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DOES LANGUAGE MODULATE COLOR PERCEPTION IN GREEK-ENGLISH
AND RUSSIAN-ENGLISH BILINGUALS?

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ABSTRACT

Can the language you speak affect your perception of the world? Thierry, Athanasopoulos, Wiggett, Dering, and Kuipers (2009) showed that the Greek language affects how native Greek speakers process the color blue (two terms in Greek: ghalazio – ‘light blue’ and ble – ‘dark blue’). Using the visual Mismatch Negativity (vMMN) component of Event Related Potentials (ERPs) as an index of perceptual change, they found that native speakers of Greek perceived the switch between these two shades more saliently in an oddball paradigm than the switch between two shades of green (one term in Greek - prasino). We sought to examine whether color perception could be modulated by the alphabetic (Experiment 1) or language (Experiment 2) context in the task at hand. Greek-English (Experiment 1) and Russian-English (Experiment 2) bilinguals were subjected to a go-no go judgment task while ERPs were recorded (Russian also has two color terms for blue, siniy and goluboy). Participants were presented with letters from the Greek or Roman alphabets in Experiment 1 and words in Russian or English in Experiment 2. They pressed a button for deviant stimuli (5%) and ignored lower case ones (95%). Letters were surrounded by peripherally perceived color circles in light or dark blue and light or dark green. The probability of occurrence of the circles conformed to an oddball paradigm and participants received no instruction regarding color. Findings show that language context did not affect color perception. As such, it may be the case that language processing in one of a bilingual’s two languages does not affect their perception of color. However, one possible interpretation of the data is that movement of the color stimuli from foveal to parafoveal view and a focus on the language task may have created an attentional difference between the present experiments and the experiment by Thierry et al. (2009).
# TABLE OF CONTENTS

List of Figures ........................................................................................................................................ iii
Acknowledgements ..................................................................................................................................... iv
Chapter 1 Introduction ............................................................................................................................ 1
Chapter 2 Methods .................................................................................................................................. 9
Chapter 3 Results .................................................................................................................................... 14
Chapter 4 Discussion ............................................................................................................................... 17
References ................................................................................................................................................. 23
LIST OF FIGURES

Figure 1. Visual representation of Thierry et al.'s (2009) stimuli presentation over time. ........... 5

Figure 2. Example stimuli in both Greek and Roman alphabet blocks. .............................. 7

Figure 3. Example stimuli for Experiment 2. ........................................................................ 8

Figure 4. Main effect of deviancy......................................................................................... 14

Figure 5. vMMN in both English (Roman) alphabet and Greek alphabet block ..................... 15

Figure 6. All standards vs. all deviants at a linear derivation of PO9 and PO10 where effects were maximal. ......................................................................................... 16

Figure 7. Blue and green standards and deviants in both English and Russian blocks (linear derivation of PO9 and PO10). ........................................................................ 16
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Chapter 1  
Introduction

Can language affect a speaker’s perception of the world? This question has been studied extensively in behavioral and neurocognitive studies in the past few decades (for a review, see Wolff & Holmes, 2011). Researchers have addressed this question in different cognitive domains, including spatial awareness (Majid, Bowerman, Kita, Haun, & Levinson, 2004), understanding of time (Boroditsky, 2001), and color perception (Regier & Kay, 2009; Roberson, Davidoff, & Davies, 2000; Thierry, Athanasopoulos, Wiggett, Dering, & Kuipers, 2009). In this thesis, we report two experiments that investigated the effects of color terms in language perception of Greek-English (Experiment 1) and Russian-English (Experiment 2) bilinguals.

The first, and classical, study of color terminology sought to understand the effects of a two color term system on color perception and memory in the Dani people of Papua New Guinea (Heider, 1972). The Dani people have only two color terms in their language. Heider showed participants color chips and taught them English color terms, asking them to remember the terms of this more complicated system. She found that the limited color terms of the participants’ native language did not affect their ability to learn new color terms and concluded that color terms do not influence a speaker’s innate ability to recognize and name colors.

