ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

RESCIF
Réseau d'excellence des sciences de l'ingénieur de la Francophonie

An Introduction to Geographic Information Systems

Thematic Maps and Semiology of Graphics
Visual Variables

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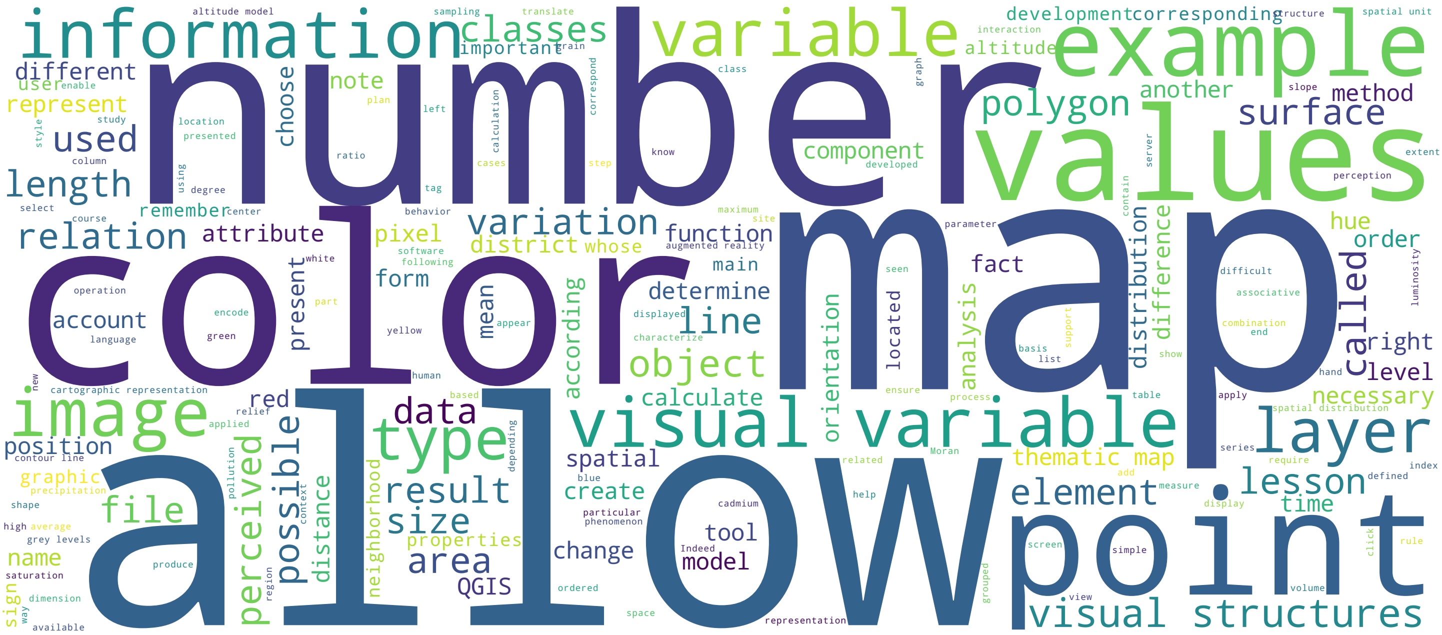

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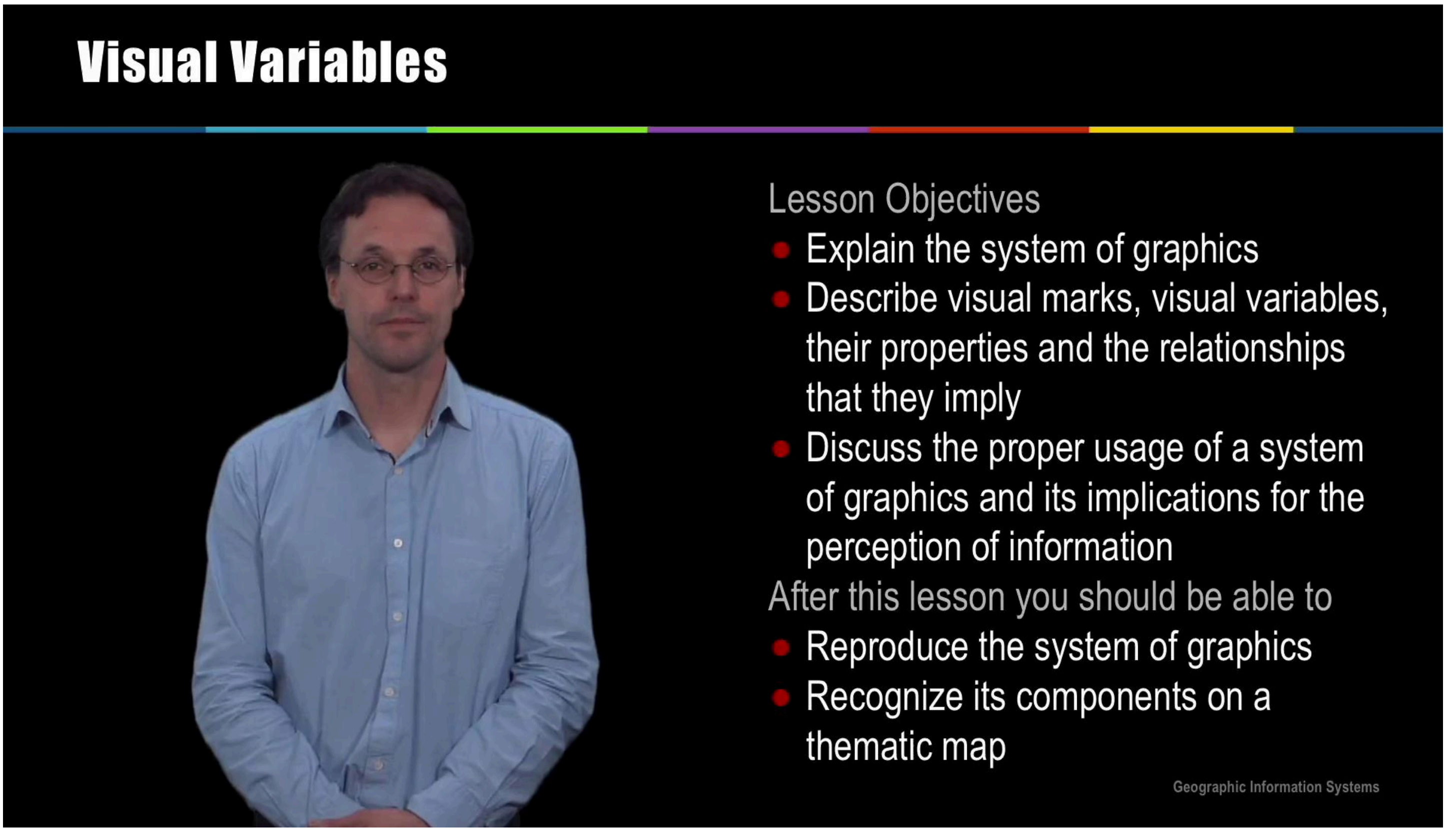
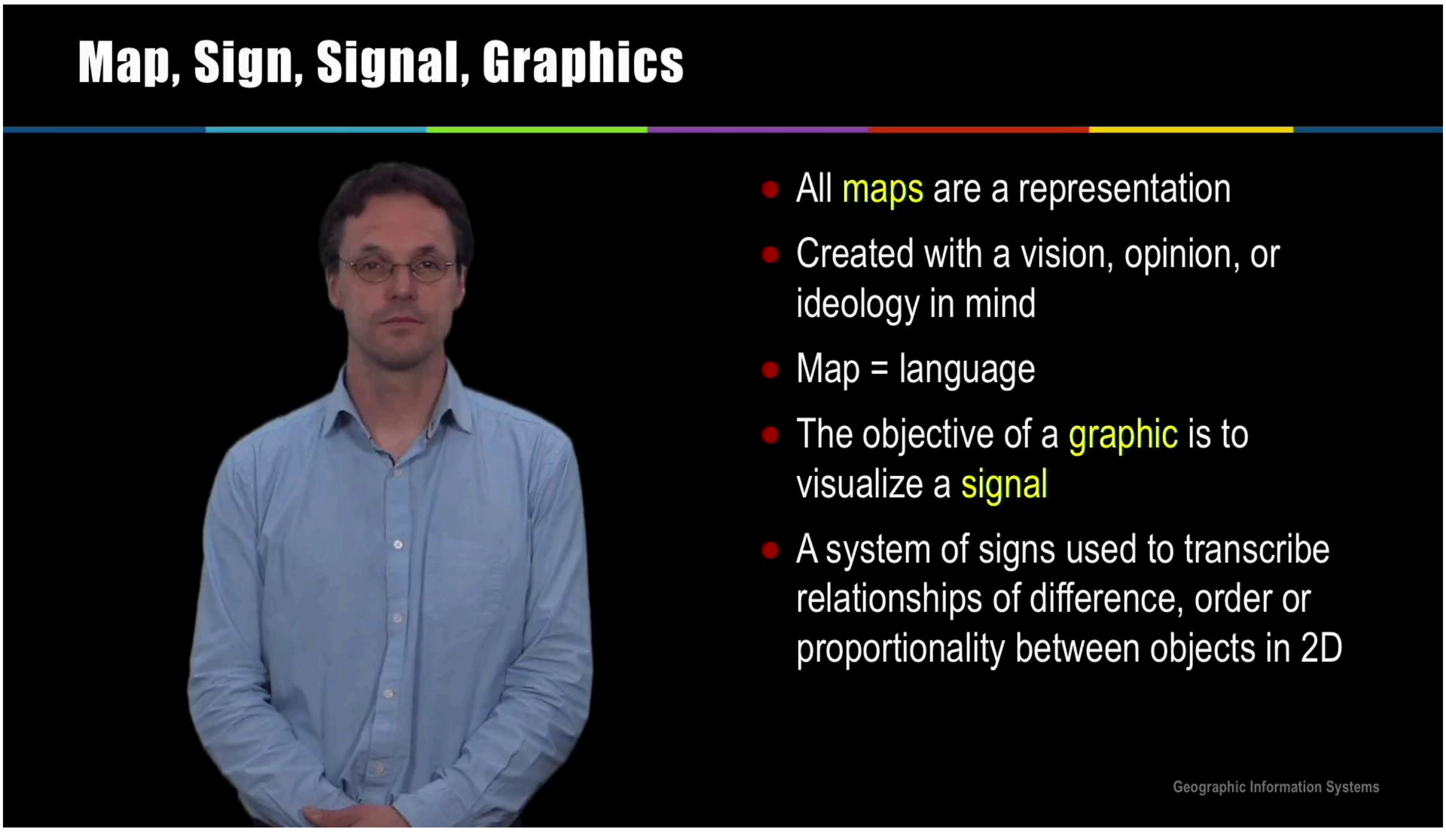


Welcome to this lesson at the top of Mont-Noble which will focus on visual variables. as we will see it, these variables constitute the grammar of the image. Indeed, we discussed in the previous lesson the fact that a cartographic representation uses a system of signs equivalent to a verbal language to encode information to be transmitted visually. The encoding in question results from the decomposition of the image into visual structures, that are the points, the lines, the surfaces and the volumes. It also results from the variation of the properties of these structures and it is these variations that we call visual variables and whose use is managed by the rules of the graphical semiology, like a grammar of the image. The objectives of this lesson are to explain Jacques Bertin's graphic system and to detail the list of components of this system, so the visual structures, the visual variables, their respective properties and the types of relations they can transcribe. They are also to show for what good reasons related to the perceptive capacities of the human being, the graphic rules must be applied. After following this lesson, you will be able to restore the graphic system, to list and recognize its components on any thematic map.

