Thinking About Spatial Auras

That smokestack? It smells like money to me!

(Drafted 2008, revised 2011, mild update 2015)

This chapter is about organizing and representing geographic information by observing the aura of a feature, the influence it can have on places around it.

Auras can be of many different sizes. For example, people within a few feet are likely to "feel the influence" of a dead skunk on the road or a person talking loudly on a cell phone. Other features can have substantial influence at much greater distances. Examples include an accident at a nuclear reactor, a missile launcher that can threaten any place within several thousand miles, or just a smokestack emitting fumes into the air.

People in different disciplines have used many different terms to describe the idea of influence on surrounding space. Common terms include *neighborhood effect*, *impact area*, *zone of influence*, *sphere of influence*, *halo*, *corona*, *field*, or, in some GIS software, *buffer*. Each of these terms is awkward, because it can have different meanings for people in different disciplines.

Take, for example, "buffer." To a GIS programmer, a buffer is a zone that extends a specified distance away from a point, line, or area. The concept allows the software to help identify features that may be impacted by something that happens in a particular place. For example, one might define a buffer around a truck accident in order to identify houses where people might be at risk from chemical exposure (Keranen and Kolvoord 2008, p. 23). In short, a GIS buffer is a device to show the extent of outward influence from a particular geometric feature.

To a civil engineer or soil scientist, however, a buffer is a zone of protection against an influence coming in from outside an area. Using this definition, the U.S. Department of Agriculture pays landowners to plant buffers of trees and grass around small streams in order to prevent sediment and farm chemicals from washing into river systems (USDA 2008). Meanwhile,

- to a political scientist, a buffer is a neutral border zone between competing powers,
- to a computer programmer, a buffer is a temporary storage area,
- to a chemist, a buffer is chemical that can neutralize excessive acidity or alkalinity.

In short, different disciplines use the same term in ways that are not just different, but occasionally diametrically opposite in meaning.

Despite the terminological ambiguity, the underlying concept of a spatial aura is easy for students to grasp. Even young children, for example, are aware that things like loud vehicles or belching smokestacks can have an influence on surrounding areas (although they are likely to describe that impact with qualitative words like "noisy" or "smelly" rather than by using a dollar value or some kind of measurement).

Toward the other end of the novice-expert continuum, the concept of a spatial aura is useful in many kinds of applied geography. Obvious examples include assessing the sonic aura of an outdoor concert, the olfactory aura of a hog feedlot, the vibrational aura of a pile driver at a construction site, the visual aura of a mall parking lot blotting out the stars at night, or the threatening aura of a crazy dictator in a nearby country.

In our own experience, we have observed the beneficial aura of an upscale grocery store that moved into a run-down neighborhood in Washington, DC. Real-estate ads in the paper soon began to mention the store by name, touting the desirability of an apartment that was "recently refurbished and only two blocks from the [name] store."

A few years later, a car-repair service near our house in Minnesota went bankrupt, and the buyers of the building turned it into a bar. Noisy patrons exiting at 2 a.m. were disruptive of neighborhood calm, and eventually two neighbors moved away, after selling their houses for substantially less than they might have gotten if the houses were not within the aura of the bar.

In short, the idea of a spatial aura is a powerful way to organize and represent ideas about spatial relationships. Indeed, the notion of influence on nearby areas is so important that it is sometimes described as "Tobler's First Law of Geography." This "law" was named after the individual who phrased it as "everything has an influence on everything else, but nearby places have more influence than distant ones" (Tobler 1970; see also Sui 2004 and other papers in that forum).

