Thinking About Spatial Regions

Birds of a feather flock together.

(Drafted 2009, revised 2011, mild update 2015)

This essay is about organizing and representing geographic information by grouping places into regions. A **geographic region** is a group of locations that are close to each other and similar to each other in some way. The process of regionalization is basically a kind of classification, but one that depends on both similarity and proximity. When geographers create a region, they search an area and try to find the objects or places that have something in common AND are located adjacent (or at least close) to each other. Then, we draw a line around those objects and call the resulting area a region.

The human visual system does a form of regionalization all of the time – it looks at the tiny patches of color that enter the eye from different sources, and it "decides" which patches belong to this car and that house and those trees over there (Corbetta et al. 1991; Quinlan and Wilton 1998; Holden et al. 2010). This natural grouping activity can be used in a classroom to introduce the concept of a geographic region. Start by showing a satellite image of an area, such as the continent of Africa, and then asking students to describe the general shape and location of the yellow-colored regions: "What do you think that tan or yellow color means?" "Maybe those are the areas that are too dry to support green grass or trees."

It seems simple, almost too obvious, but in fact students can gain a good foundation for a geographic study of Africa by doing the simple act of drawing lines around the light yellow areas, carefully transferring those borders to a blank map of the continent, and labeling the result with a verbal description of each outlined area.

As noted, this process might seem quite simple, at first glance, but the research suggests that it should be done with some care, because the initial grouping of places tends to be quite persistent in memory (see, for example, Hund and Foster 2008). After students grasp the basic idea, they can then look more closely at the image, try to identify the "rumpled" areas with rugged topography, and draw additional lines to separate these mountainous regions from the surrounding areas.

At any point in this process, a GIS can facilitate the process of regionalization by making it easy for students to select criteria, let the GIS identify the areas that meet the criteria, and then visually evaluate whether the resulting region is easy to perceive and describe. Remember, the ultimate goal of regionalization is to simplify our image of the world in order to make it easier to

- examine the spatial extent of some phenomenon,
- compare it with other regional maps, and
- communicate our observations to others.

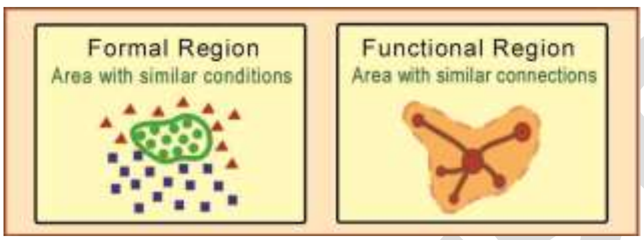
As students improve their grasp of the idea of a region, they learn how to deal with the innate "noisiness" of the real world by adopting or devising strategies for handling *inliers* (dissimilar places within a region), *outliers* (similar places that we decide are too far away from a region to be included in it), and *ambiguities* (adjacent places that are not exactly similar to those in the region but not completely different). They also learn that different regions can emerge when we use different criteria to test whether places are "similar." For example, the political regions of a continent usually have different shapes on a map than the elevation regions, land-use regions, or religious regions.

Unfortunately, this is about where the idea of region runs into a big issue that is brought on by the limited disciplinary knowledge of some people tasked with designing state-level assessments. We have tabulated questions from a dozen states, and far too many include questions like "what region of the original thirteen colonies was the major producer of wheat for export?" or even "What region of the country includes Maryland?"

A good antidote for that kind of question is to have students do an internet search for regional maps and tabulate all of the different combinations of states that are called "the South" or "the Middle Atlantic Region" in different sources. At last count, we had assembled examples of no fewer than 14 different "Middle Atlantic" regions – and, interestingly, not one state made it into all 14 regions that are identified with that name!

At some early date in their educational careers, students should learn that there is no such thing as "the" regions of the United States – regions are constructs created by people trying to solve specific problems, not groups handed down by some benevolent deity. Unfortunately, simply being aware of that fact does not necessarily protect students from this kind of assessment.

As if that weren't complicated enough, places can have dissimilar conditions but similar connections, and therefore can be included in a logically different kind of region – a *functional* as opposed to *formal* region, in the jargon of geographers (for more about how geographers have defined regions in the past, see the classic papers by James 1962 and Isard 1956).



In this essay, we restrict the term "region" to denote areas that consist of places with particular features in common – in other words, we will focus on so-called *formal* or *homogeneous* regions. Many of the entities described as functional regions are probably better put into the categories of spatial auras or zones of influence. As such, they tend to engage different parts of the human brain and are therefore the topic of another essay.

