Cognitive Aspects of Gerrymandering

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On Gerrymandering

Peter Applebome's article "If at First You Don't Secede" (New York Times, November 26, 2000) is illustrated by a map of the United States displaying the distribution of votes after the 2000 Presidential Election. The country is visually neatly divided into a group of pro–Bush and a group of pro–Gore states: a quasi–connected Republican field is surrounded by a relatively sparse set of Democratic states. Looking at the map, one may be tempted to indulge in a secessionist fantasy. Still, Applebome says,

"Gerrymandering the Republican nation to take in the South and most of the Nation's heartland, the Great Plains and Rocky Mountain states, seems a piece of cake, but figuring out a contiguous Democratic map with the Northeast, Great Lakes states, California and Pacific Northwest might take a little work."

What is this "little work" that seems to make such an important difference between two types of geographical entities defined in exactly the same terms, a difference that makes us think that one of the two is not viable? Why is the absence of contiguity an obstacle to carving out a "Democratic nation"?

'Gerrymandering' is an interesting English term, created by merging the family name 'Gerry' and the noun 'salamander'. In 1812 Massachusetts governor Elbridge Gerry (1744–1814), one of the signers of the Declaration of independence, created an electoral district of such an intriguing shape that cartoonist Elkanah Tisdale caricatured it as a salamander.

Figure 1. The salamander district.

Drawing lines on a map can favor one party against another; gerrymandering can affect the outcome of an election. There are two aspects of gerrymandering. On the one hand, by redistricting one creates a safe majority for a friend candidate: it is sufficient to draw the lines of the district so as to encompass a majority of voters for the candidate. On the other hand, one dilutes an enemy candidate's voting pool: it is sufficient to draw the lines so that an area that votes massively for that candidate is divided and the resulting parts are

incorporated in different districts, in each of which the candidate has no majority.
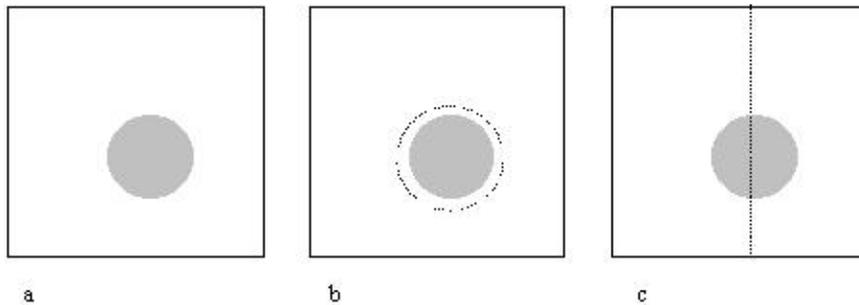

Figure 2. (a) The territorial distribution of votes for Ms. White and for Mr. Gray (an uniform population density is assumed). (b) Dividing the territory in two districts that will elect Ms. White and Mr. Gray respectively. (c) Dividing the territory in two districts that will both elect Ms. White. The way you divide up a district dramatically affect the outcome of the election.

The redistricting practice can be construed, under different circumstances, as an imperfection to be avoided or as a necessity to be encouraged. In both cases, it is often given some political justification.. Some of the arguments involve geometrical notions. One of the common criticisms is that the gerrymandered district is *oddly shaped*. The geographic monster of Fig. 1 was criticized because it favored the old Democratic–Republican party; but also because its shape looked so weird. There is, of course, a conceptual difference between political gerrymandering and geographical oddity. The districts in Fig. 2(c) are not particularly odd in the face of it, still under the circumstances they are a case of gerrymandering.

The Supreme Court of the United States repeatedly discusses implementations of redistricting that are open to the charge of shape oddity. Most famously, North Carolina's 12th Electoral District is long and skinny.

 A sentence of the Court, delivered by Justice O'Connor on June 28, 1993 (Shaw *vs*. Reno, No. 92–357), reads:

"The first of the two majority–black districts contained in the revised plan, District 1, is somewhat hook shaped. Centered in the northeast portion of the State, it moves southward until it tapers to a narrow band; then, with finger–like extensions, it reaches far into the southern– most part of the State near the South Carolina border. District 1 has been compared to a –Rorschach ink–blot test (...) and a –bug splattered on a windshield (...) The second majority–black district, District 12, is even more unusually shaped. It is approximately 160 miles long and, for much of its length, no wider than the I–85 corridor. It winds in snake–like fashion through tobacco country, financial centers, and manufacturing areas –until it gobbles in enough enclaves of black neighborhoods. (...) Northbound and southbound drivers on I–85 sometimes find themselves in separate districts in one county, only to –trade– districts when they enter the next county. Of the 10 counties through which District 12 passes, five are cut into three different districts; even towns are divided. At one point the district remains contiguous only because it intersects at a single point with two other districts before crossing over them. (...) One state legislator has remarked that –`[i]f you drove down the interstate with both car doors open, you'd kill most of the people in the district.' (...) The district even has inspired poetry: –Ask not for whom the line is drawn; it is drawn to avoid thee. (...)"

A later crucial passage in the Opinion is the following:

"In some exceptional cases, a reapportionment plan may be so highly irregular that, on its face, it rationally cannot be understood as anything other than an effort to segregate voters on the basis of race."

The reasoning behind this passage is that a very odd shape is suspect because it is *unlikely* that it has been chosen on grounds other than segregational.

This is a normative claim. It is a claim both about what counts as an odd shape and about the meaningfulness of odd shapes. The normative claim is understandable only insofar as we give a proper content to the notion of an "odd" shape and we can correctly assess the normalcy of non–odd shapes.

We do have, to be sure, an intuitive notion of what an odd shape is, when it comes to geographic entities; a notion that makes us consider a district such as the salamander district and North Carolina's 12th as oddly shaped, and a state such as Wyoming as non oddly shaped. However, this intuitive notion cannot be made into the general case. Oddity is measured against broader factors. These factors can overcome whatever measure of oddity we can come up with. Italy may be thought to have a very odd shape, but usually it is not considered as an oddly shaped country. However, if a U.S. Midwest state had the shape of Italy, it would be regarded as an oddly shaped state. An Italy–shaped country may be politically disturbing or acceptable depending on the surrounding context.

