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ARTICLE

DRIVER PREFERENCE CONCERNING IN-CAR ROUTE GUIDANCE AND NAVIGATION SYSTEM MAPS FOR DRIVERS WITH COLOR VISION DEFICIENCY

Preferência de motoristas com deficiência na visão de cores por mapas de sistemas de navegação e guia de rota em automóvel

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Abstract:

In-car Route Guidance and Navigation Systems (RGNS) are used to help drivers navigate. These maps have mainly been designed to accommodate drivers with normal color vision. However, the color perception of people with normal color vision differs from that of people with color vision deficiency. When navigating, understanding certain kinds of information presented by RGNS maps can be a more complex task for colorblind drivers and traffic safety may be impacted negatively. An important aspect related to the graphic design of RGNS maps is the use of a good combination of colors to improve map legibility. Cartographic representations with good legibility aid drivers in comprehending information and making appropriate decisions during driving tasks. This paper evaluates driver preference for RGNS maps designed for drivers with color vision deficiency. A total of 14 subjects participated in an experiment performed in a parked car. Maps were designed to accommodate red-blinds and green-blinds by using a color simulator and principles of perceptual grouping and figure-ground segregation. Based on the results, we conclude that the map grouping symbols representing car and direction arrows in blue segregated from the route in black was more acceptable to drivers compared to other combinations. It is recommended that

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RGNS should offer a specific graphic design to support drivers with color vision deficiency in navigating.

Keywords: In-Car Route Guidance and Navigation System; Map design; Color vision deficiency; Drivers' preference.

Resumo:

Os mapas de Sistema de Navegação e Guia de Rota em Automóvel (SINGRA) são utilizados para auxiliar os motoristas em suas tarefas de navegação. Esses mapas têm sido projetados e produzidos para acomodar, principalmente, motoristas com visão normal de cores. No entanto, a percepção de cor entre pessoas com visão normal de cores e pessoas com deficiência na visão de cores é diferente. Ao navegar, entender certos tipos de informações apresentadas pelos mapas de SINGRA pode ser uma tarefa ainda mais complexa para motoristas com deficiência na visão de cores e a segurança do tráfego pode ser impactada negativamente. Um importante aspecto relacionado ao projeto cartográfico para SINGRA é a utilização de uma boa combinação de cores para melhorar a legibilidade do mapa. Representações cartográficas com boa legibilidade auxiliam os motoristas a compreender facilmente as informações e tomar decisões apropriadas durante as tarefas de navegação. Este artigo avalia a preferência de motoristas por mapas de SINGRA projetados para usuários com deficiência na visão de cores. Um total de 14 indivíduos participaram de um experimento realizado em um carro estacionado em via urbana. Os mapas foram projetados para acomodar pessoas com cegueira no vermelho e no verde, a partir do uso de um simulador de visão de cores e princípios de agrupamento perceptual e segregação de figura-fundo. Com base nos resultados, conclui-se que o mapa com agrupamento perceptual por cor entre os símbolos que representam o automóvel e a seta de direção em azul segregado da rota em preto foi mais aceito pelos condutores em comparação com as demais combinações. O SINGRA deveria oferecer projetos gráficos específicos para auxiliar motoristas com deficiência na visão de cores em suas tarefas de navegação.

Palavras-chave*:* Sistema de Navegação e Guia de Rota em Automóvel; Projeto cartográfico; Deficiência na visão de cores; Preferência dos motoristas.

1. Introduction

In-Car Route Guidance and Navigation Systems (RGNS) are available worldwide to support drivers when following a route. Navigation tasks are divided into two main components: route planning and route following (Michon 1985; Burnett 1998). In recent decades, RGNS have contributed considerably to increasing economy and mobility.

Of all our senses, vision is undoubtedly fundamental in navigation. Nowadays, drivers can receive navigational information by using dynamic maps in an ego-centered reference frame. However, reading maps while driving may compromise traffic safety due to the attention required by the systems (Burnett 1998; Tsimhoni and Green 2001; Green 2002; Hwan and Jin 2010). This process may become even more serious when drivers suffer some Color Vision Deficiency (CVD).

The literature argues that aspects of color perception are different between people with Normal Color Vision (NCV) and people with CVD (Olson and Brewer 1997; Sharpe et al. 1999; Jenny and

Kelso 2007), but RGNS have been designed mainly to support drivers with NCV. Consequently, drivers with CVD may not understand the cartographic information depicted by the RGNS maps. It is argued that color vision deficiency affects approximately 8% of men and 0.4% of women (Pokorny et al. 1979, Sharpe et al. 1999). Brazilian law restricts the driver's license for color-blind people by elucidating that "candidates for vehicle driving must be able to identify green, yellow and red colors". Despite that, many Brazilians people who did not pass the Ishihara Test (Ishihara 1972) have a driver's license and are regular drivers (Moretti et al. 2013).