Quick Review of Research on Thinking about Spatial Auras

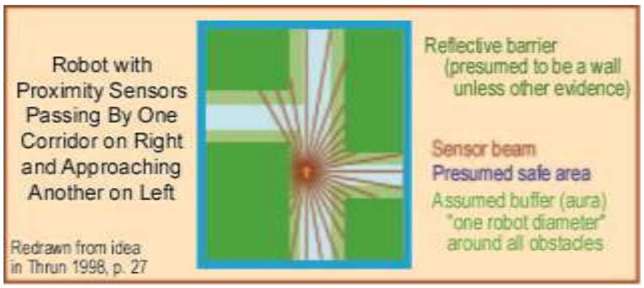
The human brain seems to have some kind of structure that more-or-less automatically visualizes an aura-buffer-halo around the person and most other objects in the surrounding area. For a long time, however, the evidence for this process was largely indirect. Some older studies, for example, showed a systematic asymmetry in spatial memory – people tend to remember distances from an object to a landmark as less than from the landmark to the object (McNamara and Diwadkar 1997; Hubbard and Ruppel 2000). This suggests that the presence of the landmark "in the brain" has a distorting influence on spatial memory. More recently, a number of studies showed that people also tend to remember objects and even entire scenes as somewhat larger than they actually are. This process, called "boundary extension," has been described as "a fundamental component of spatial cognition" (Intraub 2004, p 34; Hartley et al. 2004; Dickinson and Intraub 2008). The main role of boundary extension seems to be as a device to help people connect individual eye fixations into a seamless mental image of the world. The same process, however, may also help people navigate through a room, drive a car on a freeway, and reach for things without colliding with other people or objects (Cutting 1995; Moussaïd et al. 2009, 2011).

In 2008, researchers reported that a particular part of the brain appears to store a representation of the surrounding environment in such a way as to trigger a response when the viewer moves close to the edge of an enclosed area or to another object (Solstad et al. 2008). This research seems to provide a neurologic mechanism for a process that had been described in theoretical models for a number of years (for a review, see Barry et al. 2006). At the same time, other animal studies seem to have identified a particular part of the mammal brain that stores information about "near and far space" (Swoboda 2008; see also Bryden and Roy 2006).

Whether or not this is an accurate description of what "actually" goes on in the human brain, it is clear that the idea of putting an imaginary aura around objects has made it easier for programmers to design robots that can navigate through a room, avoid other stationary and mobile objects, and communicate with other robots that have similar programs. Consider five related statements:

A Microsoft programmer's website offered one of the best succinct illustrations of a spatial aura: "a streetlamp creates an aura, ... which allows observers to infer the lamp's presence even if it is not in view" (Baudisch 2003).

The idea of an aura can aid robot navigation. "Objects carry their auras with them when they move through space . . . when two auras collide, interaction between the objects . . . becomes a possibility." (Simsarian and Lennart 1996; see also Thrun 1998; Moulin and Kettani 1999; Moreno and Dapena 2003; Vasudevan and Siegwart 2008).



The idea of an aura can facilitate robot communication. "Users are only aware of the cells their auras intersect . . . interaction between two users can only happen when the two users' auras intersect" (Benford and Fahlen 1993)

An early robot-guidance program is the source of our preferred name for this kind of spatial thinking (AURA – AUtomonous Robot Architecture; Arkin 1991; but we are aware that this is a very specialized use of the term, and that the word probably has mystical or metaphysical connotations for many more people – see for example Lunn 2003),

A recent patent (number 7,441,298, granted October 28, 2008, identified by entering the words "robot AND proximity AND sensor" into the US Patent and Trademark Office's website) listed as examples of "prior art" more than 250 US patents and 100 international patents that had been granted since 1990.

The last fact on this list can help us understand why academic journals do not seem to have as much published research about spatial auras as about some other modes of spatial thinking, such as defining spatial regions or making spatial associations. It is not unreasonable to infer from the patent activity that the concept of a spatial aura has a great deal of commercial value, which is being protected behind relatively high legal walls (and those legal barriers, in their own way, are another example of a kind of aura or buffer!)

In any case, the concept of a spatial zone of influence around an object or landscape feature has been used for many years in many forms of applied geography:

– in criminology, to suggest plausible locations for a criminal's home base (Lundrigan and Canter 2001; Fritzon 2001).

– in epidemiology, to identify possible sources of pollutants that might be responsible for clusters of disease (Wartenberg 2002; Steinmaus et al. 2004).

– in wildlife biology, to identify areas where species are likely to be adversely impacted by traffic from a road (Reijnen et al. 1996; Forman and Alexander 1998)

– in urban design, to assess the impact of features on nearby property values (Hewko et al. 2002),

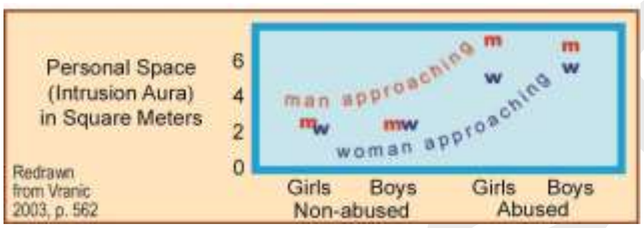
– in military training, for tasks as varied as siting artillery or defusing landmines (Staszewski 2007),

- in education, to note that children's geographic knowledge of regions depends quite strongly on their proximity to home (Axia et al. 1998), and even

- in analyzing humor, noting that close mishpas are funnier than distant ones, but distant tragedies can be seen as funny while nearby ones are simply tragic (McGraw et al. 2012).