Let us test some other intuitions about oddity by looking at districts that are considered odd. North Carolina's 12th may be oddly shaped, but it is by no means the oddest district in the U.S. Washington's 1st and 7th districts are disconnected, in the way an archipelago is – there is a body of water between the various parts (water that does not appear to belong to any of these districts). Still, these districts may appear less acceptable than a real archipelago whose islands had the shapes of the district's parts, and more acceptable than a disconnected district whose parts are not separated by water, but by land. On the other hand, some electoral districts are allowed to have very odd shapes, provided some form of connection is preserved. And of course, if you have pieces that are far apart, and you try to keep them connected at all costs, you end up with a salamander. A very interesting salamander is Illinois' 4th district, "10 miles wide, running along railroad tracks, forest preserves, and cemeteries". A skinny piece of land unites two otherwise remote areas. But why not keep the two areas as pieces of a disconnected district? What prevents us to accept a district that is composed of two disconnected pieces?

Topological guidelines for redistricting

Connection is a topological notion. Intuitively, it can be characterized in the following way. Consider a region of space, and take any two points in that region. If there is a continuous path connecting the two points that never leaves the region, then the region is connected. Connection is often synonymous with 'contiguity' in geographic and legal language. Almost all States have geometrical and specifically topological requirements about redistricting (see Table 1). Many States insist that due respect be paid to natural and social factors. Almost all require that the territory of a district be *contiguous*. Most require that it furthermore be *compact*. Compactness, in the intended sense, is a metric property (not to be confused with a homonymous topological property), paradigmatically exemplified by round objects, or more generally by objects whose boundary approximates the lowest boundary–to–area ratio. The rule of thumb here is to consider objects whose length and width (suitably defined) are approximately the same. In general, the Constitutions of the various States allege that compactness is subordinate to contiguity. The possibility of being contiguous without being compact, and the impossibility of being compact without being contiguous, are taken for granted. Contiguity is at times restricted to exclude limit cases, at times broadened to allow for exceptions. For instance, on the one hand, Georgia considers as not contiguous areas which only meet at the points of adjoining corners, Maryland accepts contiguity by water, and so does Minnesota, with the proviso that water should not be "a serious obstacle to travel within the district". On the other hand, states like Hawaii obviously take the existence of separate islands for granted and require districts to be contiguous "except in the case of districts encompassing more than one island".

A quick look at Table 1 reveals a consistent bias towards contiguity. Now, *what is the ground for the bias towards contiguity?* The question has a normative flavor, and indeed it is meant to provide a base for discussing an explicitly normative question: *Should we accept contiguity (and geometric specifications as large) as a criterion for redistricting?*

The spatial distribution of properties

The context in which we are to judge these question is provided by the peculiarities of the mapping of voting distributions onto territories. These peculiarities are an instance of two, more general, issues.

First, There are many ways a property can be distributed over a geographic area. Some of the ways depend on high order features of the property. The property of *being a forest* allows for a uniform or "dissective" distribution; modulo a certain size, every forested area is a forested area. As a contrast, the property of being a lake is not dissective: not every part of a lake is a lake. But the property of being *part of a lake* is dissective again: every part of a part of a lake is also a part of a lake (this is a consequence of the transitivity of the part relation). The spatial distribution of a property depends upon the logical fine–grained characteristics of the property. In many cases, we are explicitly after dissective aspects in order to find a convenient mapping onto spatial territories. The reason for this is that territories are regions of space that are the very paradigm of a dissective structure: every part of a region of space is a region of space itself. If you color red a region on a map, you have thereby colored red all the parts of that region.

Second, there are limits to what can be conceived of as distributed over a territory, and hence representable on a map. The property of *having an income of $20,000 or more* cannot be *directly* mapped onto a territory, and be represented on a map. What can be represented is the property of *being an area the members of whose population earn $20,000 or more*.

Putting together these two constraints, we conclude that *averaged* properties are represented with implicit provisos as to their spatial distribution. The property of *being an area the members of whose population earn $20,000 on average* is not dissective: sub– areas of the interested area could host populations whose members average higher (or lower) incomes. Furthermore, properties that have a complex mode of space occupancy (among which are those that interest us here, such as the property of *being an area whose inhabitants all vote for candidate A*) raise some problems. How fine–grained is the mapping from a property to an area supposed to be? The property of *being an area whose inhabitants all vote for candidate A* is dissective by its very nature, but clearly it can pick out a very discontinuous area. The less restrictive property of *being an area some of whose inhabitants vote for candidate A* may pick out a less discontinuous area *a* but has the inconvenient of possibly applying to a sub–area of *a* most of whose inhabitants vote for candidate B.

Now, suppose that we set for a mapping of the *single* voter on "his" or "her" region of space. How is such an atomic voting region to be defined? One may assess the value of some alternatives, and here I shall only briefly discuss one. If we choose "real estate (or rented) area inhabited by a single voter" as the atomic political unit we risk ending up with tiny superposed areas in apartment blocks. But we also risk ending up with a patchwork distribution of tiny areas. We risk ending up with areas that host different voters (wife and husband who share their possessions and vote for different parties.) All this suggests that at the very basic level, the notion of a "one voter" area is not very well defined. As a consequence, we ought not to construe larger voters areas as *sums* of atomic voter areas. As a further consequence, if you create a district which satisfies the property of *being an area whose inhabitants all vote for candidate A* you deprive the notion of a district of its spatial meaning. There is nothing intrinsically spatial about a "district" that is defined in terms of a mere set of voters.

In the last section I raised the question, How are we to individuate the geographic unit that corresponds to a single voter? It may be argued that this is not a sensible question, given that it is averages that get mapped on areas, and not single voters. Still, the very problem of gerrymandering arises precisely because in some cases a question arises as to how we can map voters onto regions of space. And the type of the mapping (through dissective or non–dissective or variously qualified properties) has some bearing on the nature of the district

you end up with.

The bias towards contiguity and the island paradigm

Along with many other topological notions, contiguity/connection is one of the basic ingredients of human spatial representation. In visual perception, we parse the scene at the a very elementary level in maximal connected uniform regions (Palmer and Rock, 1994). And in conceptualization and language we favor objects that are self–connected. Most of the names for concrete items denote entities that are of a piece. Children's early vocabulary is strongly biased towards such names (Bloom 2000). There appears to be a bias towards connection as a criterion for objecthood in cognition at large. This bias finds its way into geographic conceptualization. It is part and parcel of what we may term the *island paradigm*, according to which each geographic unit (a nation, a region, a district) is ideally like an island in the sea.