Color can be regarded as the most dominant element in searching for objects on a map (Dent, Torguson and Hodler 2009). Color enables us to distinguish clearly between the many categories of features on a map and facilitates visual grouping (Olson and Brewer 1997). However, Atchison et al. (2003) report that people with CVD have longer reaction times and make more errors than those with NCV when responding to color signals. Maps should therefore be made to aid those with color impairments as much as possible (Olson and Brewer 1997).

However, most colorful maps, including those used in RGNS, are produced without any kind of consideration of color-vision impairment on the part of map users. It is important to avoid relying on color coding to communicate critical information in a commercial application such as RGNS, according to Dingus and Hulse (1993). Carney, Campbell and Mitchell (1998) point out that redundant coding can enhance meaningfulness. For those authors, when people are using a system without those redundant clues, they might a have high level of difficulty in getting any kind of meaning.

Once detection and discrimination of color information has been identified as a problem for people with CVD, cartographers should consider this factor in map design (MacEachren 2004). There are a number of indications suggesting the process of adjusting colors on maps to accommodate red-blindness (protanopia) and green-blindness (deuteranopia) to help people use maps effectively (Olson and Brewer 1997; Gardner 2005; Jenny and Kelso 2007; Pugliesi and Decanini 2011; Kröger, Schiewe and Weninger 2013).

Since the process of communicating navigational information can have serious impact on traffic safety, researchers have pointed out the importance of evaluating usability issues by considering individual differences (Burnett 1998; Green et al. 1993; Labiale 2001; Liu 2001; Pugliesi, Decanini and Tachibana 2009; Burnett et al. 2013b; Lin and Chen 2013; Ramos et al. 2014a). Some research works about RGNS map design take the cartographic communication process into account (e.g.: Li and Ho 2004; Lee, Forlizzi and Hudson 2008; Pugliesi, Decanini and Tachibana 2009; Ramos et al. 2016), however we found few investigations in the literature that considered drivers with CVD (Pugliesi and Decanini 2011; Oliveira et al. 2012).

Besides aspects of the cartographic design, to evaluate the usability of RGNS based on a set of objective and subjective methods and measures allow verification of the capacity offered by the interactive system in an operational context to work effectively, efficiently and to give user satisfaction (ABNT NBR 9241-11 2002). The variables to evaluate the efficiency and effectiveness allow to study the interface in terms of the user's performance, while the variables to evaluate the satisfaction allow quantify the acceptance and verify the user's opinion on the interface. In the context of cartography and RGNS, one of the main works that contrasts performance and preference is presented by Pugliesi, Decanini and Tachibana (2009). Concerning user satisfaction, this is one of the three pillars of the usability evaluation process and is related to freedom from discomfort and a positive attitude towards using the product (ISO 9241-11 1998). In the context of cartography, Brock et al. (2012) considered both design and user satisfaction of interactive maps for visually impaired people, whereas Lorenz et al. (2013) addressed the factors that influence user satisfaction in indoor navigation maps.

With regard to RGNS maps, user satisfaction is seen as an important measure in the evaluation of RGNS interfaces because it allows designers to quantify driver acceptance of information and to know the drivers' opinions about the interface (Pugliesi et al. 2013). The authors state that questionnaires and interviews have been used to collect data concerning preferences, as emphasized by researches by Pugliesi and Decanini (2009), Ramos et al. (2014a) and Ramos et al. (2016). Pugliesi and Decanini (2009) evaluated the preference of 28 drivers with NCV in relation to the map representation or turn-by-turn for RGNS. The results indicated that most of drivers prefer map. Ramos et al. (2014a) evaluated the preference of 54 drivers with NCV regarding the route color and the arrow color for RGNS maps. The results indicated that most drivers preferred the navigation route in black color instead of blue. The direction arrow in green hue was the mostly preferred by the drivers instead of red arrow. Ramos et al. (2016) evaluated the preference of 52 drivers with NCV in relation to the map representation scale. Among four scales evaluated, 1: 1,000, 1: 3,000, 1: 6,000 and 1: 10,000, the results indicated that most drivers preferred intermediate scales 1: 3,000 and 1: 6,000. The studies mentioned have analyzed the preference based on quantitative and qualitative analysis, which also justifies the use of this strategy in the present study.

We suggest that creating a map to support drivers with CVD must take into account their color vision perception, perceptual grouping and figure-ground segregation principles. Thus, this study aims to design a set of RGNS maps to support drivers with CVD when following a route, and to evaluate these maps based on drivers' preference.

