

Linguistic Basicness and Colour Information Processing

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Berlin and Kay's notion of basicness was defined by a combination of linguistic and psychological criteria, but they suggested that the psychological criteria might be extended. The experiments reported here were designed to explore a possible extension by searching for perceptual effects of basicness. Russian speakers who have two basic terms for the blue region of colour space were compared with English speakers who have only one basic term for the same region on two perceptual tasks. The first two experiments sought for greater Stroop interference for the Russians than for the English for the critical "blue" stimuli, and the third experiment sought greater perceptual differentiation for the Russians in the blue region. All experiments clearly replicated standard findings, but all singularly failed to find the predicted differences between the two groups. It is argued that whilst the results are consistent with there being no psychological effect of basicness, it is necessary to search for possible effects in other domains, such as recognition memory, before accepting this conclusion.

La notion du caractère fondamental de Berlin et Kay a été définie par une combinaison de critères linguistiques et psychologiques, mais ils ont suggéré que les critères psychologiques soient étendus davantage. Les expériences rapportées ici ont été conçues afin d'explorer une telle extension en tentant de découvrir les effets perceptuels du caractère fondamental. Des parleurs Russes qui possèdent deux expressions de base pour la région bleue du spectre des couleurs ont été comparés, dans deux tâches perceptuelles, à des parleurs Anglais qui possèdent une seule expression de base pour la même région du spectre. Les deux premières expériences ont cherché à déceler une plus grande interférence de type Stroop pour les Russes que pour les Anglais pour les stimuli critiques "bleus", alors que la troisième expérience visait à déceler une plus grande différenciation perceptuelle pour les Russes dans la région bleue. Toutes les expériences ont clairement obtenues les résultats attendus, mais bizarrement, elles n'ont pas réussi à faire ressortir les différences prévues entre les deux groupes. Bien que les résultats soient consistants avec l'absence d'effets

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psychologiques reliés au caractère fondamental, il est soumis qu'il est nécessaire de continuer de chercher des effets possibles dans d'autres domaines, tels que la mémoire de reconnaissance, avant d'accepter une pareille conclusion.

INTRODUCTION

Berlin and Kay's (1969) theory of colour universals has been very influential and continues to stimulate research. According to this theory, in all languages "basic" colour terms emerge in a fixed hierarchical order up to a possible total of eleven basic colour terms, as illustrated in Fig. 1.

Thus, in accordance with this hierarchy, if a language has only two basic colour terms, they will be white and black (or, more accurately, light and dark); a language with three terms will also have red; a language with four terms will also have green or yellow; a language with five terms will have both green and yellow, and so on. Berlin and Kay have built up an impressive amount of data in support of their theory. There have been various suggested amendments to the hierarchy, some of which are mentioned further on, but they do not bear directly on the point at issue here.

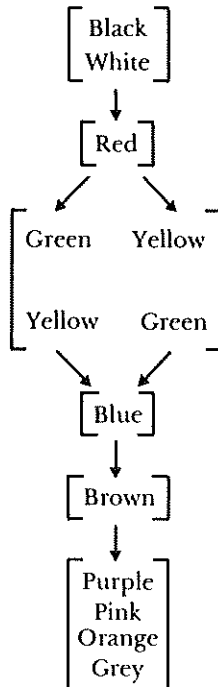


FIG. 1. The Berlin and Kay hierarchy for basic colour terms.

According to Berlin and Kay, there are four major criteria of basicness, the first three being linguistic and the fourth psychological. Of particular interest is the fourth criterion, (Berlin & Kay, 1969), which reads as follows: A basic colour term "must be psychologically salient for all informants. Indices of psychological salience include, among others (i) a tendency to occur at the beginning of elicited lists of colour terms; (ii) stability of reference across informants and across occasions of use; and (iii) occurrence in the idiolects (sic) of all informants". In addition they admit the possibility that there may be other indices of psychological salience.