Later studies challenged Heider’s (1972) conclusion and interpretation of the data. Studies of color perception have found that different languages seem to develop different
color terms based somewhat on the environment in which the language is spoken (Kay & Regier, 2003). Berinmo, for example, a language spoken in Papua New Guinea, has only five color terms: wap, mahi, war, nol and kel. These occupy the same color space as the eight English colors: red, orange, yellow, brown, green, blue, purple and pink (Roberson et al., 2000). In an ethnographic study, speakers of Berinmo (hunter-gatherers living in the forest of Papua New Guinea) and speakers of English (undergraduate students) were tested on their ability to recognize color differences. One of the experiments completed with speakers of Berinmo involved choosing a color chip from a spectrum that best matched the color chip given to them. Participants were more likely to make mistakes distinguishing between two colors when those colors both fell within a single color category (in their native language), as compared to different color categories. This was also the case for English speakers given the same task. The speaker’s color terms facilitated the matching of two color chips. This was one of the first pieces of evidence that color terms affect perception of colors.

In a follow up to Roberson et al. (2000), Roberson, Davidoff, Davies, and Shapiro (2005) recruited many more participants from an entirely different visual environment. Himba speakers from Namibia (semi-nomadic tribesmen inhabiting an arid region) participated in an identical study to speakers of Berinmo. Himba has a similar color system to Berinmo (five color terms: dumbu, vapa, burou, serandu, and zoozu). Interestingly, the boundaries of these color terms are similar to those of Berinmo. In fact, the results of the Himba speakers were very similar to those of the Berinmo speakers: speakers of Himba were more likely to make color naming mistakes when the two shades fell within the same color category. Furthermore, Himba speakers show no disadvantage
for distinguishing between Himba color boundaries, but had difficulty with those between English or between Berinmo boundaries, indicating that these effects are language specific, despite similar color boundaries. This is among the strongest evidence that color terms affect color perception.

In another study of color perception, two western languages were used to understand the cross-linguistic color differences. Winawer, Witthoft, Frank, Wu, Wade and Boroditsky (2007) utilized the fact that Russian has two color terms for the English color term blue (siniy – darker blues, goluboy – lighter blues). They compared speakers of Russian to speakers of English in a color discrimination task. Participants were asked to choose from two differently shaded blue color chips which one was more similar to a third stimulus chip. They found that speakers of Russian were quickly and accurately able to distinguish between chips that were considered siniy and goluboy, whereas English speakers had more difficulty distinguishing between colors within each of these categories. This indicates that the siniy and goluboy color terms helped Russian speakers distinguish between colors that, to an English speaker, are only different shades of one and the same color. Importantly, they also found that this difference driven by color terms could be disrupted by introducing a verbal distractor task. Participants were asked to memorize 8 digit number spans while completing the discrimination task. The Russian group’s advantage disappeared when participants were focused on remembering numbers. From this the authors conclude that the color discrimination advantage is driven by the ability to access the color terms themselves. This study connects language to color discrimination effects in color perception in Russian, a more widespread language than Berinmo.
In a recent neurocognitive study, Thierry, Athanasopoulos, Wigget, Dering, and Kuipers (2009) tested whether color perception is affected by color terms of a given language, using measurements of brain activity. They studied color term differences identical to the Russian siniy/goluboy divide in speakers of Greek and English. The Greek language separates blue into two terms: “ghalazio” (light blue) and “ble” (dark blue). In Thierry et al.’s experiment, native Greek speakers were shown circles or squares in colors that would fall into either “ghalazio” or “ble”. As a control, light green and dark greens were also presented (only one color term in both languages). Using a visual oddball paradigm, participants were presented with a series of circles with one color acting as the “deviant” to its similarly named color (see Figure 1). The deviant was whichever color was different from the previous shapes. The stimuli were presented foveally (i.e., in focal view). This task was done while recording ongoing brain activity using the Event Related brain Potentials (ERPs) technique. This technique allowed researchers to measure a preattentive perceptual difference between the two shades of blue or the two shades of green, using a component of ERPs known as a visual Mismatch Negativity (vMMN). The vMMN is an ERP component indicating a perceptual difference that occurs early in visual perception, in fact even before conscious perception. The vMMN showed a difference between the waveforms of the native Greek speaker and a control group of native English speakers: the native Greek speakers showed a higher negativity when presented with a blue deviant than when being presented with a green deviant, whereas for the native English speakers the “ghalazio” vs. “ble” ERP response was the same as the light green vs. dark green difference. This confirmed the idea that native Greek speakers were better attuned to color difference in the blues, even when
asked to attend to a dimension other than color (i.e., form). Therefore, Thierry et al. (2009) concluded that there is an *unconscious* relationship between language and the perception of color.