In this context, it is important to remember that the effect of a spatial aura can be positive, negative, or neutral. A safe park, for example, has a strong positive influence on adjacent land, often reflected in higher property values and better home maintenance. A dirty and dimly lit park that is perceived as a haven for drug-peddlers and muggers, by contrast, has an aura with negative implications.

At a more intimate scale, people from several disciplines have explored the concept of "personal space," the aura that surrounds an individual in various settings. Linguists and child psychologists, for example, have had a fruitful dialog about the conditions that seem to govern the use of terms such as next to, close, near, and far (examples include Sowden and Blades 1996; Hund and Plumert 2007). Behavioral psychologists have tried to probe the reasons for different notions of interpersonal distance among people of different ages, cultural backgrounds, or personal experiences (Vranic 2002; Kaya and Weber 2003; Webb and Weber 2003).



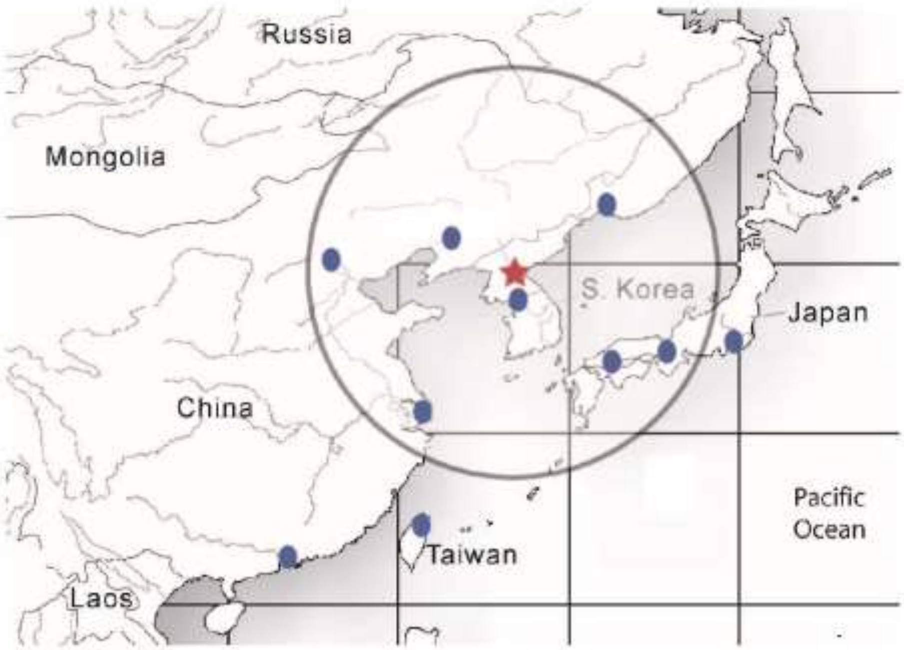
Even though the focus of this book is on spatial thinking at a broader scale than these personal-scale studies, the similarity of approaches and results seems to suggest at least some commonality (or at least parallelism) of cognitive processes.

As part of their general citizenship education, students should become familiar with the kind of landscape features that can exert an influence on surrounding area, as well as some of the ways in which we can measure that influence, and some of the graphic "languages" that people can use communicate those ideas to people whose lives may be affected. Our student activities will therefore focus on several applications that are likely to seem intuitively important even to non-geographers. The "aura" folder on the CD has some images that teachers could use to start class discussions about influence across space, along with a presentation about the aura of Disneyland and an interactive multimedia unit about the competing auras of several shopping centers.

Spatial Aura - Who Is Within the Range of a Missile?

This map illustrates the idea of a spatial aura or buffer. When geographers use those words, they mean "a zone of influence around a point or a line." Examples include smell from a skunk, smoke from a factory, noise from an airport, or higher property values from a nice park.

In this example, the red star is a missile-launching base that might be located near the center of North Korea. The estimated range of a missile from this base is about 750 miles.