Attempts to reveal psychological effects of variation in colour lexicons have in general not been successful. Heider (1972), and Heider and Olivier (1972), for example, found no differences between the Dani and English speakers in memory or speed of naming for primary colours, despite large differences in the colour vocabulary of the two languages. They argued that the perceptual distinctiveness of colour controlled language development rather than vice versa. Similarly, Bornstein (1975) argued that the underlying biology determines the range and divisions of the colour spectrum reflected in language, at least for primary colours. Lenneberg and Roberts (1953) report finding a difference between Zuni Indians and English speakers on recognition memory for colours in the yellow–orange region of colour space. The Zuni, who have a single term for this region made more errors than English speakers. So, although there is strong empirical evidence (and a persuasive argument from physiology that the basis for perception of the primary colours is universal), it remains a possibility that learning to use the colour lexicon of a particular language in turn affects the ease with which some aspects of colour information processing can be performed, particularly for secondary colours.

A primary requirement for addressing this possibility is an experimental task that affords the opportunity for processing both colour and colour name information. One such task that fulfils this requirement is available "off the psychologists' shelf" as it were, namely the Stroop task (Stroop, 1935).

The Stroop phenomenon is a robust, well-researched effect, which occurs at the interface between colour perception and language, and which may offer a way of detecting an effect of language on colour information processing (for most recent review see Cohen, Dunbar & McClelland, 1990). In the standard task, the subject is presented with a list of colour words in congruently and incongruently coloured inks (e.g. *red* in red ink, *red* in blue ink, *blue* in blue ink, *blue* in red ink, etc.), and asked to identify the ink colour. The Stroop effect is obtained if the subject's naming times are consistently slower in the incongruent than in the congruent conditions. Moreover, the times taken for the subjects to read the words are usually unaffected by incongruent coloured ink.

One way of explaining this asymmetry of interference has been in terms of the processing time advantage for reading words *vs* naming colours. The relative speed hypothesis or "horse race" model of interference depends on the notion of two competing responses being activated by the Stroop stimuli and processed in parallel. When subjects are required to respond to the colour, because the word is processed faster than the colour response it will arrive at the response-output stage first and interfere with the colour response. In contrast, responses to the word are processed rapidly enough to avoid interference from the slower colour response. Many versions of the relative speed explanation have been offered (e.g. Morton & Chambers, 1973) but all include the notion of interference as a function of processing speeds.

Traditionally, subjects make verbal responses to Stroop stimuli but evidence suggests interference is preserved if subjects respond manually by pressing coded buttons or keys. If keys are labelled with colour patches there is a considerable reduction in Stroop effect but normal interference is found when keys are labelled with words (Pritchatt, 1968). Furthermore, other studies have demonstrated that reactions to words can be slowed by incongruent colours using colour-coded keys (Simon & Sudalaimuthu, 1979).

In essence, the rationale for expecting the Stroop task to reveal language effects on colour perception, rests on the fact that, according to relative speed models, the longer it takes to detect the relevant attribute of the stimulus (its colour or its name), the more scope there is for the conflicting attribute to interfere. Non-basic colour terms are used less frequently in language, and should therefore take longer to recognise (Boynton & Olson, 1987), and be subject to greater interference from basic terms, than vice versa. Similarly, if the potential interferer is non-basic, it would be expected to take longer to recognise, allowing the subject to respond to the basic attribute with little interference. There is evidence of reduced interference from non-basic words. Klein (1964), and Proctor (1978) demonstrated the amount of interference from word distractors to be a function of the strength of association with the concept of colour. Non-basic words are by definition less strongly associated in that they often have additional non-colour referents (e.g. sky, lemon, turquoise).

A natural testing ground for this proposal is to compare the amount of Stroop interference on colour naming in two languages which differ with respect to whether the colour terms employed to describe a given colour are basic or not. The two subject groups would be presented with identical colours, but should differ in their vulnerability to Stroop interference, contingent on the basicness of the conflicting colour name.