Quick Review of Research about Thinking About Spatial Regions

As with other modes of spatial thinking, one major reason why people do geographic regionalization is to simplify their image of the world. The authors of one recent study said it well: “reducing spatial details through graphic generalization can increase memory for [other relevant] information” (Brunyé et al. 2007, p. 227; see also Todd and Marois 2004; Alvarez 2011; Cant and Xu 2012). Others have described regionalization as a two-dimensional form of “chunking” (chunking is a well-known strategy for reducing memory demands when the task is to learn a sequence of numbers, letters, events, or places; see DeStefano and LeFevre 2003; Chen and Cowan 2005; Sargent et al. 2010).

Here is a simple example of sequence chunking.

Read these numbers once: 186 121 86 54.

Now read this sentence, and say your birthdate aloud as a distractor.

Finally, look up at the ceiling, and try to repeat the numbers without looking at them.

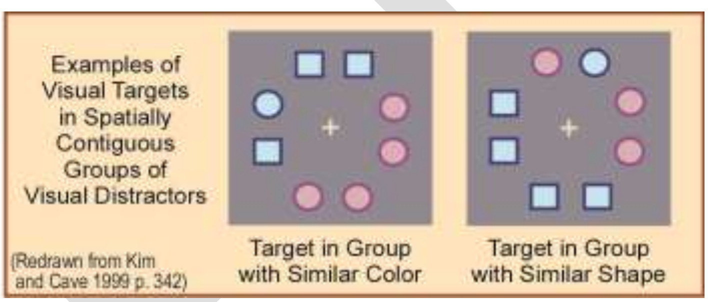
Now let’s chunk the numbers: 1861 2 1865 4

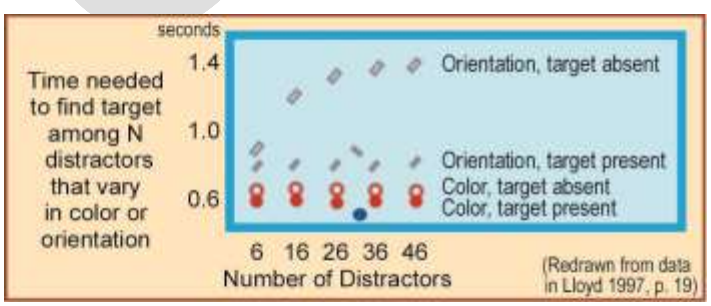
The Civil War in the United States lasted from 1861 to (2) 1865, or 4 years.

Read the rest of this paragraph, say your birthdate aloud one more time, look up at the ceiling, and then try to repeat the numbers.

Most Americans find this second task much easier, because chunking turns the ten numbers into logical groups that match how we name years, and the resulting dates may link with a prior memory from a history class.

A number of studies have looked at a 2-dimensional version of this idea with various kinds of graphs or maps, and most of those researchers observed that students who encode map information by noticing “spatial or featural groups” tended to recall information more accurately (Schwartz 1991). A beneficial side-effect of regionalization is that the mental combination of places into spatial groups can make it easier to search for places with specific characteristics – “grouping processes aided search for a visual target” (Kim and Cave 1999, p 326; Shomstein and Behrmann 2006; for applications of this principle to cartographic design, see Lloyd 1997 or Bunch and Lloyd 2000; for a caution that the process may not be as universal as some suggest, see Roberson et al. 2000).





A down side to the process of regionalization is its tendency to introduce distortions in spatial memory. The wording of that sentence is not quite correct, because in many cases the spatial memory does not exist prior to the act of making regions, and therefore it is not accurate to say that the process of regionalization causes a distortion in an existing memory. What happens is that a regionalized memory is usually encoded in a way that does not preserve all of the locational accuracy of the original visual image. "Observers of all ages consistently judged distances between elements in the same perceptual group as smaller than physically identical distances between elements in different perceptual groups" (Enns and Girgus 1985, p 241). "The estimation of location is influenced by the parsing of a visual display into spatial regions" (Laeng et al 1998, p 106; for a description that relates this process with some concepts from developmental psychology, see the recent review by Recker et al. 2007; to explore some implications for geographic memory, see Plumert and Strahan 1997; Friedman et al. 2002; Kerkman et al. 2003; Carbon and Leder 2005; Friedman 2009; Holden et al. 2013; and Miller et al. 2013).

Like other modes of spatial thinking, such as comparison of places, analysis of spatial patterns, or making spatial analogies, the process of dividing an area into regions has both a perceptual and a logical component. "Neither spatial proximity nor functional similarity was enough to significantly prime subjects in deciding whether buildings were related; both together, however, had a significant effect. People tend to cluster things when they are both functionally and spatially similar" (Merrill and Baird 1987, p 101).