To indicate the area that might be threatened by it, the map-maker drew a circle with a radius of 750 miles. Any point within this circle could be vulnerable to attack by the missile. In other words, those places are within the aura of the missile base (its zone of influence).

The cartographer could have made the message more dramatic by adding the names of some cities to this map. Look at another atlas or wall map in order to find the locations of the cities listed below. Write the correct name next to each dot on the map. Then circle the names of the seven cities that would be vulnerable to attack by this missile.

Beijing	Hiroshima	Hong Kong	Osaka	Seoul
Shanghai	Shenyang	Taipei	Tokyo	Vladivostok

Sample dialogs, from two urban-school teachers who are trying to teach students how a GIS might be used to estimate the number of people in a bomb impact zone

Teacher: Here is a satellite image of an urban area. Today, we are going to learn how to use a GIS to estimate the number of people who might be killed if a nuclear bomb exploded about right here [points]. At first, we are going to do it with a magic marker and the whiteboard. How would you start?

S: you need to know the coordinates of the explosion, right?

T: yes, that fixes its location so we can put it in the GIS. What else do you want to know?

S: well, the handout says that the bomb will kill half the people within a distance of three miles from the bomb. So let's draw a circle centered on the bomb and 3 miles in radius. [draws]

T: Why do you want that?

S: so we can query the GIS to find out which census tracts are within three miles

T: and then? S: then we can add up to find the total population in those tracts

Teacher: Here is a satellite image of a city. Imagine a bomb exploded right here [points]. How far does the handout say the bomb can kill people? S: 3 miles

T: Right. Half the people within three miles. Do you think that means half the people in every place within three miles, or more close to the bomb and fewer as you go farther out?

S: I suppose more near the explosion.

T: OK, how do we get that information from the GIS? What do we need to ask for?

S: the coordinates of the individual tracts? so we can figure distances to the bomb?

T: yes, then we can try a formula, like 100% out to a mile, then 20% less for each half mile farther.

S: How do we know those are the right percentages?

T: We don't, but it's more accurate than saying 50% anywhere within 3 miles. We can always change the formula; now, let's see how to make a multi-ring buffer in a GIS.

These dialogs highlight some differences between a lesson that reinforces a specific mode of spatial thinking and one that does not. The difference is often quite subtle, but it also is usually quite pervasive – in short, "the devil is in the details," and the details are cumulative

The two dialogs are the same length (160 words). The first one, however, had its focus on definitions and GIS procedures. The second teacher tried to put more emphasis on the actual meaning of a zone of influence. That teacher is giving the students a tool that they can use to interpret other similar problems. Those students can then apply the tools of GIS to refine the estimate.

Additional student activities that involve thinking about spatial auras

A. Positioning baseball players in an outfield, or defensive backs in a football or soccer game

1. Make a map of the playing field with an accurate scale of feet
2. Estimate the radius of the zone of coverage for an individual player, by measuring the time a hit or thrown ball is in the air and the distance the player can run in that time.
3. Position each player on the map and draw a circle around the players to indicate the extent of their effective influence. Variation: make the zone non-symmetrical if a player is more effective running and catching in particular directions. Most players, for example, can run forward faster than backward.
4. Note any uncovered areas and reposition the players to achieve maximum coverage.

B. Positioning TV stations or cell-phone towers to effectively cover an area with their auras.

1. Identify the locations of the existing TV transmitters or cell towers. Maps of their locations are available on the internet in many parts of the country.
2. Draw a circle around each tower to show the range of its broadcast.
3. Identify empty areas and suggest where new towers could be built to serve the most people (a GIS can help by providing population maps for the area).

CAUTION: while this form of applied geography is interesting, intuitively important, and an expanding employment opportunity, it does not meet many state educational standards or help much with standardized tests. It may therefore be unwise to spend too much time on it!

C. Locate oil wells to extract oil from a deposit efficiently.

1. Find a map that shows an irregularly shaped oil deposit
2. Assume a reasonable radius for the “zone of influence” (extraction) around an oil well.
3. Position wells so that their extraction zones cover the deposit efficiently.
4. If desired, add ideas about jurisdictional auras of countries – see CD unit on Law of the Sea.