One such pair of languages is Russian and English. The former seems to be an exception to the Berlin and Kay hypothesis in that, as Corbett and Morgan (1988) have shown, Russian appears to have twelve basic terms

rather than eleven. It has two terms for blue, both of which are basic: *sinij* "dark blue" and *goluboj* "light blue"¹. It is reasonable to expect, therefore, that the two Russian blues should interfere with each other in a Stroop task to a greater extent than for an English speaking group for whom the equivalent English terms used are non-basic. More specifically we would expect that for the Russian speakers, *goluboj* and *sinij* would be responded to as quickly as any other basic term and would interfere with each other as much as any other basic term. In contrast, the English speakers should respond relatively slowly to the equivalent terms and colours; these stimuli should be subject to interference from basic terms, but neither interfere with each other or other basic terms very much.

Accordingly it was decided to compare groups of native English and Russian speakers on a Stroop task which included the names and colour exemplars of the "two blues". In the first of our experiments, the Russian subjects were tested with the words: *krasnyj* "red", *želtyj* "yellow", both of which are indisputably basic, as well as *sinij* "dark blue" and *goluboj* "light blue". The comparison group of English subjects was given the words: *red*, *yellow*, *navy*, and *sky*. *Navy* and *sky* were chosen in preference to dark blue and light blue because they, like their Russian counterparts, are one-word units. The experiment was conducted in both Stroop (ink colour identification) and Reverse Stroop (word identification) conditions. The manual response version of the tasks described earlier was used in order to partial out possible differences in naming times between the two languages.

EXPERIMENT 1

Subjects

There were 12 Russian and 10 British subjects. All were adults with normal colour vision and their first languages were Russian and English respectively.

Apparatus and Stimuli

The stimuli were presented on a BBC microcomputer whose screen measured 28 cm by 21 cm. The Russian subjects saw each of the words: *krasnyj*, *želtyj*, *goluboj*, and *sinij* in cyrillic script, in letters 0.75 cm high in the centre of the screen. The English subjects saw the words: *red*, *yellow*, *sky* and *navy* in the same size letters. Each word appeared in each of the four colours, i.e. red, yellow, light blue and dark blue. Suitably labelled keys on the computer keyboard were used for responding.

¹ Berlin and Kay (1969, pp. 35–6) originally thought that *sinij* was the more general term for blue, its reference including the more specific *goluboj*; subsequently Kay and McDaniel (1978, pp. 640–1) conceded that a language could have more than eleven basic terms, and that *sinij* and *goluboj* are both basic, at least for some speakers. (See later discussion.)

Procedure

Each subject was seated approximately 40 cm from a computer screen, which was positioned at head height. Each subject did the Stroop (respond to colour) and Reverse Stroop (respond to word) conditions, half of the subjects doing the Stroop first followed by the Reverse Stroop, and half doing the reverse order. The procedure was identical in both conditions, apart from the response key labelling and the relevant stimulus attributes. The allocation of response keys to particular words or colours was randomised across subjects.

In the Stroop condition the keys were designated by the four appropriate names in white at the bottom of the screen. In the Reverse Stroop condition, the keys were designated by the four appropriate colour patches (2 cm × 2.5 cm).

Subjects had a minimum of 16 practice trials before the experiment proper; more practice trials were permitted if the subject was not sure of what was required.

Each condition consisted of four blocks of 64 random order trials, with each possible combination of word and colour appearing four times. Each trial started immediately after the subject's previous response. If the subject made an error, then that combination was repeated later in the sequence. Response times from the onset of the stimulus to the key press were recorded to the nearest 10 milliseconds, for correct responses. The subjects had a short rest between each block.

RESULTS

1. *Errors.* No subject made more than 7% errors; the mean error rates were less than 5% for both nationalities. No reliable analysis was possible.