Notes

Summary

0m 29s

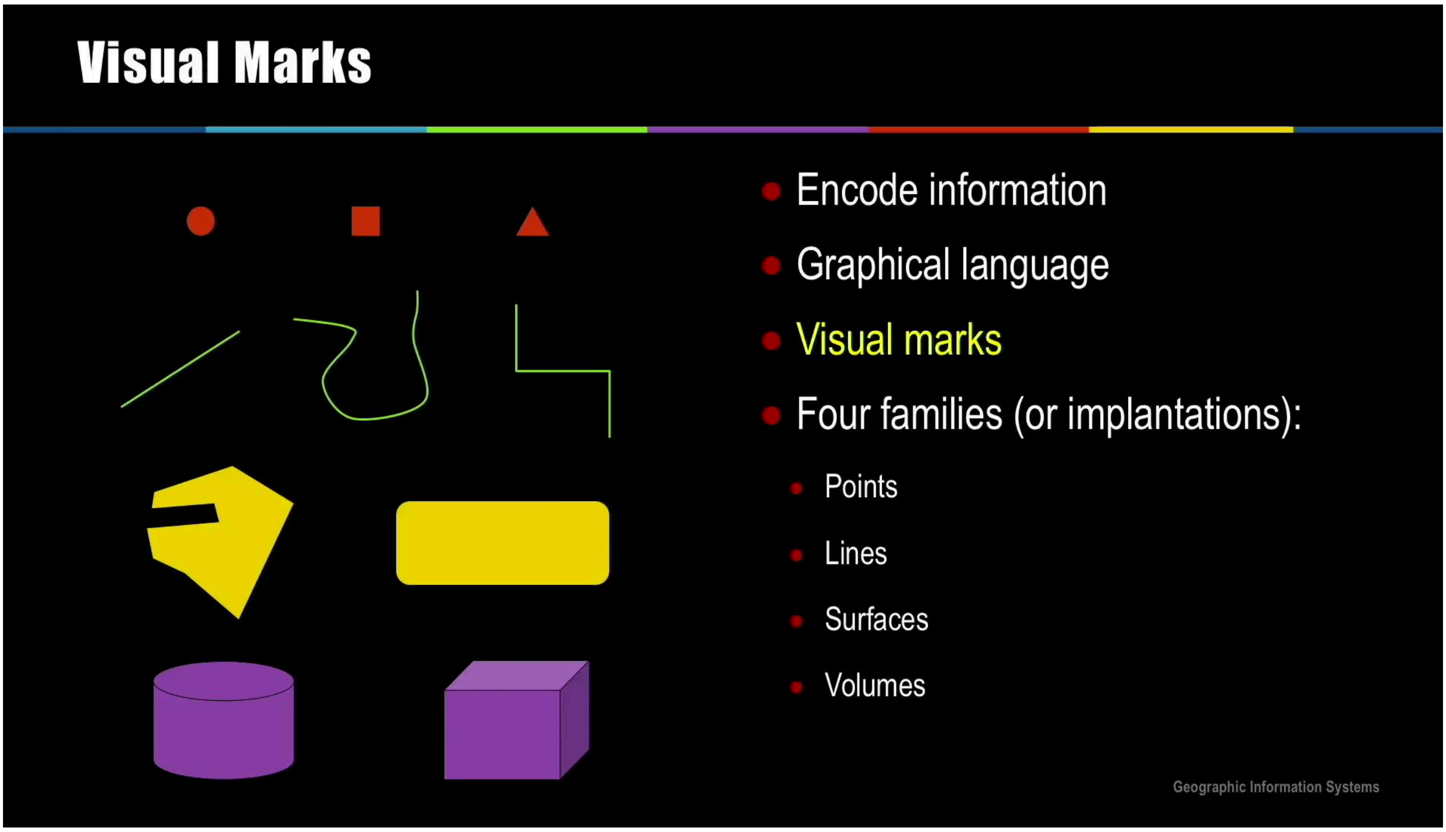


Any map is the result of a representation or a staging carried out with given technical means, for example with a pencil, a computer, with color or without color, and this according to a vision, a point of view and sometimes an ideology and of course for a certain purpose. The map is therefore the equivalent of a language, as we have seen, which allows the communication in development of knowledge and by creating information. To construct and display the map signal, we use the graph, a discipline or system developed by Jacques Bertin form the 1950s and which is about the principles of cartographic information. Concretely, it is a system of signs which allows to transcribe difference, order or proportionality relations between qualitative or quantitative data and whose domain extends to any representation, using the two dimensions of the plan.

Notes

Summary

1m 57s

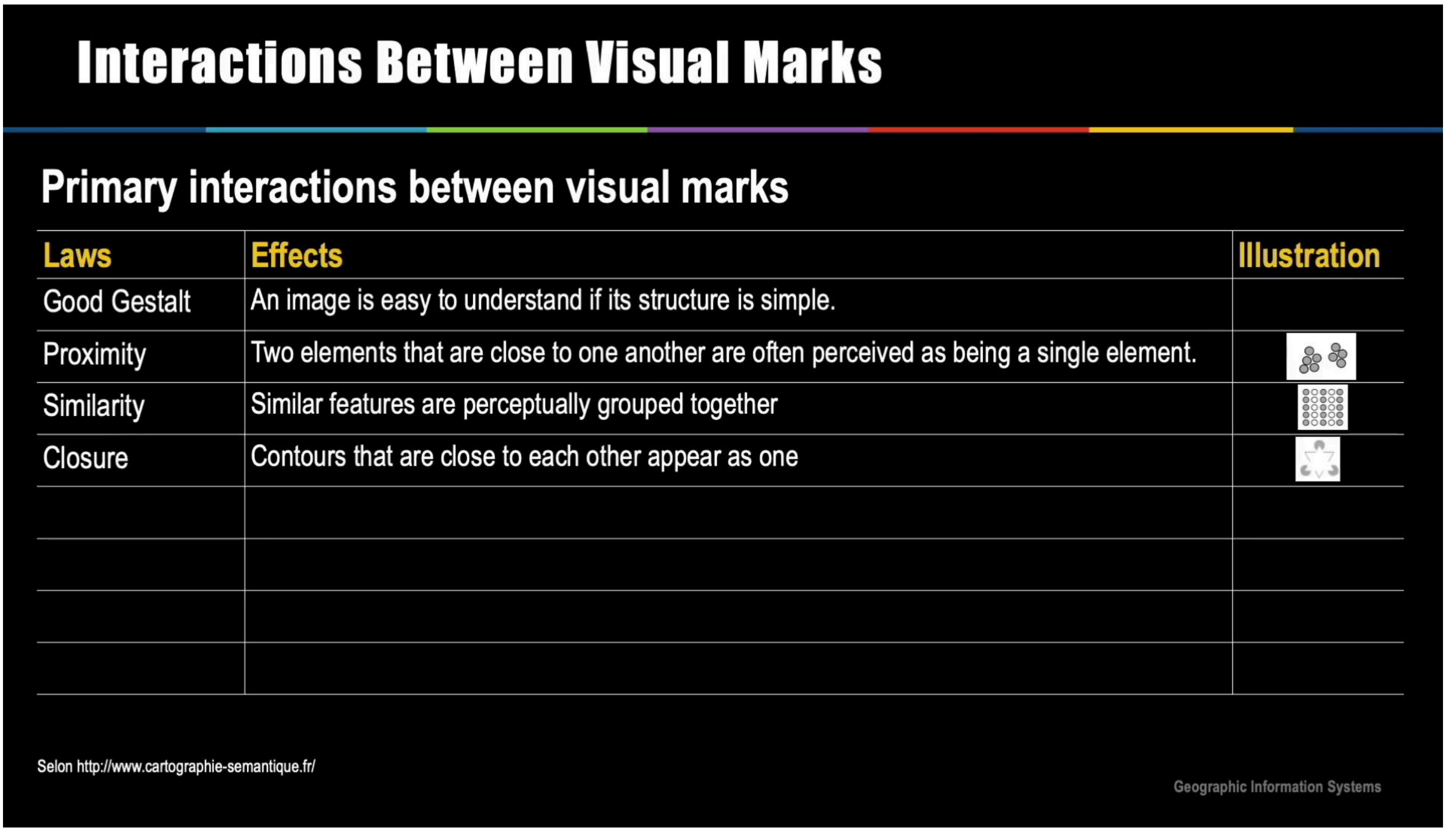


This system of signs is used to encode the information that the map must convey. This system of signs or language is graphic and it implements visual structures. There are 4 families of visual structures, or 4 implantations according to Bertin: points, lines, surfaces and volumes.

Notes

Summary

3m 00s



Interactions Between Visual Marks

Primary interactions between visual marks

Laws	Effects	Illustration
Good Gestalt	An image is easy to understand if its structure is simple.	
Proximity	Two elements that are close to one another are often perceived as being a single element.	
Similarity	Similar features are perceptually grouped together	
Closure	Contours that are close to each other appear as one	

Selon http://www.cartographie-semantique.fr/

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A map contains a set of visual structures which encodes the information to be mapped. Therefore, the visual structures are not independent from one another and the context matters a lot for the meaning assigned to them. This is important because our visual perception recognizes the models in a set of visual structures. A theory in the psychology of the form, the gestalt, which comes from the german "gestaltpsychologie", has developed laws corresponding to categories of possible interactions between the visual structures. The table that will appear on the screen synthesizes these main laws. These are important elements to know and they are easily applicable during the development of cartographic representations. The first law is that of relevancy. An image is easy to understand if its structure is simple. The law of proximity stipulates that two components which are close tend to be perceived as a single component. Here on the right, the image is perceived as two elements. The law of similarity is reflected in the fact that similar components are perceived as if they were grouped together. Here on the right, the image is perceived as a series of columns by color similarity.

