continuum, and certainly, for some speakers at least, these terms have high salience. We return to these below when considering briefly category formation.

Subsidiary aims were to see whether reliable data could be collected under fieldwork conditions, where strict control of the illuminant could be difficult, and whether estimates of BCTs would vary across colour order systems. Our data support the assumptions we made in the introduction. Naming patterns are reasonably stable across relatively small variations in illuminant, at least. This suggests, that provided extremes (direct sunlight, or extreme shade) are avoided, the estimates of BCTs will be robust. And that, provided colour space is reasonably evenly sampled, estimates of BCTs will not vary much across colour order systems.

However, these conclusions, and those to follow, must be tempered with a degree of caution. Our variations of stimuli, illuminants, informants and instructions are confounded with each other. In the worst case, it is logically possible that the stability of naming arises from chance compensatory combinations of the factors. For instance, if Munsell stimuli had been presented to Study 2 informants under the Study 2 illuminant, the pattern of naming could have differed significantly from the pattern found for NCS naming. While we acknowledge such possibilities as logically possible, we believe that the likelihood of the various factors combining to produce the apparent stability across the three main naming studies, and for this pattern to be consistent with the analysis of frequency in texts, is small.

The two blue terms had similar scores on all our measures of basicness. They had very similar frequencies in texts and very similar frequencies of use across the four naming studies. They were assigned to similar numbers of stimuli at several levels of agreement, splitting the stimuli of the blue region into two parts. In addition, in the first naming study they produced very similar ratios of consistent: inconsistent use, while in the second study with monolingual villagers, speakers of a marked dialectal group, they were offered with similar response times. Both of the blue terms survived the variations in stimuli and illuminants. The instructions to the informants did play a role, however, in restricting slightly the use of [γalázjo] "light blue". In the third study the instructions invited the use of more specific terms, while in the fourth study more generic terms were required. As a result, the term [γalázjo] "light blue" was replaced for a small number of participants by the more specific term [θalasí] "sea blue" in the third study and in the fourth study by [blé] "blue". These effects, however, were small and [γalázjo] "light blue" maintained high frequencies.

Across all studies, we saw that the main difference between the referents of the two terms was lightness with [γalázjo] "light blue" denoting colours with lightnesses above ~63 and [blé] "blue" below this level. A lesser difference was that [γalázjo] "light blue" is slightly closer to GREEN than [blé] "blue", while the latter lies slightly closer to PURPLE than [γalázjo] "light blue". The best examples of [blé] "blue" lie close to the landmark colour BLUE in the chromaticity plane with the best examples of [γalázjo] "light blue" being a little closer to GREEN (Figure 8). However, in terms of lightness, the best examples of the two terms are both displaced from BLUE with [γalázjo] "light blue" being lighter and [blé] "blue" being darker.

Comparison of the referents of the two Greek blues with their Russian and Turkish equivalents shows that the main distinction between pairs of terms in each language is in lightness, they differ across languages in the locations of the boundary. On average, *sinij* "dark blue" denotes darker colours than [blé] "blue", and *lacivert* "dark blue" is even darker. Comparing the Russian and Turkish terms to the landmark BLUE reveals that *goluboj* "light blue" has on average about the same lightness as BLUE but *mavi* on average is darker than BLUE These differences suggest that the origins of the pairs of blue terms in the three languages cannot be just universal forces, such as a nascent dark blue and light blue universal categories or nascent points of perceptual salience. There may be universal influences, nonetheless, to combine lightness information with chromatic information, with fine tuning from other forces.

Lightness range is one of the parameters required to specify the domain of many colour terms. For instance, Boynton and Olson (1987) found that *blue* and *green* were the only English colour categories that occurred at all lightness levels. The remainder occupy restricted lightness regions. We have seen throughout the four naming studies reported here, that the same is true for Greek BCTs including the two blue terms. The chromatic terms [γalázjo] "light blue", [róz] "pink", [portokalí] "orange" and [cítrino] "yellow" only occur above L* = 63, while the terms [blé] "blue", [móv] "purple", [kafé] "brown", and [kócino] "red" only occur below this lightness (e.g. Figure 4). Even the marginal terms [laδí] "olive green", [béz] "beige", [bordó], "claret" and [fúksia] "fuchsia" occupy restricted lightness ranges. [Laδí], [bordó], "claret" and [fúksia] "fuchsia" occur only below L* = 63, whereas [béz] "beige" only occurs above that lightness.

