Language relativity re-visited:

Perception of blue and green in Greek, Irish, and German[1]

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Abstract: Some languages have multiple terms for one colour category. For example, Greek has two terms for blue and Irish has two terms for green. Studies into this phenomenon are closely related to the Sapir-Whorf Hypothesis. This hypothesis states that language influences one's perception of the world. In academic literature, this hypothesis is mainly tested in relation to colour perception. Studies often establish that speakers of a language with multiple terms for one colour have a different perception of this colour and, therefore, a different perception of the world.

In this research proposal, adjustments to the research design of a study by Thierry et al. (2009) are proposed. Thierry et al. observed ERP-data retrieved from Greek and English participants participating in a recognition task. They concluded that perception differences between the two groups existed. The proposed design in this paper aims to observe ERP-data retrieved from Greek, Irish and German participants. The goal is to see if there are differences between languages having multiple terms for the colour blue or green, like Greek or Irish, and languages not making this distinction, like German. Furthermore, it is proposed to study if the expected differences in Greek- and Irish-speaking participants are similar to each other and if they are contrasting to the findings found in German-speaking participants.

The potential outcome of this proposed study is a difference in brain activity between languages with one term for one colour category and languages with multiple terms for one colour category. It is also expected that the brain activity in languages distinguishing two terms for blue (e.g. Greek) and the brain activity in languages distinguishing two terms for green (e.g. Irish) will be sharing the same characteristics and thus will be similar to each other.

Key words: language relativity, colour perception, Sapir-Whorf hypothesis, research proposal

[1] An adjustment of Thierry et al. (2009)

1. Introduction

For ages, researchers have been interested in the topic of how language influences one's thoughts. This can be seen in the ideas from Wilhelm von Humboldt, in fictional literature by the author George Orwell, and in the linguistic works of Edward Sapir and Benjamin Lee Whorf (Koerner, 1992). The Sapir-Whorf hypothesis is a principle that states that human thought is affected by language. According to the hypothesis, this results in speakers of different languages having a different view of the world (Regier & Yang, 2017). This hypothesis has two approaches, namely a strong approach and a weak approach. The strong approach states that language completely determines cognition. This means that one's thoughts are never free from the constraints that exist in the language that is spoken. The weak approach makes a less strong distinction. In this case, it is believed that language influences cognition in habitual thought patterns, categorising issues and retrieval of objects and events (Han & Cadierno, 2010).

The large number of research carried out over the years shows that perception of colour is one of the most ideal test cases for this hypothesis (Heurley, et al., 2012). Within most Germanic Indo-European languages, colours usually have one term (Kay & Maffi, 2013). In languages like English, German and Dutch, a further discrimination within a colour term is not obligatory. This means there is a need for just one word for blue, one word for green and so on. In other language families, this pattern is not always followed (Brown & Lenneberg, 1954). Greek, for instance, has two terms for what is called "blue" in English to distinguish between dark and light blue. Furthermore, Irish has two terms for what is called "green" in English, distinguishing between natural and artificial green. In both languages this distinction is mandatory (Coventry et al., 2006; Swinkels, 2015). According to the Sapir-Whorf hypothesis, it could be assumed that speakers of Greek and Irish perceive those colours (and thus the world) differently than speakers of a Germanic Indo-European languages like English, German or Dutch.

This assumption has been tested in the case of multiple languages with two terms for the English "blue", including Greek and Russian (Thierry et al., 2009; Winawer et al., 2007). Thierry et al. (2009) researched if Greek-speaking participants and English-speaking participants had a different electroencephalography (EEG) reaction to varying shades of blue. Participants were observed via EEG while performing a distinguishing task. The results of the study indeed show that there was a greater distinction between different shades of blue than different shades of green in Greek participants. In contrast, English speakers did not show this distinction. In another study, Winawer et al. (2007) researched if speaking Russian would lead to differences

in colour discrimination in comparison to English. In this study, Russian and English participants took part in a perceptual task in which they had to categorise shades of blue in different conditions. The results of this study also suggest that there is a difference between speakers of a language with multiple terms for one colour and speakers of English.