A combination of behavioral and neuroscientific evidence suggests that this process of clustering begins in the pre-conscious part of the visual processing stream in your brain. One late-1990s study concluded that people tended to create map-like configurations of objects by grouping them according to color or shape. This study was somewhat tentative in concluding that "perceptual, not memory processes were responsible for the formation of cognitive clusters" (Hommel et al 2000, p.1).

Later studies built on that foundation by using a more elaborate research design in order to isolate variables that might act independently. Their carefully controlled experiments allowed them to state their conclusions somewhat more forcefully: "Results from 5 experiments suggest that participants were unable to mentally impose a spatial category boundary without perceptual support, even when explicitly instructed to do so" (Simmering and Spencer 2007, p 871).

Attempts to analyze the process of spatial grouping are complicated by the computational complexity of the task. The blunt fact is that fully conscious grouping of perceptual information is simply not efficient enough to make sense of the complex world we inhabit. A little math can drive that point home. The human brain has about 100 billion neurons. The average neuron has about a thousand synapses. That provides 100 trillion places where a single logical bit of information might be stored. That sounds like a staggeringly large number, because, in fact, it is – the brain is a magnificent storage machine. BUT, the potential demands imposed by visual processing are even more staggering. One human eye has 120 million light-sensitive rods and cones. Those structures have an average of 1200 layers (a light is perceived as brighter if it penetrates farther down into the stack of sensitive layers). Each layer of each rod or cone sends about 8-12 yes-no messages toward the brain every second ("I see light; or no I don't"). You now have enough information to do the math – the messages coming out of one eye, if you somehow figured out how to remember every one of them, could fill every synaptic connection in your brain in less than one minute.

Obviously, the eye-brain system has to do something to reduce the massive flow of information.

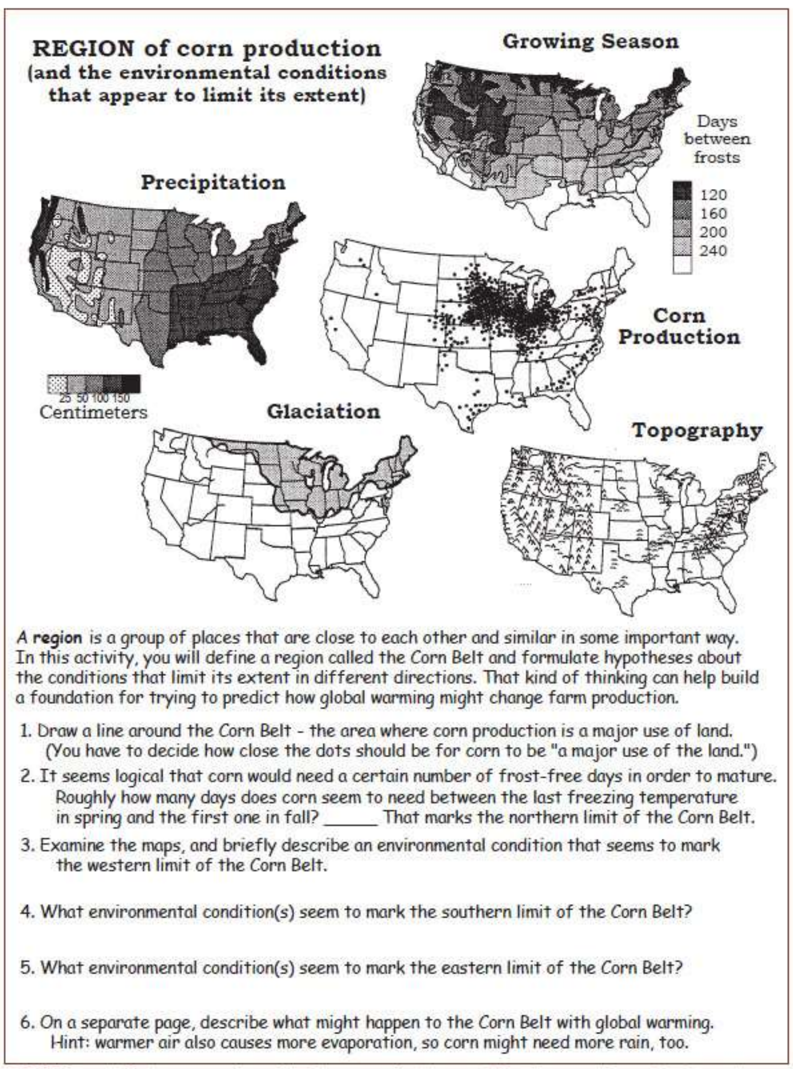
One well-established idea is that the "unconscious" parts of the visual system quickly search for information-rich parts of the visual scene, transforming raw retinal inputs into "symbolic tokens" such as edges that can then form the basis for higher-level searches for surfaces and objects (Palmer 1977; see Bafna 2003 for a summary of ideas about "space syntax"). In short, the conscious process of spatial regionalizing, when applied to something like an aerial photograph or satellite image, is in many ways quite similar to the partly-unconscious process of scene classification that the human eye-brain system has to do every waking moment. The take-home message for teachers is that the brain must do that simplification-by-grouping in an extremely efficient way in order to prevent brain overload. This is the basis for an old adage: "teaching is not a process of convincing students to remember something; teaching is showing them how not to forget something."