Kay and McDaniel (1978) suggested that derived categories (the last six terms on the hierarchy) were fuzzy set intersections of primary terms. Within this framework, we suggested in the Introduction that [γalázjo] "light blue" could be thought of as the intersection of BLUE-WHITE. The neuro-physiological basis for Kay and McDaniel's theory has had to be modified (de Valois & de Valois 1993) and the invariance of the universal foci has been questioned at both the language level (e.g. Roberson et al. 2000, but see Regier, Kay & Cook 2005) and at the perceptual level (e.g. Malkoc, Kay & Webster 2005). Nevertheless, most visual scientists accept that there is something singular about the four unique hues, and that the cardinal directions of psychological colour space — red-green and blue-yellow — correspond with Kay and McDaniel's chromatic primary categories. In the early stages of colour processing chromatic and achromatic mechanisms are processed in independent channels (e.g. Lennie and Movoshon 2005). But the involvement of lightness in specifying the domains of most BCTs implies that category formation involves the interaction of chromatic and achromatic mechanisms. Moreover, this involvement continues in the formation of new BCTs such as [γalázjo] "light blue" and secondary terms such as those given above. It may be that the mechanisms underlying fuzzy set intersection can be found in the interactions of luminance, with the two chromatic channels.

9. Summary

Taken overall, these data indicate that Modern Greek has twelve basic colour terms including two terms for blue — [γalázjo] and [blé] — and that these are glossed most appropriately as "light blue" and "dark blue". The term [laδí] "olive" has the next highest claim on basic status. Our data were relatively stable across stimuli, informants and illuminants suggesting that precise control over these variables is not crucial in field studies aimed at establishing a language's BCTs.

Notes

* Some of the work reported here was used in Anna Androulaki's Ph.D. After completing her thesis, Anna returned to her native Athens and continued her academic career there. She died shortly after her return, leaving great sadness in her family, friends and colleagues, and ending, very prematurely, a promising career. She was very proud of being Greek, and she would have been delighted that this sample of her work on the Greek language is being published in a journal of Greek Linguistics. (Androulaki, Anna. 2003. *Colour term acquisition and the development of working memory in children: a cross-linguistic investigation and a test of the linguistic relativity hypothesis*. Ph.D. Dissertation, University of Surrey.)

1. The idea of 'fundamental neural responses' was derived from the neurophysiology of the time (de Valois & Jacobs 1968). They appeared to have identified the neural basis for the Hering (1964) primary opponent process pairs: red-green, blue-yellow and black-white. Subsequent work has undermined this claim (de Valois & de Valois 1993). Nevertheless, the best examples of these terms appear to be psychologically unique, perceptual primitives, for reasons unknown (see Jameson & D'Andrade 1997 and Saunders & van Brakel 1997 for dissenting views).Focal colours were also part of Kay & McDaniel's (1978) theory of category formation: they were prototypes and categories crystallised around them. The importance of foci in category formation has been questioned (e.g. Jameson 2005) as has the claim that there is good agreement over the foci (e.g. Roberson, Davies & Davidoff 2000, Saunders & van Brakel 1997), but see Kay & Regier 2003 and Regier, Kay & Cook 2005.

2. The term *λευκό* [lefkó] can also be translated as "white". However, none of our informants in any of the studies used the term to name a colour. It tends to be used metaphorically, meaning for instance "pure".

3. One set of NCS stimuli was presented as emulations on a computer monitor. Although rarely used in the field, laboratory studies now commonly use computer displays. However, colour constancy may be compromised when stimuli are viewed singly on a monitor in a dark environment (Hurlbert 1999). This may also be the case for viewing real surface stimuli singly under concealed illuminants. Under less reduced viewing conditions there are usually potential comparison stimuli available that allow colour constancy mechanisms to function more optimally. Thus, paradoxically, field methods may give results more indicative of the standard use of terms than some laboratory methods. Using emulated NCS colours was thus a further check on the robustness of Greek BCTs.

4. There is also a range of individual differences in colour vision. There are inherited defects such as: Daltonism (red-green colour blindness), subtler effects due to small differences in the sensitivity of the cone photo pigments, and differences in pre-retinal filtering that produce variations in the effective wavelength. There are also acquired defects such as: yellowing of the lens due to ultra violet damage, which again changes the effective wavelength composition at the retinae; and various drugs and illnesses affect colour vision. In order to function in effective widespread communication colour naming must be robust enough to be reasonably constant across individual differences, just as for illuminants. However, apart from extreme cases such as dichromatism or advanced lens brunescence, focal colours are unlikely to be named with the wrong BCT.

5. Excluded cards were: 3 to 21, and 31, 41, 49, 67, 73, 79, 87, 95, 113, 119, 123, 131, 137, 143, 149, 161, 171, 179, 195, 201.

