

A developmental study of the acquisition of Russian colour terms*

IAN R. L. DAVIES, GREVILLE G. CORBETT,
HARRY MCGURK† AND CATRIONA MACDERMID

University of Surrey

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ABSTRACT

We report a study of the acquisition of colour terms by Russian children which had two main aims: first, to test Berlin & Kay's (1969) theory of colour universals using acquisition order as a measure of basicness; and secondly, to see if the two BLUE terms of Russian are genuinely basic. Two hundred children aged from three to six-years-old were tested on three colour-tasks – colour term listing, colour term production and colour term comprehension. To a reasonable approximation, the order of colour term acquisition was in accord with Berlin & Kay's theory, but the data are also consistent with the weaker claim that primary terms tend to be learned before derived terms. On balance the data were consistent with Russian exceptionally, having an extra term for the BLUE region. But, the two BLUE terms – *goluboj* 'light blue' and *sinij* 'dark blue' – were confused more often than other pairs of terms even by the five- to six-year-old sample.

INTRODUCTION

Berlin & Kay's (1969) theory of colour universals is one of the most enduring and influential theories in the field of colour categorization. At the core of the theory is the proposal that all languages draw their inventory of 'basic' colour terms from a universal inventory of just eleven possible terms (designated here by small capitals). Thus no language should have more than eleven such

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[†] Now at The Australian Family Research Unit, Melbourne.

terms. There are good grounds, however, for believing that Russian has twelve basic colour terms – it has two basic terms for BLUE – and thus appears to be an exception to the theory. The work we report here is a developmental study of the acquisition of Russian colour terms with two main aims. First, to test the theory in general, and second, to establish the status of the two BLUE terms. We will first outline the theory briefly, and consider the relevance of the developmental approach to the theory. Then we describe Russian and the implications of the two BLUE terms for the theory, and lastly, we outline the rationale for the current study.

The Berlin & Kay theory

Berlin & Kay's crucial insight was that although there were striking variations across languages in the mapping of colour terms onto colour space, there was much less variation in the foci (the best exemplars) of colour terms than there was in the boundaries of colour categories. They argued that all possible sets of basic colour terms are drawn from 11 universal colour categories, (characterized by their foci) listed on the hierarchy shown in Fig. 1.

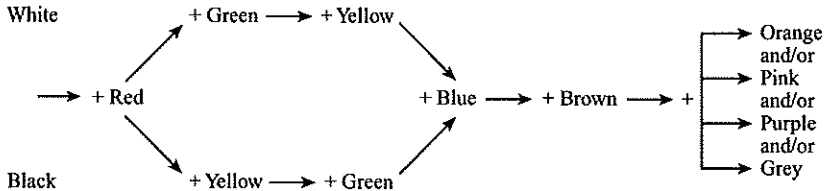


Fig. 1. The Berlin and Kay (1969) hierarchy of basic colour terms.

The hierarchy constrains basic colour term inventories in the following ways: first, all languages have between two and 11 basic terms; second, if a language has one of the possible terms, then it should have all the terms to the left of it on the hierarchy. Thus, if a language has two basic colour terms, they should be WHITE and BLACK; if it has three basic colour terms, they should be WHITE, BLACK and RED, and so on up to the theoretical maximum of eleven basic colour terms.

There have been a number of major developments to the theory since its inception (see Kay, Berlin & Merrifield, 1991, for a statement of their current position). For our immediate purposes the most crucial development is the distinction between 'primary' categories (the first six terms on the hierarchy) and 'derived' colour categories (the last five terms) (see Kay & McDaniel, 1978). The latter argue that the colours denoted by the primary terms are

fundamental: they are perceptually and neurologically independent of each other, and irreducible to other colours. These are the primary colours, and their linguistic labels are the primary colour terms. Secondly, they argue that the underlying structure of colour categorization can be understood in terms of the logic of fuzzy sets. Derived colour categories are the fuzzy set intersection of two of the primary categories: for example, according to the theory, the derived term PURPLE emerges from the fuzzy set intersection of RED and BLUE. Further, they proposed that colour categories in languages with less than the six primary terms should be thought of as composite categories; these are the fuzzy set unions of two or more primary categories. According to Kay & McDaniel, the evolution of colour terms consists of first of all the decomposition of composite categories as a language moves from two composite colour terms through to six primary colour terms; followed by 'infilling' between the primary terms by fuzzy set intersections to yield the derived colour terms. Finally, non-basic terms arise through the subdivision of basic categories, but they retain membership in the basic category: thus, for example, the English term, *scarlet* denotes a sub-region of the category *red*, while retaining membership of the *red* category.

Although many reservations have been expressed over Berlin & Kay's idea of basicness – see for instance Crawford (1982), Moss (1989) and Simpson (1991) – the issue is not crucial to our present concerns. Here we will use Hardin & Maffi's (1997) succinct definition: basic colour terms are 'simple and salient'. Salience has been variously operationalized as, for instance, frequency of use, speed of naming, agreement across speakers and the tendency to occur early in elicited lists. The most common paradigm for establishing the basic colour terms in a language is based on the original Berlin & Kay method (see MacLaury, 1991: 36–37 for a description of the original procedure and subsequent developments). It consists of mapping the region of colour space denoted by likely basic terms and establishing the best example for each such term in an array of 330 Munsell colour chips. The informants in such studies are usually adults.

Developmental studies

A complementary approach is to study the acquisition of colour terms by children. The rationale underlying such a developmental paradigm was suggested by Berlin & Kay: it is essentially that children should acquire the basic colour terms in the order of the hierarchy, because of the fundamental nature of the perception of the referents of the primary terms, and because of greater exposure to the more frequent colour terms in the language.

There have been a number of studies of colour term acquisition in languages with relatively few basic colour terms. Dougherty (1978) studied the acquisition of colour terms by twelve-year-old Western Futonans, using a combination of production (what do you call this?), comprehension (show

me a —) and colour mapping tasks. She combines performances on these tasks into a single composite index of mastery of each basic colour term, and reports a strong relationship between the order of acquisition of basic colour terms and the Berlin & Kay hierarchy. Harkness (1973) studied speakers of Mam and Spanish in Central America using two production tasks and a comprehension task. She presents data for seven- to eight-year-olds on one of the production tasks where the performance scores are ordered very closely to the Berlin & Kay hierarchy.

