

**CONSTRUCTION OF SPATIAL KNOWLEDGE AND SPATIAL ANALYSIS OF EFFICIENCY  
IN SPATIAL TRANSFERABILITY OF INFORMATION TO SUBWAY MAP OF THE CITY OF  
SÃO PAULO (BRAZIL)**

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**BACKGROUND AND OBJECTIVES**

The media like television, magazines and books, using maps and other forms of expression to promote events or phenomena spatialization. Being exposed to these mass media seems to be constant in a society that like of the "image" to buy, sell or explain about an event that occurred somewhere on the planet. We observed that this "image" is not familiar to most people because it represents a simplified and even complex phenomena. Therefore, it is important to noted that research trying to understand how people read the information on a map, and how they are able to interpret and relate these informations to their tasks and are also important to understand the spatial reasoning which will assist in design development and use of map.

Thinking about how space is represented or perceived permeates to understand how cartographers can check the communicative efficacy of their products regardless of having generated them by the aid of computational techniques or by the analog techniques. Therefore, we should take other parameters to indicate the communicative performance of maps: the idea of qualitative assessment of the cartographic product (Kolacny, 1977; Keates, 1982; Board, 1981; Robinson and Petchenik, 1976).

In the present study we evaluated the quality of information transmission of the subway map of Sao Paulo for experienced users and tourists. To analyze the results we used the ideas of Kulhavy and Stock (1996) linking them with the ideas of basic-level categories of Rosch et al. (1976) and the classification process of information of MacEachren (1995).

Our research also shows that there are people who use the visual stimuli and of relatively low levels of abstraction to read maps that allow such a mechanism. This fact will be explained later.

**COGNITIVE FACTORS**

When trying to understand a map, people use two cognitive factors to do it: control processes and memory system (Kulhavy and Stock, 1996:123). In this paper we will emphasize the control processes as a means of analysis and classification of the subway map of Sao Paulo.

Control processes are closely linked to user experiences which will use maps to accomplish their tasks, and this will determine how successful it will be your task. Contrary to this premise, we hypothesized that there are maps that can be worked with and at different levels of abstraction, knowledge, or any other difference. In this context of hypothesis, it is possible to have maps that use both the interpretive capacity of more experienced users and their ability to relate the data and the perception of less experienced users, and still get the same results.

To better defend this idea it makes necessary to stand out, more cautiously, some concepts of cognitive factors proposed by Kulhavy and Stock (1996). Nevertheless, we'll try to understand how this process of easy transmission of information occurs, and prove the hypothesis by applying the tests.

**CONTROL PROCESSES**

When receiving a task to be performed with the aid of a map, the control processes begin to act. They begin at the moment that the task is assigned and the user has to do a quick map study: the user decides when it is no longer necessary, and starting to perform the task. This process of deciding when to complete the study of the map is a meta-cognitive element, in which the user carries the information of the map to your reality and adapts to your usage needs. Moreover, prior knowledge also plays an important role with regard to these control processes, which allow the user decides to use perception and "turn on automatic" (Lakoff, 1987:6), or continue to acquire information represented on that particular stretch.

Dropping a few differences between people, like gender, for example, which they called "inconsistencies", Kulhavy and Stock (1996:124) proposed two categories of knowledge important enough to affect the process of reading maps: the general and the specific. The first relates to the use of maps with information that can be read by most people, the second includes maps with specificities. They linked these two aspects with the words general map knowledge and specific map knowledge, respectively.

Kulhavy and Stock (1996:125) indicate that there is a relationship between the level of training and the way the readings are made. The strategy employed by the person in conducting the activities may vary and indicate your success or failure. But it can be argued that strategies can depend of the cognitive process (Lobben, 2004:272). There are people who don't have a strong visual memory and can not rely on memorizing the map to analyze it. However as there are different elements in the map, you can use different cognitive processes which are controlled by different brain regions, which are accessed by different strategies (Lobben, 2004:270), which can treat a person who didn't use a map with a trained person in the use of maps.

To better understand these statements is necessary to know a little more about these two aspects, general map knowledge and specific map knowledge, so we can best draw the situation raised in our research hypothesis.

### **General Map Knowledge**

Early on we have connect with graphical tools for representation of information acquired in the environment such as maps, charts, diagrams and other forms of expression and language; although all they are representations, people are able to differentiate them. This can be a way of presenting what Bertin (1983) called monosemous, where maps are recognized by characteristic features to your group representation models.