2. Method

2.1 Design of maps for drivers with CVD

A set of maps with different graphic aspects was designed. The purpose of the maps was to aid drivers with CVD following a route, specifically to get directions in a tactical task before a roundabout. Tactical task refers to a preparation to reach the next maneuver (Michon 1985). It is necessary to create an unambiguous mental image of the space in which driver is located (Ross et al. 1996; Labiale 2001). The roundabout selected for this study is located in the town of Alvares Machado, in the west of Sao Paulo state. Arterial, collector and local roads connect the roundabout.

The graphic design took account of protanopia and deuteranopia color perception as well perceptual organization principles. Color Oracle, developed by Jenny and Kelso (2007), was used to simulate the color vision of protanopes and deuteranopes. A set of color vision simulators was investigated, and Color Oracle was considered the most suitable for map design (Oliveira et al. 2014).

Perceptual organization principles as defined by Gestalt and considered appropriate for Cartography (MacEachren 2004), figure-ground segregation (heterogeneity and contour) and perceptual grouping (proximity, similarity, good continuation and simplicity) were employed. Some aspects of cartographic symbols applied on RGNS maps followed the recommendations of

Pugliesi, Decanini and Tachibana (2009). These symbols are classified as figure (e.g. car, route and direction arrow) and ground (e.g.: road network, roads toponym, blocks, green area and railway).

A pictorial symbol of a car was used to indicate the location of the driver on the route. A thick line describes the path the driver should follow. An arrow represents the direction to be taken from the entrance to the exit at the roundabout. Symbols were organized according to categories, classes, visual hierarchy, spatial dimension and level of measurement (Table 1).

Table 1: Hierarchy of the information elements for route following.

Hierarchy	Information category	Information elements	Spatial dimension	Level of measurement
1st	Location on route	Car	Point	Nominal
	Maneuver direction	Direction arrow		
	Path to follow	Route	Line	Sequential
2nd	Spatial context	Road network: Arterial road Collector road Local road	Line	
3th		Railway	Line	Single class
		Green area	Area	Single class
		Blocks	Area	Single class

Making maps of different graphic aspect hue was the only visual variable applied. The limitations concerning the number of colors perceived by protanopes and deuteranopes were taken into account. Blue (RGB = 55,55,248) and black (RGB = 0,0,0) were used in different combinations to represent car, route and direction arrow. Contours were used to form a visual hierarchy helping to establish perceptual figure-ground segregation. Contours with continuous lines were applied to create an arrow filled with white. White was also used to contour car symbols and ensure segregation from other objects. This allowed the creation of perceptual grouping between cars and other thematic elements. A unique design consisting of arterial road (RGB = 255,255,0), collector road (RGB = 252,252,130), local road (RGB = 255,255,255), railway (RGB = 0,0,0), block (RGB = 200,200,200), and green area (RGB = 219,218,169) was used for the ground.

Eight cartographic representations were made creating four different pairs of combinations and two sequences of maps, in order to make some basic comparisons about drivers' preference. In the first pair, a perceptual grouping was established by color for all three thematic symbols, by using blue (Figure 1a) or black (Figure 1b). Also, similarity by color was used to provide a greater grouping between car and route. The same color and thickness were used to promote good continuation between route and arrow. In the second pair, the goal was to promote grouping between two thematic symbols, car and route, separating them by arrows (Figures 2a and 2b). In one map, car and route were represented in blue, with arrow contour in black (Figure 2a), while in the other map, route and car were represented in black, with arrow contour in blue (Figure 2b).

In the third pair, visual grouping between car and arrow was employed to separate them from the route. The thematic symbols of car and arrow had smaller dimension. In one map, blue was applied for the car and arrow contour, with black for route (Figure 3a). In the other map, black was used for car and arrow contour, while the route was depicted in blue (Figure 3b).

In the fourth pair, grouping between route and arrow was established employing good continuation in the arrow contour. Consequentially, the car was separated. In one map, blue was used for the car and black for route and arrow contour (Figure 4a). In the other map, blue was used for route and arrow contour while black was used for car (Figure 4b).

The scale used for the maps was 1/6000, since this was easier than other map scales used by a group of drivers with NCV in the context of route guidance (Ramos et al. 2014b; Ramos et al. 2016). Maps were created by using ESRI ArcGIS software.

Figure 1: Perceptual grouping by color for car, route and arrow, by using blue (a) and black (a).