In contrast, studies of the acquisition of colour terms in languages with the full set of basic colour terms (usually English) have found less clear-cut support for the theory. In general, primary terms are acquired before derived terms, but the match with the Berlin & Kay sequence has only been moderately close; the major deviation from the hierarchy is that *white* and *black* are consistently too low in the order of acquisition. However, colour production tasks as used by Johnson (1977) and Andrick & Taylor-Flusberg (1986) yield stronger correlations with the hierarchy than comprehension tasks. Andrick & Tager-Flusberg suggest that this may be the reason Heider (1971), who used a comprehension task, found little relationship with the Berlin & Kay sequence.

All the studies mentioned so far have used cross-sectional methods, whereas Cruse (1977) and Bartlett (1978) used longitudinal procedures. Cruse reports a single case study of the acquisition of colour terms by a child who was almost two-years-old by the end of the study. Although the child had not yet mastered the full set of basic terms, Cruse (1977: 310) concluded that there was a 'broad congruence between the Berlin & Kay ordering and the development of colour naming in one individual'. Bartlett studied the acquisition of colour terms by thirty-three two- to four-year-olds; she tested the children on four occasions at roughly six-week-intervals. Using a combined production and comprehension index, she reported that on average the acquisition order was similar to the hierarchy. However, when considering individual cases, only two out of 15 children who knew less than six terms when the study started, acquired all the primary terms before acquiring at least one derived term. This latter finding suggests that group data alone may be misleading. Accordingly, we consider individual subject profiles, as well as mean scores, in assessing whether the data fit the hierarchy.

Russian colour terms

There is now good evidence that Russia has two non-overlapping terms to cover the blue region (e.g. Vamling, 1986; Corbett & Morgan, 1988; Davies & Corbett, 1994). The two blue terms of Russian are *sinij* 'dark blue' and *goluboj* 'light blue', both of which meet the criteria for basicness. This gives an inventory of twelve basic terms:

belyj 'white', *černyj* 'black', *krasnyj* 'red', *zelenyj* 'green', *želtyj* 'yellow', *sinij* 'dark blue', *goluboj* 'light blue', *koričnevyy* 'brown', *fioletovyy* 'purple', *rozovyy* 'pink', *oranževyy* 'orange', *seryj* 'grey'.

The possibility that there were two basic terms for blue was noted by Berlin & Kay themselves (1969: 99)¹ and Kay & McDaniel (1978: 640); the latter suggest that *goluboj* 'light blue' may be a twelfth basic term for some Russian speakers but not others. Nor would a twelve-colour-term language necessarily pose a problem for the theory. The possibility of languages acquiring more than eleven basic colour terms was considered by Kay & McDaniel (1978: 640–641): 'The process that characterizes derived category formation has not been logically exhausted by any known language; so there is no apparent reason to believe that the process will not continue, extending basic colour term lexicons beyond their present eleven terms'.²

If *goluboj* and *sinij* are both basic then children should acquire and master the use of both terms at least earlier than they acquired any non-basic terms. Early work by Šif (1940) and Istomina (1960a, 1960b/1963) on children aged from two to 14 years suggests that *goluboj* has at least the level of salience of derived terms such as *fioletovyy* (see the Appendix for a summary of this early work). Istomina's work, in particular, is important, but it cannot be used as a complete test of the Berlin & Kay theory, because her test-stimuli did not include tokens of all of the 11 universal categories. The principal aims of the investigation we report here were to see to what extent the order of the acquisition of Russian basic colour terms fits the Berlin & Kay hierarchy, and to clarify the status of the two blue terms. Accordingly, we studied the 'colour behaviour' of Russian speaking children, aged from three- to six-years-old, on a list task, a production task, a comprehension task and a measure of general vocabulary.

Assessing the fit to the hierarchy and alternative orders

The various colour tasks we use yield an ordering of colour terms derived from the number of children who 'pass' the test for a given term, for instance, the number of children that offer a given term in the list task. The

[1] Russian is probably the clearest counter example in this regard. Note, however, that Bolton, Curtis & Thomas (1980: 317) state that in their work on Nepali *akāshi* 'sky light blue' was "the most commonly elicited secondary term", and that there is evidence that *celeste* 'light blue' may be acquiring basic status in Guatemalan Spanish (Harkness (1973): 177) and Peruvian Spanish (Bolton 1978: 293–4).

[2] Zollinger (1984) pointed out that there was ample room in colour space between focal BLUE and GREEN for the development of a derived term. He conjectured that *turkis* 'turquoise' in German and *turquoise* in English would both become basic. However, it appears, for reasons that are unclear, that BLUE has split into two categories in Russian (and possibly other languages such as Turkish (Özgen & Davies, 1997) before the acquisition of a derived TURQUOISE term.

orders can then be compared to the order predicted by the hierarchy using a correlation coefficient. However, high correlations between acquisition orders and the hierarchy can be produced from acquisition orders other than the hierarchy. Corbett & Davies (1995: 310) point out that if the six primary terms were acquired before the five derived terms, but that there was no difference in order within the primary and derived sets, the rank order correlations with the hierarchy would be greater than 0.8 (Spearman's $\rho = 0.89$; Kendall's $\tau = 0.80$). As we shall see, these values are larger than many of the correlations between acquisition orders and the hierarchy that we report in the results section. Thus, rather than just considering the fit to the hierarchy, we will compare the latter to the fit to alternative 'models' of the structure underlying the observed acquisition orders. The alternatives we consider are lower 'resolution' versions of the hierarchy, such as the two set (primary derived) order described above. In addition, we use Guttman scaling to see if there is some consistent empirically derived linear ordering of the terms, other than the hierarchy, that fits the data.