Although both studies seem to imply that having two terms for a colour indeed results in respectively different electrophysiological data and a category advantage, there are many gaps in the study designs resulting in a lot of uncertainty. For example, the Greek participant group lived in England, and the Russian participant group lived in the United States of America (Thierry et al., 2009; Winawer et al., 2007). Therefore, the influence of English could have been a factor that might have altered the results. An important aspect of conducting research is to ensure that the influence of external factors is kept to a minimum. In the case of colour perception within languages, it is important to look at which languages are spoken by the speakers and to what level this external factor affects the tested language. In colour perception research, it is studied whether there is a difference in colour perception between native speakers of two different languages. It is therefore important to establish with certainty that a participant in such an investigation also uses the language in question to distinguish the colours and that there is no influence from a possible second language.

In both studies mentioned above, only English was used as a control language. It can therefore not be ruled out that the effects shown in Thierry et al. (2009) and Winawer et al. (2007) are only present in the tested languages in comparison with English. Despite this, it could be concluded that, based on the earlier mentioned literature, one's (native) language, or more precisely, the number of terms for a colour, influences the perception of colour. However, what is not fully known is what this influence is, where this influence stems from and if it occurs only in languages distinguishing different blues. The design presented in Thierry et al. was a good design as it enables one to observe how the brain reacts to the appearance of a particular use with the use of EEG. If this is done for different speakers of multiple languages, it is possible to compare the event-related potential (ERP) results and see if there is a difference.

To rule out the noise, as mentioned earlier, it is important to look closely at the weaknesses in the study by Thierry et al. (2009). One of the biggest pitfalls in this study might be the choice of languages. One of the participant groups (the Greek group) is residing in England, therefore the influence of English cannot be excluded. Furthermore, there is no form of comparison with another language having a different colour distinction. As a result, coincidence cannot be completely ruled out. By looking

closely at the languages used in the research design, the noise can be cancelled out and the real influence of having multiple terms for a single colour can be examined. This would add the actual perception and impact of specific terms for colour to our understanding and show if there is a pattern within retrieving colours from the brain.

For this reason, this research proposal suggests a number of adjustments to the design of Thierry et al. (2009). Thierry et al. focused on the following research question: "Does the existence of two colour terms in Greek lead to greater and faster perceptual discrimination in native speakers of Greek than in native speakers of English?" In this study design, 20 native English speakers and 20 native Greek speakers were examined while they had to do a basic shape discrimination task. This task consisted of 4 blocks with 16 green or blue circles and a square. During this experiment, electrophysiological data was recorded. Thierry et al. concluded that the comparison of the electrophysiological data indeed shows that the Greek participants made a different distinction between the shades of blue than between the shades of green. English participants do not show any differences in distinction. Even though the research by Thierry et al. has been quoted frequently in other studies (Gallagher, 2017; Regier & Kay, 2009; Simmons et al, 2009) some adjustments for improvement of the design are brought forward in the design of this proposal.

The proposed design will focus on two questions. First, it will be examined if there is a significant difference of colour perception between a language having multiple terms for "blue", a language having multiple terms for "green", and a language with one term for each colour. Based on previous literature (Winawer et al. 2007; Thierry et al. 2009), this difference can be expected, at least for blues. If this difference is established, it is examined whether this recorded difference is comparable in EEG data for participants distinguishing blue and participants distinguishing green. It can be expected that both participant groups show certain overlapping differences in common properties, such as equivalent peak size of the brain potential amplitude, simultaneous intervals and firing of the same neurons at the same moment in time. However, because mainly languages with a distinction in terms of blue have been studied, it is not known whether the properties for blue can also be assumed for other colours, such as green. If this could be assumed it could be discussed if some sort of general practice for processing multiple colour terms exists.