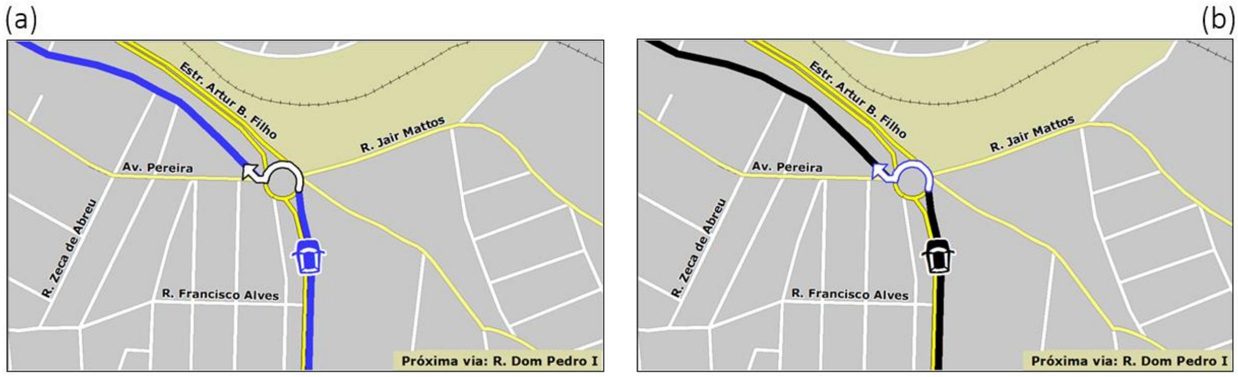

Figure 2: Perceptual grouping by color for car and route, by using blue (a) and black (b).

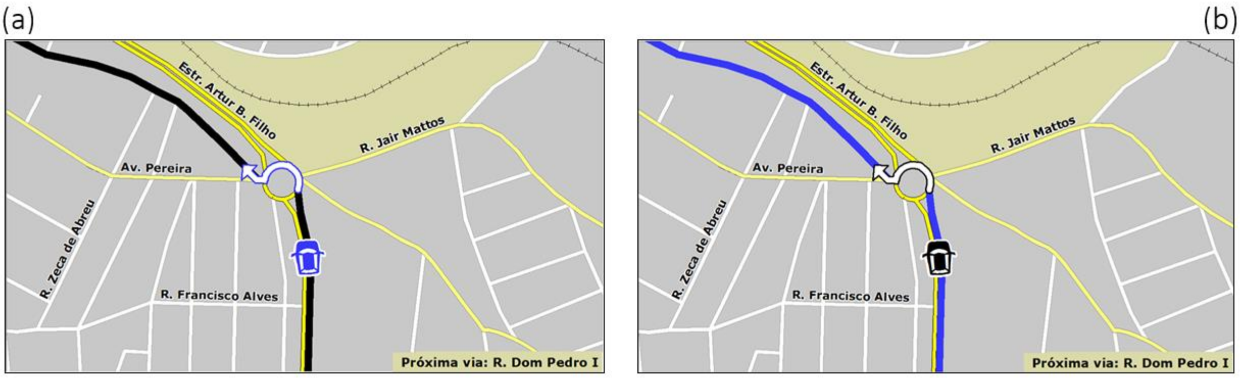

Figure 3: Perceptual grouping by color for car and arrow, by using blue (a) and black (b).

Figure 4: Perceptual grouping by color for route and arrow, by using black (a) and blue (b).

2.2 Evaluation of preference

As mentioned in the introduction to this article, user satisfaction is one of three pillars of the usability evaluation process (ISO 9241-11 1998). Hence, user preference was evaluated with a group of drivers with color vision deficiency, since the preference of these drivers for RGNS maps could support map design decisions and consequently improve RGNS usability.

2.2.1 Participants, apparatus and display

Participants having CVD had to have a driver's license, as well driving experience. A group of 14 experienced drivers (all male) aged 21-31 years (mean 25.64), participated in the test. Each driver filled in a questionnaire with information about age, driving time, experience with RGNS and color vision deficiency. Concerning CVD, eight participants reported having mild confusion with red, green and blue, while five participants reported having mild confusion with red and green. Only one participant reported not having any type of color vision deficiency, but during the Ishihara test (Ishihara 1972), applied afterwards to confirm the CVD, it was proven that the driver is deficient in color vision. All drivers participating in the test therefore presented at least slight confusion with red and green, which is compatible with the purpose of the designed maps. In terms of experience with RGNS, one driver reported that he uses RGNS often, eight drivers use occasionally and five drivers rarely use the system. All drivers already had some experience with the types of RGNS maps. However, previous experience with RGNS was not considered when carrying out the statistical analyses as this would have reduced the number of candidates.