METHOD

Subjects

The study was carried out in two phases. In total there were 200 children, 80 in phase one and 120 in phase two. No child took part in both phases. In phase one the sample was composed of the full factorial combination of sex, age (three-year-olds or four-year-olds) and education (attended day nursery or did not) with equal numbers (10) in each cell. The sample in phase two had the same basic composition, but there was an additional age group of five-year-olds; again the number in each cell was 10. The mean (and standard deviation) ages for the three groups were: 3;6 (0;2), 4;6 (0;2) and 5;7 (0;3).

Stimuli

The stimuli for the production and comprehension tasks consisted of 12 five-centimetre square coloured 'tiles' presented on a neutral grey background. The colours were selected from the Color-aid Corporation range of coloured papers. The colours were good examples of the universal foci (see Heider, 1971) except for the two Russian blues. In the latter case, the colours were selected such that they were good examples of *goluboj* in one case, and *sinij* in the other case. (Both stimuli were good examples of English 'blue'.) Table 1 shows the dominant name given to each of the tiles by Russian speakers, the English gloss, their Color-aid codes, and their CIE (Commission Internationale Eclairage) co-ordinates. (See Moss, Davies, Corbett & Laws, 1990, for the Russian naming data and a description of the Color-aid system; and

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TABLE I. *Russian colour terms, and the Color-aid code and CIE coordinates for the tile-colours*

Term	Gloss	Color-aid code	CIE coordinates		
			Y	x	y
belyj	white	White	0·81	0·32	0·33
černyj	black	Black	0·04	0·34	0·33
krasnyj	red	RO Hue	0·16	0·58	0·33
zelenyyj	green	YG Hue	0·15	0·28	0·48
želtyj	yellow	Y Hue	0·65	0·47	0·48
siniij	dark blue	B S ₁	0·09	0·20	0·18
goluboj	light blue	BGB T ₂	0·22	0·20	0·23
koričnevyyj	brown	O S ₃	0·09	0·42	0·36
fioletovyyj	purple	V Hue	0·05	0·26	0·17
rozovyyj	pink	R T ₄	0·24	0·40	0·27
oranževyyj	orange	YO Hue	0·40	0·51	0·41
seryj	grey	Gray 4	0·19	0·31	0·31

Newhall, Nickerson & Judd (1943) for a table which translates CIE coordinates into Munsell specification.)

Procedure

The same experimenter collected the data in both phases; she lived in Moscow and Russian is her first language. In all instances, the experiments were conducted solely in Russian. As well as the performance data on the children, information about the parents' occupations was collected.

In phase one each child did two tasks: colour term elicitation (the list experiment) and colour term production (the naming experiment), in that order. In phase two, each child did the same two tasks as those in phase one, but also did a colour comprehension task, and three further list tasks: animal term, children's name and body-part term listing. These were included to assess general verbal ability. All children did the colour term elicitation task first, followed by the production task for half the children in each sub-group, or by colour comprehension for the remaining half of each sub-group. This was followed by the three additional list tasks in the order: animal, body-parts and children's names; and finally the remaining colour task, either production or comprehension. The experiment was carried out either at the child's home, or at the day nursery, indoors, under natural day light, avoiding either direct sunlight or excessive shade.

The children were assessed individually. For the four list tasks, the children were put at their ease, and then asked to say as many of the appropriate terms as they knew. The experimenter recorded the child's responses in the order they produced them, encouraged them to offer more terms when they paused, and only moved on to the next task after they had

said they did not know any more terms. In most cases each list task lasted less than one minute.

In the colour production task, the children were shown each tile, one at a time, in random order, and were asked what they called the colour. Their verbatim responses were recorded. In the colour comprehension task the children were asked to 'point to the X-tile', where X was one of the basic colour terms. They were asked to respond to each of the twelve basic terms, in a different random order for each child. The tile they pointed to was recorded. For both colour term production and comprehension, if children said they did not know, they were encouraged to try, but a 'don't know' response was recorded if they still said they did not know.

RESULTS

Colour term elicitation

The number of children in each age group that offered each colour term is shown in Table 2, expressed as a percentage of the sample size, together with

TABLE 2. *The percentage of children (P) that offered each term and the rank orders (R) of the terms on the percentage scores*

Term	Gloss	Age (years)								
		3-4		4-5		5-6		Total sample ^a		
		P	R	P	R	P	R	P	R	Position
Primary terms										
belyj	white	53.8	5	65.0	6	77.5	5	64.4	5	5.7
černyj	black	33.8	6	71.3	5	82.5	2	62.5	6	5.8
krasnyj	red	90.0	1	96.3	1	92.5	1	93.0	1	3.0
zelenyj	green	77.5	2	90.0	2	77.5	5	81.7	2	4.1
želtj	yellow	62.5	4	82.5	3.5	77.5	5	74.2	3	4.0
sinij	dark blue	67.5	3	82.5	3.5	80.0	3	76.7	4	4.2
goluboj	light blue	25.0	7	56.3	7	72.5	7	51.3	7	6.0
Derived terms										
koričnevij	brown	20.0	8	47.5	9	62.5	8	43.8	8	6.4
fioletovij	purple	8.8	11	31.3	11	50.0	10	30.0	11	6.7
rozovij	pink	16.3	9	40.0	10	47.5	11	34.6	10	6.6
oranževij	orange	15.0	10	51.25	8	55.0	9	40.4	9	6.3
seryj	grey	5.0	12	21.3	12	45.0	12	23.8	12	7.1
Secondary terms										
sirenevij	lilac	1.3	14.5	18.8	13	20.0	14	13.3	13	7.6
malinovij	raspberry	2.5	13	8.8	14	15.0	15	8.8	15	7.7
salatovij	salad green	0.0	16.5	7.5	15.5	27.3	13	11.6	14	7.9
bordovij	claret	1.3	14.5	7.5	15.5	7.5	17	5.4	16	7.8
beževij	beige	0.0	16.5	1.3	17.5	10.0	16	3.8	17	7.9

^a The final column shows the mean list-position for each term across the total sample.