What is so special about islands? First, they form a connected piece of land: two separate pieces of land surrounded by sea are not *one* island. Second, islands are maximal: a half–island is not an island. Third, an island's border is extremely salient. Crossing the border of the unit must be a physically engaging activity. Those who enter the island can be clearly identified as they approach. We know all too well what distinguishes the island from the surrounding environment: Outside the island there is only sea – whose main feature is that it is *something else* than the interior of the island.

These facts about islands make up a core theory of geography, whereby they assume normative status of constitutive principles. The core theory carries over to other types of unit. States and districts, one may think, are just like islands in many a respect. Not in all respects (they may be contiguous in space to each other in a way islands are not), but enough as to validate the analogy. They have a meaningful, if not salient, boundary; they are connected; and they are maximal.

It is interesting that where the geography includes real islands, criteria for drawing political units become compounded. So that the Hawaii Constitution, Article IV, Section 6, has it that district should be contiguous "except in the case of districts encompassing more than one island ".

The principle that underlie the island paradigm are given normative status and appear to be required for reasoning about or for making practical decisions about the allocation of space, but with what justification? The bias towards connection is far from sufficient as a rational ground for drawing connected districts. It is just a tendency to categorize as unitary those objects whose parts are not disconnected. In itself, this is just a description of a psychological regularity, whose normative implications are of little import. We would obtain a more interesting rational ground if we could show that the bias towards connection is criterial for some other interesting property of connected geographic areas.

Causality and space

In non–geographic conceptualization, connection may indeed be taken as criterial in many cases. Connection is an effective and reliable proxy for *causal unity*. Units of ecological significance are predominantly self–connected objects, such as animals, trees, stones. Bounded units, clearly demarcated by the perceptual environment because of the possibility of independent motion, are typically animals. Non–maximal connected units are typically parts of individuals and not full–blown individuals. It is quite plausible that cognition has evolved so as to interpret maximal connection as a reliable indication of the presence of an individual, and maximal connected boundedness as a reliable indication of the presence of an animal. This would explain the presence of the cognitive bias towards connection and boundedness.

We do have some means of detecting causal unity in the absence of connection, and causal disunity in the presence of connection. Whenever disconnected units, such as flocks of birds and schools of fish, are

ecologically significant, they usually display some form of coordinated movement. Conversely, whenever connection is not a good indicator of causal unity, as when people are tightly packed together in a metro car, sooner or later the scene will change and people, still remaining connected to each other, will appear to move independently form each other. However, it is often enough the case that boundaries and connection indicate that the main responsibility for an object's shape and movement are to be found more *within* the object than *outside* it.

If we extend this reasoning to geographic entities that conform to the island paradigm, we can easily come up with some properties that mimic the causal unity of connected objects. Political units (districts, nations) may be seen as *causal* units insofar as their territory is a playing field for exerting some form of (socially mediated) causality – be it be political control, free circulation of goods, accessibility by road, transfer of electric power, and so on.

Moreover, it is clear that (*ceteris paribus*) *some shapes serve causal transmission better than others*. In a flat country, a round state will be easily managed from its geometric center. Goods can reach faraway parts of the state more effectively. Resources can be allocated more rationally: A disconnected state would need to maintain a different fire brigade in each of its disconnected parts. And a long and skinny state would be more difficult to protect against external threats than a compact state, whose boundary approximates the lowest boundary−to−area ratio. Some constitutions explicitly relate district shape to these non−spatial factors. For instance, districting in South Dakota ought to ensure "protection of socioeconomic relationship by means of compact and contiguous districts."

However, much as contiguity and compactness may ensure or enforce protection of socioeconomic relationship, they are not, *per se*, correlated with the existence of such relationships. Here we see the reason for the *ceteris paribus* clause of the previous section. In different geographic contexts, the same shapes can serve very different causal purposes. A continuous and compact area may straddle two sides of a mountain range inhabited by two populations, one on each side. These populations may have little or no contacts with each other. A long a skinny state may be built along a river, that ensures causal transmission. And two or more islands can be united by commercial links or strategic position (Malta and Cyprus on the route from Gilbratar to Suez.)

We should conclude that the cognitive grounds for the bias towards connection cannot be turned automatically into reasons for the island paradigm. And we can see an immediate consequence for gerrymandering by the creation of "odd" shapes. The insistence on connection when the principle of unity is not related to space appears idle. Political power is assumed not to travel, in Illinois' 4th district, through cemeteries and railroad tracks, nor to fly over water on Washington's 1st district (that crosses Puget Sound, with no ferry or bridge connection). The only *raison d'être* of the district seems to be related to electoral matters.

Actually, political power and control is only one part of what makes a geographic unit an unit. Take *families whose members, for whatever reason, live in noncontiguous states*. It is constitutive of the hypothetical Association of Divided Families that their members do not live in the same place. If one were map the territory of the community formed by families living in noncontiguous states, one could not by definition come up with a contiguous district. Should we entitle these families with a political representation, we would have to gerrymander the territory of the U.S. in an extremely complex way.

Conclusions

I have argued that geographic conceptualization is prone to endorse the *island paradigm*. The island paradigm incorporates a bias towards connectedness (in addition to maximality and boundedness) in our conception of an acceptable political unit. It models geographical units on the prototypical geographical proxy of an island. Why is connection so important? As the island paradigm makes clear, connection is not just a spatially meaningful notion. It is also a *causally* meaningful notion. Less clear are the reason for keeping connection in the geographic domain at all costs, in particular at the cost of creating salamander districts. Salamanders are born for two reasons: the political desire to dilute or concentrate votes, and the independent desire to keep the district connected. But the first desire can be served quite independently of the second.

And, as a matter of fact, an even farther reaching argument may be put forward as to the *irrelevance of districts*.

"Gerrymandered" is a relative notion. In order to decide whether a certain district is the result of gerrymandering, one has to take into account the voters' distribution over a *larger* area than the area of the district under study. For if *per hypothesis* only a lone district existed, then it could not be gerrymandered, no matter how oddly shaped it is. Herein lies a deep conceptual problem – not with gerrymandering, but with the very notion of a district. If political representation of an area A is decided by electing candidates in sub–areas of A, the distribution of elected candidates may well turn out not to correspond to the distribution of voters in A. If one wishes to make those two distributions correspond, then one is most likely forced to draw districts in an *ad hoc* manner. For it is extremely unlikely that a generic partition of A into sub–areas turns out to allow the election of a slate of candidates that exactly matches the overall distribution of votes. And the more the distribution of votes in A is uniform on the territory, the less likely the match (if each single district has a 80–20 split, then the overall vote will yield a 100–0 split.) Under the assumption that a match is to be preserved, one should rather not draw districts altogether.