Why we prefer to see maps than photos? The simplification of reality and the emphasis given to the reference points are features that make the maps more receptive to reading. Turnbull (1993:15) indicates that pictures are representations of specific objects on the surface of a particular point of view, and maps are representations of portions of the surface without a particular point of view. Maybe that's why maps are important tools in the cognitive-space development of people, because they allow each person to observe their way the same reality. However, at this point is useful to remember that not only cognition contributes to the map reading, but the perception is an important factor to be studied.

The idea of General Knowledge Map encounters the following premise: the act of using the perception is easier and faster than incite cognition. At this point, this idea of "general" means having or not having a prior knowledge interferes little in the way that you read a map. The subway map of São Paulo presents malleable characteristics of the type of reading strategy, allowing the performance of both cognition and perception.

However, we must emphasize that not always get it will succeed with this kind of reasoning, since not all the maps allow readings based on perception, as is the case of maps with more specificities, that participate in the group called by Kulhavy and Stock (1996) Specific Map Knowledge.

### **Specific Map Knowledge**

A map depicting a specific phenomenon in the surface participates of category Specific Map Knowledge. When the information is more limited less will be the possibility of a person without the knowledge interprets what it sees.

There are maps that require a higher level of abstraction than is normally used by people. It also requires a minimum level of education about the phenomenon represented for achieve their goals. Usually, these maps encourage a synthesis of knowledge, which is necessary not only to relate data but also to generate information from the initially data representation. To this end, the tasks associated with the use of this map are important factors to consider in the organization of cartographic project.

The core of Idea of Specific Map Knowledge is linked to different cognitive abilities that are more experienced users to read maps. This capability is made possible by those who hold specific knowledge, which in a given situation can be a geographer reading a geomorphological map. Taking this hypothetical example, a geomorphological map has specific information with very condensed and uses an individualized symbology. A geographer is able to read and link the information contained in this map because this product synthesizes geographic knowledge, but a reader without such a load of information probably will be unaware of the relevant content in this type of map. Moreover, we can not guarantee the success of reading done by a geographer because it depends on their cognitive processes and strategies for classifying information.

## **APPROACH AND METHODS**

We sought to evaluate the responses of volunteers based on the ideas of Kulhavy and Stock (1996) internconnected with the ideas of theory of mental categorization from Rosch et al. (1976) and classification process from Maceachren (1995). The tests were elaborate with five open questions to be submitted soon.

The methodology used was the qualitative method proposed by Suchan and Brewer (2000), which eliminates the need to expand the number of participants. The qualitative method of analysis consists in observation, consultation and analysis of documents that are, respectively: (1) Development of a semi-structured questionnaire; (2) Direct observation of the respondents while performing the topological tasks of spatial nature; (3) Comparison of responses of volunteers who use the subway every day, with those obtained by the tourists, who never had contact with the map in analysis.

The total number of volunteers interviewed was twenty, where ten reported using the subway system daily and ten claimed to have never used the subway, therefore, also never used the subway map;

It should be noted that the interviews took place at 9 a.m., 11 a.m. and 15 p.m. and at stations Bresser, Tietê and Brigadeiro. Furthermore, we had no distinction of gender and interviewed people of different skill levels and different ages, all participants reported negative congenital blindness (Montello, 2002; Santil, 2008).

### Maps used on the tests

The maps used on the tests were obtained from web site of Companhia do Metropolitano de São Paulo – Metrô (Metropolitan Company of São Paulo – Subway), available at <[www.metro.sp.gov.br](http://www.metro.sp.gov.br)>. This map was adapted. In this case, the variable color tone was changed, by passing it to monochrome. With regard to breakpoints represented by the primitive graphics point, these were deleted in two situations: on the map in monochrome and modified original map. These adjustments were generated four maps, being held in one of the colors and pattern of the original map. The maps used in the tests and the sequence in which they were presented to respondents are shown in Figure 1.