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TABLE 3. *Percentage of children (P) that correctly named each tile, and the rank orders (R) of the scores for each tile for the production task*

Term	Gloss	age (years)					
		3-4		4-5		5-6	
		P	R	P	R	P	R
Primary terms							
belyj	white	77.5	2	96.3	1	97.5	3
černyj	black	63.8	5	91.3	4	97.5	3
krasny	red	85.0	1	96.1	2	100.0	1
zelenyj	green	76.3	3	83.8	5	97.5	3
želtyj	yellow	73.8	4	92.5	3	92.5	5
sinij	dark blue	50.0	6	72.5	6	82.2	6
goluboj	light blue	18.8	9.5	42.0	11	70.0	8.5
Derived terms							
koričnevij	brown	28.8	7.5	57.6	8.5	67.5	10
fioletovij	purple	10.0	11.5	21.3	12	57.5	12
rozovij	pink	18.8	9.5	57.6	8.5	70.0	8.5
oranževij	orange	28.8	7.5	63.2	7	75.0	7
seryj	grey	10.0	11.5	42.8	10.0	65.0	11

the combined figures for the total sample.³ In addition, Table 2 shows the rank order of the frequency with which each term was offered by each age group. The colour terms are ordered according to the Berlin & Kay hierarchy; thus the primary basic terms come first followed by the derived basic terms, and these are followed by the five most frequent non-basic terms. *Sinij* and *goluboj* are placed between the primary and derived terms, in acknowledgement of their uncertain status.

It is apparent that the children offered far more basic than non-basic terms; the youngest age group offered only three non-basic terms: *sirenevij* 'lilac', *malinovij* 'raspberry' and *bordovij* 'claret'; and these were offered only four times in total. For each age group there is no overlap between the frequency with which basic and non-basic terms are offered; the most frequent non-basic term is always offered less frequently than the least frequent basic term. Within the basic terms the primary terms are offered more frequently than the derived terms, but this difference appears to narrow with age. These impressions were supported by formal statistical procedures. Two-way ANOVA on age and type of colour term (primary or derived)

[3] There were reliable effects of sex, child's education and parent's education. Briefly, girls score higher than boys, home-educated children score higher than nursery-educated children, and children of parents with a degree score higher than children of parents with no degree. However, as none of these effects is central to the test of Berlin & Kay's theory, or to the status of the two BLUE terms, we will not consider these data any further here.

showed that both main effects and the interaction were all highly significant (minimum $p < 0.005$).

It can be seen that the rank orders for the colour terms are reasonably stable across age. With the exceptions of *belyj* 'white' and *černyj* 'black', there is a reasonable correspondence between the rank orders of the frequencies with which the basic terms are offered and the rank orders of the Berlin & Kay hierarchy (Kendall's τ ranges from $\tau = 0.62$; $p < 0.004$, to $\tau = 0.75$; $p < 0.001$; *goluboj* 'light blue' and *sinij* 'dark blue' were assigned equal ranks, sharing the sixth and seventh positions). Table 2 also shows a measure of the order in which terms were offered; this is the mean across the whole sample of the serial position in which terms were offered; (if a child did not offer a particular term, that term was given a score of one greater than the total number of terms offered by that child). It can be seen that on average basic terms are offered earlier than non-basic terms, and that the mean positions for the terms correspond reasonably well with the positions of the hierarchy ($\tau = 0.64$; $p < 0.003$).

The two BLUE terms

Sinij and *goluboj* were offered relatively frequently. In terms of rank order, *sinij* had a maximum rank of four across all age groups, while *goluboj* ranked seven across all age groups. These scores place both terms above the universal derived terms: *koričnevyyj*, 'brown', *fioletovyyj* 'purple', *rozovyyj* 'pink', *oranževyyj* and *seryj* 'grey'.

Colour term production

Table 3 shows the percentage of correct responses to each colour tile and their rank order, for each age group.

It can be seen that there is a trend for the older children to score higher than the younger children, and for primary terms to be used correctly more often than derived terms; this latter difference appears to be particularly pronounced for the youngest group, with the difference declining with age. Two-way ANOVA on age and type of colour term (primary or derived) showed that both main effects and the interaction were all highly significant (minimum $p < 0.005$). The correlations with the hierarchy are all reasonably large; τ ranges from 0.66 ($p < 0.002$) for the middle group to 0.74 ($p < 0.001$) for the oldest group.

The two BLUE terms

Sinij has the sixth highest score for each age group, while *goluboj*, although it ranks lower than *sinij*, has a maximum rank (for the four- to five-year-old group) of 11. This latter rank places *goluboj* above *fioletovyyj* for all age groups,

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TABLE 4. *The most frequent error-term for each tile, and the frequency with which they were used, for each age group*

Tile		Error-term		Frequency age (years)		
				3-4	4-5	5-6
belyj	(white)	krasnyj	(red)	3	0	0
černyj	(black)	krasnyj	(red)	7	0	0
krasnyj	(red)	belyj	(white)	4	0	0
zelenyj	(green)	krasnyj	(red)	4	0	0
želtij	(yellow)	zelenyj	(green)	8	0	0
sinij	(dark blue)	goluboj	(light blue)	12	10	1
goluboj	(light blue)	sinij	(dark blue)	35	26	7
korničevyj	(brown)	černyj	(black)	14	4	3
fioletovyj	(purple)	sinij	(dark blue)	29	18	7
rozovyj	(pink)	krasnyj	(red)	37	17	2
orančevyj	(orange)	želtij	(yellow)	21	12	4
seryj	(grey)	černyj	(black)	14	4	1

and above all the derived terms except *oranževyj* 'orange' for the oldest age group.

Types of error

Table 4 shows the most frequent error-term for each tile for the youngest age group, and the frequencies for that error-term for the two older groups.⁴ For instance, the first row shows that the WHITE tile was called *krasnyj* 'red' by three children, but no children in the older groups made the same mistake.