References

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Table 1

Criteria adopted by the Constitutions of the U.S. states as to geometric properties of electoral districts (with excerpts.)

Alabama	Contiguous and reasonably compact.
Alaska	Contiguous and compact territory
Arizona	Contiguous and reasonably compact

Arkansas	No special provisos
California	Contiguous
Colorado	Contiguous
Connecticut	Contiguous
Delaware	Contiguous; bounded by major roads, streams or other natural boundaries
District of Columbia	No special provisos
Florida	Contiguous
Georgia	Contiguous
Hawaii	"Except in the case of districts encompassing more than one island, districts shall be contiguous... Insofar as practicable, districts shall be compact... Where possible, district lines shall follow permanent and easily recognized features, such as streets, streams and clear geographical features, and, when practicable, shall coincide with census tract boundaries."
Idaho:	Contiguous, and "to the maximum extent possible, the plan should avoid drawing districts that are oddly shaped"
Illinois	Contiguous and compact
Indiana	Contiguous
Iowa	Compact and contiguous "3. Districts shall be composed of convenient contiguous territory. Areas which meet only at the points of adjoining corners are not contiguous. 4. It is preferable that districts be compact in form, but the standards established by subsections 1, 2 and 3 take precedence over compactness where a conflict arises between compactness and these standards. In general, compact districts are those which are square, rectangular or hexagonal in shape to the extent permitted by natural or political boundaries. When it is necessary to compare the relative compactness of two or more

	districts, or of two or more alternative districting plans, the tests prescribed by paragraphs
	"b" and "c" of this subsection shall be used. Should the results of these two tests be
	contradictory, the standard referred to in paragraph "b" of this subsection shall be given greater weight than the standard referred to in paragraph "c" of this subsection."
	" b. The compactness of a district is greatest when the length of the district and the width
	of the district are equal. The measure of a district's compactness is the absolute value of
	the difference between the length and the width of the district."
Kansas	as compact as possible and contiguous. " 9. Districts should be easily identifiable and understandable by voters. "
Kentucky	Contiguous
Louisiana	Contiguous and compact
Maine	Contiguous and compact
Maryland	"C. Contiguity. The territory of each legislative district should be contiguous. Although not legally or constitutionally required, Congressional districts, to the extent possible, should be contiguous including contiguity by water. D. Compactness. To the extent permitted by other controlling considerations and by the geographical Configuration of the State, the subdivisions, and election precincts, each legislative district Should be compact in form. Although not legally or constitutionally required, Congressional districts, to the extent possible, should be compact. To the extent possible, recognition may also be given to prior legislative boundaries."
Massachusetts	Contiguous and compact

Michigan	"contiguous, and as nearly uniform in shape as possible"
Minnesota	Contiguous. " Contiguity by water is sufficient if the water is not a serious obstacle to travel within the district. "
Mississippi	Contiguous and compact
Missouri	Contiguous territory "as compact as may be"
Montana	Contiguous and compact
Nebraska	Contiguous and compact
Nevada	Contiguous and "reasonably compact"
New Hampshire	No special provisos
New Jersey	"contiguous territory, as nearly compact... as possible "
New Mexico	Contiguous and "as compact as is practical and possible"
New York	Contiguous
North Carolina	Contiguous. (Not requiring compactness seems to allow for the oddity of the 12th congressional district. The Senate Committee Report, May 21, 1998, explicitly asks to "Eliminate the constitutional defects in the 12th Congressional District".
North Dakota	Contiguous and compact
Ohio	Contiguous and compact "and the boundary of each district shall be a single nonintersecting continuous line. "
Oklahoma	Contiguous and compact
Oregon	Contiguous, and "connected by transportation links"
Pennsylvania	Contiguous and compact
Rhode Island	Contiguous and "as compact as possible".
South Carolina	Contiguous and compact. "III. Contiguity

All legislative and congressional districts will be composed of contiguous geography.

Contiguity by water is acceptable to link territory within a district provided that there is a

reasonable opportunity to travel within the district and the linkage is designed to meet the

other criteria stated herein.

VIII. Compactness

Scrutiny of the compactness of districts has heightened under recent judicial decisions

which have invalidated or criticized majority–minority districts that were the result of

racial gerrymandering and were not narrowly tailored to satisfy a compelling state interest.

In determining the relative compactness of a district, consideration should be given to

overall geographical and demographic compactness.

A. As a first level of inquiry, a district's compactness may be determined by considering

its appearance and the area of dispersal of the district. This should include a

mathematical analysis of:

1. how round, square, long, or wide the district is (round or square being preferable to

long or wide);

2. how similar and regular the sides of the district are; and

3. how regularly the population is distributed within the district (where the people are

within and just outside the district and where the unpopulated areas are within the

district).

Irregular geographical boundaries and/or significant land areas with little or no population

may justify unequal district lines if such district lines follow a significant geographical

	feature or political subdivision boundary or must be drawn to include necessary
	population(s).
	B.1. Compactness also may be determined by an analysis of the function of the district.
	The district should be drawn to facilitate:
	a. enhanced communication between a representative and his constituents; and
	b. enhanced opportunity for voters to know their representative and the other voters he
	represents.
	2. Therefore, and in addition to a mathematical analysis of a district's compactness, a
	functional analysis may be undertaken to ensure that the compactness also reflects:
	a. utilization of historically defined political subdivisions as building blocks to ensure
	voter identity and efficient political mobilization;
	b. utilization of vernacularly insular regions so as to allow for the representation of
	common interest; and
	c. utilization of districts which facilitate a representative's capabilities to effectively and
	efficiently communicate with his constituents in cognizably media markets."
South Dakota	contiguous and compact. "Protection of socioeconomic relationship by means of compact and contiguous districts"
Tennessee	Contiguous " and contiguity by water is sufficient"
Texas	Contiguous
Utah	As contiguous and compact as practicable
Vermont	contiguous and compact
Virginia	contiguous and compact

	"C. Compactness. Districts shall be reasonably compact. Irregular district shapes may be justified because the district line follows a political subdivision boundary or significant geographic feature. D. Contiguity. Districts shall be composed of contiguous territory. Contiguity by water is acceptable to link territory within a district in order to meet the other criteria stated herein and provided that there is reasonable opportunity for travel within the district."
Washington	Contiguous and compact. " To the extent reasonable, each district shall contain contiguous territory, shall be compact and convenient, and shall be separated from adjoining districts by natural geographic barriers, artificial barriers, or political subdivision boundaries. " "(b) Districts should be composed of convenient, contiguous, and compact territory. Land areas may be deemed contiguous if they share a common land border or are Connected by a ferry, highway, bridge, or tunnel. Areas separated by geographical Boundaries or artificial barriers that prevent transportation within a district should not be Deemed contiguous."
Wisconsin	Contiguous and " be in as compact form as practicable "
West Virginia	Contiguous and compact
Wyoming	Contiguous, compact "and reflect a community of interest".