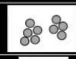
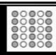
Notes

Summary

3m 22s

Interactions Between Visual Marks

Primary interactions between visual marks

Laws	Effects	Illustration
Good Gestalt	An image is easy to understand if its structure is simple.	
Proximity	Two elements that are close to one another are often perceived as being a single element.	
Similarity	Similar features are perceptually grouped together	
Closure	Contours that are close to each other appear as one	
Continuity	Near elements are perceptually grouped together if they share a common characteristic	
Symmetry	Symmetrical elements are perceived to be one continuous shape	
Common Fate	Elements along the same trajectory are perceptually grouped	
Past Experiences	Elements are more easily grouped if they belong to a familiar grouping	

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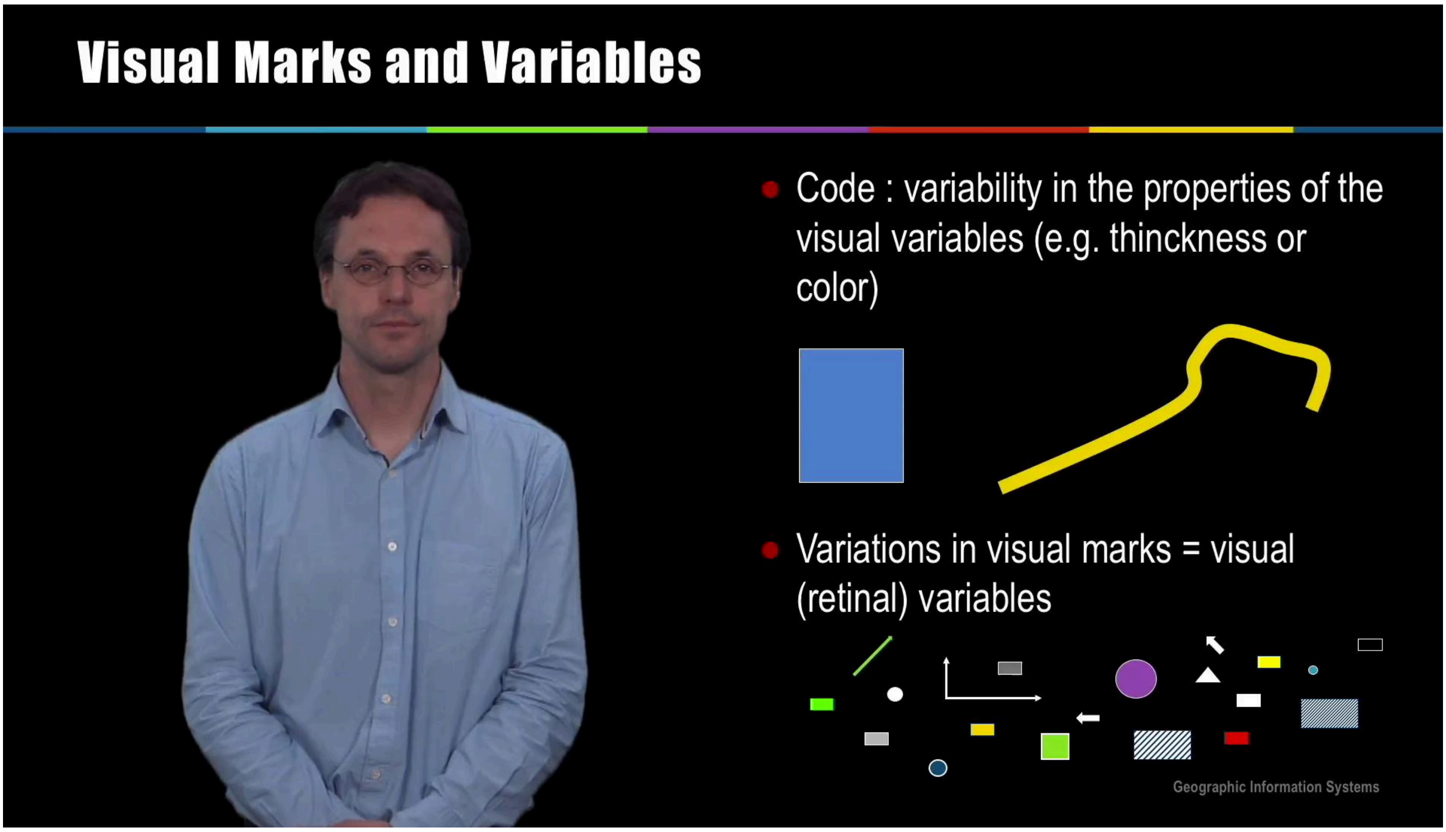
For the closure law, the close contours are perceived as unified. In the image on the right, we see a white triangle while it is not drawn. For the continuity law, neighboring elements are perceived as grouped when they potentially possess a trait that connects them. In the illustration on the right, the image is perceived as a cross. The law of symmetry says that elements are perceived as a global element when they form a symmetry. In the example here, the two elements on the left are not perceived as a single element, unlike the other two. For the trajectory law, the elements which move with the same trajectory appear to be grouped. And for that of the familiarity, the elements are more easily grouped if the grouping characteristic is familiar.

Notes

Summary

4m 39s

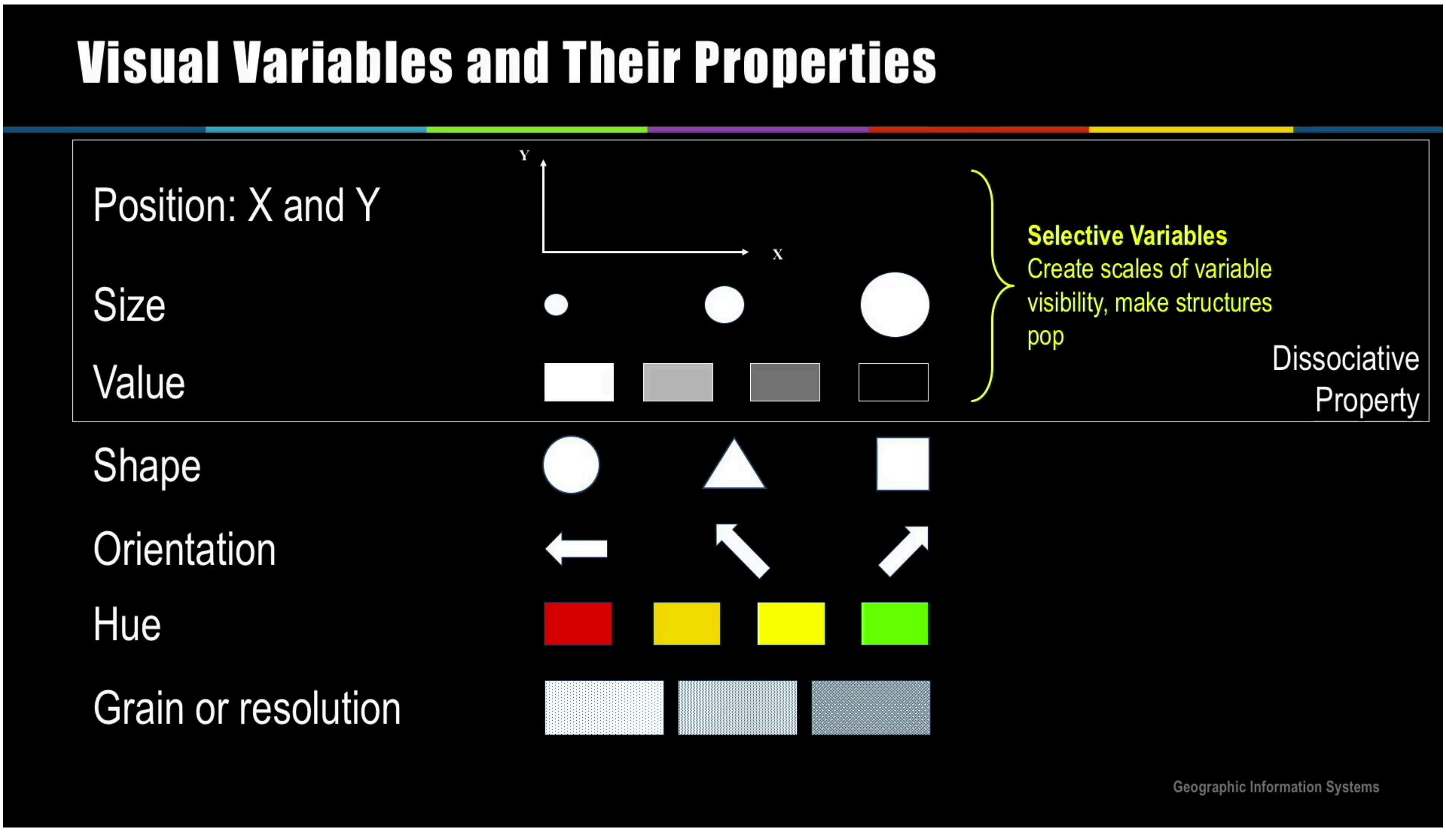


In addition to interactions between visual structures, the graph will make the properties of the latter vary to encode the information, for example like changing the color or changing the thickness. These variations on the visual structures are grouped by type and they are called the visual variables or the retinal variables according to Bertin.

Notes

Summary

5m 28s

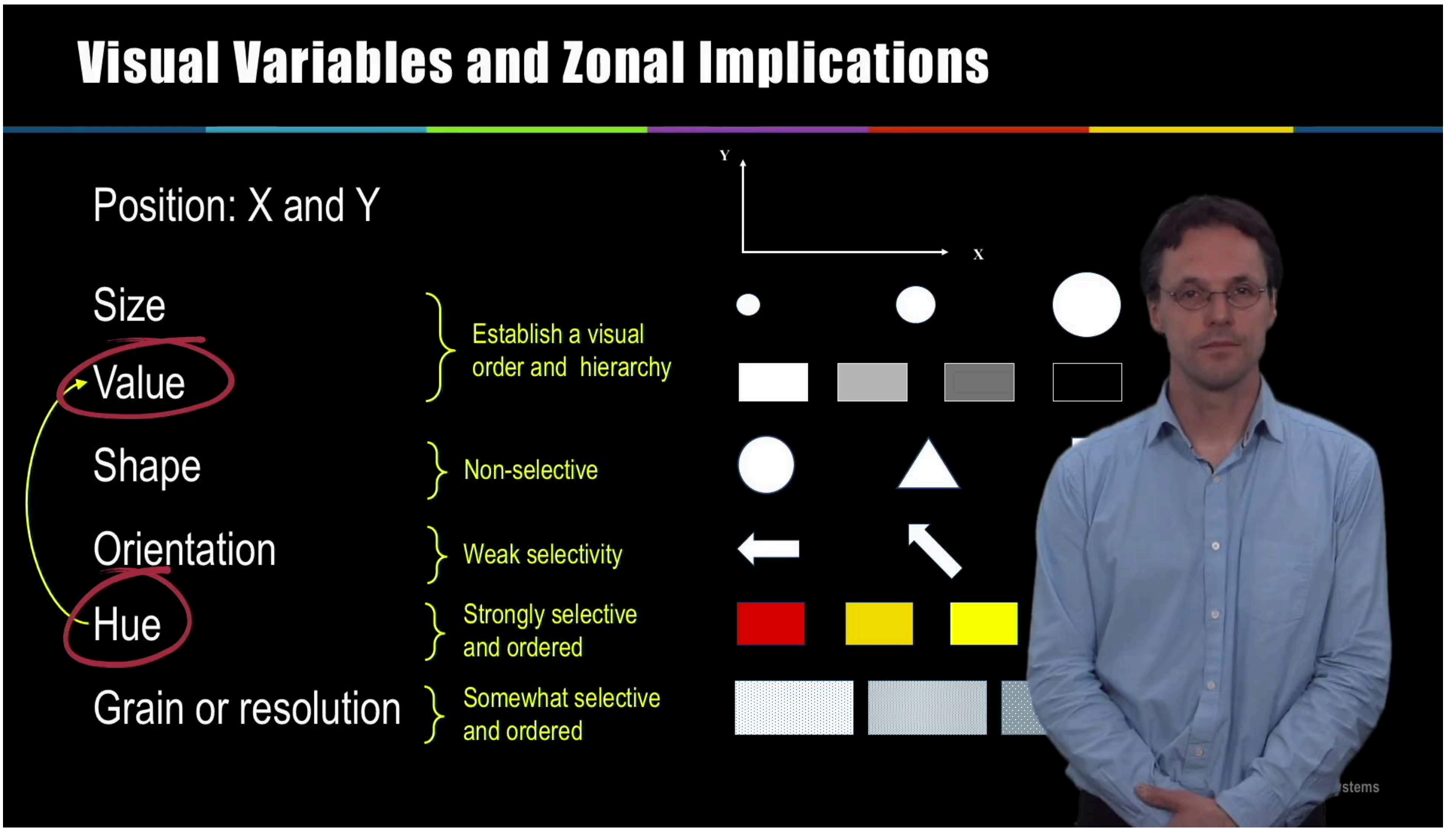


Bertin distinguished 8 visual variables: the position which is composed of the variables X and Y, so the two dimensions of the plan. The variation in size which allows to perfectly translate the quantitative variations. The change in the value of a color is a variation of light intensity from the brightest to the darkest or vice versa, it translates a relation of order and relative differences. The form expresses the identity of the object to be represented and therefore the differences. The orientation enables to position a sign with regards to the two axes of the graph, it expresses the differences and gains in efficiency when combined with the grain and value variables. The color reflects differences but cannot arrange these differences between themselves. The color is charged with cultural and psychological meanings. The grain or resolution combines the shape and the size and translates a relation of order and relative differences. The position variables, the size and the value are called image variables because they construct ranges of variable visibility, they reveal forms on a background, they suggest reliefs. This variable visibility is the consequence of the dissociative property.