Incorrect responses tend to be primary rather than derived terms, and conversely, primary colours are less likely to be named incorrectly than derived colours. The incorrect term tends to be the name of a perceptual neighbour of the mis-named colour. This results in asymmetric pairings of terms and colours; that is a primary term tends to be used over inclusively to name a derived colour, but the inverse pairing is less common. Thus, for the three-year-olds, the PINK tile is called *krasnyj* 'red' 37 times, whereas the RED tile is never called *rozovyj* 'pink'. Other such asymmetric pairs are *černyj* 'black' and *koričnevyn* 'brown', *želtij* 'yellow' and *oranževyj* 'orange', *sinij* 'dark blue' and *fioletovyj* 'purple' and finally a triplet, *seryj* 'grey' with either *belyj* 'white' or *černyj* 'black'. *Sinij* and *goluboj* also exhibit this asymmetry: the three-year-olds called the 'light blue' tile *sinij* rather than *goluboj*, 35

[4] In general, the older children do not make errors that were not made by the younger children. The main exception is that the four- to five-year-old group used *seryj* 'grey' to name the BROWN tile, whereas none of the youngest group made the same error.

times, whereas the 'dark blue' tile was only called *goluboj* 12 times. These errors decline with age, but even for the oldest group, seven out of 40 children still call the 'light blue' and the 'purple' tiles *sinij* 'dark blue'.

Colour term comprehension

This task was included only in the second phase, and therefore the sample size is smaller than for the previous two tasks (120 in total). Table 5 shows

TABLE 5. Percentage of children (*P*) that chose the right tile in the comprehension task for each term, and the rank orders (*R*) for each term, for each sample

Term	Gloss	Age (years)					
		3-4		4-5		5-6	
		P	R	P	R	P	R
PRIMARY COLOURS							
belyj	white	75.0	3	95.0	3	97.5	4
černyj	black	63.8	5	91.3	4	97.5	3
krasnyj	red	85.0	1	96.1	2	100.0	1
zelenyj	green	76.3	3	83.8	5	97.5	3
želtyj	yellow	73.8	4	92.5	3	92.5	5
sinij	dark blue	50.0	6	72.5	6	82.2	6
goluboj	light blue	18.8	9.5	42.0	11	70.0	8.5
DERIVED COLOURS							
koričnevij	brown	28.8	7.5	57.6	8.5	67.5	10.0
fioletovij	purple	10.0	11.5	21.3	12	57.5	12
rozovij	pink	18.8	9.5	57.6	8.5	70.0	8.5
orančevij	orange	28.8	7.5	63.2	7	75.0	7
seryj	grey	10.0	11.5	42.8	10	65.0	11

the percentage of each age group that selected the appropriate colour tile for each of the twelve basic colour terms, together with their rank orders.

There appears to be a similar pattern in the data as for the two tasks described previously, (and two-way ANOVA supports these impressions): there is a general improvement with age, reaching a ceiling for some terms; primary terms produce higher scores than derived terms; and the scores for the colour terms are ordered similarly to the hierarchy: the rank order correlations with the hierarchy range from $\tau = 0.41$ ($p < 0.04$) for the youngest group to $\tau = 0.54$ ($p < 0.02$) for the oldest group. These correlations are lower than the equivalent correlations for production or listing; this arises partly because of the ceiling effect mentioned earlier, which means that several terms have tied scores which do not correspond with their scores

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TABLE 6. *The most frequent tile-colour chosen in error, and the frequency with which they were chosen, for each term, for each age group*

Term		Tile-error		Frequency age (years)		
				3-4	4-5	5-6
belyj	(white)	seryj	(grey)	2	0	0
černyj	(black)	sinij	(dark blue)	2	0	0
krasnyj	(red)	sinij	(dark blue)	2	0	0
zelenyj	(green)	želtjy	(yellow)	2	0	0
želtjy	(yellow)	zelenyj	(green)	2	0	0
sinij	(dark blue)	goluboj	(light blue)	10	12	8
goluboj	(light blue)	sinij	(dark blue)	17	8	4
korničevyj	(brown)	černyj	(black)	2	0	0
fioletovyj	(purple)	sinij	(dark blue)	19	4	6
rozovyj	(pink)	krasnyj	(red)	9	1	1
orančevyj	(orange)	želtjy	(yellow)	4	0	0
seryj	(grey)	belyj	(white)	10	3	1

on the hierarchy, and partly because both 'blue' terms often have ranks much lower than their ranks on the hierarchy.

The two blue terms

Despite the preceding reservations about the relative salience of *sinij* and *goluboj*, the former term ranks six across all age groups, while the latter, at worst, scores higher than *fioletovyj* 'purple'.

Types of error

Table 6 gives the tile most frequently pointed to in error for each colour term. For instance, when asked which tile is *belyj* 'white' the most frequent error for the youngest group was to point at the GREY tile ($F = 2$).

Considering the data for the youngest group first, it can be seen that similar asymmetric error pairings occur as for the colour production task, but the asymmetry is in the opposite direction. For example whereas the 'pink' tile was often labelled 'red' in the production task, in the comprehension task, asked to point to a 'pink' tile the children often pointed to the 'red' tile. The asymmetric pairs evident from Table 6 are, with the colour term given first and the colour pointed at second: *goluboj* 'light blue' and *sinij* 'dark blue', *rozovyj* 'pink' and *krasnyj* 'red', *fioletovyj* 'purple' and *sinij* 'dark blue' and *seryj* 'grey' and *belyj* 'white'. In addition, despite the asymmetries just described, when asked to point to *sinij* 'dark blue' it was quite common (10 times) to point to the 'light blue' tile or to the 'purple' tile (six times). As well as the general decline in the number of errors with age, these asymmetries are less evident for the two older groups.