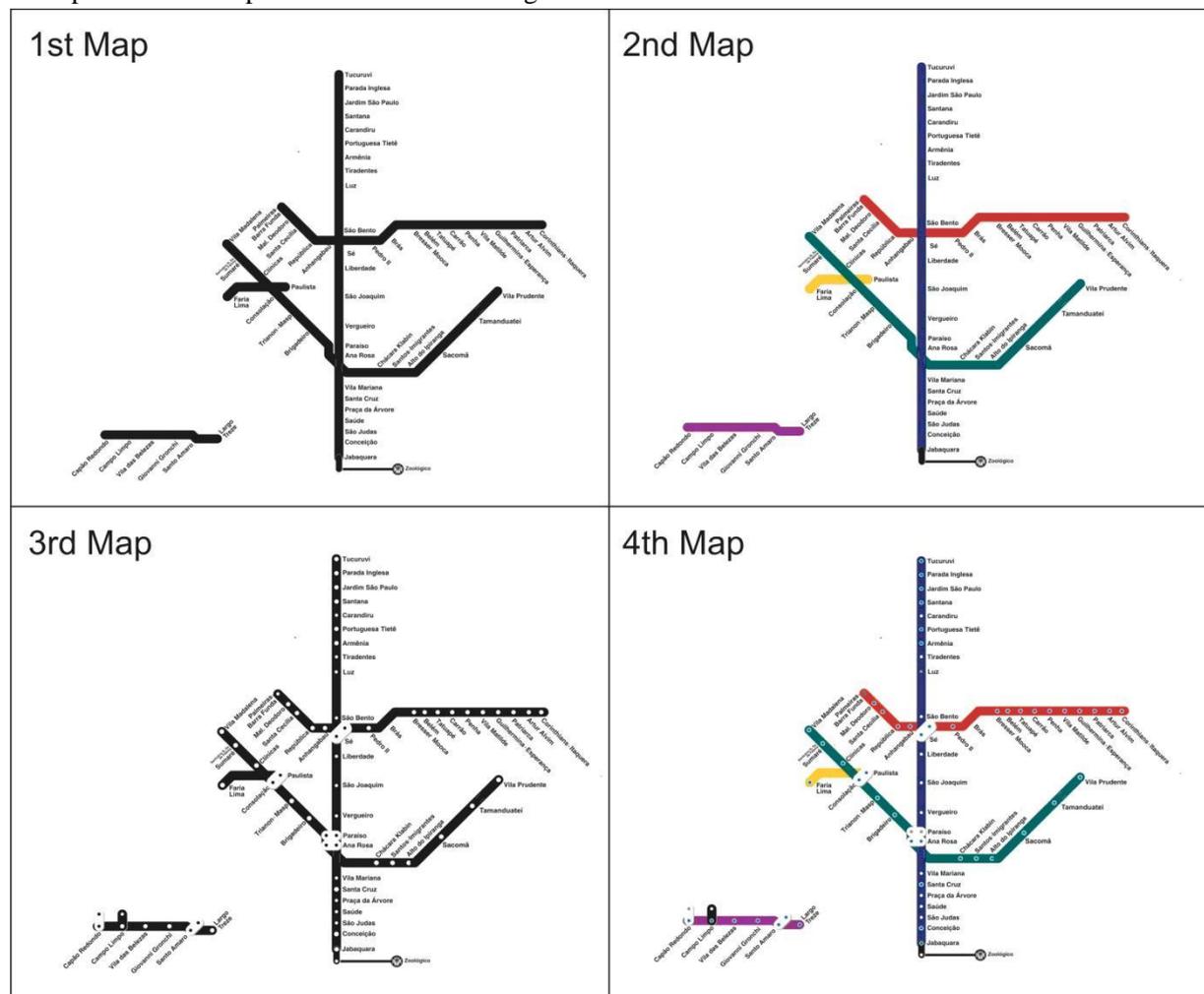


Figure 1 - Maps used on the tests, adapted from Companhia do Metropolitano de São Paulo Available in [www.metro.sp.gov.br](http://www.metro.sp.gov.br)

### Evaluation Procedures

The volunteers were evaluated separately and had three minutes to answer five questions posed. The specifications were formulated by which the questions will be presented later.

Were evaluated in four stages, and the questions were as follows for each map submitted:

1. What do you see?
2. Can you see some visual sequence? If yes, what?
3. The following were defined points of departure and arrival. How you organized the trip?  
- Starting Point: Vila Madalena  
- Arrival Point: Corinthians-Itaquera
4. Would you change something on the map?

The fifth question posed in the first map of the evaluation was as follows:

5. Have you the habit of using maps? If yes, what and why?

In other maps remained the questions 1 through 4 and the fifth question now has the following format:

5. Regarding the last statement, would you rate the current map as better or worse? Justify.

### **Objective of questions**

We sought to evaluate the following aspects of the proposed questions:

1. Taxonomy and partonomy
2. Categorization by level of abstraction.
3. Transferability of information
4. Semantic quality
5. Familiarity with maps and classification of the best product.

### **RESULTS**

The effectiveness of the original representation, as to the topological relations, we observed an excellent level of understanding: all respondents were able to perform the proposed task in the tests on time, at this stage the issues and tasks were related to the close relations of represented objects, where there also, reversibility, where all respondents understood an action of "departure" and a "arrival" at each station.