Notes

Summary

6m 00s

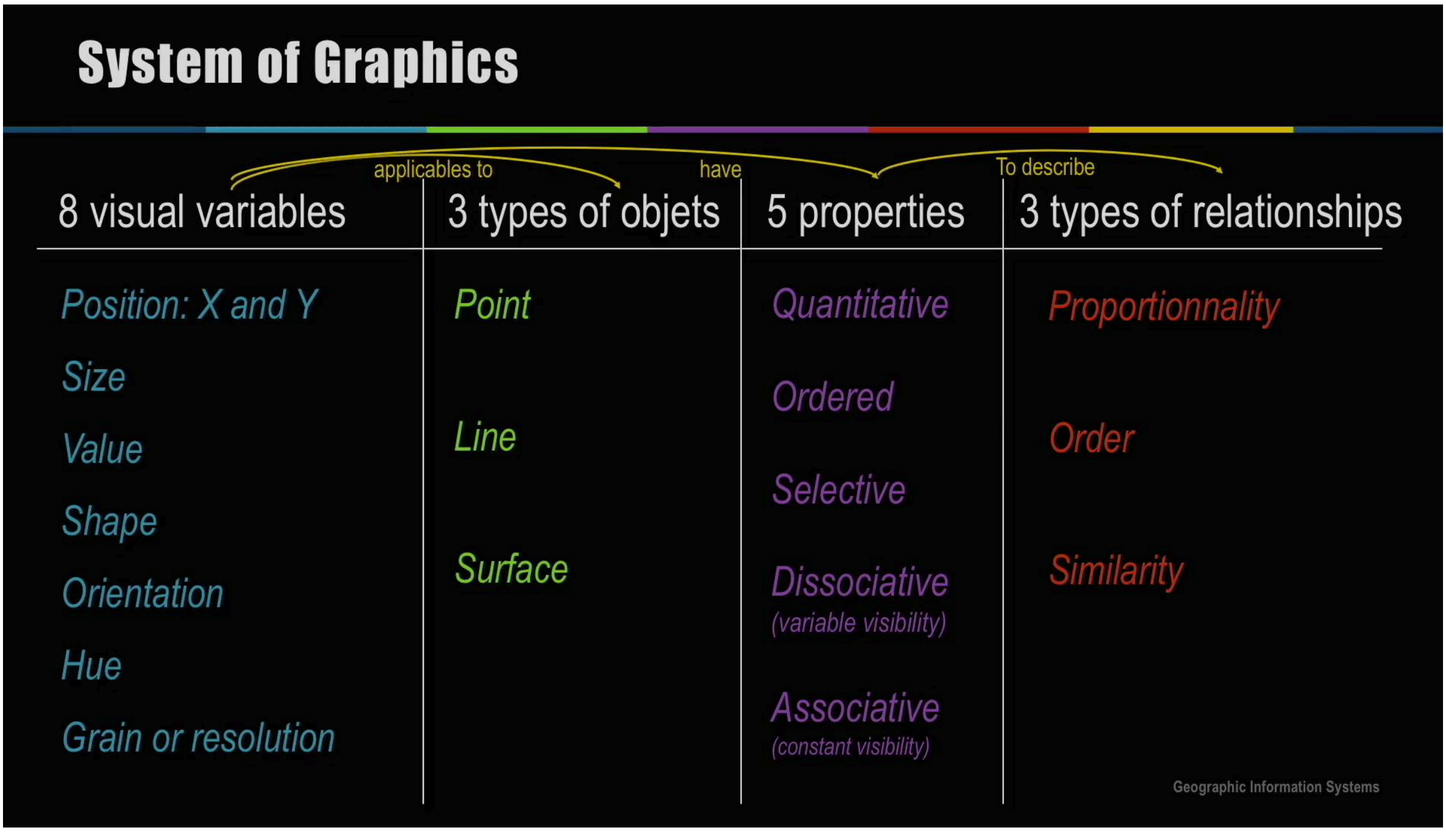


The shape, the orientation, the color and the grain, unlike the position variables, of size and value, that build homogeneous visibility ranges, without relief, and that merely separate elements from each other without making forms appear on a background. For these reasons, these variables are called separation variables. This translates an associative property. When considering surfaces, as is the case with choropleth thematic maps, and which is relatively frequent, we must remember that the size and value ensure a strong differentiation between ranges, that they create a visual order and build hierarchies in the image. The form does not allow to transcribe differences. It is associative and its selectivity is null. The orientation is associative. It allows to construct ranges of homogeneous visibility and its selectivity is very low. The color associated with the value is highly selective and ordered, but we must remember that a range of colors of equal value constructs an image without relief. Finally, the grain can be compared to a analogical photographic enlargement, it is therefore associative, but it can ensure a certain selectivity. It is also ordered.

Notes

Summary

7m 24s

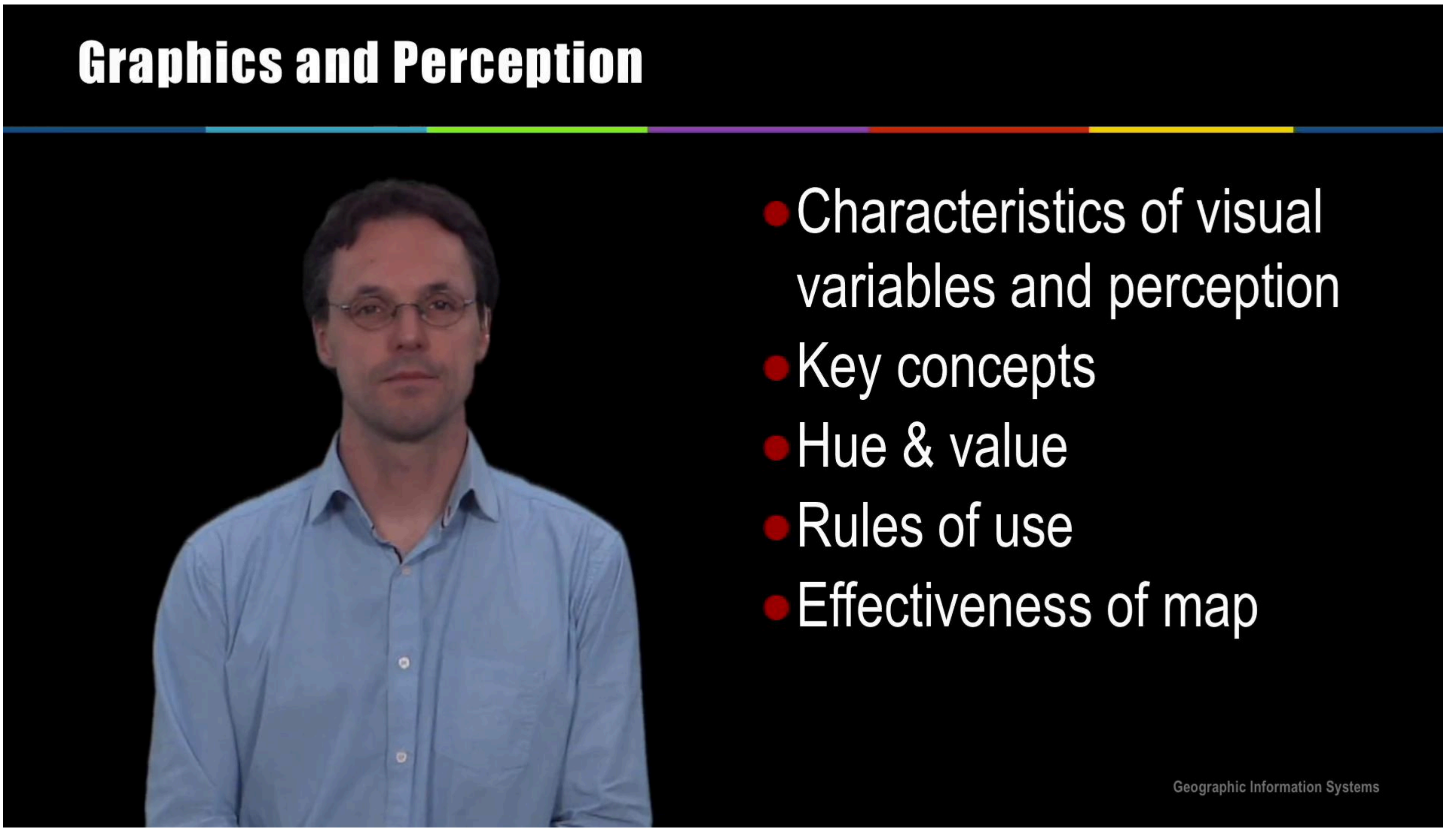


To sum up, the graphic system developed by Bertin considers eight visual variables which can be applied to three types of implantations: points, lines and surfaces. These visual variables possess five different properties, quantitative, ordered, selective, dissociative and associative, which allows to transcribe the three types of relations between the data that are the proportionality, the order and the resemblance. You will notice that we do not consider the volume or two and a half dimensions implantations in this system.