A GIS can serve as a very useful support structure for this kind of spatial thinking, because it can:

1. quickly search through a mass of non-visual data,
2. find areas that fall within a specific range of numbers, and
3. display the results in a way that can be perceived and processed through the visual system.

In this way, places that have similar ethnic compositions, religious preferences, life expectancies, or trends in house prices can be grouped into regions as easily as places with similar land cover. In effect, a GIS display allows us to examine those abstract topics by using the same mental processes that we used to group the dry-looking yellow areas on a satellite image into a region called the Sahara.

To understand what is happening inside a computer, however, it is probably essential for students to "create" a region from a dot map and use other maps to interpret its boundaries, as in this Corn Belt activity:



Sample dialogs, from two urban-school teachers who are trying to help students understand the legend categories on a map of land-use regions – "residential," "commercial," and "industrial"

T: Here is a satellite image of an urban area [a Google-Earth or other image of the area around the school]. Today, we are going to learn how to divide an image like this into regions. Anybody remember what we said a region is? S: an area that is similar?

T: Yes, that's about it – as long as we remember what we mean by "similar." The idea is a little fuzzy, because regions can be similar in many different ways. For example, we can talk about climate regions, or land-use regions, economic regions, and so forth. That's what we're going to learn more about today. Can you see a region on this image? S: that big green area in the upper left corner?

T: Good. That's a region of houses and trees – you can hardly see the houses because the trees shade them. Look closely – you can see some brown and blue rectangles. Those are house roofs. Why do you think people like to live there?

T: Here is a satellite image – a picture made by a satellite going around the earth. Today, we are going to learn how to divide an image like this into regions.

T: What do you think this is? [pointing to the green area in the upper left corner]
S: It looks like trees.

T: Maybe . . . What are these little brown and blue rectangles? S: maybe cars or house roofs?

T: If so, what do you think this area looks like from the ground?
S: Some houses with big trees around them.

T: Kind of like [names a familiar neighborhood]? [nods]

T: OK, let's say that's what it is, for now, and let's draw a line around the area. Stop me when I've reached the edge of the region [slowly moving pointer away from the original area].
S: about there?

T: Good – let's call that the edge of a region we see on the image – we called a house-and-tree region, but we need to check to make sure. That's what image analysts call ground-truthing . . . .

These dialogs highlight some differences between a lesson that reinforces a specific mode of spatial thinking and one that does not. The two dialogs are the same length (165 words). The first one, however, had its focus on definitions, image interpretation, and feature naming. The second teacher tried to put more emphasis on the process of dividing the image. That teacher is giving the students a tool that they can use to interpret any image, even if they cannot always figure out exactly what is "actually" there in a particular part of the image. Those students can then use some other tools of geographical analysis to narrow the range of possibilities and help them decide what is represented by a particular combination of color, shape, and texture on the image.

Both teachers have communicated one important characteristic of regions – the first teacher noted that an area can have a number of different regions, based on different features. The second noted that a focus on the process of delimiting the extent of a region can help us understand the concept of a region.

ILLUSTRATE WITH A GOOD IMAGE - choose images that also have a role in history or earth-science standards – e.g. Taklamakan, Nile, Machu Picchu, Aral Sea, . .

Additional student activities that involve thinking about spatial regions

A. Make a map of land use, language, etc. in the local community

Given the status of "region" as one of the Five Themes of Geography, many teachers already have their students do an activity like this as part of the curriculum. Success in using the local community to teach about regions, unfortunately, seems to vary greatly, depending on the degree to which the local community actually has distinct regional categories and boundaries (a variation of the "legibility" idea described below). Here are the logical steps in the activity:

1. Carefully observe conditions on a block or at some other kind of sample point.
2. Estimate (or calculate) a ratio that makes sense for your topic, e.g. the percentage of land used for corn, proportion of the block used for stores, or fraction of visible signs in Spanish
3. Record that information at the proper location on the map
4. Repeat steps 1-3 until you have information for a reasonable number of sample points
5. Draw lines around areas with similar conditions – this step involves making a judgment call, and the key to pedagogical success is to pick areas with regional differences that are clear but not too obvious!