Individual profiles

In this section we consider how many of the children's individual profiles (patterns of correct performance across the colour terms) were consistent with the hierarchy. Table 7 shows first, the number of children whose profile

TABLE 7. *The number of individual profiles consistent with the hierarchy (B & K) and the number of children making each possible number of correct scores (F), for each of the three tasks*

Number of correct terms	Elicitation		Production		Comprehension	
	B & K	F	B & K	F	B & K	F
0	—	0	—	6	—	3
1	—	7	—	6	—	4
2	0	6	1	7	0	2
3	0	10	1	5	0	3
4	3	21	4	18	1	4
5	0	35	1	15	0	5
6	3	25	5	15	0	6
7	4	30	4	20	0	9
8	0	20	7	23	5	12
9	7	22	12	19	4	16
10	10	16	12	21	8	19
11	5	8	16	19	3	8
12	—	0	—	26	—	29
Total	32	200	63	200	20	120

was consistent with the hierarchy, for each possible number of correct terms (B & K). Second, it shows the distribution of numbers of children across the range of possible correct scores (0–12), for each of the three colour tasks. For instance, six children had scores of two correct terms (column 3) for the elicitation task; of these six children, none (column 2) had profiles consistent with the hierarchy. Continuing along this row in Table 7, it can be seen that for the production task, seven children scored two, and of these just one had a profile consistent with the hierarchy. (Note that if a child was correct on either zero or one terms, this could not be consistent with the hierarchy, as the minimum score according to the hierarchy is two (WHITE and BLACK). Similarly, if a child has 12 correct terms, then this profile must be consistent with the hierarchy. Accordingly, although we show the number of children with scores of zero, one and 12, we do not give a score for the number of these fitting the hierarchy.)

It is apparent that only a minority (about a fifth) of the profiles are completely consistent with the hierarchy. The production tasks produced more profiles consistent with the hierarchy (about one third) than either the

elicitation task or the comprehension task (about one sixth for both tasks). Some of the mismatch with the hierarchy, particularly for less than five terms, is because *belyj* 'white' and *černyj* 'black' (the two primary achromatic terms) tend to be acquired later than the primary chromatic terms. Until *belyj* 'white' and *černyj* 'black' are part of a child's repertoire, no combination of other terms can fit the hierarchy.

The hierarchy and other models

We have seen that while there are reasonably high correlations between the rank orders of the performance data and the hierarchy, the majority of profiles are inconsistent with the hierarchy. In this section we test whether some other structure fits the data better than the hierarchy. We do this in two ways. First, we consider models that are essentially lower resolution versions of the hierarchy, such as the PRIMARY-DERIVED model: primary terms are acquired before derived terms, but there are no consistent differences in acquisition order among the primary or derived groups. Secondly, we use Guttman scaling to see if there is some reliable linear ordering of the twelve terms that fits all of the data. We then compare the correlations between these various models and the data with the correlations between the hierarchy and the data.

Model 1 : primary > derived

[WHITE BLACK RED GREEN YELLOW SINIJ]

> [BROWN PURPLE PINK ORANGE GREY GOLUBOJ].

The notation signifies first, that terms grouped by square brackets are not differentiated by the model: the model makes no prediction as to their relative acquisition order. Second, groups of terms to the left of a greater than sign (>) should all be acquired before the groups of terms to the right of the inequality sign. In this, and subsequent models, we assume that *goluboj* 'light blue' is the derived term and *sinij* 'dark blue' the residual primary term within Kay & McDaniel's (1978) framework. This assumption is partially *ad hoc*, but it is consistent with the greater salience of *sinij* compared to *goluboj* (Davies & Corbett 1994). (In model 3 we place *sinij* outside the primary group, reflecting its position in the current data sets.)

Model 2 : chromatic-primary > achromatic-primary > derived

[RED GREEN YELLOW SINIJ] > [BLACK WHITE]

> [BROWN PURPLE PINK ORANGE GREY GOLUBOJ].

In this model we have positioned the two primary achromatic terms lower than the primary achromatic terms. This distinction is partly empirically derived, reflecting their relative positions in the current data, but the distinction also rests on physiological difference between the coding of chromatic and achromatic stimuli (Livingstone & Hubel, 1992).

Model 3 : modified model 2 (lower sinij)

[RED GREEN YELLOW] [BLACK WHITE] [SINIJ]
 [BROWN PURPLE PINK ORANGE GREY GOLUBOJ]

This model retains *sinij* 'dark blue' in sixth position, as in the hierarchy, and this position also reflects its rank order in the current data.

Model 4 : Guttman scaling

The data matrix for each task (term by correct/incorrect by individual) was subjected to Guttman scalogram analysis using the PAP package (Hammond, 1986). In addition, the data were combined across the three tasks and the equivalent analysis performed. In every case the analysis showed that the data could be described with a linear ordering of the 12 terms with a coefficient of reproducibility greater than 0.6. Although there were minor variations in the linear orderings that best fit the data for the various analyses, there were considerable consistencies across the orderings. Here, for illustration, we give the ordering derived from the combined data set (coefficient of reproducibility = 0.66):

krasnyj 'red', *zelenyj* 'green', *želtij* 'yellow', *belyj* 'white', *černyj* 'black', *sinij* 'dark blue', *koričnevij* 'brown', *oranževij* 'orange', *goluboj* 'light blue', *rozovij* 'pink', *seryj* 'grey', *fioletovij* 'purple'.

Kendall's *tau* between the hierarchy and the order of the terms combined across tasks and age groups is 0.71. The equivalent correlations for the four models are: model 1 = 0.74; model 2 = 0.71; model 3 = 0.81; model 4 = 0.91. (All the correlations are significant at the 5 per cent level, at least.) Thus the best fit with the performance data is for the Guttman scale, and the next best fit is for model 3. Model 1 and model 2 fit the data about as well as the hierarchy.

DISCUSSION

Fit with the Berlin & Kay hierarchy

Within the constraints of a cross-sectional study, there is reasonably strong support for the claim that Russian children learn colour terms in a sequence that fits the Berlin & Kay hierarchy at least stochastically. This can be seen at three levels of resolution. First, basic terms are learned before non-basic terms. On the list task (Table 2) the most frequent non-basic term was less frequent than the least frequent basic term. The youngest children offered virtually no non-basic terms, showing that the basic terms were learned before the non-basic terms. Similarly, on the production task (Table 3), it was rare for a non-basic term to be used to name any of the colours.

Second, within the basic terms, primary terms were mastered before the derived terms. Primary terms were offered more often than derived terms

(Table 2); they were produced correctly more often than the derived terms (Table 3); they induced correct pointing more often than derived terms in the comprehension task (Table 5); and where errors were made, they were most commonly either overextension of the referents of a primary term (Table 4), or pointing to the referent of a primary colour as an example of a derived term (Table 6). Further, these patterns were strongest for the youngest age group, and the difference between the two sets of terms declines with age, which is consistent with the claim that primary terms are learned before derived terms.