Notes

Summary

8m 49s

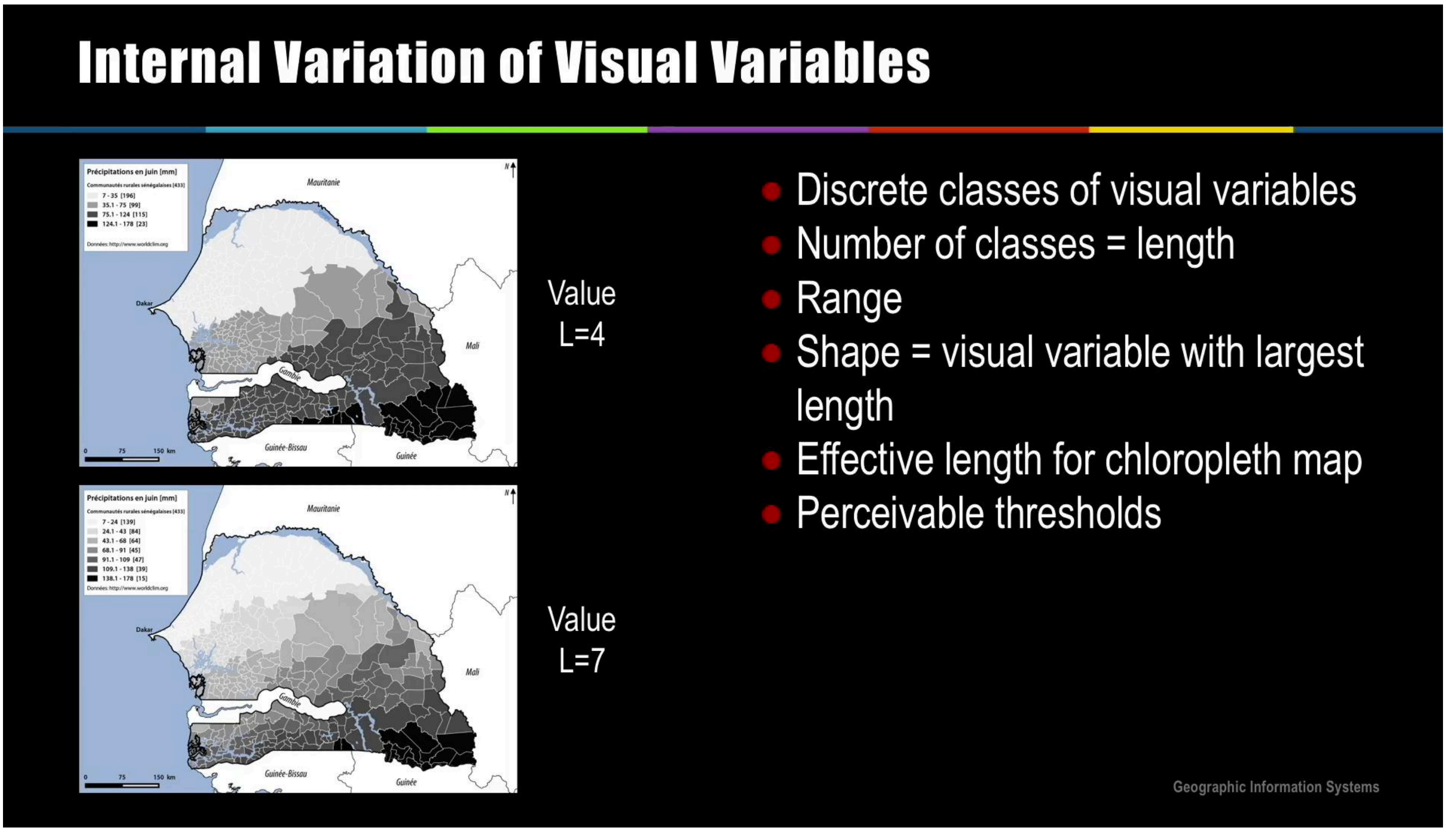


We will now highlight important characteristics of the visual variables, in relation to the capacities of perception of the human being. These characteristics correspond to key concepts, most often linked to "color" and "value" variables, and rules of use which give maximum efficiency to cartographic representations.

Notes

Summary

9m 33s

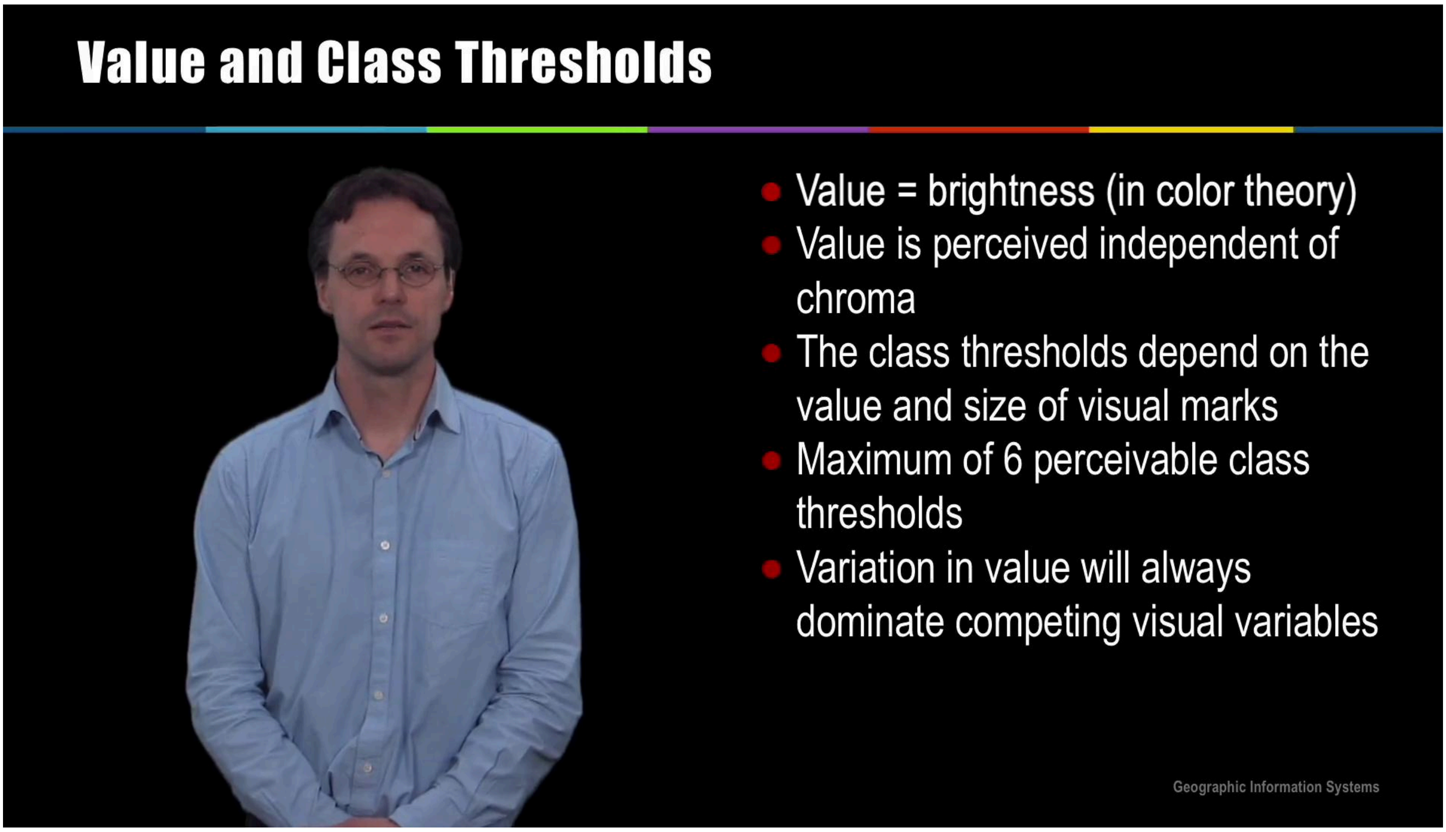


Each visual variable consists of a number of discrete degrees a number which is fixed for a given graphical representation. This is the number of sensitive bearings that a visual variable can support. This number is called the length of a visual variable. The length is not the same as the extent of a visual variable. The extent is the gap between the extreme valuesof the parameter whereas the length is the number of relevant subdivisions which exist along this gap for a given image. The form is the longest of the visual variables, followed by the position. The length of the value is particularly interesting as it is this that we use to set a number of classes in the process of discretization in choropleth mapping. The main thing is to determine thresholds that are perceptible by the eye of the majority of users. On this first precipitation map in rural communities in Senegal, the length of the value of the grey levels is four, the interclass thresholds are clearly perceptible. The second map shows the same information, with a length of the value of grey levels of seven. This time, it is more difficult to perceive the thresholds between classes and the signal is less efficient.

Notes

Summary

9m 56s

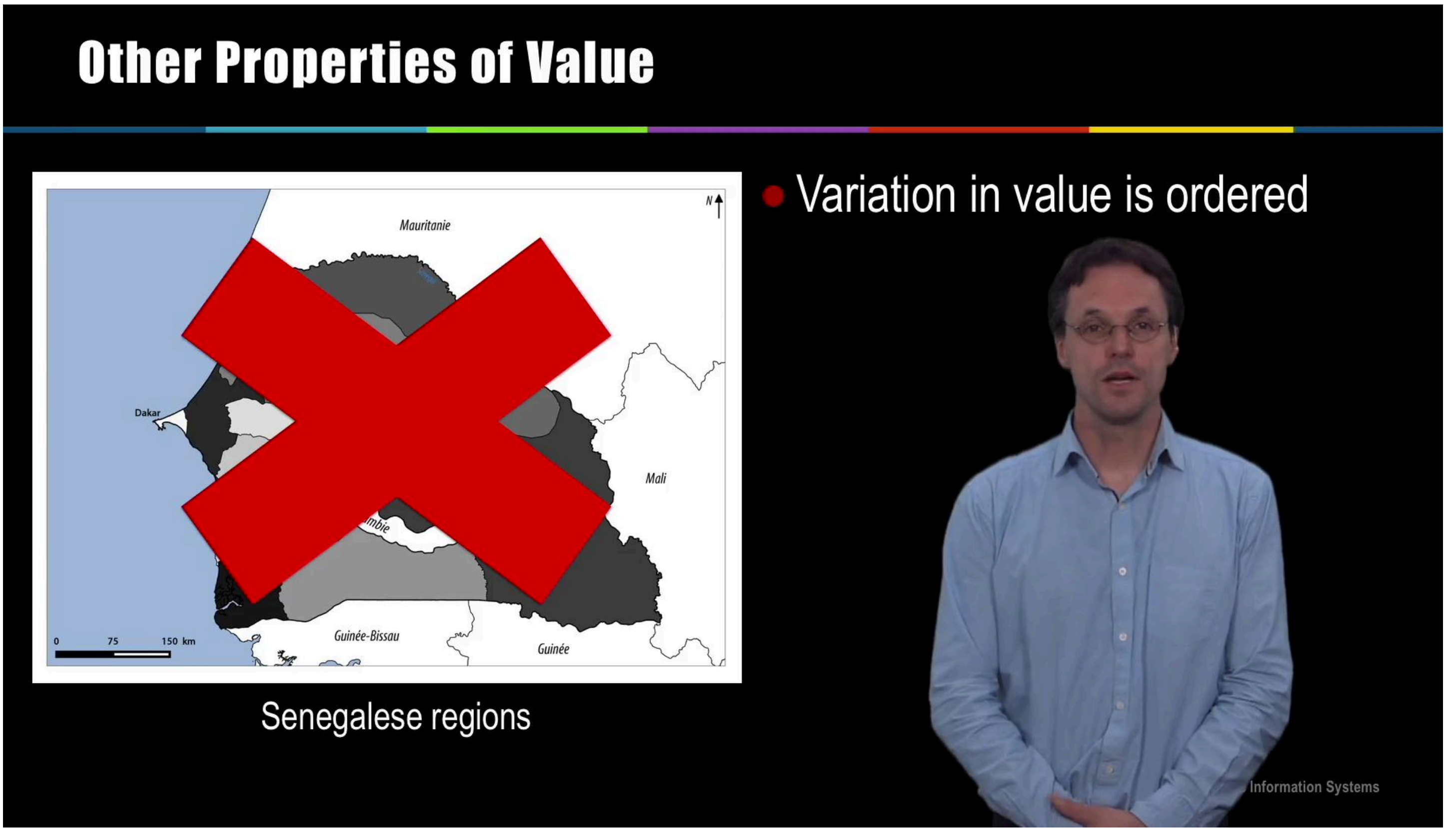


As we have seen, the variation of valuesis dissociative, which means that this variable is able to bring out various visibility ranges. The value is related to the notion of luminosity in the color theory and we consider that it is a perception independent of the chromaticity. The number of perceptual thresholds will therefore depend on the value of the map background and the size of the graphic elements it brings. We turn ideally to a maximum of 6 perceptive thresholds, so a length of seven as in the example shown a moment ago. This change in values will always dominate any other visual variable which interferes with it.