B. Make a map of land use, language, religion, etc. in a selected world region

A logical extension of the process of making a regional map from first-hand observation is to divide an area into regions based on observations made by others, e.g. with instruments at weather stations or questionnaires during a census. A GIS can be very helpful in displaying all kinds of data, but students need to go through the process of making boundary decisions "by hand" at least once in order to get a good feeling for what the GIS may be doing electronically "inside the black box."

1. Select a topic from the list of data available in the GIS. Language and religion are good topics to use in this activity, given their prominence in most state assessments (and as an often-named cause for conflict in various parts of the world).
2. Have the GIS color the countries that exceed a specific threshold value, e.g. more than 50 percent Hindu religion, or more than 70 percent Bantu language.
3. Print the map and use a color marker to draw a line around the area that seems to have similar conditions (or use the freehand drawing tool in the GIS to enclose the region).
4. Display your results to each other in small groups, comment, and adjust. (One useful tactic in some settings is to have different students use GIS displays with different numbers of categories or category breakpoints – e.g. 30-50-70 percent French speaking, vs. 20-40-60-80 – as input for their regional decisions, and then compare the results of their decisions.
5. Optional: Repeat for the other languages, religions, land uses, etc.
6. Make a composite map, adjust boundaries as needed, and make a legend.

CAUTION: Making a regional map can be hard work, and it may be viewed as "busywork" if it is positioned as the main product for a class activity. Students are more likely to get the point if the regional map is described as one key component of a larger investigation, like a search for ways in which a land use region may shift position in response to global warming, or a search for reasons why a religious region is limited in specific directions. Use discretion in picking topics for investigation, and make a convincing rationale for its utility.

C. Make a regional map of a "fun" topic

Observant teachers often "discover" a printed map or data set of a somewhat frivolous but intuitively interesting topic, like UFO sightings, names of soft drinks, music styles, poll results, etc. Take advantage of the moment by having students make regional maps of those topics.

1. Decide on criteria for inclusion in the region.
2. Draw a line around the sample points, counties, states, etc. that fit inside the region.
3. Examine the map and speculate about causes that limit the extent of the region.

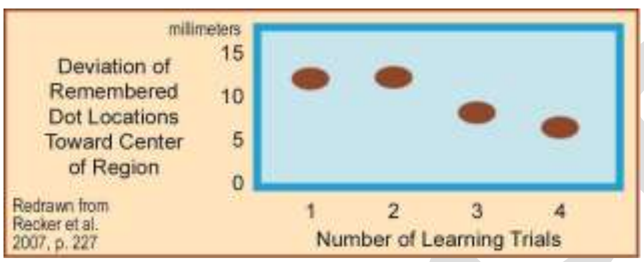
D. Examine a printed regional map, and describe the steps used to gather data and make the map.

Detailed Review of Research on the Process of Thinking about Spatial Regions

As noted in the introduction to this chapter, geographers and other social scientists have long suspected that spatial regionalization is a kind of mental strategy that people use to simplify their perception of a complex world (Montello 2003).

As part of this ongoing research, developmental psychologists also note that:

- even pre-verbal infants appear to have a concept of category (Ricciuli 1965),
- toddlers start with shape when they group things (Waxman 1990; Baldwin 1992),
- children can be prompted to use other criteria in grouping (Gelman and Markman 1986; Stiles-Davis 1988),
- "like adults, children use categories for increasing average accuracy in estimating inexact stimuli" (Duffy et al. 2006, p 597; for a look at development of the regional concept, see Lange-Küttner 2006; for a more general review, see Markman and Ross 2003; for a elegant exploration of how a disorder like schizophrenia can impair this process, see Kurylo et al. 2007), and
- at first, people tend to remember locations as parts of groups, and therefore to remember the location as being in the middle of the group; with time and practice, they learn more precise ways of fixing the location of individual places within a region (Recker et al. 2007; Holden et al. 2010).



- early in the visual processing system (in the areas called V1 thru V4 in the back of the head), the brain defines "similarity" on the basis of clues that we illustrated with an satellite image of Africa – texture and color (Bhatt et al. 2007; Casco et al. 2010; Parkes et al. 2009; Cavina-Pratasi e al. 2010). Similarity of patterns of color or texture (e.g. plaids) or other regularities (e.g. illumination) are processed later (Lennie and Movshon 2005; Guttman et al. 2007; van den Berg et al. 2011)

The definition of *similarity* has always been an issue in geographic regionalization; in the late 20th century, it also became a topic of interest among psychologists (Goldstone 1994b). Not surprisingly, the idea of *dissimilarity* has emerged as just as important as the notion of similarity in refining the ideas of category (Hampton et al. 2005; Stewart and Brown 2005; Holmes and Franklin 2009).