DEBRIEFING: this is precisely the same logic that is used to locate, say, grocery stores or schools or health clinics in a city, and it is subject to the same caveat – the pattern that provides the most oil for the first wells (i.e., their extraction zone is entirely within the deposit) is seldom the one that extracts the most oil most efficiently. That is a valuable message that is worth hearing during debates about the value of regulation!

D. Describe the geographic aura of a major event, person, or structure in history

1. Identify some historic event that occurred in a specific place (e.g. invention of iron weapons, Declaration of Independence, opening of the Erie Canal)
2. Draw lines at varying distances from the event or structure to identify areas where its influence would have been strong, moderate, or weak.
3. Examine those areas and describe the people who are likely to be affected; if desired, adjust your lines to reflect other considerations, such as travel time or terrain.

E. Describe the aura around a nuclear reactor (see also Keranen and Kolvoord 2008 pp 5-22)

1. Identify the location of the proposed reactor
2. Examine maps of previous accidents and try to infer the radius of the zone of influence (or simply assume a radius of, say, 60 miles to start – that’s about “one Chernobyl”!)
3. Draw a circle of appropriate size on a map around the location of the proposed reactor Variation: make the zone non-symmetrical to reflect prevailing winds in that area.
4. Investigate and describe the places that might be within the zone of influence.

F. Identify areas where fans are most likely to root for particular professional or college teams. This is another high-interest activity that has relatively low value in a standardized test environment, so it should be deployed carefully to gain motivational benefits without risking damage to test scores.

Detailed review of research on thinking about spatial auras

A detailed review of research about the concept of spatial aura has to wrestle with a fact that was mentioned earlier, namely that a computationally efficient solution to the idea of influence over territory in a changeable environment would be of enormous financial value for many people, including store managers, clinic planners, robot programmers, and military planners.

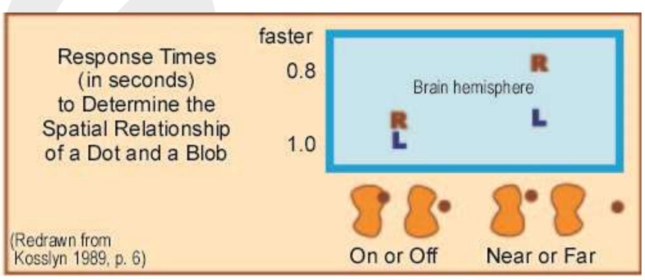
As a result, some of the most interesting research remains hidden behind a variety of legal and procedural walls. Moreover, much of the publicly available research is in the form of conference proceedings, symposium transcripts, temporary websites, and other fugitive sources. An example is the following quote: “This [software subroutine] simulates an audio aura which is smaller than the visual aura.” This statement is a useful acknowledgement that the aura around a person or landscape feature may be of different size when measured in different ways. For example, smoke from a factory usually extends farther than the noise of machinery. Unfortunately, the author of the quote is listed only as “Green Space System,” and the source is Chapter 4 of document that was available on the web for a short time in 2008 and 2009 but is described as forbidden in 2014. Try for yourself:

http://www.hitl.washington.edu/publications/pulkka/5.html (accessed 5/25/08).

Despite these difficulties, we can find more than enough research to suggest that the human brain does have an “innate” tendency to use the idea of an aura or influence as one way to organize part of its mental map of the world. At a personal scale, as already noted, this skill is essential to avoid colliding with other features as we navigate through space. The laws of physics “strongly suggest” that the time to think about changing your motion in order to prevent a collision with another object is <u>before</u> you have touched its edge, not after. In order to prevent collisions in personal space, the brain needs to do four things more-or-less automatically:

1. monitor the locations of other objects in terms of a fairly precise representation of their edges, not just a general representation of their centers. This process has been shown with a number of animal studies (e.g., Carlson-Radvansky et al. 1999),

2. create a kind of extension or buffer around that edge, either by assuming that the object is actually larger than it is, or by generating some kind of signal when you approach within a specified distance of the object. This was accomplished first in the hypothetical world of electronic simulation; “a separate unit, an aura manager (AM) constantly monitors objects as they move around the shared world and informs objects when other objects collide with their aura” (Lea et al. 1999; Wang et al. 2001; Bailey and Durant-Whyte 2006). It took another half dozen years for neuroscience researchers to identify brain structures that do the same job in living organisms (Barry et al. 2006; Solstad et al. 2008; Berryhill and Olson 2009). Meanwhile, behavioral studies had already established that the brain seems to use structures on opposite sides of your head to process the concepts of “near” and “on” (Kosslyn 1989).