Studying the differences in colour perception between languages is important because it can say something about the worldview of different language populations. With this study, the neural patterns of colour perception can be determined and it answers if the effects, as seen in the literature, can be generalised to multiple languages with the same phenomenon.

2. Method

2.1 Participants

The first adjustment concerns the participants of the study. Thierry et al. (2009) focussed on English and Greek participants. In this experiment , brain event-related potentials (ERPs) are recorded for monolingual speakers of Greek living in Greece, monolingual speakers of Irish living on the Irish islands, and monolingual speakers of German living in Germany or Austria. The addition of an Irish participant group to the set-up of Thierry et al. has been done so that a comparison can be made between the ERP data of distinguishing blue terms and distinguishing green terms (in other words, answering the second sub-question). Because an Irish participant group will be chosen, it is important to exclude the influence of other languages. On the Irish island (The Republic of Ireland and Northern Ireland) English is widely spoken in addition to Irish. In order to keep the differences between the groups of participants clear-cut, it is decided to exchange English for a language with the same number of terms for a colour. For this reason, it is decided to change the English participant group for a German participant group, as both English and German have the same colour classification within their language. Similar to Thierry et al., the same size of participant groups applies (n=20).

Due to the nature of the study, it is important to recruit monolingual participants. It is chosen to recruit participants within secondary vocational educational schools where English does not play a major role. Finding Greek monolingual participants and German monolingual participants is not expected to be a problem. However, given the influence of English within Ireland and Northern Ireland, it cannot be expected to find monolingual speakers of Irish. A solution might be to establish that Irish is the preferred language over English within the participant group. This can be done with a survey.

2.2 Material

Recruitment material is needed to recruit participants. In order to determine whether the participants are suitable for this study, it has to be determined whether they are monolingual Greek or German or whether they have Irish as their preferred language. A survey is used to retrieve language information on all the participants and an English proficiency test is used for the Greek and Irish participants to check if their proficiency in English is not too high, enabling it from interfering with their colour

perception in Greek or Irish. This is not necessary for the German participants as both English and German have the same amount of terms for one colour and interference is therefore not an issue.

During this experiment the stimuli presented in Figure 1 and Figure 2 are used to assess the participants' perception of the presented colours. As described earlier, Greek has two terms for blue, namely ble for darker blue and ghalazio for a lighter blue. Irish has two terms for green, namely glas for natural (darker) green and uaine for artificial (lighter) green. German only has one term for both categories, namely blau for all shades of blue and grün for all shades of green. The colour classification of the colours blue and green can be seen in Figure 1. The colours used in this experiment will be #6FDEFF for light blue, #0D3078 for dark blue, #94FB86 for light (artificial) green and #2D5F26 for dark (natural) green. For the measurement of brain responses, an ERP set-up is used.

Figure 1. Colour terms in Greek, Irish, and German.

2.3 Task

In order to establish that the participant groups do indeed determine the colours as shown in Figure 1, a test run with a test group must be carried out first. In this test run some speakers of Greek, Irish and German have to name the colours of the circles in Figure 1. These speakers will not participate in the experiment. Once the correctness of the colour terms has been established, the real experiment can take place.

All the participants are going to participate in a basic shape discrimination task (Figure 2) based on the stimuli sample of Thierry et al. (2009). In this task, participants have to look at the shapes presented in four different blocks while wearing an EEG cap to collect neurological data. The blocks will consist of a random pattern with 16 light or dark circles in respectively green or blue and one square in respectively green or blue. The shapes will be presented one by one for 200 milliseconds and the inter-

stimulus duration will be 800 milliseconds. The participants are asked to push a button when they observe a square within the stimuli pattern. This task is a distraction task to maintain the attention of the participants. While the participants complete the task, the EEG cap records brain responses to the stimuli below.