2. *Reaction Times.* The median reaction times (RT) for correct responses were calculated for each subject for all 16 combinations of colour and word in both Stroop and Reverse Stroop conditions. The means across subjects for each colour-word combination and for both nationalities and conditions were calculated. The data was subjected to a four-way analysis of variance, Stroop/Reverse Stroop, by nationality, by target attribute, by interfering attribute. Overall, the Russian mean RT of 842.6 ms was much slower than the English mean of 681.2 ms ($F = 16.2$, $df = 1, 20$, $P < 0.0001$). The Stroop task was slower than the Reverse Stroop task (773.4 ms and 735.8 ms; $F = 11.7$, $df = 1, 20$, $P < 0.003$), and the effect of target colour or name was also significant. (Red = 768.3 ms, yellow = 750.1 ms, light blue = 751.1 ms, dark blue = 748.9 ms; $F = 4.3$, $df = 3, 60$, $P < 0.009$).

In addition to these main effects there were several significant two-way interactions. One interaction was between target attribute and interfering

TABLE 1
Experiment 1—Mean RT (ms) for Target Name/colour and Interfering
Name/colour

<i>Target Name/colour</i>	<i>Interfering Name/colour</i>			
	Red	Yellow	L Blue	D Blue
Red	734.1	780.0	763.0	796.1
Yellow	774.8	708.8	729.1	787.6
L Blue	775.8	772.0	694.2	762.4
D Blue	768.4	793.2	726.1	708.0

TABLE 2
Experiment 1—Mean RT (ms) for Target Name/colour and Nationality

<i>Nationality</i>	<i>Target name or colour</i>			
	Red	Yellow	L Blue	D Blue
Russian	874.7	858.4	807.4	830.1
English	679.6	659.8	704.2	681.2

attribute ($F=8.0$, $df=9,180$, $P<0.001$). Table 1 shows the mean RTs collapsed across nationality and task. It can be seen that the RTs lying along the diagonal are in each case the fastest in their respective rows and columns, which indicate that there was a strong Stroop and Reverse Stroop effect.

The second important interaction was between nationality and target attribute ($F=6.4$, $df=3, 60$, $P<0.001$). Table 2 shows the mean RTs for the Russians and the English for each target colour. It can be seen that whereas light blue has the fastest RT for the Russians, and dark blue the next fastest, light blue has the slowest RT for the English. In order to test the experimental predictions more specifically, and to reduce the essentially irrelevant effect of the overall slowness of the Russians, the data was transformed into a proportional interference score:

$$\frac{\text{Conflict RT} - \text{Congruent RT}}{\text{Congruent RT}} \times 100$$

Further, the mean of the definitely basic colours, red or yellow (shown as red/yellow in Tables 3 and 4), interference scores on each of light blue and dark blue, and the reverse, were calculated. (The direction of interference was preserved in the data; so, for example, if the target attribute was the colour red which was interfered with by the word yellow this is referred to as the effect of yellow on red, whereas if the target attribute was yellow interfered with by the word red, this would be the effect of red on yellow.) This data was subjected to a four-way analysis of variance (nationality, by Stroop/Reverse

Stroop, by colour combination, by direction of interference) with repeated measures on the last three factors. The only significant effects were:

1. An interaction between nationality and colour combination ($F=2.72$, $df=3,60$, $P<0.05$). Table 3 shows the means across subjects and direction of interference for each colour combination and nationality. It appears that the reason for the interaction is primarily because the Russians showed least interference for the red–yellow combination whereas the English showed the most.
2. An interaction between colour combinations and the direction of interference ($F=2.86$, $df=3,60$, $P<0.05$).

Table 4 shows the means across subjects and Stroop/Reverse Stroop, for each colour combination and for each direction of interference. The interaction seems to be due to light blue (either the colour or appropriate name) being the weakest interferer: it slows red and yellow down by 5% and dark blue by 4%, which is less than half the extent of interference for all other combinations.