![Figure 1](image.png)

**Figure 1.** Visual representation of Thierry et al.’s (2009) stimuli presentation over time.

In a follow-up experiment, Athanasopoulos, Dering, Wiggett, Kuipers and Thierry (2010) introduced bilingualism into the realm of language driven color perception. They examined Greek-English bilinguals to understand how immersion in a second language (L2) environment might have affected Thierry et al.’s (2009) findings. They ran the same experiment with Greek-English bilinguals, but split them into two groups: short-stay bilinguals and long-stay bilinguals. Short-stay bilinguals had spent an average of 7.2 months in an English-speaking environment while long-stay bilinguals had spent an average of 42.6 months in an English-speaking environment. Bilingualism may alter previous findings because there are now two color term systems (Greek and English) the bilingual speakers can use to describe the blue difference, but only one system (Greek) uses two different color terms for blue. Athanasopoulos et al. found that the vMMN was not attenuated in the short-stay bilinguals, while the long-stay bilinguals had smaller vMMNs. The short-stay bilinguals were much more attuned to the color
switch, while the long-stay bilinguals had not seen the difference as saliently, more resembling English monolinguals. This is a critical effect because it shows that while proficiency in Greek was maintained in long-stay bilinguals, the language environment could modulate unconscious color perception.

The present study seeks to understand how emphasizing one of the bilingual’s languages during color task performance modulates the pattern of findings observed by Thierry et al. (2009). More specifically, we extended the Thierry et al. study of color perception to investigate whether reading characters or words in one language (rather than forms as in Thierry et al.), as compared to the other language, would alter this color perception effect for a bilingual speaker of both Greek and English (Experiment 1). Greek-English bilinguals completed a go-no go judgment task while ERPs were recorded. Greek-English bilinguals were presented with letters from either the Roman or Greek alphabets. These letters created a language-based orthographic context to investigate how bilingualism might offer two different ways for a speaker to process color. The letters were surrounded by color circles in light/dark blue and light/dark green (identical to the circles used by Thierry et al., 2009). However, the circles were presented in peripheral view, in contrast to the foveal (centered) presentation in Thierry et al. (2009) to ensure that participants read the letters that were presented parafoveally (see Figure 2).
If language modulates perception during online processing, then the vMMN difference between blues should be strongest between blues in the Greek alphabet block and diminished in the Roman alphabet block, thus showing that bilinguals’ perceptual systems are more “Greek-like” in a Greek alphabet context and more “English-like” in the Roman alphabet context. This would show that processing one of two languages affects unconscious perception of color.

Russian-English bilinguals then participated in an experiment of similar design (Experiment 2) with one critical difference: rather than using letters as a linguistic context, words were used (see Figure 3). This aimed to create a stronger linguistic cue. Because Russian has a similar blue breakdown to Greek, language groups were treated similarly.

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1 Experiment 1 is the core study of this thesis; Experiment 2 is an ongoing experiment reported for the reader’s interest.
Similar to Experiment 1, if language (in this case, word reading) affects color perception then the vMMN difference in the blues should be larger in the Russian context than in English. This would have two theoretical implications in relation to Experiment 1. First, this effect is extendable to another language population with a similar categorical system, and, second, that the effect is as viable in a word processing context as it is in a letter-processing context.
Chapter 2

Methods

Experiment 1

Participants: Thirteen Greek-English bilinguals (Mean age = 27.1, SD = 6.3) with normal or corrected to normal vision consented to and participated in the study. They were all native Greek speakers that had spent an average of 3.6 years (SD = 1.9) at a British university. The mean age at which they began speaking English was 7.6 (SD = 1.6). All participants reported proficiency in both Greek and English. The data of one participant were discarded from the data analysis because of excessive blink artifacts.

Materials: Seventeen matched letters, upper and lower case, were selected from the Greek and Roman alphabet on the criterion that they shared no orthographic similarity with any other letters in either alphabet. Chromaticity of color rings was measured using a Minolta CS-100 Colorimeter. The following Munsell colors were used (CIE 1931 Y, x, y chromaticity coordinates are given in parentheses): dark blue: 5PB/value 4 (Y = 10.7, x = 0.234, y = 0.230), light blue: 5PB/value 7 (Y = 41.5, x = 0.259, y = 0.264), dark green: 5G/value 4 (Y = 10.7, x = 0.259, y = 0.397), light green: 5G/value 7 (Y = 41.7, x = 0.279, y = 0.377). Munsell chroma was held constant across stimuli (chroma 6).
The language history questionnaire (LHQ) collected self-ratings of proficiency in reading, writing, speaking, and comprehension, as well as a detailed history of the participants’ language exposure, use, and learning history. It was presented in a Google form.