Third, at the finest level of resolution, there may be some additional association between our indices of the acquisition order and the hierarchy, beyond that due to the separation between primary and derived terms. The correlations between the positions of the basic colour terms on the hierarchy, and the rank orders of the degree of mastery of the terms or the colours in the three colour tasks were all reasonably large and positive; they ranged from values of *tau* of about 0.7 for the list and production tasks to between 0.4 and 0.5 for the comprehension task.

Alternative models to the hierarchy

The claim that the data match the hierarchy needs some qualification. The majority of the subject's individual profiles were inconsistent with the hierarchy (Table 7). Further, none of the correlations approached the maximum value of one, showing that even with data aggregated across a large number of children, the rank order of mastery of the terms did not correspond perfectly with the hierarchy. The correlation coefficients are all lower than $\tau = 0.8$, the value that would be produced if the data matched model 2 (primary terms > derived terms). The main divergence between the observed scores and the hierarchy was for the achromatic terms or colours, *belyj* 'white' and *černyj* 'black'; these terms, rather than occurring in the first two places in the rank orders of colour or colour term mastery, tended to occur lower than the other primary terms. This may be because, as in English and German, but not Japanese, BLACK and WHITE are not considered to be colours (Zollinger, 1988: 1380).

Model 3 (modified primary-derived) and model 4 (the Guttman scale) both fit the observed order better than the hierarchy. These two models place three of the primary terms (*krasnyj* 'red', *zelenyj* 'green' and *želtyj* 'yellow') above *belyj* 'white' and *černyj*, but leave *sinij* 'dark blue' in sixth position in accord with the hierarchy. The modified primary-derived model performs almost as well as the Guttman scale, even though the former has just four positions in its order, whereas the Guttman scale allocates separate positions to each of the 12 terms.

There is some support from studies of other languages that the depressed position of the achromatic primary terms relative to that proposed by the

hierarchy might not be just a quirk of Russian. We have developmental data on English and Catalan that shows the same depressed position for the primary achromatic terms, and Lin Zhongxian and Zhang Zenghui (1991) report similar results for four languages from mainland China. However, this pattern is not universal. For instance, Dougherty's (1978) data on Western Futona places the achromatic primary terms clearly in first place on the hierarchy.

Overall, the data are consistent with the position that whatever the forces are that produce the hierarchy observed at the socio-linguistic level, these forces yield a prevalent order of colour term acquisition that fits the hierarchy to a reasonable approximation. Other, less consistent influences, modulate the order in individual cases, accounting for individual deviations from the hierarchy, while leaving the average acquisition order fitting the hierarchy more strongly than the majority of individual ones. On the other hand, the fit with the hierarchy may be primarily due to the difference between the primary and derived terms. This would make sense in terms of the underlying neurophysiology and Hering's opponent process theory (Hering, 1920; Jameson, 1985). According to Hering, primary colours have an equal fundamental status, which distinguishes them from the colours denoted by derived terms. Alternatively, if we want to provide the most comprehensive summary of the acquisition order of Russian colour terms, then the Guttman scale would achieve this aim. It would be useful to use the same technique on other languages in order to assess whether the scale is peculiar to Russian, or whether it captures more universal patterns.

The two BLUE terms

So far we have assumed tacitly that both blue terms are basic; we now turn to consider their status more directly. On the list task (Table 2) the evidence is clear cut: *sinij* 'dark blue' has the third or the fourth highest rank, and it is grouped with the primary basic terms as expected. The more contentious term, *goluboj*, is the next most frequent term after the conventional primary terms for all age groups. However, the patterns on the other two tasks suggest that their status is not so clear cut. *Sinij* 'dark blue' is used correctly less frequently than all the primary basic terms, particularly by the youngest age group (Table 3). Even the five- to six-year-olds have not yet mastered its use: about 20 per cent of them call the 'dark blue' tile *goluboj* 'light blue' rather than *sinij* 'dark blue', whereas almost all of this group use the other primary terms correctly. *Goluboj*, 'light blue', has a relatively low score on this task: it now clearly belongs with the derived terms rather than vying for primary status as in the list task. There is evidently some confusion between the two BLUE terms; the youngest age group are almost as likely to call the light-BLUE tile *sinij* 'dark blue', as they are to call the dark-BLUE tile *sinij* 'dark blue'. Similarly, they are almost equally likely to use the term *goluboj* for the light

and the dark BLUE tiles. The degree of confusion declines with age but has not completely disappeared in the oldest group. A similar, but more extreme pattern shows itself in the comprehension task (Table 5): the performance on *sinij* now drops below several of the derived terms; it ranks tenth for the youngest group, has the lowest rank for the middle group, and even for the oldest group it still only ranks eleventh. For the two oldest groups, it is not used correctly as often as *goluboj*. The error data show that the two BLUE terms and colours are the most frequently confused sets: on being asked to point to the *goluboj* tile the youngest group are more likely to point to the dark-BLUE tile than the correct light-BLUE tile. And these confusions persist even for the oldest group: here, about a quarter of them point to the light-BLUE tile as an exemplar of *sinij*, rather more than make the inverse error. There was also greater discrepancy between performances on the three colour tasks for the two BLUE terms than for any of the other basic colour terms; for example, *sinij*, 'dark blue' and *goluboj*, 'light blue' were offered relatively frequently on the list task, but scored relatively poorly on the comprehension task.

Even so, for each age group, performance on *goluboj* 'light blue' was generally better than at least one other accepted basic term, usually *fioletovyyj*, 'purple', or *seryyj*, 'grey'. Further, with the exceptions mentioned above *sinij*, 'dark blue', generally seems to be a primary term according to the list and production indices, but is less clearly so on the comprehension index. On balance the data support the contention that both BLUE terms are basic. But this support is less strong than from the adult data we reported in the introduction. While the children know the terms, and they readily come to mind, even the five- to six-year-olds have not all mastered their uses. It may be that having two terms for the BLUE region has the potential to increase the precision of the colour lexicon, once the two terms are mastered, while at the same time increasing vulnerability to misnaming until they are learned. We need to extend the age range of the children studied to find out when children typically master the two BLUE terms.