At first glance, this might seem like a picky distinction – the issue gains credibility when we recognize that categorization is almost always a sequential process, because the conscious visual system has to make a judgment about each individual eye fixation, and because fixations occur in a specific order, the grouping is also done sequentially, not all at once (Razpurker-Apfeld and Kimchi 2007; recently, however, some researchers have suggested that a parallel process captures the "gist" of a scene while the primary visual cortex is engaged in the process of individual place perception and grouping – see Walther et al. 2009; Ganaden et al. 2013).

Within the process of sequential grouping, immediately-prior experience can bias future judgments in ways that are not always predictable (Petzold and Haubensack 2004; a teacher would instantly recognize this as a variant of the problem of maintaining grading consistency as you read essays of widely dissimilar quality – woe to the student whose essay you pick up just after reading an exceptionally good one!)

In fact, the very act of deciding about membership in categories can make behavioral and even structural changes in the brain that predispose the individual to make similar distinctions more easily (i.e., with less thought!) in the future (Jiang et al. 2007; Davidesco et al. 2013).

Grouping by similarity is one arena where a computer GIS can be of great value, because it is able to maintain mathematical accuracy as it "decides" whether a given pixel, county, state, or country meets all of the requisite criteria to be included in a regional group.

That assertion, however, begs an important question – how do we specify the criteria that are used to decide whether a given place belongs in a specific region? For example, should the letters in this display be grouped according to shape (rounded or angular), stance (vertical or slanted), or position in the alphabet?

That question, in turn, raises the issue of the role of *prototypes* and *exemplars* in forming categories. This distinction is basically an acknowledgement of the logical difference between deductive and inductive reasoning:

- a **prototype** is an *a priori* definition of the traits that constitute the core of a category, whereas
- **exemplars** are places that may vary in details but are all considered as belonging to the category (Ashby and Maddox 1993).

Psychologists have paid a lot of attention to how children learn the prototype or exemplar categories that are represented by specific direction-words or spatial prepositions (for a review, see Huttenlocher et al. 2004; compare Franklin et al. 1995; Crawford et al. 2000; for a geographer's view of the idea, see Lloyd, 1994).

A geographer must then merge these spatial categories with categories based on similarity in order to form the more abstract notion of a region as an area that is defined on the basis of both similarity and proximity. A question the sprawls across both parts of this regionalization process is the extent to which particular kinds of inference learning tend to foster the formation of prototype or exemplar categories (Johansen and Kruschke 2005; cf. Yamauchi et al. 2002).

Neuroscientists have added some complexity to this discussion by noting that categorical ("what?") and coordinate ("where?") relations may actually be processed and stored through different pathways in the brain (Kosslyn et al. 1989; Rybash et al. 1993; Postma et a. 2006).

Vision scientists, meanwhile, have approached this question from a different angle, by looking at the role of perceptual boundaries in shape recognition. Fundamentally, a perceptual boundary must be inferred from changes in luminance in different parts of a visual scene (Agostini and Galmonte 2002). These luminance gradients interact with other visual variables, such as texture or color, to form a composite image. As one pair of researchers said, "the neural mechanism in the cerebral cortex that mediates the appearance of brightness at a boundary inhibits the activity of chromatic mechanisms at that same boundary" (Gordon and Shapley 2006, p. 133). This inhibitory action may be part of the reason behind the findings of one widely cited study, which demonstrated that the brain responds more strongly to lines or surfaces if they enclose a space than if they do not (Epstein and Kanwisher 1998).

Indeed, mental grouping tends to increase “discriminability” near category boundaries; as a result, “experience in acquiring new categories can alter perceptual sensitivity” (Goldstone 1994a, p 197). Other researchers have tried to approach this question by invoking Gestalt principles such as proximity or continuity (e.g. Kubovy et al. 1998; Quinlan and Wilton 1998). Finally, many of the most revealing insights come from people studying the way in which the brain “decides” to favor one of two or more alternative interpretations of an intentionally ambiguous display (Kramer and Yantis 1997; Hasson et al. 2001; Petersik and Rice 2008; Aydin et al. 2011).

A third independent body of research by architects and urban planners has its focus on the role of spatial categories and perceived regional boundaries in promoting the acquisition of knowledge about a building (and therefore facilitating memory for locations and routes within the building; examples of these investigations include Herzog and Leverich 2003; Kuipers and Tetuci 2003; Werner and Schindler 2003; Kim and Penn 2004). A more recent article provides a bridge between architects and brain scientists, as well as a useful summary quote about perceptions of regional boundaries: “any feature of the environment to which the brain has a very specific and very powerful response is very important and, hence, worth studying” (Stamps 2005 p 102). Architectural studies have also added an important observation that different people often tend to group landscape features in similar ways. As one study concluded, “there was considerable agreement [among subjects] as to the boundaries separating these segments,” and therefore “these findings suggest a similarity between route segmentation in macrospatial cognition and categorization in other cognitive-domain tasks” (Allen and Kirasec 1985, p 218; see also Wiener et al. 2004). Ideally, these studies should be replicated by geographers with other kinds of regional maps. This is something that could be done by having a GIS display data using different category boundaries for color selection, and then having different viewers try to identify the areas that they would call regions. In short, geographers need to update some of our pioneering cartographic studies, such as the ones that tried to identify the conditions under which people grouped map symbols in mental clusters (e.g., Slocum and Gilmartin 1979).