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"Gerrymandering the Republican nation to take in the South and most of the Nation's heartland, the Great Plains and Rocky Mountain states, seems a piece of cake, but figuring out a contiguous Democratic map with the Northeast, Great Lakes states, California and Pacific Northwest might take a little work."

What is this "little work" that seems to make such an important difference between two types of geographical entities defined in exactly the same terms, a difference that makes us think that one of the two is not viable? Why is the absence of contiguity an obstacle to carving out a "Democratic nation"?

'Gerrymandering' is an interesting English term, created by merging the family name 'Gerry' and the noun 'salamander'. In 1812 Massachusetts governor Elbridge Gerry (1744–1814), one of the signers of the Declaration of independence, created an electoral district of such an intriguing shape that cartoonist Elkanah Tisdale caricatured it as a salamander.

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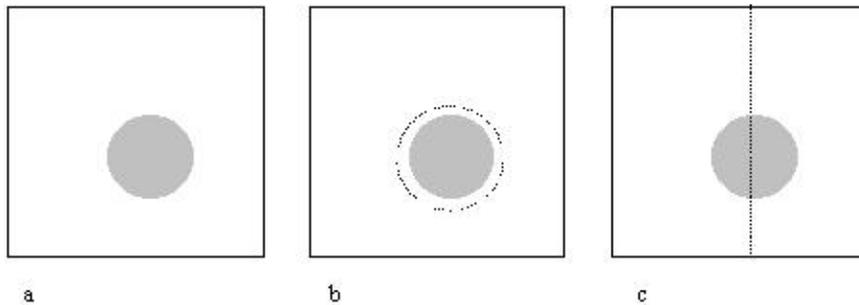

Figure 2. (a) The territorial distribution of votes for Ms. White and for Mr. Gray (an uniform population density is assumed). (b) Dividing the territory in two districts that will elect Ms. White and Mr. Gray respectively. (c) Dividing the territory in two districts that will both elect Ms. White. The way you divide up a district dramatically affect the outcome of the election.

The redistricting practice can be construed, under different circumstances, as an imperfection to be avoided or as a necessity to be encouraged. In both cases, it is often given some political justification.. Some of the arguments involve geometrical notions. One of the common criticisms is that the gerrymandered district is *oddly shaped*. The geographic monster of Fig. 1 was criticized because it favored the old Democratic–Republican party; but also because its shape looked so weird. There is, of course, a conceptual difference between political gerrymandering and geographical oddity. The districts in Fig. 2(c) are not particularly odd in the face of it, still under the circumstances they are a case of gerrymandering.

The Supreme Court of the United States repeatedly discusses implementations of redistricting that are open to the charge of shape oddity. Most famously, North Carolina's 12th Electoral District is long and skinny.

 A sentence of the Court, delivered by Justice O'Connor on June 28, 1993 (Shaw *vs*. Reno, No. 92–357), reads:

"The first of the two majority–black districts contained in the revised plan, District 1, is somewhat hook shaped. Centered in the northeast portion of the State, it moves southward until it tapers to a narrow band; then, with finger–like extensions, it reaches far into the southern– most part of the State near the South Carolina border. District 1 has been compared to a –Rorschach ink–blot test (...) and a –bug splattered on a windshield (...) The second majority–black district, District 12, is even more unusually shaped. It is approximately 160 miles long and, for much of its length, no wider than the I–85 corridor. It winds in snake–like fashion through tobacco country, financial centers, and manufacturing areas –until it gobbles in enough enclaves of black neighborhoods. (...) Northbound and southbound drivers on I–85 sometimes find themselves in separate districts in one county, only to –trade– districts when they enter the next county. Of the 10 counties through which District 12 passes, five are cut into three different districts; even towns are divided. At one point the district remains contiguous only because it intersects at a single point with two other districts before crossing over them. (...) One state legislator has remarked that –`[i]f you drove down the interstate with both car doors open, you'd kill most of the people in the district.' (...) The district even has inspired poetry: –Ask not for whom the line is drawn; it is drawn to avoid thee. (...)"

A later crucial passage in the Opinion is the following:

"In some exceptional cases, a reapportionment plan may be so highly irregular that, on its face, it rationally cannot be understood as anything other than an effort to segregate voters on the basis of race."

The reasoning behind this passage is that a very odd shape is suspect because it is *unlikely* that it has been chosen on grounds other than segregational.

This is a normative claim. It is a claim both about what counts as an odd shape and about the meaningfulness of odd shapes. The normative claim is understandable only insofar as we give a proper content to the notion of an "odd" shape and we can correctly assess the normalcy of non–odd shapes.

We do have, to be sure, an intuitive notion of what an odd shape is, when it comes to geographic entities; a notion that makes us consider a district such as the salamander district and North Carolina's 12th as oddly shaped, and a state such as Wyoming as non oddly shaped. However, this intuitive notion cannot be made into the general case. Oddity is measured against broader factors. These factors can overcome whatever measure of oddity we can come up with. Italy may be thought to have a very odd shape, but usually it is not considered as an oddly shaped country. However, if a U.S. Midwest state had the shape of Italy, it would be regarded as an oddly shaped state. An Italy–shaped country may be politically disturbing or acceptable depending on the surrounding context.

Let us test some other intuitions about oddity by looking at districts that are considered odd. North Carolina's 12th may be oddly shaped, but it is by no means the oddest district in the U.S. Washington's 1st and 7th districts are disconnected, in the way an archipelago is – there is a body of water between the various parts (water that does not appear to belong to any of these districts). Still, these districts may appear less acceptable than a real archipelago whose islands had the shapes of the district's parts, and more acceptable than a disconnected district whose parts are not separated by water, but by land. On the other hand, some electoral districts are allowed to have very odd shapes, provided some form of connection is preserved. And of course, if you have pieces that are far apart, and you try to keep them connected at all costs, you end up with a salamander. A very interesting salamander is Illinois' 4th district, "10 miles wide, running along railroad tracks, forest preserves, and cemeteries". A skinny piece of land unites two otherwise remote areas. But why not keep the two areas as pieces of a disconnected district? What prevents us to accept a district that is composed of two disconnected pieces?