3. adjust the aura so that it automatically extends farther from an object in the direction it is moving, rather than recalculating those differences every time you update the scene (Moulin and Kettani 1999; Zender et al. 2008; for an exploration of the hypothesis that these differences may be mediated by sensations of head position in living animals, see Prado et al. 2005).

4. create a wider zone of potential influence in areas that are not known as well (in other words, act like careful drivers, who tend to slow down as they approach the crest of a hill or a blind curve). A number of studies show that this process has a strong influence on spatial memory; people tend to remember distances as significantly longer when they involve turns or other things that interfere with sight lines (Jansen-Osman and Wedenbauer 2004; for a more general review of spatial memory, see Newcombe et al. 1999; Hund et al. 2002).

This research on personal mobility is matched by a parallel series of investigations in psychology. These investigations trace their roots to the pioneering work of Jean Piaget, who posited that children started with an egocentric view of space and later learned how to use allocentric representations (ones that depend on other objects rather than your own body to help give meaning to concepts such as distance and direction). The modern consensus, however, is that the human brain has different areas that maintain different frames of reference more or less simultaneously (Woodin and Allport 1998; Postle and d'Esposito 2003; Committeri et al. 2004; Burgess 2008; but see Piccardi et al. 2014 for evidence that "near-space representation develops before far-space representation in children").

According to this consensus, Piaget was correct in noting that children do tend to use different frames of reference at different ages, but the difference is a result of selecting a frame of reference that is appropriate in a given activity space, rather than following a developmental sequence in innate cognition. As noted in Chapter 2, the debate about the primacy of egocentric and allocentric mental representations of personal space could be regarded as somewhat tangential to our real concerns about geographic space, <u>except</u> insofar as the same neural mechanisms might be recruited to perform particular kinds of spatial analysis even at radically different scales (Morgan et al. 2011).

This possibility is quite plausible with what we might call "aura-thinking" – the same kind of perceptions that govern our use of tools in our immediate surroundings (personal space) may also help us organize our impressions of relative influence over geographic space, e.g. in planning travel that might use different means of transportation, or in a military confrontation where we can choose between several weapons with different ranges of influence (see, e.g., Longo and Lourenco 2004).

Also at a geographic scale, the concept of an aura of influence was the basis for one of the first (and most influential) explorations in economic geography: Johann Heinrich von Thünen's pioneering study of the influence of a city on the use and value of surrounding land (Hall 1966 is the most widely cited English translation of this 19th-century German work). It would take another book of this size to do an adequate review of all of the studies that trace their roots to von Thünen's analysis. For example, some mid-20th century analysts tried to modify the von Thünen model in order to explain some of the details of land use close to the margin of a city (Sinclair 1967). Others tried to reconcile the land-rent model with other economic theories (Fujita and Thisse 1986). An internet search continues to provide examples of the recent range in interest in this "ancient" theory (e.g. Venables and Lima 2002; Sasaki and Box 2003; or Anglesen 2007; for a thoughtful exploration of some issues involved in using Thünen's ideas in a GIS environment, see Cromley and Hanink 2003).

The problem with closing this section by citing a powerful example like the von Thünen land-rent model is the implication that the concept of aura is primarily about the economic influence of point features. A recent compilation of GIS instructional materials provides a set of examples that do a good job of stretching the definition to include more diffuse kinds of influence, such as the well-known moderating effect of an ocean or lake on the climate of adjacent land (Malone et al. 2005 p 132). In a similar way, a military cartographer might make a buffer to show how far armies (or terrorists) from a country might be able to invade in a given period of time. See also the list in the general review above for other practical applications of this powerful way of organizing knowledge.

In short, the brain "contains multiple representations of space, appropriate to the demands of perception and action in near and far space" (Marshall and Fink 2001).

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

One obvious logical overlap is between the concepts of aura and region, especially if one defines an aura somewhat imprecisely as "the area that can be influenced by a feature in a particular location." The difference is primarily one of focus (and neurological apparatus!) If the focus is on the influence, e.g. by measuring its strength right next to the source and trying to assess how rapidly it decreases with distance, you are definitely thinking about a spatial aura. If, on the other hand, the focus is on the area, perhaps by trying to count the number of people or describe the characteristics of the area that is likely to feel the influence, then it is a region (a functional region, in the jargon of geographers – see Chapter 7).