TABLE 3
Experiment 1—Mean Proportional Interference Scores in Percentages
Collapsed Across Task and Direction of Interference

	<i>Colour and Colour/name Combinations</i>			
	red/yellow	(red/yellow) light blue	(red/yellow) dark blue	light blue/ dark blue
Russian	5	8	12	8
English	14	9	11	7

TABLE 4
Experiment 1—Mean Proportional Interference Scores Collapsed Across
Nationality and Task

Direction	<i>Colour and Colour/name Combinations</i>			
	red on yellow	(red/yellow) on light blue	(red/yellow) on dark blue	light blue on dark blue
	12	12	12	4
	yellow on red	light blue on (red/yellow)	dark blue on (red/yellow)	dark blue on light blue
	8	5	12	10

DISCUSSION

The most prominent feature of the results was the significantly slower responses obtained from the Russian than from the English subjects (Table 2). It is possible that this was because the Russians were less familiar with computers and keyboards. Also, they were responding in less familiar surroundings which may have led to greater tension, and they were marginally older, both of which could have slowed responses down.

Secondly, responses to light blue were significantly faster than to red, yellow, or dark blue for Russian subjects, but not for the English subjects; hence our prediction that the English would display slow RTs to sky and navy, has only been met partially. This could be due to the "local response frequency" overriding the effect and frequency in the language. In other words, equal response frequency in the experiment rather than frequency in the language, was critical (a point taken up below).

Although Stroop and Reverse Stroop effects were obtained for all colour/word combinations in both languages (in that responses in the congruent combinations were consistently faster than in the incongruent combinations), closer analysis of the effect of nationality did not reveal the predicted larger effects for the *sinij/goluboj* combinations with Russian subjects than for the *navy/sky* combinations with English subjects. Light blue did interfere less than other colours or names, but this was so for both language groups. It is worth commenting on the establishment of a Reverse Stroop effect, an effect not generally found in Stroop experiments without manipulations to "weaken" or slow down the reading response (Gumenik & Glass, 1970; Dyer & Severance, 1972; Dunbar & MacLeod, 1984). Its appearance here may have something to do with the manual responses used; the effect of using colour-coded keys was mentioned earlier. It is also interesting to note that categorisation tasks produce a dramatic reversal of the usual asymmetries (Glaser & Dungenhoff, 1984): matching words on the screen to colour-keys is, in essence, a kind of categorisation task. This would explain the Reverse Stroop effect.

One possible reason for not detecting more Stroop interference for the Russian speakers than for English speakers was that "local response frequency" has masked the effect of frequency in the language. That is, although *goluboj* and *sinij* are indeed basic and occur more frequently in Russian than *navy* or *sky* in English, within the experiment each term and corresponding colour had to be responded to in equal amounts. Proctor (1978) has shown that the response frequency required in the immediate experimental context affects response time, and the degree of Stroop interference; the more frequent the response requirement, the greater the Stroop interference. Words which were of the same set produced greater interference in naming colours. Proctor (1978) suggests this could be due to prior activation of the internal units corresponding to words in the response set.

A second experiment was designed to remove the effect of "local response frequency" on the magnitude of the Stroop interference for the two blues. The basic task was the Reverse Stroop task (name the word), that was used in the first experiment. There were four colour words: *red*, *yellow*, *green* and *blue* for the English speakers, and *krasnyj*, *želtyj*, *zelenyj* and *sinij* for the Russian speakers. Each word appeared in each of the four colours, but in addition they also appeared in two colours whose names never had to be responded to. In the critical condition the word *blue* (or *sinij*) appeared in the non-response colour light blue. For the English speakers this should produce little interference as light blue is an instance of blue; for the Russian speakers however, *sinij* appearing in light blue should interfere more than for the equivalent English pairing, because light blue corresponds to *goluboj*. A second non-response interfering colour, magenta, was included to estimate the size of the "local response frequency" effect.

EXPERIMENT 2

Subjects

The English subjects were one male lecturer and nine female secretaries working at the University of Surrey, with ages ranging from 22 to 30. The Russian subjects were three male and seven female teachers of English visiting the University of Surrey on an exchange scheme, with ages ranging from 25 to 33. All had normal colour vision. None had taken part in Experiment 1.