Topological guidelines for redistricting

Connection is a topological notion. Intuitively, it can be characterized in the following way. Consider a region of space, and take any two points in that region. If there is a continuous path connecting the two points that never leaves the region, then the region is connected. Connection is often synonymous with 'contiguity' in geographic and legal language. Almost all States have geometrical and specifically topological requirements about redistricting (see Table 1). Many States insist that due respect be paid to natural and social factors. Almost all require that the territory of a district be *contiguous*. Most require that it furthermore be *compact*. Compactness, in the intended sense, is a metric property (not to be confused with a homonymous topological property), paradigmatically exemplified by round objects, or more generally by objects whose boundary approximates the lowest boundary–to–area ratio. The rule of thumb here is to consider objects whose length and width (suitably defined) are approximately the same. In general, the Constitutions of the various States allege that compactness is subordinate to contiguity. The possibility of being contiguous without being compact, and the impossibility of being compact without being contiguous, are taken for granted. Contiguity is at times restricted to exclude limit cases, at times broadened to allow for exceptions. For instance, on the one hand, Georgia considers as not contiguous areas which only meet at the points of adjoining corners, Maryland accepts contiguity by water, and so does Minnesota, with the proviso that water should not be "a serious obstacle to travel within the district". On the other hand, states like Hawaii obviously take the existence of separate islands for granted and require districts to be contiguous "except in the case of districts encompassing more than one island".

A quick look at Table 1 reveals a consistent bias towards contiguity. Now, *what is the ground for the bias towards contiguity?* The question has a normative flavor, and indeed it is meant to provide a base for discussing an explicitly normative question: *Should we accept contiguity (and geometric specifications as large) as a criterion for redistricting?*

The spatial distribution of properties

The context in which we are to judge these question is provided by the peculiarities of the mapping of voting distributions onto territories. These peculiarities are an instance of two, more general, issues.

First, There are many ways a property can be distributed over a geographic area. Some of the ways depend on high order features of the property. The property of *being a forest* allows for a uniform or "dissective" distribution; modulo a certain size, every forested area is a forested area. As a contrast, the property of being a lake is not dissective: not every part of a lake is a lake. But the property of being *part of a lake* is dissective again: every part of a part of a lake is also a part of a lake (this is a consequence of the transitivity of the part relation). The spatial distribution of a property depends upon the logical fine–grained characteristics of the property. In many cases, we are explicitly after dissective aspects in order to find a convenient mapping onto spatial territories. The reason for this is that territories are regions of space that are the very paradigm of a dissective structure: every part of a region of space is a region of space itself. If you color red a region on a map, you have thereby colored red all the parts of that region.

Second, there are limits to what can be conceived of as distributed over a territory, and hence representable on a map. The property of *having an income of $20,000 or more* cannot be *directly* mapped onto a territory, and be represented on a map. What can be represented is the property of *being an area the members of whose population earn $20,000 or more*.

Putting together these two constraints, we conclude that *averaged* properties are represented with implicit provisos as to their spatial distribution. The property of *being an area the members of whose population earn $20,000 on average* is not dissective: sub– areas of the interested area could host populations whose members average higher (or lower) incomes. Furthermore, properties that have a complex mode of space occupancy (among which are those that interest us here, such as the property of *being an area whose inhabitants all vote for candidate A*) raise some problems. How fine–grained is the mapping from a property to an area supposed to be? The property of *being an area whose inhabitants all vote for candidate A* is dissective by its very nature, but clearly it can pick out a very discontinuous area. The less restrictive property of *being an area some of whose inhabitants vote for candidate A* may pick out a less discontinuous area *a* but has the inconvenient of possibly applying to a sub–area of *a* most of whose inhabitants vote for candidate B.

Now, suppose that we set for a mapping of the *single* voter on "his" or "her" region of space. How is such an atomic voting region to be defined? One may assess the value of some alternatives, and here I shall only briefly discuss one. If we choose "real estate (or rented) area inhabited by a single voter" as the atomic political unit we risk ending up with tiny superposed areas in apartment blocks. But we also risk ending up with a patchwork distribution of tiny areas. We risk ending up with areas that host different voters (wife and husband who share their possessions and vote for different parties.) All this suggests that at the very basic level, the notion of a "one voter" area is not very well defined. As a consequence, we ought not to construe larger voters areas as *sums* of atomic voter areas. As a further consequence, if you create a district which satisfies the property of *being an area whose inhabitants all vote for candidate A* you deprive the notion of a district of its spatial meaning. There is nothing intrinsically spatial about a "district" that is defined in terms of a mere set of voters.

In the last section I raised the question, How are we to individuate the geographic unit that corresponds to a single voter? It may be argued that this is not a sensible question, given that it is averages that get mapped on areas, and not single voters. Still, the very problem of gerrymandering arises precisely because in some cases a question arises as to how we can map voters onto regions of space. And the type of the mapping (through dissective or non–dissective or variously qualified properties) has some bearing on the nature of the district

you end up with.

The bias towards contiguity and the island paradigm

Along with many other topological notions, contiguity/connection is one of the basic ingredients of human spatial representation. In visual perception, we parse the scene at the a very elementary level in maximal connected uniform regions (Palmer and Rock, 1994). And in conceptualization and language we favor objects that are self–connected. Most of the names for concrete items denote entities that are of a piece. Children's early vocabulary is strongly biased towards such names (Bloom 2000). There appears to be a bias towards connection as a criterion for objecthood in cognition at large. This bias finds its way into geographic conceptualization. It is part and parcel of what we may term the *island paradigm*, according to which each geographic unit (a nation, a region, a district) is ideally like an island in the sea.

What is so special about islands? First, they form a connected piece of land: two separate pieces of land surrounded by sea are not *one* island. Second, islands are maximal: a half–island is not an island. Third, an island's border is extremely salient. Crossing the border of the unit must be a physically engaging activity. Those who enter the island can be clearly identified as they approach. We know all too well what distinguishes the island from the surrounding environment: Outside the island there is only sea – whose main feature is that it is *something else* than the interior of the island.

These facts about islands make up a core theory of geography, whereby they assume normative status of constitutive principles. The core theory carries over to other types of unit. States and districts, one may think, are just like islands in many a respect. Not in all respects (they may be contiguous in space to each other in a way islands are not), but enough as to validate the analogy. They have a meaningful, if not salient, boundary; they are connected; and they are maximal.