6. All reported means are weighted means: total RT across all occurrences divided by total occurrences. Thus, the mean score for the various dominance levels, for instance, is not the same as the mean of the respective mean scores in Table 4.

7. [θalasí] is an object-name derived from [θálasa] "sea", and [siél] " sky blue" is a French word meaning "sky".

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Appendix: Notes on colorimetry, illuminants and colour order

There are several colour order systems that try to embody the perceptual structure of colour space in their dimensional structure. The studies we report use three of these — Color-aid, Munsell and the Natural Colour System (NCS) — and we describe each of these briefly below. The stimuli in all systems can be described in a common set of co-ordinates taken from CIE (Committee International d'Éclairage) and they function as a *lingua franca* that allows translation among the systems. Throughout the paper we use CIE (L*, u*,v*) to specify the stimuli, and this is explained below. Finally, colour appearance (and CIE co-ordinates) depends on both the stimulus surface and on the light falling on it (the illuminant). Colour order systems are usually standardised under a particular illuminant, and deviations from the specified illuminant change the co-ordinates, and to a lesser extent, their appearance. This 'damping' of perceptual change is known as colour constancy. To some extent the visual system seems to be able to take the illuminant into account. Colour temperature is a simple metric that characterises illuminants, and this is also described briefly below. Hunt (1987) is a good source of further information.

1. Colour order systems and CIE

1.1. Natural colour system
The NCS is a colour notation system based on Hering's (1964) opponent theory of colour and developed in Sweden by Johansson, Hesselgren and Hård (see Hård, Sivik & Tonnquist 1996, Sivik 1997). The NCS three-dimensional colour space has the six primary colours arranged in opponent pairs on three orthogonal axes, which form a double-cone. The achromatic colours are placed at the tips of the two cones, white at the top and black at the base. A horizontal colour circle, where the two cones are joined, bisects the figure, with yellow (Y), red (R), blue (B) and green (G) placed on it like the points of a compass, in this order. Each quarter of the circle is subdivided into ten regularly spaced hues. For example, starting from Y clockwise towards R, the steps are Y10R, Y20R, Y30R … Y90R, finally R. There are forty vertical equilateral triangles, one for each of the hues of the circle. The vertical side on the left of each triangle is the grey scale from white to black, from 0% (top) to 100% (bottom) blackness. The apex on the right, opposite to the white-black side, is the maximum strength of the particular hue, again from 0% (left) to 100% (right). The second edition of the atlas contains 1750 'paper' samples standardised under illuminant D65 (see below). The stimuli used here in the first naming study were a subset of 685 of these. Note that the NCS atlas on average does not include colours as saturated as the Munsell system (described below), but there are matching colours in the two systems.

1.2. Color-aid

The Color-aid corporation supplies a set of several hundred colours. Their system is based on the Ostwald colour solid (see Foss, Nickerson & Granville 1944). There are six cardinal Hues: Y (yellow), O (orange), R (red), V (violet), B (blue) and G (green), and intermediate Hues such as OYO (orange yellow orange). Each Hue has four Tints, T1-T4, with increasing lightness, and other variations not used here (Shades and Pastels). For instance, Y-T1 has the Hue yellow, but is lighter than Y-Hue. We show the CIE coordinates of the stimuli used here and these allow 'translation' from Color-aid to better known systems such as Munsell or OSA (Optical Society of America), see for instance, Foss, Nickerson and Granville 1944.

1.3. The Munsell system

Munsell stimuli are standardised colours produced with high reliability. Munsell colour space is three-dimensional: Hue, Value (lightness) and Chroma (colourfulness, rather like saturation). In Munsell notation, Hue is specified by abbreviations of five main Hues: R (red), Y (yellow), G (green), B (blue) and P (purple). Combinations of the main hues such as YR designate intermediate hues. A number as in 7.5RP, 10RP, 2.5R, 5R precedes the Hue abbreviation indicating the degree of the Hue. Value ranges from 0.5 (darkest) to 9.5 lightest. Chroma ranges from 0 (achromatic: white, black or grey) upwards, with increasing numbers indicating increased colourfulness. The maximum Chroma realisable varies with Hue and Value; but 16 is about the maximum available in the Munsell colour atlas.

The system was standardised so that each dimension was intended to be perceptually uniform. Thus, equal differences in Value anywhere in the space for constant Hue and Chroma appear the same. The situation with Hue is more complicated. For constant Chroma, equal Hue differences appear the same; however, the perceptual distance between Hue steps increases with Chroma. Thus, it is particularly important to use constant Chroma if the Munsell metric is used to give equal perceptual distances. The standardisation was done under CIE illuminant C (~6700°K) and the colour appearance and uniformity of the spacing only hold under this illuminant (but see below on colour constancy).