The test was accomplished in a car, parked on an urban street, in daytime. The visual device used to display maps was fixed in the central portion of the windshield and directed at the face of the driver at an angle of approximately 25 degrees between the center of the monitor and the road center. That location and angle were selected as it allow drivers to carry out a visual search moving eyes horizontally without turning the head (Wittmann et al. 2006; Burnett et al. 2013a). A tablet (Asus ME371MG model), seven-inch screen, video resolution of 1024 x 768 pixels, was used to display the maps.

2.2.2 Procedure

Inside the car, each participant used a seat belt to enhance the driving context. Information about the visual device, test script and navigation task assisted drivers in understanding the steps of the experiment. Doubts were clarified by the experimenter who was on passenger seat. The sequence of questions follows the cases presented in the section entitled Design of maps for drivers with CVD. Questions were organized in the following way:

- First pair (Figures 1a and 1b): “Which map do you prefer to use in a RGNS? And why?”;
- Second pair (Figures 2a and 2b): “Which color do you prefer for car and route? And why?”;
- Third pair (Figures 3a and 3b): “Which color combination do you prefer for car and arrow? And why?”
- Fourth pair (Figures 4a and 4b): “Which color combination do you prefer for arrow and route? And why?”.

Also, two sequences of maps created previously were presented to the driver sequentially. The first (Figures 2a, 3a and 4b) and second (Figures 2b, 3b and 4a) had a single question: “Which map do you prefer to use in an RGNS? Please, indicate the order of preference and justify it". All the maps were displayed using Microsoft Power Point software and answers were recorded in audio for data organization and analysis from the application of a questionnaire in the form of a semi-structured interview.

During the presentation of the pairs and map sequences evaluated, the participant had 5 seconds to look each map in each case evaluated, but the driver could request a return to the map to confirm his choice. To maintain a standard in data collection, all participants underwent the same conditions of use during the evaluation. In each of the pairs and sequence of maps evaluated, the driver was asked if he was able to notice differences between the maps presented. It was suggested that the participant pay as much attention as possible to the maps, since after presenting the cartographic representations, a series of questions would be asked about the observations of each of the users.

2.2.3 Organization of data and statistical analysis

Answers to these questions were organized using Microsoft Excel software, according to each of the six cases. Data processing was carried out using SPSS 21.0 (Statistical Package for the Social Sciences) software. A preliminary statistical analysis was based on the percentage values for all cases. Additionally, nonparametric statistical analyses were employed taking into account a level of confidence higher or equal to 95%. This type of analysis is recommended when using qualitative data, as well when data does not follow a normal distribution (Conover 1999).

To quantify preference data, observed frequency (F_0) was used in the first four cases. Chi-Square test (χ^2) was used for groups with F_0 equal or higher than five elements by considering two unrelated samples. Friedman's test was applied to analyze groups with F_0 smaller than five elements, taking three related samples into account. In addition, trends were considered when results were not statistically significant.

3. Results

Results are presented for the four pairs and two sequences evaluated, which were analyzed separately. This allowed verification if the preference was influenced by perceptual grouping and/or segregation between thematic symbols.

In the first pair of maps (Figure 1a versus Figure 1b), 42.85% of the drivers preferred route, car and arrow contoured in blue (Figure 1a), while 57.15% preferred route, car and arrow contoured in black (Figure 1b). For the second pair of maps (Figure 2a versus Figure 2b), 42.85% of the drivers preferred route and car in blue, arrow contoured in black (Figure 2a), while 57.15% preferred route and car in black, arrow contoured in blue (Figure 2b). In the third pair of maps (Figure 3a versus Figure 3b), 71.42% of the drivers preferred route in black, car and arrow contoured in blue (Figure 3a), while 28.58% preferred route in blue, car and arrow contoured in black (Figure 3b). In the four pair of maps (Figure 4a versus Figure 4b), 64.28% of the drivers preferred car in blue, route and arrow contoured in black (Figure 4a), while 35.72% preferred car in black, route and contour arrow in blue (Figure 4b). Comparisons on the percentages are showed in Figure 5.