The problem with the distinction noted above is that it raises the possibility of another kind of overlap between different modes of spatial thinking – a graph of declining influence with distance away from an object is clearly a kind of spatial transition (Chapter 8). If that graph is built from observations or measurements made in a sequence of locations at varying distances from the object, it is clearly a spatial transition and should engage the sequence-processing areas in the frontal lobe of the brain. If, on the other hand, the decrease of influence with distance is simply assumed, as some kind of general tendency, then the thinking is likely to engage only the boundary-extension areas in the back side of the brain. (Memo to brain-scanners: those are testable hypotheses, and we'd love to know the answers!)

It is also possible to confuse the ideas of aura and hierarchy, especially when looking at the hierarchy of central places in a state or country. In that hierarchy, the position of a small city is often described in terms of which larger city's "territory" it fits inside. That apparent overlap is not unique – we can also talk about a hierarchy of regions, or a hierarchy of spatial patterns, a hierarchy of spatial associations, and so forth. So be it. Our stock answer to this kind of observation is to repeat the idea that the various modes of spatial thinking are much like the different muscles that control your arm. Suppose your goal is to throw a crumpled piece of paper into a wastebasket across the room. To accomplish that task, you are likely to use a number of different muscles, each acting at different times and usually at different rates. Likewise, if the goal is to assess the relationship between a large city and a smaller town inside of its sphere of influence, you are likely to use a number of different modes of spatial thinking, of which aura analysis is only one.

In terms of applied geography, however, we should repeat that the idea of influence upon surrounding area has been deemed important enough that it has been called "the first law of geography! (see above).

Issues with language

Another complicating issue is the fact that different languages may "carve" space into different categories, depending on distance. English is the "poor relative" in this family –using only two terms, "here" and "there" or "this" and "that." Japanese has three disting categories: kono near speaker, sono near hearer, ano distal to both. Spanish has two separate groups of three: este near, ese mid, aquel far, and ahi, aqui and alla. Tlingit yaa the one right here, hei nearby, wee over there, yoo far away. CiBemba (a Bantu language) u-no next to speaker, u-yu closer to speaker, u-yoo equidistant, u-yo closer to hearer, u-lya far from both. Malagasy has seven terms, ety, eto, eo, etsy, eno, eroa, and ery (but this may be controversial – see Kemmerer 1999).

Issues with using a GIS to support thinking about spatial auras

Mindless use of a GIS can pose a big problem with analyzing a zone of influence; thoughtful use of a GIS can help solve that problem. The issue is the fact that the default "buffer" command in a typical GIS will usually define an area that extends the same distance in all directions from a designated point, line, or area. That, unfortunately, is not how the world works, even for relatively simple interactions such as noise or air pollution (see Eldridge and Jones 1991 for more examples).

In the case of air pollution from a point source, for example, it is certainly reasonable to assume that the pollution will decrease as you go away from the source. It is also reasonable to assume that the pollution will extend farther away from the source in the direction toward which the wind is blowing at the time of pollutant release. The GIS user, therefore, should adjust the command so that the buffer is non-symmetrical. (One of the best student projects that I ever read was done by a high-school student who simply walked away from an oil refinery in different directions and counted the number of different kinds of lichen growing on the bark of trees. The result was a superb map of influence, in the form of a gradual increase in diversity as you went away from a "lichen desert" that occupied about half a square mile near the refinery. This area of reduced diversity did, in fact, extend much farther to the east than to the west. The great thing about this project is that the student was able to make a useful map without even knowing the names of the lichens, although that kind of taxonomic information would have added more evidence to the study.)

In other cases, the extent of an aura depends in part on the nature of the land or people in its path. For example, a river is likely to flood different distances away from its bank, depending on the slope of the land in different directions. In this case, the GIS can be used to combine a layer of elevation data with the notion of a buffer around the stream, in order to come up with a better estimate of the at-risk area for floods.

In short, the key to using a GIS to help think about geographic auras is to resist doing what the GIS makes easy, namely to assign a buffer of uniform radius in all directions from a feature of interest! Look a little deeper into the menus, use the far more powerful tool of a multiple-ring buffer, and let that buffer interact with the conditions of the land to produce a more comprehensive view of the influence that one place is likely to have on its neighbors.

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