1.4. CIE (L*u*v*)

The CIE (Committee International d' Éclairage) have several systems for describing colour. The one we use here is recommended for describing differences in colour appearance. L*, u*, v* are the axes of the colour space and equal distances in the space are intended to correspond with equal perceptual distances. In other words it is perceptually uniform. L* is lightness; u* is approximately the red-green axis; and v* is approximately the blue-yellow axis.

The graphs representing the stimuli in CIE coordinates include the positions of the Berlin and Kay (1969) focal colours taken from Heider (1971). These can be used as landmarks supporting interpretation of the rest of the space. For instance, in Figure 3 focal red is towards the right of the diagram; focal green is towards the centre-left of the diagram; focal blue is bottom-left; and focal yellow is top-right. Achromatic colours (white, black and grey) lie towards the centre of the diagram. Note that around the co-ordinate envelope, the sequence of hue changes resembles the traditional colour-circle; for instance, moving clockwise from GREEN gives the hue sequence: green-yellow-orange-red-purple-blue. BROWN and PINK lie inside this envelope (along with the achromatic colours) indicating that they have lower saturation than the main hues. Distances among the loci represent the perceptual similarity of the colours: the closer together the more similar they are.

2. Light sources, colour temperature, and colour constancy

2.1. Light sources

As mentioned above, Munsell standardisation was done under CIE illuminant C and NCS under CIE D65. For our purposes, these two illuminants are very similar; both have approximately equal amounts of visible wavelengths, and appears more or less white. It is similar to light from the north on a clear day, in northern Europe. Light from the south is 'yellowier', particularly direct sunlight, and the prevailing daylight in Greece, where the colour lexicon we investigate here was developed, has more long-wavelength light and less short-wavelength than in northern Europe. This is even more so for normal domestic lighting (incandescent light); it appears yellowish and should be avoided for colour work, unless the issue is colour appearance under that lighting.

2.2. Colour temperature

These variations in spectral composition of lights are captured by variations in 'colour temperature'. The short-wavelength component increases and the long wavelength decreases as the temperature increases from 2500°K (domestic) through 6700°K (illuminant C) to > 10000°K (red hot through white hot to blue hot). The colour temperatures used in the naming studies reported here ranged from 4700°K to about 7500°K.

2.3. Colour constancy

The spectral composition incident at the eye is determined by first, the spectral composition of light falling on the viewed surface, and second by the nature of the surface. Under 'north light' (illuminant C) the wavelength composition of the light is fairly evenly spread across all visible wavelengths, but the light arriving at the eye after reflection from the surface will be changed to varying degrees depending on the nature of the surface. A red surface tends to reflect the longer wavelength component of the incident light and absorb the shorter wavelengths, whereas a blue surface does the reverse. However, under an illuminant with less long-wavelength light, the absolute amount of long-wavelength light hitting the eye will fall, and the shorter wavelength component will increase. The reverse would happen with a blue surface. If colour appearance were determined solely by the absolute amounts of light hitting the eye, then appearance should change with the illuminant. On the other hand, if colour appearance is determined solely by the nature of the surface, it should not vary with the illuminant. In practice, depending on the circumstances, colour appearance falls between the two extremes. It does vary with the illuminant, but it is reasonably invariant; this is known as colour constancy.

One of the aims of the studies reported here was to see how consistent colour naming was across different illuminants. Such consistency could have two components. First, the repertoire of terms could stay the same, but the stimuli (the real surfaces) to which they were applied could shift with the illuminant. For instance, if one light was bluer than another, and if naming was determined by how much blue light hit the eye, naming would shift in the direction of *less* blue colours. On the other hand, if perfect 'naming constancy' existed, then the same surfaces would receive the same name irrespective of the illuminant.

CIE coordinates have no colour constancy. They faithfully co-vary with the illuminant. There are several ways we could use to represent the stimuli in CIE co-ordinates across different illuminants to assess naming constancy. The way we have chosen is to use the landmark colours as fixed points across all illuminants and to show the test stimuli as though they too were under their standard illuminant. Knowing the illuminant, we therefore know what the true CIE co-ordinates would be, and can predict what direction the naming domains would shift in if there was no or only limited naming constancy. For instance, Munsell stimuli were viewed under fluorescent lighting that was much yellowier than the illuminant C. With no naming constancy, the domain of all terms should shift towards blue to compensate for the shortage, and they should all be displaced in that direction from the landmark colours. Similarly, we can predict what shift there ought to be in the naming domains of stimuli seen under different illuminants, such as in Study 2 and Study 5. To the extent the shift occurs we can infer the degree of naming constancy.