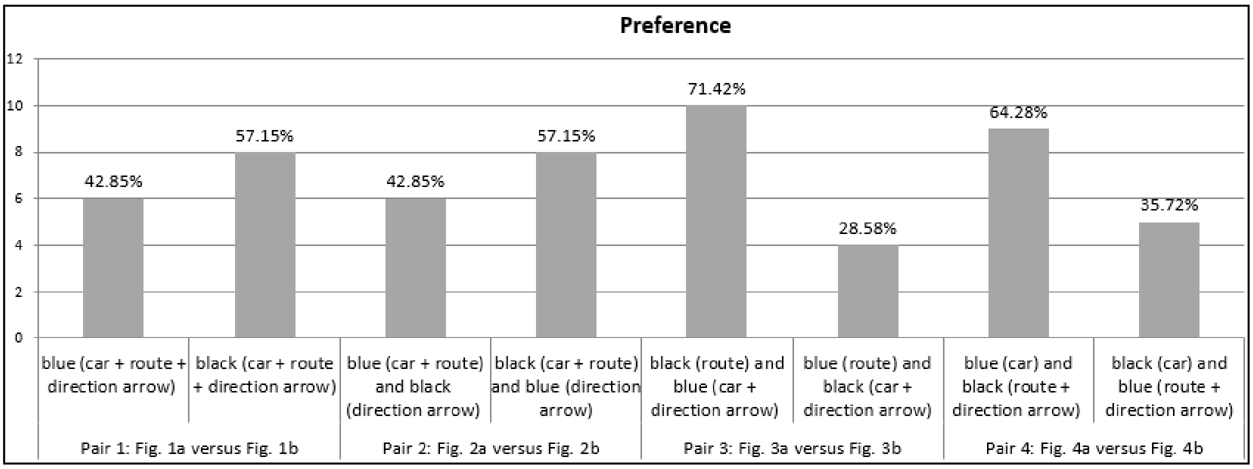

Figure 5: Percentage of preference for the four pairs of maps.

A more detailed analysis was undertaken. Chi-square test results show that for the first (χ^2 = 0.286, p = 0.593), second, (χ^2 = 0.286, p = 0.593), third (χ^2 = 2.571, p = 0.109) and fourth (χ^2 = 1.143, p = 0.285) pairs there was no statistically significant difference, considering a significance level less than or equal to 0.05. Table 2 describes the reasons for drivers' preference for each evaluated map.

Table 2: Comments provided by drivers for the four pairs of maps.

Pair	Map	Comments
1	Blue (car + route + direction arrow)	"Greater emphasis on the route; blue draws more attention than others; clarity; route can be confused with hydrographic features"
	Black (car + route + direction arrow)	"Greater emphasis on the main symbols of the map; ease of distinguishing information; the route draws more attention"
2	Blue (car + route) and black (direction arrow)	"The route in blue is more prominent; quick to identify the main symbols of the map; blue draws more attention"
	Black (car + route) and blue (direction arrow)	"The route in black is more prominent; it facilitates better distinction of map elements; clarity; draws more attention; the objects appear closer"
3	Black (route) and blue (car + direction arrow)	"Easier to understand the car and the arrow in relation to the route; clarity; I can see the car easier; the objects are closer; the car and the arrow in front of the route; draws more attention"
	Blue (route) and black (car + direction arrow)	"Route more prominent; greater difference between elements; arrow with contour in black is more prominent in relation to the route"
4	Blue (car) and black (route + direction arrow)	"Map is clear; easier to perceive differences; contour of the arrow in black helps identifying information"
	Black (car) and blue (route + direction arrow)	"The car, arrow and route are more notable; better difference between different elements; car in black draws more attention"

The questions "Which map do you prefer to use in an RGNS? Please, indicate the order of preference and justify it" were used for those two sequences of maps evaluated as shown in Figure 6 and Figure 7, respectively.