**Procedure:** Letters and color rings (presented at visual angle of 2°) were presented on the screen in a go no-go task in which participants were asked to do nothing upon seeing a lowercase letter and press the space bar on a keyboard for an uppercase letter (target stimulus). Participants viewed 8 blocks of ~250 stimuli (50 critical), 4 in the Roman alphabet, 4 in the Greek. Two blocks in each alphabet condition were blue and 2 were green. Within a block, one color stimulus was frequent (standard) and its corresponding (deviant) color was rare (light blue with dark blue and light green with dark green). Target stimuli appeared 6% of the time and never in tandem with a deviant color ring. Stimulus presentation was pseudorandomized such that two deviants or two targets were never presented in sequence, with at least three standard stimuli in between deviants. Stimuli were shown for 200 ms with an 800 ms interstimulus interval. The language history questionnaire was administered during ERP setup and electrode montage.

**Event-related potentials:** Electrophysiological data were recorded in reference to Cz at a rate of 1 kHz from 64 Ag/AgCl electrodes placed according to the extended 10–20 convention (Jasper, 1958). Impedances were kept below 10 kΩ. EEG activity was filtered online with a band pass between 0.01 Hz and 200 Hz, and refiltered offline with a
20-Hz low-pass zero phase shift digital filter (slope 48 db/Oct). Eye blinks were mathematically corrected, and epochs with activity exceeding 75 µV at any cap electrode site were automatically discarded. There was a minimum of 360 valid epochs per condition in every subject. Epochs ranged from -100 to 1,000 ms after the onset of the stimulus. Baseline correction was performed in reference to prestimulus activity and individual averages were digitally rereferenced to the global average reference. The vMMN analysis was conducted on individual ERPs elicited by passive standard and deviant circles irrespective of luminance (light and dark circles combined) to discard luminance effects. The vMMN was maximal over the parietooccipital scalp and studied at electrodes IZ, O1, O2, OZ, PO7, PO8, PO9, and PO10. The P1 analysis was conducted on individual ERPs elicited by the 4 standard circles in each of the 8 blocks at electrode PO8.

Experiment 2

Participants: Five Russian-English bilinguals ($\text{Mean age} = 32.2, \text{SD} = 9.4$) with normal or corrected to normal vision consented to and participated in the study. They were all native Russian speakers that had spent an average of 13.8 years ($\text{SD} = 7.8$) in the USA. The mean age at which they began speaking English was 6.6 ($\text{SD} = 0.9$). All participants reported proficiency in both Russian and English. One participant was discarded for excessive artifacts.
**Materials:** Color rings were identical to Experiment 1. Instead of letters, words were used in this experiment. Five hundred nouns with direct translations were generated in English and translated to Russian, excluding cognates and homographs. They had a mean concreteness rating (on a scale of 5) of 3.97 (SD = .95) and length of 5.6 (SD = 1.72) characters in English and 6.1 (SD = 1.78) characters in Russian. Each word was presented twice in each language.

The language history questionnaire collected self-ratings of proficiency in reading, writing, speaking, and comprehension, as well as a detailed history of their language exposure, use, and learning history. It was presented in a Google form.

**Procedure:** Words and color rings (presented at visual angle of 2°) were presented on screen in a go no-go task in which participants were asked to do nothing upon reading a non-animal word and press the space bar on a keyboard for an animal word (target stimulus). Participants viewed 8 blocks of ~250 stimuli (50 critical), 4 in Russian, 4 in English. Two blocks in each language condition were blue and 2 were green. Within a block, one color stimulus was frequent (standard) and its corresponding (deviant) color was rare (light blue with dark blue and light green with dark green). Target stimuli appeared 6% of the time and never in tandem with a deviant color ring. Stimulus presentation was pseudorandomized such that two deviants or two targets were never presented in sequence, with at least three standard stimuli in between deviants. Stimuli were shown for 300 ms with an 800 ms interstimulus interval. Language history questionnaire was administered during ERP setup.
Event-related potentials: Electrophysiological data were recorded in reference to FCz and rereferenced offline to an average of the left and right mastoids at a rate of 1 kHz from 32 Ag/AgCl electrodes. Impedances were kept below 10 kΩ. EEG activity was filtered online with a band pass between 0.01 Hz and 200 Hz, and refiltered offline with a 20-Hz low-pass zero phase shift digital filter (slope 48 db/Oct). Eye blinks were mathematically corrected, and epochs with activity exceeding 75 µV at any cap electrode site were automatically discarded. There was a minimum of 360 valid epochs per condition in every participant. Epochs ranged from -100 to 1,000 ms after the onset of the stimulus. Baseline correction was performed in reference to prestimulus activity. The vMMN analysis was conducted on individual ERPs elicited by passive standard and deviant circles irrespective of luminance (light and dark circles combined) to discard luminance effects. The vMMN was maximal over the parietooccipital scalp and studied at electrodes PO9 and PO10. (Because of the low number of participants, a vMMN was only found at these two electrodes.)
Chapter 3