More recently, neuroscientists have identified the specific brain areas that appear to be involved in category learning (Knowlton and Squire 1993; Reber et al. 1998; Harel et al. 2012). A number of researchers have looked at the possibility of “top-down” or attentional guidance of early visual perception – like the region you see is the region you are looking for (Fazl et al. 2009; Davidesco et al. 2013; see a more extended discussion in the essay on spatial pattern). Some even claim that they can use brain-scanning data to predict which objects a person has mentally grouped into specific categories (Weber et al. 2009). The issue is complicated by the fact that the brain appears to use two different areas for categorizing faces and other objects, although there is some disagreement about how sharp this distinction really is (for several early views on this topic, see Haxby et al. 2001 and Cohen and Tong 2001; for a more comprehensive and more recent review, see Brooks and Cooper 2006). As if this were not complicated enough, the processing of visual regional boundaries appears to require a different brain area than the identification of object locations (Byrne and Becker 2004;).

In the 1980s, the idea of regionalization became a question of interest for people doing research on artificial intelligence and mobile robots (I’ll pick one example from each end of the alphabet: Achanta et al. 2008; Zivkovik et al. 2007). For reasons outlined in the essay on spatial auras, research on spatial reasoning by robots is harder to find and evaluate. Moreover, in the case of regionalization, it is oriented mostly toward very local-scale analysis linked with wayfinding (for an accessible look at this work, see Bailey and Nebot 2001 or Persson et al. 2007). Here, we will simply repeat a point made earlier: identification of regions within a visual scene (such as a brief look at a group of buildings or a map) is a dauntingly complex task that the human eye-brain system seems to do almost effortlessly. “Teaching” a computer to do it as well as the human eye-brain system, even in a greatly simplified environment, remains “an elusive goal” (Serre et al. 2007).

Overlaps between thinking about regions and other modes of spatial thinking.

This chapter has already noted one potentially blurry boundary between modes of spatial thinking: the processes of regionalization and pattern identification appear to overlap, especially when our visual system is "automatically" putting colors into regions as part of the process of recognizing shapes and identifying objects. Here is one test you can use to keep the processes logically separate when looking at maps: ask whether places maintain their individual identity as you think about them. If you are regionalizing, the answer is no; individual places tend to "adopt" a group identity, as in "this county is part of the Rust Belt" (see Chapter 7). With spatial pattern analysis, by contrast, individual places maintain their identity, as in "these towns are arranged in a kind of string, like the railroad towns of the Great Plains" (see Chapter 11; see also Han et al. 2005).

Another logical overlap can occur between regionalization and the analysis of spatial hierarchies. Indeed, many geographers stretch the concept of "region" to include "subregions," in effect merging the ideas of regions and spatial hierarchies (we actually did that, in the first edition of *Teaching Geography*, until persuaded otherwise by Reg Golledge and others!)

A third logical overlap occurs when geographers include the idea of spatial aura in their definition of regions. For example, one definition of a functional region is as an area that is connected by some kind of physical, economic, or political influence – which is, in essence, a pretty good description of the concept that we are calling a spatial aura. (This point was questioned by Mitchell 2007; our response, on page 43 in that same journal, was that "if our attempt to describe the difference between aura and region is not satisfactory, we need to refine our prose (suggestions welcome), because the neuroscience is compelling." In other words, we should respect the fact that the brain does seem to use different networks to process the ideas of region and aura.)

Here is one attempt to refine the prose: if the focus is on the influence, and the actual delimitation of a boundary around the area of influence is secondary, then we are thinking about a spatial aura (and probably using a brain area on the side of the head). If, on the other hand, the focus is on drawing a line around the area that is likely to feel an influence from some feature, and then examining the characteristics of that area (e.g. by counting the number of children under age 5 in an area likely to be impacted by smoke from a factory), then we are thinking about a spatial region (and probably using more areas in the back of the brain). In practice, of course, people often use two or more different modes of spatial thinking together in order to address a specific problem – much like using different muscles in your arm, in different combinations, to do different tasks, such as strumming a guitar, shooting a basketball, or paddling a canoe.