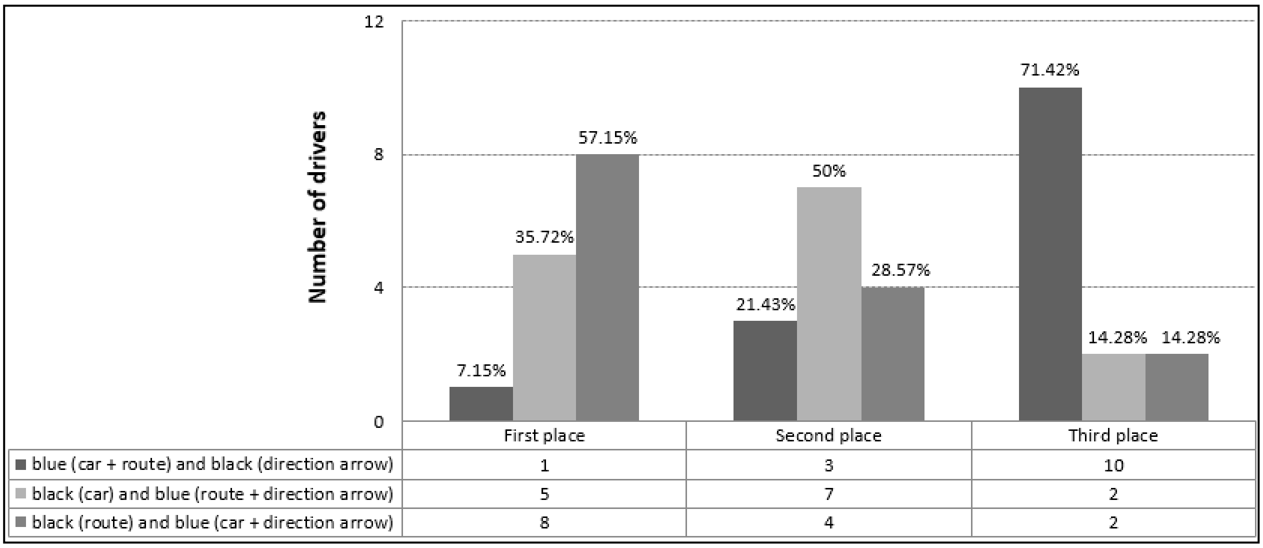

Figure 6: Order of preference for maps considered in the first sequence.

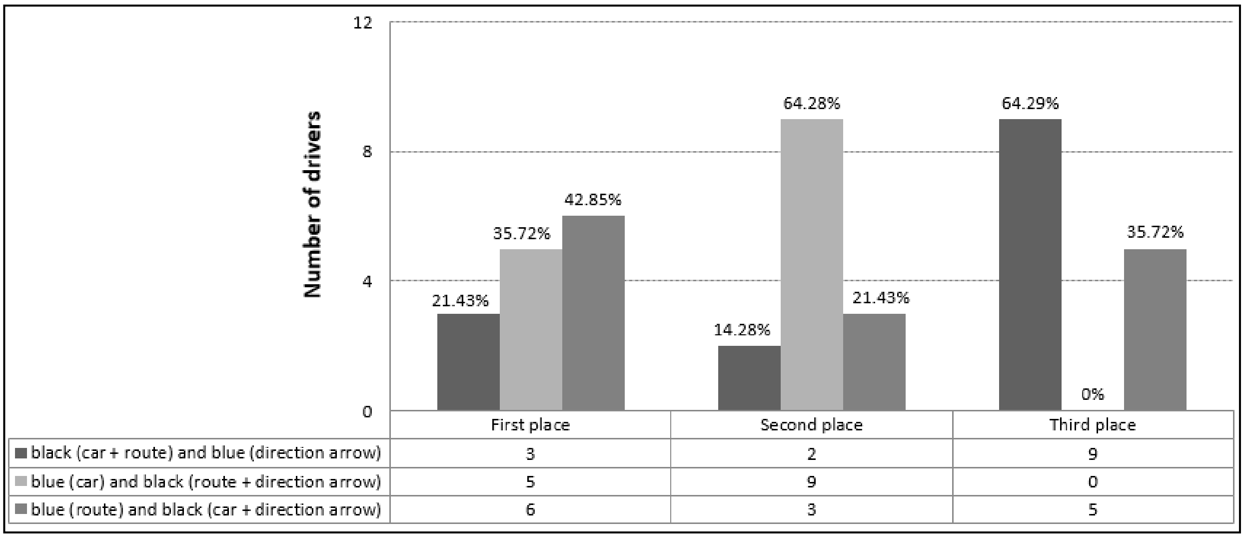

Figure 7: Order of preference for maps considered in the second sequence.

Results from the Friedman test show drivers' preference is not random ($\chi_2^r = 9.000$, $p = 0.011$) for the first sequence (Figures 2a, 3a and 4b). In terms of sequence, drivers prefer route in black, car and arrow contoured in blue (Figure 3a), followed by car in black, route and arrow contoured in blue (Figure 4b). Considering the second sequence, results from the Friedman test show that, in this case, drivers' preference is random ($\chi_2^r = 4.429$, $p = 0.109$). Table 3 provides drivers' comments.

Table 3: Comments provided by drivers, considering both the two sequences.

Sequence	Map	Comments
5	Blue (car + route) and black (direction arrow)	"Easy to identify the information; arrow well defined"
	Black (car) and blue (route + direction arrow)	"Route in blue has greater prominence; importance of locating car; good differentiation between the car, route and arrow; arrow and car most prominent"
	Black (route) and blue (car + direction arrow)	"Route and car most easily notable; get the most attention; greater contrast between the main symbols of the map; greater readability; ease of perceiving distance between car and maneuver; biggest highlight for the car on the route; route highlighted in relation to other roads"
6	Black (car + route) and blue (direction arrow)	"Black helps differentiating other elements; arrow most notable"
	Blue (car) and black (route + direction arrow)	"Greater emphasis on the route - most important element on the map; higher contrast and clarity; ease in identifying the car; contour of the arrow facilitates understanding the maneuver"
	Blue (route) and black (car + direction arrow)	"The route is more prominent; the difference between the elements is clearer; the map is clear; the route draws more attention"