Materials

The stimuli were displayed on a BBC microcomputer. The programme was constructed in such a way that the words: *red*, *yellow*, *blue* and *green* (for the English subjects), and: *krasnyj*, *želtyj*, *sinij* and *zelenyj* (for the Russian subjects) appeared in the colours: red, yellow, green, dark blue, light blue and magenta in random order. The keys were identified by red, yellow, green and dark blue squares, and the assignment of response keys to colour words was randomised across subjects.

Procedure

The procedure was exactly the same as in the first experiment, except that only the Reverse Stroop condition was run, and that a block consisted of 96 stimuli instead of 64.

RESULTS

The median reaction times for correct responses were calculated for all subjects for all combinations. As in the first experiment, there were not enough errors to make an error analysis feasible (mean error rates were less than 3%). The means across subjects for each word-colour combination, for Russian and English subjects are shown in Table 5.

It appears from Table 5 that, as in Experiment 1, the Russian group were generally slower than the English, and that there was a marked Reverse Stroop effect. This is best evidenced by the fact that the congruent combination is fastest in each row. A three-way analysis of variance (nationality by target colour word by interfering colour) supported this impression; (nationality $F=4.4$, $df=1, 18$, $P<0.05$, target by colour interaction $F=3.2$, $df=15, 270$, $P<0.0009$). However, there was no suggestion of any interaction with nationality.

As a more direct test of the predictions, the data was again transformed into proportional interference scores, and the mean score across the three basic interferers calculated for each of the four response words. These means across subjects, for basic interferers and magenta and light blue are shown in

TABLE 5
Experiment 2—Means Across Subjects in Milliseconds for Each Word
Colour Combination, and for Each Nationality

<i>English Responses</i>	<i>Interfering Colour</i>						<i>Mean</i>
	<i>Red</i>	<i>Yellow</i>	<i>Green</i>	<i>Blue</i>	<i>Magenta</i>	<i>L Blue</i>	
<i>Red</i>	689.0	739.0	725.0	742.0	719.5	706.0	720.1
<i>Yellow</i>	822.5	738.5	779.0	776.0	770.5	811.5	783.0
<i>Green</i>	758.5	746.0	691.5	783.0	762.5	775.0	752.8
<i>Blue</i>	825.0	774.5	768.0	709.0	762.5	744.0	763.8
<i>Means</i>	773.8	749.5	740.9	752.5	753.8	759.1	
<i>Russian Responses</i>							
<i>Krasnyj</i> "Red"	909.5	1024.5	964.5	1129.5	966.5	930.5	987.5
<i>Zeltyj</i> "Yellow"	964.5	896.5	1000.0	976.5	924.0	927.5	948.2
<i>Zelenyj</i> "Green"	934.0	922.5	871.0	939.5	917.0	942.0	921.0
<i>Sinij</i> "Dark Blue"	985.0	990.5	992.5	888.5	940.5	930.5	954.6
<i>Means</i>	948.3	958.5	957.0	983.5	937.0	932.6	

TABLE 6
Experiment 2—Mean Proportional Interference Scores Collapsed
Across Nationality

Target Word	Interfering colour		
	Mean of red, yellow and green	Magenta	Light blue
<i>Red</i> (<i>Krasnyj</i>)	0.099	0.06	0.03
<i>Yellow</i> (<i>Želtyj</i>)	0.088	0.014	0.08
<i>Green</i> (<i>Zelenyj</i>)	0.096	0.09	0.11
<i>Blue</i> (<i>Sinij</i>)	0.11	0.06	0.05

Table 6, for both nationalities. A three-way analysis of variance (nationality by response word by interfering colour) was performed. The only significant effect was of the interfering colour ($F = 4.0$, $df = 2, 36$, $P < 0.03$). This seems to be due to the smaller interference produced by magenta and light blue.