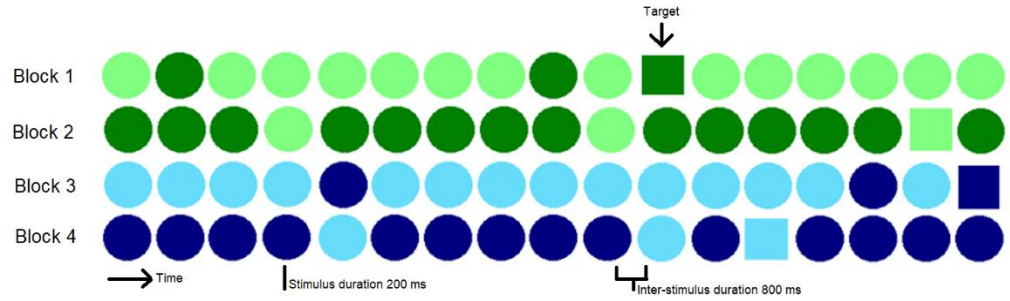

Figure 2. Stimuli sequences.

2.4 Analysis

After obtaining ERP data, this data will be filtered using, among other things, a band pass to create a clear graph from the brain activity. When the data is complete and edited, the data can be analysed. The first analysis looks at the differences in ERP data between the Greek and German group of participants and the differences in ERP data between the Irish and German groups of participants. This analysis will be used to try to answer the first question, namely "Is there a significant difference of colour perception between a language having multiple terms for blue, a language having multiple terms for green and a language with one term for each colour?"

The second analysis will focus on the differences in ERP data between the Greek and the Irish group of participants. With this analysis the second question ("Are the differences that are seen in Greek or Irish compared to the German similar to each other?") is answered.

3. Expected results and discussion

Similar to the findings by Thierry et al. (2009), it is expected that there will be a visible reaction of colour change within the ERP data. This reaction will be present when the dark and light colour alternate in all blocks and does not require an active response of the participants. The visible reaction (called visual mismatch negativity (vMMN) in Thierry et al.) is expected to be similar for green and blue in German participants, thus not making a further distinction between different colour terms within blue or green.

This reaction will be in line with the findings for the English participant group in Thierry et al. For Greek participants, Thierry et al. established that there will be a different reaction for blue than for green, with a greater vMMN effect for the blue shapes. By adding an extra group, there is no known vMMN data for a language that distinguishes between terms for the colour green, such as Irish. However, it is to be expected that Irish participants will give a different response to green versus blue. It can also be expected that this difference in vMMN effect is the opposite of that of Greek participants. For Irish participants, it is expected that there will be a different reaction for green than for blue, with a greater vMMN effect for the green shapes. The assumption can be made that the greater vMMN effect for blues in Greek participants and the greater vMMN for greens in Irish participants will have similar characteristics, because having several terms for one colour category can be traced back to the same rationale, regardless of the colour itself.

The potential outcome from this study is that there is a difference in brain activity between languages with one term for each colour category (such as English, German, and Dutch) and languages with multiple terms for one colour category (such as Greek, Irish, and Russian). It is also expected that the brain activity in languages distinguishing two terms for blue (e.g. Greek) and the brain activity in languages distinguishing two terms for green (e.g. Irish) will share the same characteristics, and thus be similar.

Although the mentioned adjustments will give more insight into colour perception within different languages and show that the Saphir-Whorf hypothesis and the discussed literature could indeed be (partially) true, there is still a great deal of uncertainty about the influence of language on thought. In this paper it is assumed that the vMMN effect for the colour blue for Greek participants and the VMMN effect for the colour green for Irish participants share the same characteristics. This can be seen as a generalisation and future ERP studies should be carried out in order to prove or disprove this assertion. However, when proven correct, with the adjustments proposed it is still not clear what could be considered the origin of the differences in ERP data. For this reason, further research is needed to indicate a possible similarity or a possible difference in vMMN effects. Further research should also address the possibility that the differences in ERP data do not (solely) originate from the variance in colour terms in a language, and, if this is the case, where this difference might originate from. Another interesting change of perspective would be an alternative research design that focuses on multilinguals and the possible influence of one of their languages on their colour perception.

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