It is interesting that where the geography includes real islands, criteria for drawing political units become compounded. So that the Hawaii Constitution, Article IV, Section 6, has it that district should be contiguous "except in the case of districts encompassing more than one island ".

The principle that underlie the island paradigm are given normative status and appear to be required for reasoning about or for making practical decisions about the allocation of space, but with what justification? The bias towards connection is far from sufficient as a rational ground for drawing connected districts. It is just a tendency to categorize as unitary those objects whose parts are not disconnected. In itself, this is just a description of a psychological regularity, whose normative implications are of little import. We would obtain a more interesting rational ground if we could show that the bias towards connection is criterial for some other interesting property of connected geographic areas.

Causality and space

In non–geographic conceptualization, connection may indeed be taken as criterial in many cases. Connection is an effective and reliable proxy for *causal unity*. Units of ecological significance are predominantly self–connected objects, such as animals, trees, stones. Bounded units, clearly demarcated by the perceptual environment because of the possibility of independent motion, are typically animals. Non–maximal connected units are typically parts of individuals and not full–blown individuals. It is quite plausible that cognition has evolved so as to interpret maximal connection as a reliable indication of the presence of an individual, and maximal connected boundedness as a reliable indication of the presence of an animal. This would explain the presence of the cognitive bias towards connection and boundedness.

We do have some means of detecting causal unity in the absence of connection, and causal disunity in the presence of connection. Whenever disconnected units, such as flocks of birds and schools of fish, are

ecologically significant, they usually display some form of coordinated movement. Conversely, whenever connection is not a good indicator of causal unity, as when people are tightly packed together in a metro car, sooner or later the scene will change and people, still remaining connected to each other, will appear to move independently form each other. However, it is often enough the case that boundaries and connection indicate that the main responsibility for an object's shape and movement are to be found more *within* the object than *outside* it.

If we extend this reasoning to geographic entities that conform to the island paradigm, we can easily come up with some properties that mimic the causal unity of connected objects. Political units (districts, nations) may be seen as *causal* units insofar as their territory is a playing field for exerting some form of (socially mediated) causality – be it be political control, free circulation of goods, accessibility by road, transfer of electric power, and so on.

Moreover, it is clear that (*ceteris paribus*) *some shapes serve causal transmission better than others*. In a flat country, a round state will be easily managed from its geometric center. Goods can reach faraway parts of the state more effectively. Resources can be allocated more rationally: A disconnected state would need to maintain a different fire brigade in each of its disconnected parts. And a long and skinny state would be more difficult to protect against external threats than a compact state, whose boundary approximates the lowest boundary–to–area ratio. Some constitutions explicitly relate district shape to these non–spatial factors. For instance, districting in South Dakota ought to ensure "protection of socioeconomic relationship by means of compact and contiguous districts."

However, much as contiguity and compactness may ensure or enforce protection of socioeconomic relationship, they are not, *per se*, correlated with the existence of such relationships. Here we see the reason for the *ceteris paribus* clause of the previous section. In different geographic contexts, the same shapes can serve very different causal purposes. A continuous and compact area may straddle two sides of a mountain range inhabited by two populations, one on each side. These populations may have little or no contacts with each other. A long a skinny state may be built along a river, that ensures causal transmission. And two or more islands can be united by commercial links or strategic position (Malta and Cyprus on the route from Gilbratar to Suez.)

We should conclude that the cognitive grounds for the bias towards connection cannot be turned automatically into reasons for the island paradigm. And we can see an immediate consequence for gerrymandering by the creation of "odd" shapes. The insistence on connection when the principle of unity is not related to space appears idle. Political power is assumed not to travel, in Illinois' 4th district, through cemeteries and railroad tracks, nor to fly over water on Washington's 1st district (that crosses Puget Sound, with no ferry or bridge connection). The only *raison d'être* of the district seems to be related to electoral matters.

Actually, political power and control is only one part of what makes a geographic unit an unit. Take *families whose members, for whatever reason, live in noncontiguous states*. It is constitutive of the hypothetical Association of Divided Families that their members do not live in the same place. If one were map the territory of the community formed by families living in noncontiguous states, one could not by definition come up with a contiguous district. Should we entitle these families with a political representation, we would have to gerrymander the territory of the U.S. in an extremely complex way.

Conclusions

I have argued that geographic conceptualization is prone to endorse the *island paradigm*. The island paradigm incorporates a bias towards connectedness (in addition to maximality and boundedness) in our conception of an acceptable political unit. It models geographical units on the prototypical geographical proxy of an island. Why is connection so important? As the island paradigm makes clear, connection is not just a spatially meaningful notion. It is also a *causally* meaningful notion. Less clear are the reason for keeping connection in the geographic domain at all costs, in particular at the cost of creating salamander districts. Salamanders are born for two reasons: the political desire to dilute or concentrate votes, and the independent desire to keep the district connected. But the first desire can be served quite independently of the second.

And, as a matter of fact, an even farther reaching argument may be put forward as to the *irrelevance of districts*.

"Gerrymandered" is a relative notion. In order to decide whether a certain district is the result of gerrymandering, one has to take into account the voters' distribution over a *larger* area than the area of the district under study. For if *per hypothesis* only a lone district existed, then it could not be gerrymandered, no matter how oddly shaped it is. Herein lies a deep conceptual problem – not with gerrymandering, but with the very notion of a district. If political representation of an area A is decided by electing candidates in sub–areas of A, the distribution of elected candidates may well turn out not to correspond to the distribution of voters in A. If one wishes to make those two distributions correspond, then one is most likely forced to draw districts in an *ad hoc* manner. For it is extremely unlikely that a generic partition of A into sub–areas turns out to allow the election of a slate of candidates that exactly matches the overall distribution of votes. And the more the distribution of votes in A is uniform on the territory, the less likely the match (if each single district has a 80–20 split, then the overall vote will yield a 100–0 split.) Under the assumption that a match is to be preserved, one should rather not draw districts altogether.

References

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Table 1

Criteria adopted by the Constitutions of the U.S. states as to geometric properties of electoral districts (with excerpts.)