Results

Experiment 1

Three main effects were analyzed in this study: deviancy (all standards vs. all deviants), color (green vs. blue), and language block (Greek blue difference vs. English blue difference), as well as their interactions. As expected, there was a main effect of deviancy ($F(1,11) = 29.451, p < .001$); as can be seen in Figure 4, deviants elicited the expected vMMN effect. The effect of color was marginally significant ($F(1,11) = 3.477, p = .089$). However, there was no significant effect for language block ($p < .1$, see Figure 5). These analyses were done at a linear derivation of the electrodes IZ, O1, O2, OZ, P07, PO8, PO9, PO10, where the effect was maximal.

![Figure 4. Main effect of deviancy.](image-url)
Four interactions were analyzed: deviancy by color, deviancy by language, color by language, and a three-way interaction. None of the interactions were significant.

**Experiment 2**

The same main effects and interactions were analyzed for Experiment 2, but the sample size is much lower ($n=4$). Not surprisingly, there were no significant main effects for deviancy (see Figure 6) or color, nor were there any for the deviancy by language, color by language, or three way interactions (see figure 7). However, the main effect of language was marginally significant ($F(1,3) = 6.28, p = 0.087$) as was the deviancy by color interaction ($F(1,3) = 5.64, p=0.098$); this marginally significant interaction suggests that deviancy was greater for blues than for greens, independent of language block.
Figure 6. All standards vs. all deviants at a linear derivation of PO9 and PO10 where effects were maximal.

Figure 7. Blue and green standards and deviants in both English and Russian blocks (linear derivation of PO9 and PO10).
Chapter 4

Discussion

This thesis sought to understand the potential effects of color term systems on color perception, focusing on the neurocognitive underpinnings of this relationship. Previous work on color perception has shown that color terms can affect a speaker’s ability to distinguish between colored chips (Heider, 1972; Kay & Regier, 2003; Roberson, Davidoff, Davies, & Shapiro, 2005; Winawer et al., 2007) and can affect unconscious perception of switches between colors in an ERP task (Athanasopoulos, Dering, Wiggett, Kuipers, & Thierry, 2010; Thierry, Athanasopoulos, Wiggett, Dering, & Kuipers, 2009). In order to understand how emphasizing one language would affect the earlier reported relation relations between color terms and color perception (Thierry et al., 2009), we tested Greek-English (Experiment 1) and Russian-English (Experiment 2) bilinguals in a go no-go task that utilized the vMMN component of ERPs as an index of perceptual deviancy.

In Experiment 1, a significant effect of deviancy was observed, signifying that participants were sensitive to the difference between deviant and standard stimuli. The effect of color was marginally significant, but the main effect of language block nor any of the interactions between the factors was statistically significant. The participants were not more attuned to the switch between blues than between greens, nor were the switches more salient in the Greek than in the English blocks. In Experiment 2, no significant
effects were found at all, although the effect of language was marginally significant, as was the interaction between color and deviancy. It should be noted, however, that the participant number was very small so this second experiment was underpowered.

These experiments were an extension of the study by Thierry et al. (2009), in which the researchers sought to understand how multiple color terms in Greek for what is considered blue in English might affect perception of switches between these colors. Thierry et al. presented colored circles and squares in the center of the screen to native Greek and native English speakers to understand the effects of native language on the switch between light blues and dark blues (ghalazio and ble, respectively, in Greek) and light green and dark green (both prasino in Greek). They used the same ERP measure, the vMMN, to measure visual sensitivity to the switch. Thierry et al. found a statistically significant interaction between color and deviancy, showing that native Greek speakers were more attuned to differences in blue than in green, and that this difference was greater than for native English speakers. This is attributed to the separate color terms for blue that exist in Greek, but not English. The present study sought to understand how focusing a bilingual participant on one language during the color perception task might modulate the relation between color terms and color perception.