4. Discussion

According to the drivers, the route shown in black draws more attention to the path in the first and second pairs, which was regarded as the most important information on the map. Comparing the first and second pairs of maps, only two participants changed their minds: a participant who had preferred the blue route in the first pair, opted for the black route in the second pair; conversely, a participant who preferred the black route in the first pair preferred the blue route in the second. Some of the participants who preferred the route in black commented that the route in blue can be confused with hydrographic features. In the research by Ramos et al. (2014a), the authors verified drivers' preference about the color of the route (blue versus black) with a group of drivers with normal color vision. These authors reported that the route in black was preferable because it helped to increase contrast on the map and allowed association with road asphalt.

For the third pair, drivers' preference was higher when the route was in black and car and contour of arrow were in blue. Participants argued that this graphic configuration increases contrast between the cartographic symbols. Putting the car in blue on the route in black produced an advance and retreat effect for each symbol, respectively. According to drivers who chose the route in black, arrow contoured in blue and car in blue as well, priority was higher in terms of location on route and segments that compound the roundabout. Probably, unity was perceived by proximity and color between car and arrow. Distance from the car to the maneuver contributes to performing the tactical task (Ross et al. 1996; Pugliesi, Decanini and Tachibana 2009; Ramos et al. 2016). Moreover, those who prefer the route and arrow contoured in black with the car in blue seem to put priority on location.

Concerning the fourth pair, most drivers preferred the map with the car in blue and route and arrow contour in black. This composition also ensured separation of car and route as well as maintaining differentiation compared to the maneuvering arrow contoured in black. In the participants' opinion, the identification of the car is immediate, and this element stands out in relation to other things. In addition, the map ensures a great highlight for the route in black, where the arrow appears to be part of the route and its contour favors identification of the direction of maneuver. On the other hand, those who preferred the car in black and route and arrow contour in blue gave priority to its location on the route, symbolized by the car.

Although the elements of the map show variation between the pairs considered, analysis of the four pairs of maps evaluated indicated that the majority of drivers preferred maps with route in black (Figure 5). However, the driver preference of is not influenced only by the color of the route, as can be verified from the drivers' comments (Table 2).

In relation to the two map sequences, the order of preference for the first sequence shows that drivers prefer the route in black and the car and arrow contour in blue. This confirms results found previously, such as those obtained in the evaluation of the third pair of maps, in which the first map considers the route in black with the car and arrow contour in blue being preferred by the greater number of drivers (10) when compared to the map with route in blue and car and arrow contour in black, preferred by only 4 drivers. With the second sequence of maps, the drivers preferred the route in blue with car and arrow contour in black. Analyzing the two cases mentioned above, it seems that, probably, reading thematic elements occurs in the following order of importance: first car and arrow, then route. This representation was considered by drivers as the most legible. According to the comments and justifications on the preference of the drivers, the most readable map is that which considers the perceptual grouping between car and maneuver direction arrow, both segregated from the route. This type of representation appears in the two map sequences evaluated. In the first sequence, among three options, most drivers (8) preferred the map with the route in black, car and arrow contour in blue. In the second sequence, also among three options, different from the first sequence, most drivers (6) preferred the map with route in blue, car and arrow contour in black. The justifications presented by the drivers were based on the fact that the car and arrow are easily and immediately identified and seem closer. In addition, these elements stand out in relation to the route, which is identified by the drivers next. The results found from this work corroborate the approach presented by Morita (1993), which points out that, during tactical tasks, drivers try to answer questions related to their location followed by what they should do next.

5. Conclusions and recommendations

This paper presents a preliminary study of drivers' preference for maps of route guidance designed for people with color vision deficiency, protanopia and deuteranopia. When considering principles of cartographic communication, specifically perceptual grouping and figure-background segregation, as well the color vision perception of people with CVD, it seems possible to design readable RGNS maps for users with this kind of perceptual impairment. The most prominent representation was that designed to form perceptual grouping by color between car and arrow contoured in blue, segregating them from the route in black. From the analysis and comments of the participants, drivers with CVD read these thematic symbols in the following order: first car and arrow, then route, finally the ground. Our results are important for determining user satisfaction. Further evaluation is still needed to determine map usability, taking into account objective measures, to verify the effectiveness and efficiency of the RGNS, by means of metrics such as navigational errors and visual demand. They are strictly related to performance when driving and navigating aided by RGNS. Thus, we suggest conducting experiments using driving simulators in order to maintain traffic safety. In addition, in terms of preference, it is recommended to consider other factors such as order of presentation of maps, greater or lesser experience with the use of RGNS.

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