Alabama	Contiguous and reasonably compact.
Alaska	Contiguous and compact territory
Arizona	Contiguous and reasonably compact

Arkansas	No special provisos
California	Contiguous
Colorado	Contiguous
Connecticut	Contiguous
Delaware	Contiguous; bounded by major roads, streams or other natural boundaries
District of Columbia	No special provisos
Florida	Contiguous
Georgia	Contiguous
Hawaii	"Except in the case of districts encompassing more than one island, districts shall be contiguous... Insofar as practicable, districts shall be compact... Where possible, district lines shall follow permanent and easily recognized features, such as streets, streams and clear geographical features, and, when practicable, shall coincide with census tract boundaries."
Idaho:	Contiguous, and "to the maximum extent possible, the plan should avoid drawing districts that are oddly shaped"
Illinois	Contiguous and compact
Indiana	Contiguous
Iowa	Compact and contiguous "3. Districts shall be composed of convenient contiguous territory. Areas which meet only at the points of adjoining corners are not contiguous. 4. It is preferable that districts be compact in form, but the standards established by subsections 1, 2 and 3 take precedence over compactness where a conflict arises between compactness and these standards. In general, compact districts are those which are square, rectangular or hexagonal in shape to the extent permitted by natural or political boundaries. When it is necessary to compare the relative compactness of two or more

	districts, or of two or more alternative districting plans, the tests prescribed by paragraphs "b" and "c" of this subsection shall be used. Should the results of these two tests be contradictory, the standard referred to in paragraph "b" of this subsection shall be given greater weight than the standard referred to in paragraph "c" of this subsection." " b. The compactness of a district is greatest when the length of the district and the width of the district are equal. The measure of a district's compactness is the absolute value of the difference between the length and the width of the district."
Kansas	as compact as possible and contiguous. " 9. Districts should be easily identifiable and understandable by voters. "
Kentucky	Contiguous
Louisiana	Contiguous and compact
Maine	Contiguous and compact
Maryland	"C. Contiguity. The territory of each legislative district should be contiguous. Although not legally or constitutionally required, Congressional districts, to the extent possible, should be contiguous including contiguity by water. D. Compactness. To the extent permitted by other controlling considerations and by the geographical Configuration of the State, the subdivisions, and election precincts, each legislative district Should be compact in form. Although not legally or constitutionally required, Congressional districts, to the extent possible, should be compact. To the extent possible, recognition may also be given to prior legislative boundaries."
Massachusetts	Contiguous and compact

Michigan	"contiguous, and as nearly uniform in shape as possible"
Minnesota	Contiguous. " Contiguity by water is sufficient if the water is not a serious obstacle to travel within the district. "
Mississippi	Contiguous and compact
Missouri	Contiguous territory "as compact as may be"
Montana	Contiguous and compact
Nebraska	Contiguous and compact
Nevada	Contiguous and "reasonably compact"
New Hampshire	No special provisos
New Jersey	"contiguous territory, as nearly compact... as possible "
New Mexico	Contiguous and "as compact as is practical and possible"
New York	Contiguous
North Carolina	Contiguous. (Not requiring compactness seems to allow for the oddity of the 12th congressional district. The Senate Committee Report, May 21, 1998, explicitly asks to "Eliminate the constitutional defects in the 12th Congressional District".
North Dakota	Contiguous and compact
Ohio	Contiguous and compact "and the boundary of each district shall be a single nonintersecting continuous line. "
Oklahoma	Contiguous and compact
Oregon	Contiguous, and "connected by transportation links"
Pennsylvania	Contiguous and compact
Rhode Island	Contiguous and "as compact as possible".
South Carolina	Contiguous and compact. "III. Contiguity

All legislative and congressional districts will be composed of contiguous geography.

Contiguity by water is acceptable to link territory within a district provided that there is a

reasonable opportunity to travel within the district and the linkage is designed to meet the

other criteria stated herein.

VIII. Compactness

Scrutiny of the compactness of districts has heightened under recent judicial decisions

which have invalidated or criticized majority–minority districts that were the result of

racial gerrymandering and were not narrowly tailored to satisfy a compelling state interest.

In determining the relative compactness of a district, consideration should be given to

overall geographical and demographic compactness.

A. As a first level of inquiry, a district's compactness may be determined by considering

its appearance and the area of dispersal of the district. This should include a

mathematical analysis of:

1. how round, square, long, or wide the district is (round or square being preferable to

long or wide);

2. how similar and regular the sides of the district are; and

3. how regularly the population is distributed within the district (where the people are

within and just outside the district and where the unpopulated areas are within the

district).

Irregular geographical boundaries and/or significant land areas with little or no population

may justify unequal district lines if such district lines follow a significant geographical

	feature or political subdivision boundary or must be drawn to include necessary
	population(s).
	B.1. Compactness also may be determined by an analysis of the function of the district.
	The district should be drawn to facilitate:
	a. enhanced communication between a representative and his constituents; and
	b. enhanced opportunity for voters to know their representative and the other voters he
	represents.
	2. Therefore, and in addition to a mathematical analysis of a district's compactness, a
	functional analysis may be undertaken to ensure that the compactness also reflects:
	a. utilization of historically defined political subdivisions as building blocks to ensure
	voter identity and efficient political mobilization;
	b. utilization of vernacularly insular regions so as to allow for the representation of
	common interest; and
	c. utilization of districts which facilitate a representative's capabilities to effectively and
	efficiently communicate with his constituents in cognizably media markets."
South Dakota	contiguous and compact. "Protection of socioeconomic relationship by means of compact and contiguous districts"
Tennessee	Contiguous " and contiguity by water is sufficient"
Texas	Contiguous
Utah	As contiguous and compact as practicable
Vermont	contiguous and compact
Virginia	contiguous and compact

	"C. Compactness. Districts shall be reasonably compact. Irregular district shapes may be justified because the district line follows a political subdivision boundary or significant geographic feature. D. Contiguity. Districts shall be composed of contiguous territory. Contiguity by water is acceptable to link territory within a district in order to meet the other criteria stated herein and provided that there is reasonable opportunity for travel within the district."
Washington	Contiguous and compact. " To the extent reasonable, each district shall contain contiguous territory, shall be compact and convenient, and shall be separated from adjoining districts by natural geographic barriers, artificial barriers, or political subdivision boundaries. " "(b) Districts should be composed of convenient, contiguous, and compact territory. Land areas may be deemed contiguous if they share a common land border or are Connected by a ferry, highway, bridge, or tunnel. Areas separated by geographical Boundaries or artificial barriers that prevent transportation within a district should not be Deemed contiguous."
Wisconsin	Contiguous and " be in as compact form as practicable "
West Virginia	Contiguous and compact
Wyoming	Contiguous, compact "and reflect a community of interest".