Error patterns

There is an interesting pattern of symmetrical and complementary errors in the production and comprehension tasks (Tables 4 and 6). In the production task, there were high error scores for several of the derived colours. The predominant error was to misname a colour with a perceptually related primary colour term. The clearest examples of this were for the following pairs (the target colour given first, and the error term given second): *goluboj* 'light blue' *sinij* 'dark blue'; *fioletovyyj* 'purple' *sinij* 'dark blue'; *rozovyyj* 'pink' *krasnyj* 'red'. About half of the youngest group made these errors. These errors may just be examples of the frequently observed overextension of the range of a referential term during the early stages of learning the range

of the term (see e.g. Kuczaj, 1997). However, when we consider the errors on the comprehension task, many of the children who made the overextension errors on the production task now make the opposite error: they point to the primary term when asked to point to the derived term. For instance, 17 children pointed at the *sinij* 'dark blue' tile when asked to point to the *goluboj* 'light blue' tile. There is no simple overextension account of these latter choices. Conventional overextension should lead to the child first choosing the best example of the category, and then, if allowed further choices, next choosing other perceptually related colours. In addition, the errors on the comprehension task complicate the overextension interpretation of the production task errors. The children do not choose colours at random, or say they do not know; rather they make systematic choices of perceptually related colours. This pattern of results suggests that they know something of the semantics of *goluboj* 'light blue', *fioletovyj* 'purple' and *rozovyj* 'pink'. Perhaps, at this stage, the derived term may be represented in part by its relationship to the neighbouring primary term: for instance '*goluboj* is like *sinij*'. With such a representation, until focal *goluboj* 'light blue' is learned reliably, the child may fallback (regress) to choosing *sinij* in the comprehension task. The latter conjecture is consistent with Kay & McDaniel's (1978) account of the formation of derived categories. At a sociolinguistic level, *goluboj* 'light blue' splits from the primary category *sinij* 'dark blue' by fuzzy set intersection with *belyj* 'white'. If Kay & McDaniel's theory applies to individual development as well, then the pattern of errors we find might be expected during the period that the derived category is formed over. We plan to extend the age range of our subjects and the range of stimuli they are tested on to see if the complementary error patterns persist. By including several examples of each basic category varying in their focality, we should be able to plot the referential range of colour categories more precisely and to explore the degree of over extension (or under extension) in both production and comprehension tasks (see Kuczaj, 1997).

Summary

The data are consistent with Russian, exceptionally, having 12 basic colour terms. The 12 term inventory arises because Russian has two basic terms for the BLUE region, although the support for this contention is not as strong as from adult data. In addition, the data support Berlin & Kay's theory at a stochastic level: Russian children acquire colour terms in an order which has a reasonable degree of correspondence with the hierarchy. But, the apparent fit with the hierarchy may be due to some other underlying structure such as primary basic terms being learned before derived basic terms. In fact, the best fit to the observed ordering of the acquisition data is provided by a Guttman scale of the 12 basic terms of Russian. However, it is not yet clear whether the Guttman scale, and other models which outperformed the

hierarchy in predicting the data, are restricted to Russian, or whether they have some universal currency. It remains possible that the hierarchy embodies that which is universal, while local cultural influences will modulate the universal pattern such that each culture will have its own local linear ordering.

APPENDIX

SUMMARY OF WORK BY ŠIF AND ISTOMINA

Šif (1940) and Istomina (1960a, 1960b/1963) report studies of the acquisition of colour terms by Russian children that we describe here in some detail as they are not available fully in English. Šif (1940) assessed the colour vocabulary of children ranging in age from two to 14 years, including deaf and dumb and learning disabled samples as well as normal children. He found that *goluboj* 'light blue' was more prevalent in their repertoires than *rozovyyj* 'pink', *oranževyyj* 'orange', or *fioletovyyj* 'purple' (Table 2: 73, Table 6: 77 and Table 11: 80). He attempted to assess how accurately the children could match, name, and comprehend colours using a set of 18 colours made up of each of six hues at each of three levels of saturation; 12 of the colours were examples of four primary terms: *krasnyj* 'red', *zelenyj* 'green', *želtyj* 'yellow', *sinij* 'dark blue'; and six of the colours were examples of two derived terms: *oranževyyj* 'orange' and *fioletovyyj* 'purple'. He also, tantalisingly, used one sample each of *goluboj* 'light blue' and *rozovyyj* 'pink' (1940: 72), but results on these are given only for colour naming. Overall the main finding of immediate concern is that the primary basic colours and colour terms were coped with better than the derived colours or colour terms on all tasks.

Twenty years later, Istomina (1960a and 1960b/1963) carried out an important series of experiments on the acquisition of colour terms by Russian children. Basically she repeated Šif's work, using only normal children and she added three exemplars of *goluboj* to Šif's main colour set to give seven hues in each of three levels of saturation. She studied cross-sectional samples totalling 100 children, varying in age from two- to seven-years using a set of colour matching, colour naming, and colour comprehension procedures. On all tasks, even the colour matching tasks, performance on the *goluboj* 'light blue' colours was the poorest or joint poorest (of the seven) for the youngest age group, whereas performance on the *sinij* 'dark blue' colour was of the same order as the other primary colours (see table 1: 38 and table 2: 39 for colour matching; page 41 for name production; and tables 5 and 6: 42 for comprehension in the [1960b]/1963 paper). However, for the four- to seven-year-old groups performance on *goluboj* 'light blue' was at least as good as performance on *fioletovyyj* 'purple' (here references are to the 1960a paper): on the production task it was considerably better than *fioletovyyj* 'purple'

though less good than *oranževyj* 'orange' (table 8: 92); on the comprehension task it was better than *fioletovyj* 'purple' and the same as *oranževyj* 'orange' (table 14: 99); and on the matching task there was considerable fluctuation with age (table 5: 87, table 6: 88). Overall, the pattern of data suggests that *goluboj* is basic, but that, within Kay & McDaniel's framework, it belongs to the derived rather than to the primary terms.

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