DISCUSSION

It was evident from the results that the central prediction was not supported. The response to the word *blue* or *sinij* was slowed down by displaying it in light blue, but no more so for the Russians than the English; further, the interference was of the same order as the control colour magenta, but less than the effect of the colours whose corresponding names were part of the response set. This indicates that local response frequency does have an effect; those colours whose corresponding words had to be responded to produce most interference. However, there was also a residual interference effect of the two non-response colours, magenta and light blue, but no suggestion that the magnitude of interference varied between the two language groups. As magenta and light blue did not require a response, local response frequency cannot be appealed to, in order to explain away this lack of difference.

It remains possible that basicness does affect colour information processing, but the effect is masked by the inherent variation in reaction time tasks, and in particular the marked difference in RT between the two groups. However, as the interference effect was reliably observed in both experiments, and there were reliable differences between colour combinations, the magnitude of any hidden effect of basicness must be relatively small.

Nevertheless, it was worth looking for an effect of basicness using a different procedure which did not rely upon response time as its index. A

third experiment required subjects to judge the similarity of each possible pair of 12 colours (the basic colours of Russian) either in the form of two simultaneously presented colour squares, or two presented colour names.

If there is an effect of the additional blue name in Russian, it might be expected that this region of colour space would be more differentiated for Russian speakers, and particularly so when the judgement was made on the basis of colour names. This should lead the Russian speakers to judge the two blues as less similar than an English sample.

EXPERIMENT 3

Subjects

The English subjects were one male lecturer and nine female secretaries working at the University of Surrey, aged between 22 and 35. The Russian subjects were four male and five female teachers of English visiting the University of Surrey on an exchange scheme, aged between 25 and 30. All had normal colour vision. None had taken part in Experiments 1 or 2.

Apparatus

The stimuli were displayed on an Archimedes computer. Two-inch squares of focal examples of each of the 12 basic colours of Russian were constructed. The full list of Russian colour names or their corresponding colours was: *belyj, černyj, krasnyj, želtyj, sinij, goluboj, zelenyj, koričnevyy, fioletovyy, rozovyy, seryj, oranževyy*.

The same colour samples were used for the English subjects with the corresponding colour names: *white, black, red, yellow, dark blue, light blue, green, brown, purple, pink, grey, orange*. *Dark blue* and *light blue* were used in place of *navy* and *sky* to maximise the chances of finding a difference between the two nationalities. Even so, the English found them, if anything, less similar than the Russians.

Procedure

The subjects were seated individually in front of the computer, and asked to judge the similarity of either two colour squares, or the similarity of two colours referred to by their names, on a seven-point scale. A response of one indicated "extremely similar", seven "extremely dissimilar", and so on. The subjects used the computer keyboard to indicate this response.

After making each similarity judgement, the subject pressed the return key and a new pair of stimuli appeared on the screen. There were, in all, 66 pairs of colour squares and 66 pairs of colour words, consisting of all the possible combinations of colours or words, excluding identical pairs. The order of

presentation of the colour-squares and colour-word pairs was randomised for each subject. Half the subjects were required to make the colour-square judgements first, followed by the colour-word judgements, and half in the reverse order.

The experiment lasted for about twenty minutes for each subject.

RESULTS

The critical comparisons were the relative similarities of the two blues for the English, compared to the relative similarities of the two blues for the Russians. The English judged *purple* and *pink* colours to be the most similar (mean = 1.4), and the two blues the next most similar (mean = 1.7). The Russians judged the two blue colours to be most similar of all (mean = 1.4).

For the word stimuli, the English judged the three most similar pairs to be *purple* and *dark blue* (mean = 2.3), *black* and *dark blue* (mean = 2.5) and *light blue* and *dark blue* (mean = 2.8). The Russians judged *sinij* and *goluboj* to be most similar (mean = 1.9).

A multi-dimensional scaling analysis of the judgements indicated that for both groups the pattern of judgements was a reasonable approximation to the classical colour circle (cf. Boynton 1979).

DISCUSSION

It is clear that again the main prediction was not supported. For both the word and colour stimuli, the Russian sample judged the "blue stimuli" to be the most similar pairs, and the mean scale values for their judgements were lower than the equivalent English measures. Both groups of subjects replicated patterns of judgements found in previous work (Boynton, 1979) and which make sense in terms of classical descriptions of colour perception.