Notes

Summary

11m 21s

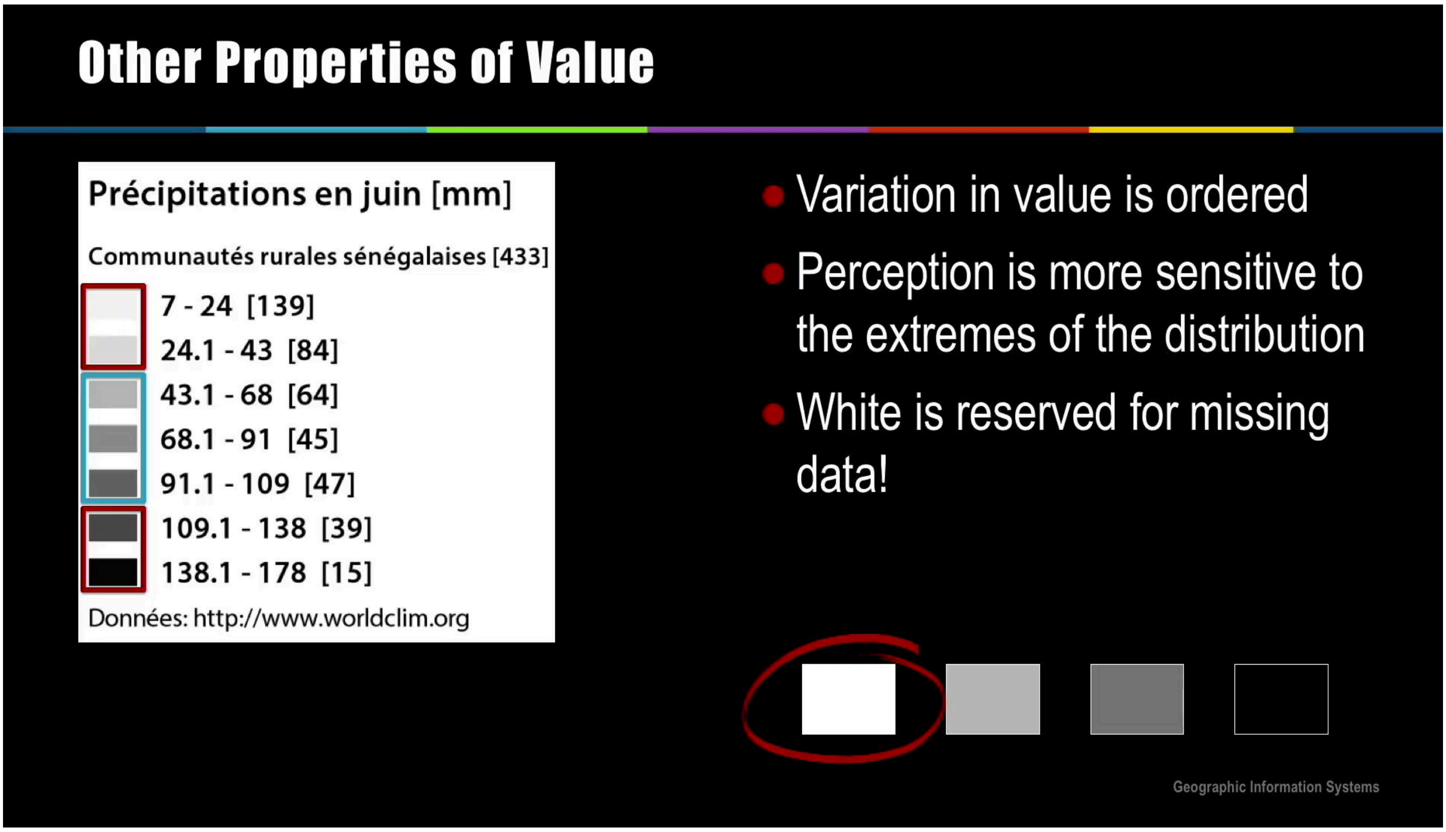


The variation of values is ordered and not using it as such generates a semantic problem. For example, using a grey gradient to represent qualitative classes is an error that compromises the transmission of the information. Here, the value of grey levels allocated to the regions of Senegal depends on the initial letter of their names in alphabetical order, it is a mistake.

Notes

Summary

12m 00s

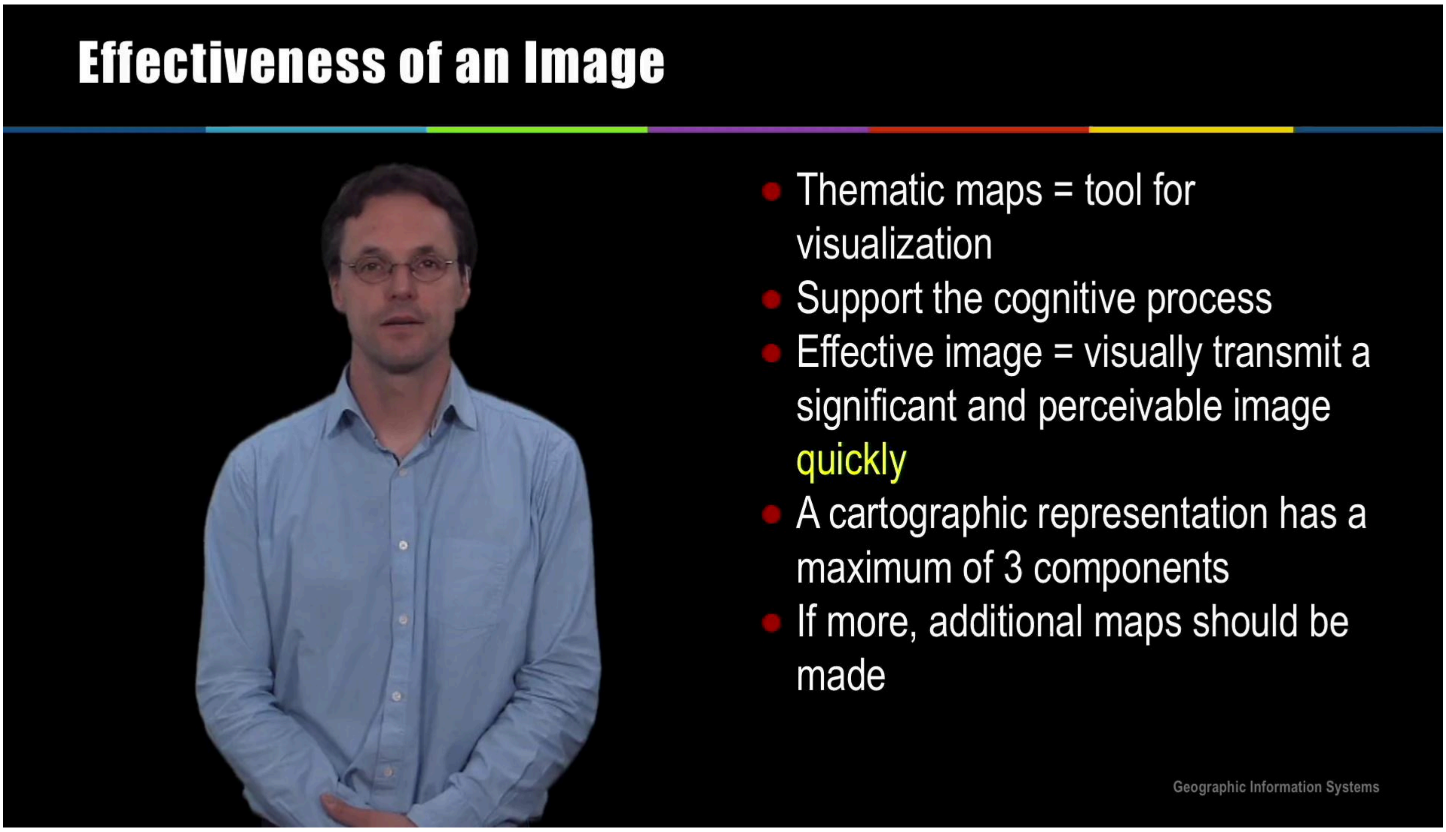


We will instead use discrete colors to mark the qualitative aspect, the non-continuity. On the other hand an arithmetic progression of grey levels is not equidistant in terms of perception. Indeed, the differences are more sensitive to the extremities than at the center of the distribution. We will note at this point that the rule is to keep the white for the missing data and that the white should not be integrated as initial class in a gradation of values of any kind of shade.

Notes

Summary

12m 23s

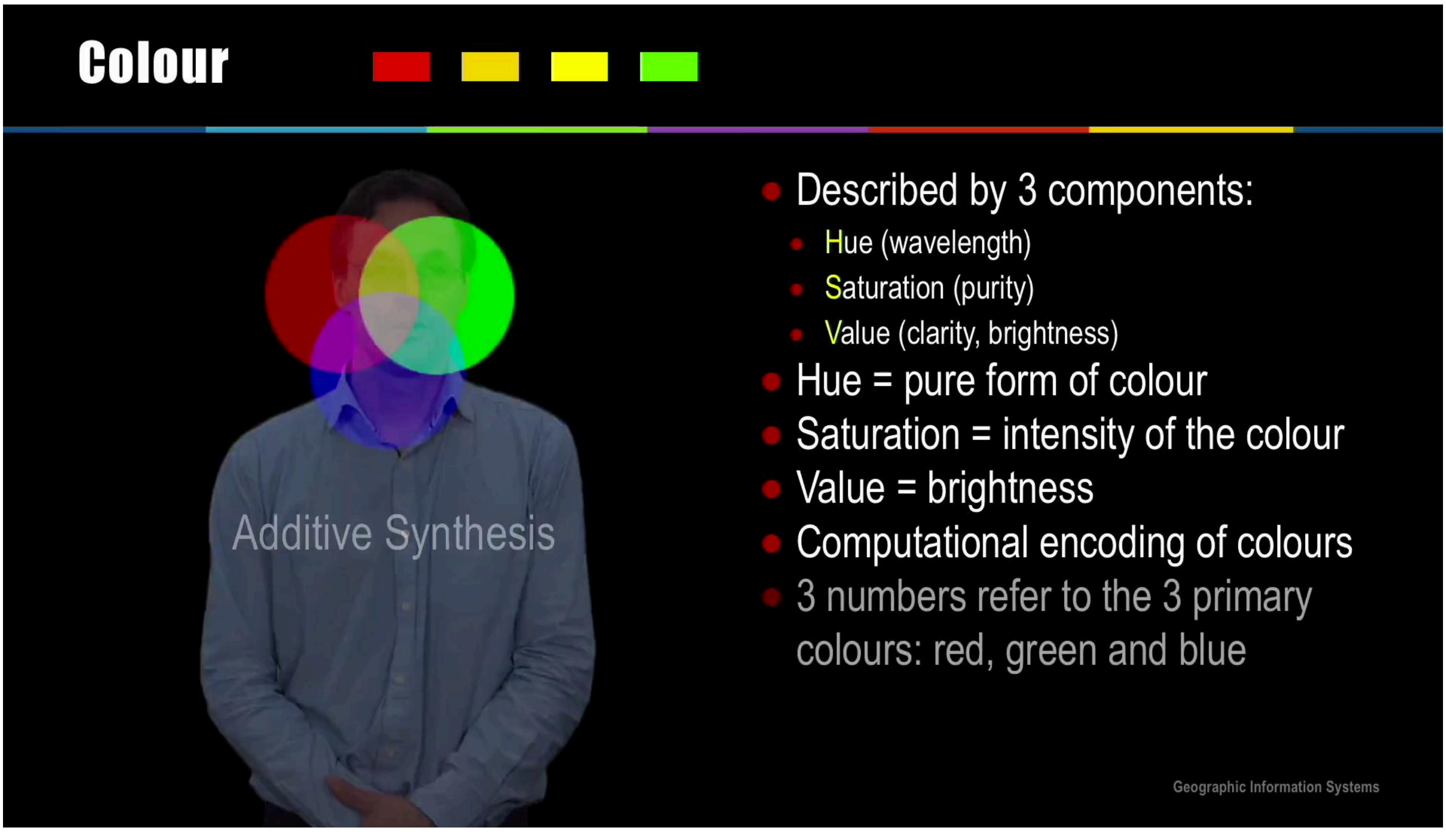


Statistical thematic maps are part of visualization tools and they are able to assist man in his reasonings. They help to improve the cognitive process by playing the role of thought support, but this requires that an important condition is fulfilled: it is necessary for the image to be a significant visual form, perceptible in the minimum moment of vision. A map that requires a shorter time of perception than another to transmit an information is more effective. In this context, any cartographic representation which has more than three components cannot be constructed as a single image and will require several instants of perception, so the development of several maps.