Right now it is an exception to one of the respondents who confused the main junction, the Sé Station, with São Bento Station, describing the following route in all its answers where asked about the organization of the trip: "Vila Madalena - Ana Rosa – São Bento - Corinthians Itaquera". This is due to the distance that exists between the graphic symbol referring to the junction with Sé Station of the lines.

It was observed that the level of abstraction used was compatible with the basic level proposed by Rosch et al. (1976) in her Prototype Theory, on the basic level categories. Golledge and Stimson (1997) proposed three categories of knowledge and they are: declarative knowledge, procedural knowledge and configurational knowledge. The procedural knowledge is linked to tasks, which can be done in the case of maps is the knowledge needed to create paths, routes. It matches the Rosch's basic level category, where the degree of abstraction to be carried out created the mind map was small. MacEachren (1995), in turn, suggests that there are two classification levels of information: the taxonomic and partonomic. The taxonomy is linked to the use of cognitive tasks and is more complex in relationships between objects. The partonomy uses basically the perception to identify the objects to create the mental map. Therefore, it can be inferred that all participants used the partonomy to perform the proposed task, even the group of users who use the subway every day. This is justified by the simplicity and objectivity with which the information was implemented in the product analysis.

The first question from the first map, we observed the use of long-term memory on the part of respondents who use the subway every day, so characterized a high level of abstraction. But in the first question of the 2nd, 3rd and 4th maps, one could see what Lakoff (1987:6) called "turn on automatic", participants used the perception and a low level of abstraction to address these questions. Although the first question, three tourists were able to identify the map reported having recognized the name from the central station which coincides with a famous square in downtown São Paulo, they found lines and concluding that it could be the map "subway lines" or "train lines". This represents a high degree of abstraction, described by Rosch as the superordinate level and Maceachren as use of the taxonomy.

On the second question, none of those interviewed were able to observe a visual sequence in both groups. However, we make an exception to the comment from four of the respondents who questioned whether the response was related to the element "color," to be ignored the question, the candidates chose to answer "no" on all maps. This indicates a low level of abstraction, so the perception used to answer the question.

In the third question, where it was sought to evaluate the cartographic communication, through carrying out a task, we observe the use of perception in both groups, the answers were guided in each breakpoint, and there generalization or simplification of the description of the route in either case. This sorts the map as being excellent in terms of ease of reading, which classifies, as called Kulhavy and Stock, General

Knowledge Map, or a simple map which all people of all skill levels have access to an effective reading in relation to the tasks demanded.

The fourth question, where the idea was to evaluate the graphic interface and if there was any kind of interference with communication, the result was again positive. Respondents preferred the original model to others. In the early maps, even without knowing the original, some asked to put different colors in the lines and put the breakpoints: precisely the changes that had been made. Interestingly, there were participants of the group who had never handled the product asking the same changes of the group of experienced users.

In the fifth question, where the idea was to assess respondents' familiarity with map products and, consequently, tasks with the use of maps, three of the respondents said they do not constantly work with maps, justifying its lack of practical difficulties inherent in reading: the three are from the tour group. The remainder indicated the use of maps to choose routes, measure distances and locate specific points, which are basic and common tasks.

As we can see, almost all responses were guided by perception, which classifies the subway map as being excellent in terms of ease of reading, called by Kulhavy and Stock of General Map Knowledge: a simple map and all people of all skill levels have access to an effective reading in relation to the tasks demanded.

## **CONCLUSION**

Guelke (1977:137) states that the map is invaluable for enabling the user to detect interrelations between phenomena and understand the significance of particular elements in relation to the whole, that is, in its geographical context. If a cartographic product achieves these goals, it is acceptable to search for the causative agents of communicative effectiveness, because in this way, product improvement will be constant.

Based on the preliminary results we note that for purposes of analyzing the transmission of information in the subway map of Sao Paulo, the method described was efficient for the hypothesis raised by the research team.

As for the graphic design of cartographic product, colors and graphics primitives used to build the product reaches excellent levels of transmission of information. At this point it is worth noting that the variable acts as a visual stimulus from the moment it is applied to symbols. This organization takes, for example, users interpret the information contained in products such as in analysis. Thus one can identify the effectiveness of this product on the transferability of information and joint action with their spatial reasoning of respondents.

We noted, too, that the product is capable and be understood by people of all skill levels, age, etc. Moreover, with the growth of cities, maps of urban transport become increasingly important because these products are often used by thousands of people around the world. This becomes increasingly important research related to graphical quality of maps and transferability of information of these.

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