GENERAL DISCUSSION

All three experiments exhibit a similar pattern of results; they reveal strong evidence of the effect of the variable on which the experiment was predicated, but no differential effect of nationality. The first experiment showed reliable Stroop and Reverse Stroop effects; the size of these effects varied with the interfering colour or word, in that "light blue" produced less interference, but crucially this variation was the same for both language groups. Similarly in Experiment 2, the Reverse Stroop phenomenon clearly occurred; the magnitude of the effects was smaller for those colours paired with words not in the response set ("light blue" and "magenta"), but there was no differential effect of nationality. The pattern of judgements in Experiment 3 exhibited the classical colour circle pattern, but there was no hint that the blue region of colour space was more differentiated for the Russian group.

Three general interpretations of these results are possible. First, there is no effect of variation in the colour lexicon on colour information processing. This would be consistent with Heider's (1972) and Bornstein's (1975) arguments. However, we believe it is premature to accept this interpretation without further exploration.

Second, that there are effects of variations in the colour lexicon, but that the experiments reported here were not sufficiently sensitive to detect them. This interpretation of a negative result, is of course, always logically valid, but the fact that the experiments were sensitive enough to exhibit some major predicted effects, suggest that if the insensitivity argument is true, the magnitude of the effects we are looking for must be relatively small. Nevertheless, one strategy we are currently pursuing is to compare languages with a larger difference in colour lexicons than English and Russian; we assume that if language effects on colour processing exist, they should be more detectable in such a comparison.

Third, that there are effects of variations in the colour lexicon, but we are looking in the wrong place for them. Perhaps the processes we have been investigating may be cognitively impenetrable, or too low level for influence by variations in the lexicon. This seems unlikely, in that the Stroop phenomenon depends on the subject categorising the colour in order for the effect to occur and, as Brown and Lenneberg (1954) noted: "cultural differences possibly operate on the level of categorisation rather than controlled laboratory discrimination". Nevertheless, perhaps the processes underlying the Stroop phenomenon are not sufficiently understood to make clear-cut predictions of linguistic effects. In particular, the model of Stroop interference adopted here, a simple relative speed of processing account, may be inappropriate. Although past research suggested that non-basic colour names should interfere less with colour naming (Klein, 1964; Proctor, 1978) our assumption that slower naming times found for non-basic colours would lead to reduced interference from colours in reading words depended on the correctness of the relative speed hypothesis. Glaser and Glaser (1989) suggest their results, and those of Dunbar and McLeod (1984), now allow rejection of this model of Stroop interference. Detailed consideration should be given to any predictions that might be made from more recent models (Cohen, Dunbar & McClelland, 1990; Glaser & Glaser, 1989; Virzi & Egeth, 1985) which might be useful in pursuing colour language effects within this paradigm.

Brown and Lenneberg (1954) showed that one possible area to find phenomena that show a reliable effect of colour categorisation within a language is recognition memory. The more codeable a colour was in English, the easier it was to recognise in a memory task. Further, Lenneberg and Roberts (1953) showed that Zuni Indians, who have a single term for yellow and orange, frequently confused these colours in a memory task, whereas English speakers never did. It follows from this that Russian speakers should

be advantaged in recognition memory tasks in the blue region of the spectrum. Perhaps we should search here for cross-cultural effects.

Another task that met the requirement of reliable within-language effects is colour naming. Bornstein and Monroe (1980) showed that naming time was a function of how close to a category boundary the colour stimulus was; the closer to the boundary, the slower the naming time. If this effect is due to the subjects having learned to categorise colour space in the way designated by their native tongue, then Russians should display slow naming times at the *sinij/goluboj* boundary, whereas for English speakers, such colours would be relatively central to the blue category, and they should display relatively fast responses.

Part of our continuing programme of research on refining the notion of basicness and seeking behavioural effects of language differences, includes a comparison of English and Russian speakers on recognition memory for colours, and for category boundary effects on naming times.

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