Notes

Summary

12m 52s

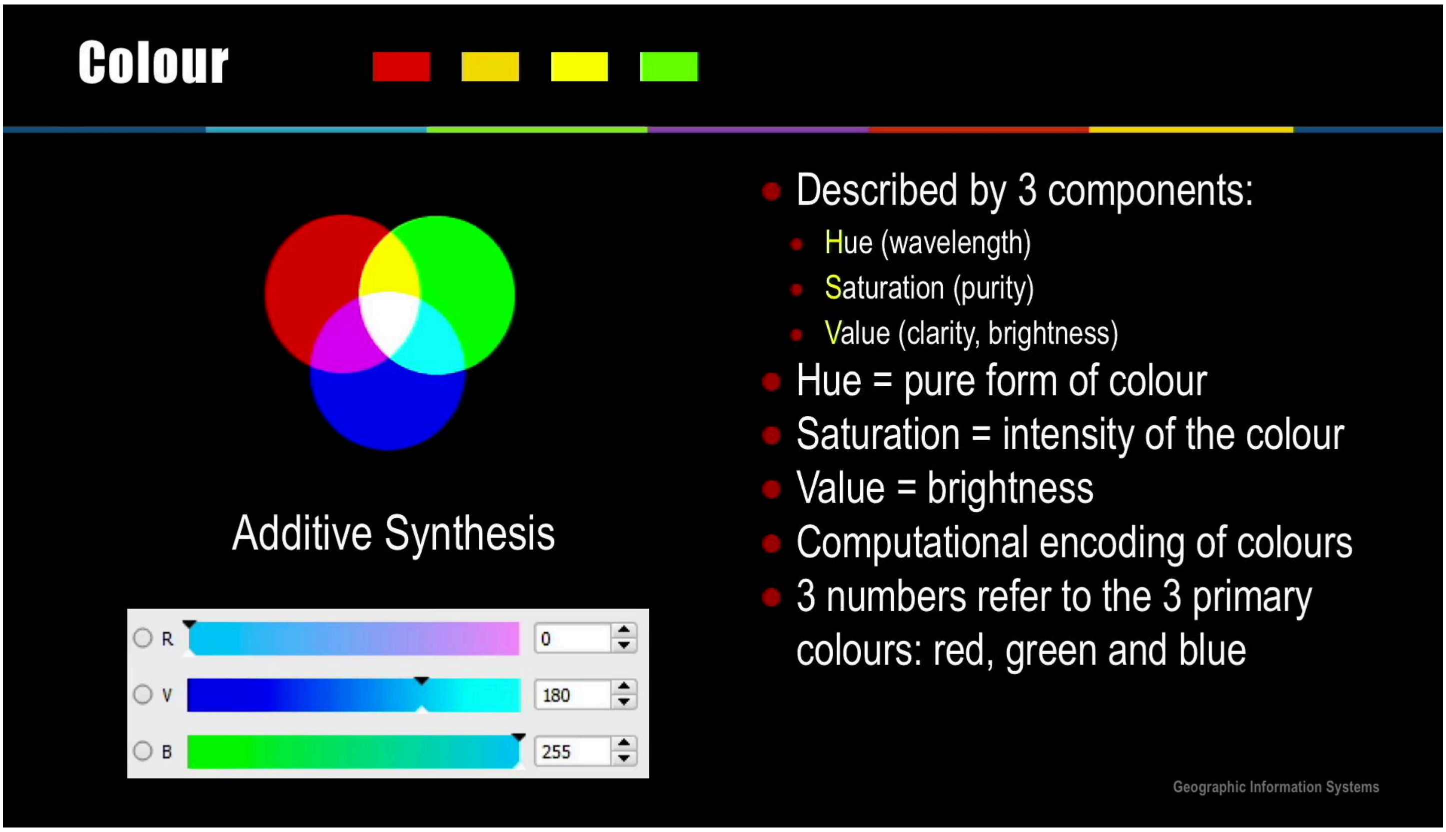


Here are some important information to know concerning the color, which is the other significant visual variable with the value for the production of choropleth statistic thematic maps. There are different colorimetric systems based on the three description parameters a color that are the hue, the saturation and the luminosity. The hue is the pure form of a color in that it opposes the white, black and gray. The saturation expresses the intensity of the color compared to the maximum possible in the system. The brightness expresses the impression of clarity or brightness of the color and as we have already seen, the luminosity is an independent perception of the chromaticity. TSL designates several color description models which are used in computer graphics and in infography, the disciplines that are implemented during the production of thematic maps. The important thing to remember here is that it is necessary to code the colors on the computer, so as to be able to designate the large number of possible combinations of hue, saturation and brightness levels and to apply them to visual structures representing the spatial units on the maps.

Notes

Summary

13m 42s



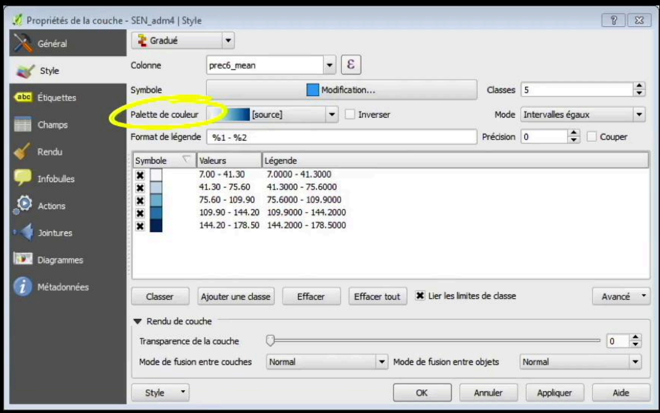
Computer coding represents colors with a triplet of values relating to each of the primary colors of the additive synthesis, so the red, the green and the blue of the screen. By the addition of these three light beams, it is possible to obtain practically all the visible colors. This method is based on the trichromatic sensitivity of the human eye. The color codes are integers between 0 and 255, so 256 values which can be coded on 8 bits, so 1 byte. This way, we can creat more than 16 million color codes.

Notes

Summary

14m 54s

Computational Colour Encoding



- RGB system is easy to use
- Difficult for the user to manage, vast number of possible combinations
- How do we determine which parameters are properly adapted to specific color scales?
- Predefined QGIS palettes

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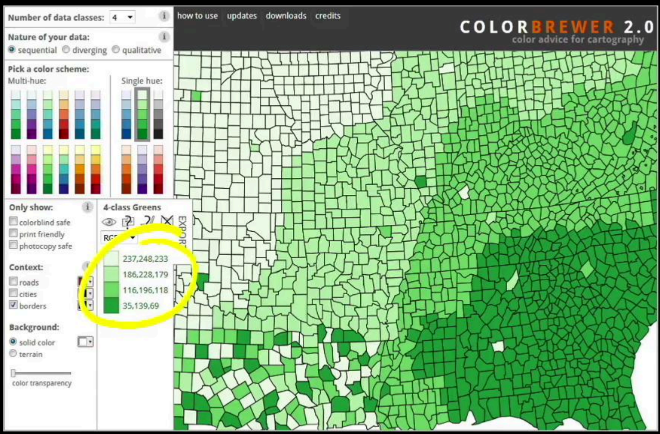
Color coding by the values of the primary colors red, green and blue has the advantage of being simple for programming, but it is difficult to manage for the user who needs to manipulate simple colors which allow to manufacture distinct readability ranges to characterize the visual structures. Here is the parametrization window which appears in QGIS when you want to select a filling color. The first line, H, for hue, allows you to determine a hue. The value is given in degrees and corresponds to the position of the hue in the chromatic circle represented on the left. On the second line, S, for saturation, you can determine the saturation for the selected color between 0 and 100 %. The third line, V, allows the value to be set between 0 and 100% also. Changes to these three parameters are reported automatically on the corresponding R, V, B values displayed below and characterized by numbers between 0 and 255. It is still possible to adjust the transparency and the system will automatically encode the HTML notation of the selected color. We note that the number of combinations is enormous and that the determination of the parameters allowing to produce adequate color ranges is difficult. So how do we proceed? The first solution is to use one or the other predefined palettes available in QGIS via the "style" tab in the properties of the layer.

Notes

Summary

15m 28s

Computational Colour Encoding



- RGB system is easy to use
- Difficult for the user to manage, vast number of possible combinations
- How do we determine which parameters are properly adapted to specific color scales?
- Predefined QGIS palettes
- Predefined palettes with decision support system

http://colorbrewer2.org/
GeoVISTA Center at Penn State University, USA
C.Brewer, M.Harrower, B.Sheesley, A.Woodruff, D.Heyman