Experiment 1, which examined Greek-English bilinguals, recruited from the same population as in Thierry et al., did not show significant effects of color (blues versus greens) or language block (Greek versus Roman letters). In fact, only a main effect of deviancy was observed, verifying that the oddball procedure that was used did yield the typical vMMN effect. So although the participants noticed the switch between deviants and standards, there was no difference between the blue and green colors or between
language blocks, or the predicted interaction between color, deviancy, and language. The present study thus did not replicate the differential sensitivity to blue and green in the Greek language as observed by Thierry et al. (2009).

A possible explanation for the discrepancy between the original Thierry et al. study and the present experiment is that there are two critical differences in the stimulus materials used in the two experiments: the letter (Experiment 1) and word (Experiment 2) tasks were introduced in the present study (rather than circles and squares as in Thierry et al.), but at the same time the color rings were moved from the foveal (as in Thierry et al.) to the parafoveal vision. We had decided to present the letters and words in foveal vision to ensure participants would read the language information. However, there is some evidence in the literature that color saturation is harder to distinguish in the parafoveal vision than in the foveal vision. Specifically, Fuller and Carrasco (2006) presented participants with colors of different hue and saturation in the parafoveal vision and found that participants had difficulty distinguishing stimuli of different saturation, but not hue. In the present experiment, it is not the case that movement of color rings from foveal to parafoveal made it impossible to distinguish the colors, as there is still a marginally significant effect of color (blues versus greens). It is possible, however, that the movement of the color rings from foveal to parafoveal reduced the distinguishability of similar color shades (light and dark blue, for example).

An alternative interpretation is that attention shift, from color to language task, drove the null results. In the attention literature (e.g., Carrasco, Ling, & Read, 2004), there is some evidence that attention boosts the contrast between stimulus and environment, thereby increasing visual salience of the attended object. In Thierry et al.
participants only needed to attend to the colors; in the present experiment they had to attend to the language task while processing the unattended colors. Given this, it is possible that because in the present experiment the color rings were not the only stimuli requiring attention of the participants, the visual saliency of the color rings in the present study was less noticeable than in Thierry et al. (2009).

As a follow-up study that controls for these alternative explanations, we propose to conduct an experiment in which color returns to the foveal view while keeping the letter or the word presentation the same. This would allow us to address the alternative explanations of reduced color perception in parafoveal view and reduced color saliency as possible reasons for the discrepancy between Thierry et al. (2009) and the current experiments. Possibly, with both the color and the letter/word in foveal view, the vMMN effect of the blues will be stronger than that of the greens in the Greek (or Russian) letter/word condition, but not in the Roman letter/English word condition.

There are numerous future directions this work can take, in addition to addressing the potential attentional and color differences previously discussed. For instance, we would like to understand this effect in native English speaker who are second language (L2) learners of Greek and Russian. Athanasopoulos et al. (2010) examined the effect of long term immersion of a Greek speaker in an English environment by using the same paradigm as Thierry et al. (2009) and separating the participants into two groups, short-stay bilinguals and long-stay bilinguals. They found evidence that bilinguals longer immersed in an L2 environment (long-stay bilinguals) revealed effects more similar to a native speaker of that language while those more recently introduced to an L2
environment (short-stay bilinguals) showed effects more similar to native speakers. If language experience drives this effect, and not environment, a second language learner must, at some level of proficiency, acquire this perceptual ability. Testing L2 learners of Greek and Russian at varying levels of proficiency would allow us to see whether or not a native English speaker can learn these categories. Almost all studies of language and color perception test a non-native English speaker’s ability to learn English terms. We would therefore like to understand at what level of proficiency of a second language an English speaker can learn the color terms of that language.

To conclude, the present experiment did not find any evidence to suggest that processing one of two languages influences the relation between color terms and color perception, and did not replicate the effect of color terms on unconscious color perception as found by Thierry et al. (2009). While the main effect of deviancy was present, confirming that the procedure that was used yielded a vMMN effect, the vMMN was not modulated by language and color. In trying to understand the absence of this interaction between deviancy, language, and color in the present study, two possible explanations were discussed. First, the movement of color from the foveal to the parafoveal view may have decreased the distinguishability of the saturation of the colors. A second possible explanation is that the attentional shift from color to a language (letter, word) may have decreased the visual saliency of the color. It should be noted that Experiment 1 has a low participant number (see also Footnote 1), so we should be careful in drawing any strong conclusions at this point (although Experiment 1 had sufficient power for a vMMN to emerge). In the near future, additional participants will be recruited for Experiments 1 and 2. Moreover, the follow-up studies I proposed in the Discussion may yield additional
insights about the neural underpinnings of the relationship between color terms and color perception, as well as the role of foveal-parafoveal vision, attention and second language proficiency.
References


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