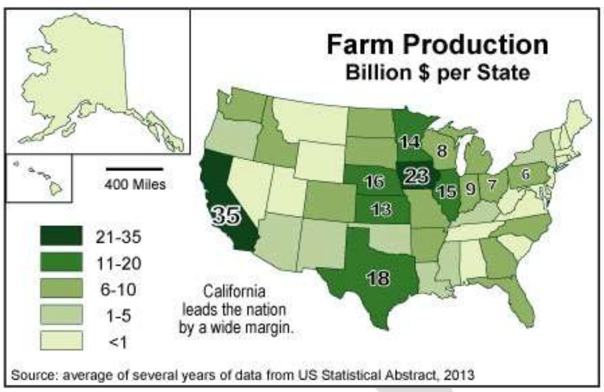
That cooperative tendency is even more noticeable when we try to draw a distinction between the process of regionalization and the analysis of spatial transitions. Indeed, these two modes of spatial thinking usually work together, almost like the blades of a scissors. Regionalization has its focus on the core characteristics of an area, the conditions that places within the region have in common. That mental activity takes place primarily in the visual cortex in the back and sides of the brain. If you focus on the rate of change in some condition as you cross the boundary between one region and another, however, you are really thinking about a spatial transition. The observation of conditions at various points along that kind of spatial sequence makes use of structures in the front of the brain, above and behind your left eyebrow (see Chapter 8).

Ideally, of course, a geographic lesson should encourage all of these kinds of spatial thinking, in order to promote the kind of cross-brain linkage that helps make memories more durable. That statement provides a good place to end this section (for now!)

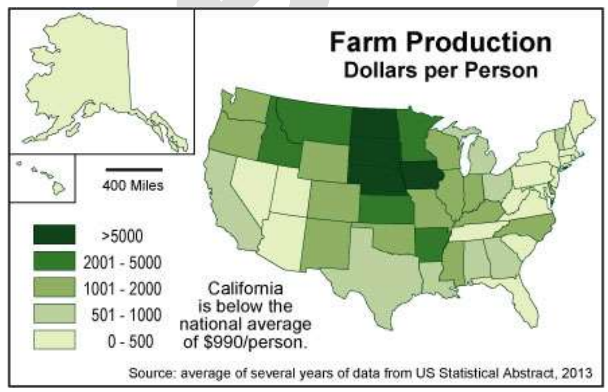
Issues with using a GIS to support thinking about spatial regions

Of all the modes of spatial thinking, regionalization is the one that is most obviously and transparently supported by modern mapping software. The process of identifying and delimiting regions is greatly aided by the ability of a GIS to select criteria, filter information in various ways, and display the results with a variety of symbols and colors. One can then tweak the cartographic decisions, such as the selection of category breakpoints on a choropleth map or the data-per-dot ratio on a dot map, until the resulting display clearly shows the regional pattern you would like to emphasize.

That ease of producing regional maps, of course, raises the major issue, namely the ability of the GIS user to “fine tune” the display so that it can give different visual impressions from the same input data. That statement applies with even more force when we realize that the user can also combine data in various ways (a process infelicitously called “normalization” in some GIS books – that term has a somewhat more restricted meaning among statisticians). Introductory textbooks are full of visually compelling comparisons of the dissimilar spatial regions that emerge when we map, for example, the absolute number of people over age 65 in each state, as opposed to the percentage of each state’s population that is over age 65 (see the CD unit on capital gains in California, which begins with a pair of maps that show total food production in each state and food production per person in each state – the patterns are dramatically different, especially for California, which drops from the top category to the second lowest one).



Source: average of several years of data from US Statistical Abstract, 2013



Source: average of several years of data from US Statistical Abstract, 2013

A GIS simply allows people to make this kind of decision more quickly, or even to automate the process, as in the iterative selection of category breakpoints to search for regional groups that have maximum within-group spatial compactness or minimal within-group statistical variation. The depiction of spatial regions has certainly become richer and more complicated, as a result of the development of powerful spatial-analysis algorithms, such as iterative category selection, alternative forms of spatial interpolation such as kriging, and mathematical ways of combining data, such as factor analysis or various forms of automated clustering.

These technologies can make it easier for ethical cartographers to use a GIS to help them display data in a compelling and memorable way. They can also make it easier for less ethical cartographers to “lie with maps” (for a survey of this obviously relevant topic, see Monmonier 1996, especially p41).

Wouldn’t it be nice to be able to end this chapter with the observation that we now live in a world where everyone obeys at least one of this pair of self-imposed mandates?

cartographers all make clear statements of the origins and subsequent manipulations of all data displayed on their maps, and

map readers are all familiar with the many ways in which cartographers can manipulate a map image and still “accurately” display the input data.

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