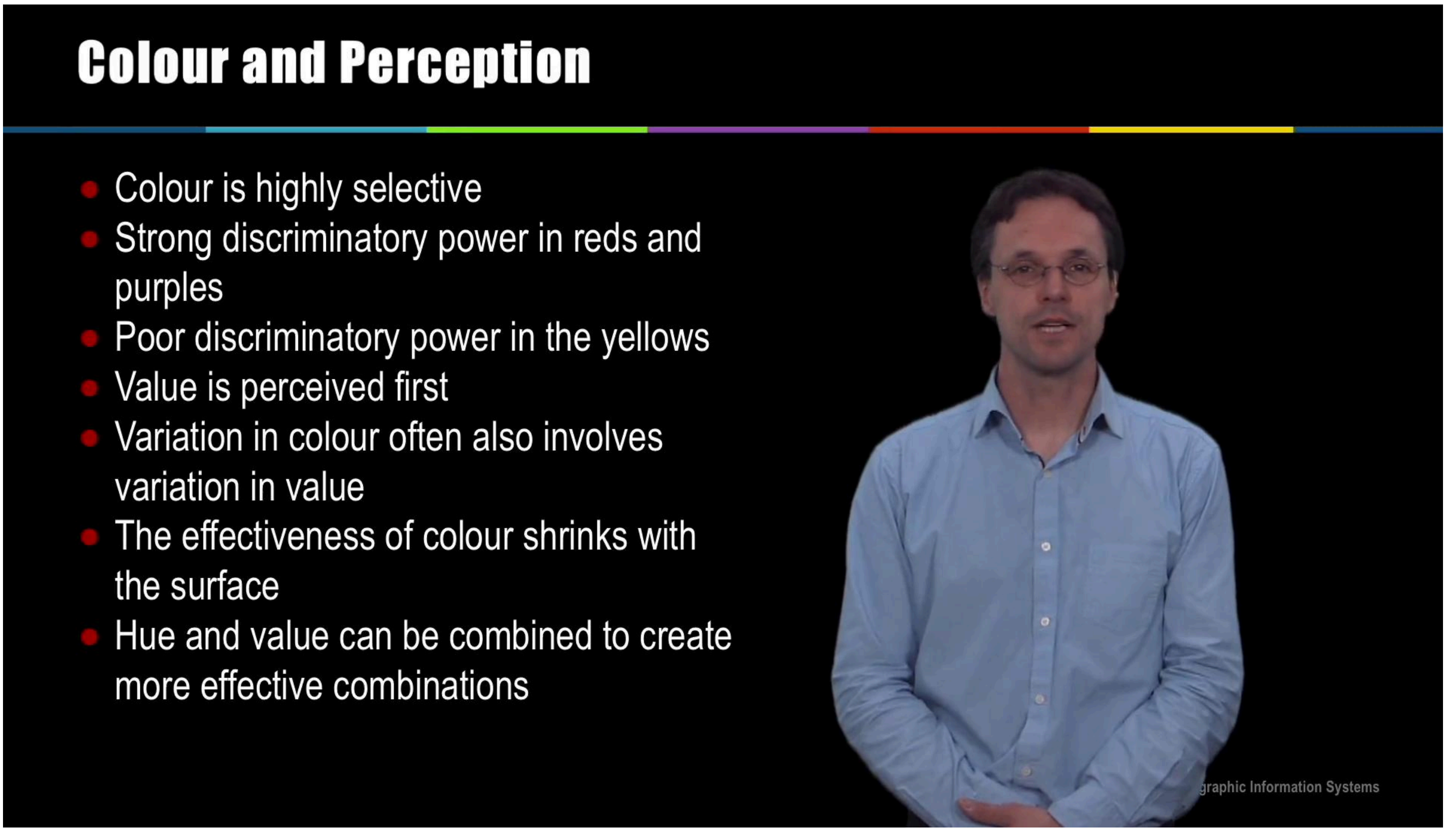
Geographic Information Systems

But that does not solve all the problems since the user must take a number of decisions relating to the number of classes, to the nature of the statistical distribution or the types of colors to use, for example. There is a very valuable tool developed at the Penn State University, in the United States by Cynthia Brewer of the GeoVISTA Center, which allows to directly visualize the effect of the choices of the selected parameters on the basis of a series of predefined pallets and which guarantee an optimum efficiency, that is to say the fact that the combination of visual variables "hue" and "value" always allows to distinguish two successive classes. Once a palette has been determined, the color brewer allows to export the correspondingR, V, B values and to use them in QGIS to make this palette available in this software. We will come back to the use of this tool in the next lesson.

Notes

Summary

17m 07s

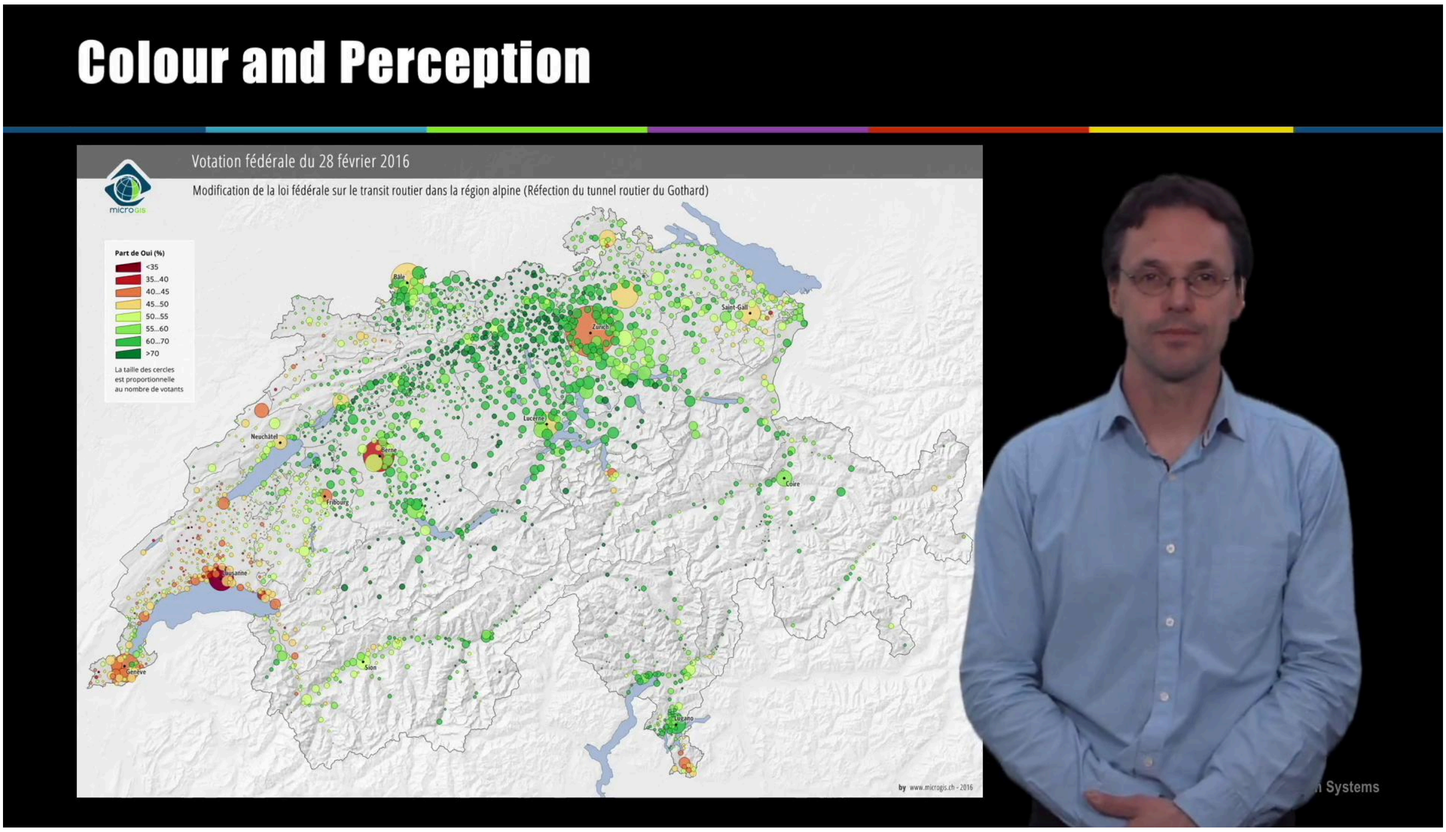


Here are some more details related to the use of the color and its perception. The color is highly selective, it allows better discriminations in the reds and violets and less good discriminations in the yellows. The color is ordered, and to transcribe order relations, it is necessary to take into account the value visual variable, so the brightness component of the color and use a homogeneous shade. Without variation of the value, the color is useless to the ordered perception. When using different colors, the value that retranscribes the order relation is perceived first before the hue which allows the selection. But we must take into account the fact that the color variation often implies a change in value. Another point, the effectiveness of the color decreases with the surface of the visual structures.

Notes

Summary

18m 05s

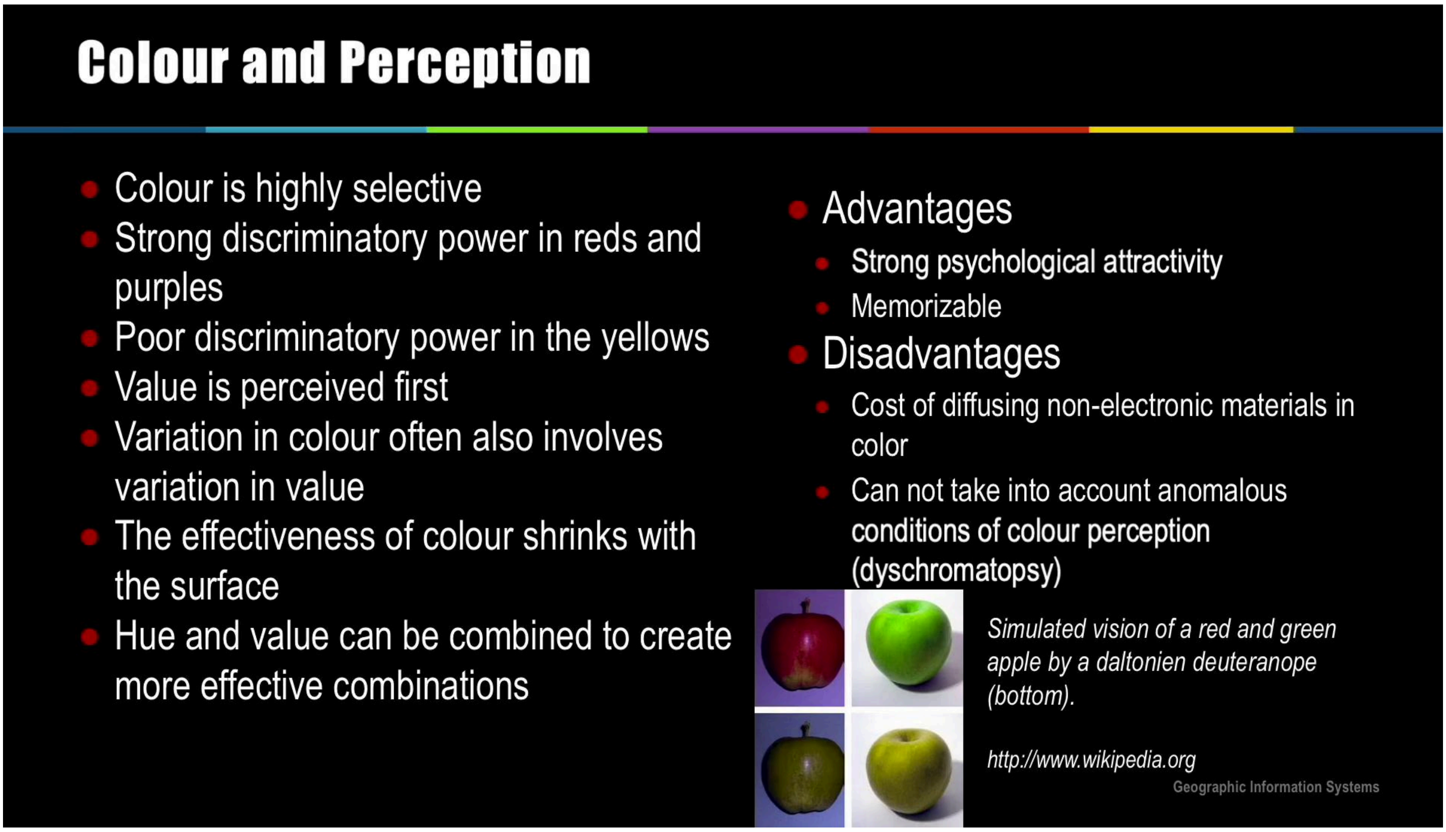


And finally, We can note that the combination of the variation of the hue and the variation of the value offers more perceptive thresholds. In some cases, this combination offers undeniable advantages, we will be able to increase the number of classes and allow a finer reading of the cartographic image produced. For example, this map shows the result of a recent Swiss vote on the construction or not of a second road tube at the Gothard tunnel in the Alps. Here the authors used a green shade to represent the share of yes and a red shade to represent the share of no, with in both cases a change in the value to express the gradation of the percentage. The limit between the red classes and the green classes is located at the acceptance threshold, so from 50%. The use of a single shade and the variation of its value would not have allowed to distinguish the diversity of behaviors with as much precision.

Notes

Summary

19m 01s



To sum up, the main advantage of using color in cartographic images is the fact that it is associated to a strong psychological attractiveness and that it makes the information easier to remember. On the side of the disadvantages, we have to note the high cost of diffusion of colored documents on supports which are not electronic, but above all the difficulty of taking into account the users who have perceptions anomalies, we often talk about color blindness, but it is only one of the seven known forms of dischromatopsies ranging from the total absence of color vision to the absence of a retinal receptors to blue, green or red. The anomaly corresponding to color blindness is the deuteranopia and it is the absence in the retina of reception cones to green, meaning that those affected are unable to differentiate the red from the green.

Notes

Summary

19m 55s