3.A. Settlement Scalar Thresholds
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In this section, I deal with "scalar thresholds:" how big can human groups get before X or Y happens? And why? Scalar thresholds have been recognized for decades; they are of interest to a wide range of disciplines from philosophy to AI. They have a checkered past in American archaeology. Scalar issues were a small but significant theme in New and processual archaeologies. (Indeed, scalar issues – "packing densities" – were central to Lewis Binford's last book, 2001's *Constructing Frames of Reference*.) Today – and rather curiously – rear-guard processualists dismiss "magic numbers" (REFS). Post-processualists of course dismiss numerical thresholds as reductionist, under-nuanced, scientific … whatever. For an excellent critical review, see philosopher Benoit Dubreuil's (2010) *Human Evolution and the Origins of Hierarchies*.

Back to the future! Despite the unpopularity of thresholds and "magic numbers", I think Southwestern archaeology can ally with evolutionary cognitive science and complexity science (discussed below) to perhaps resolve scalar threshold issues – "resolve" as: to make clearer; not as: to solve.

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The ancient Southwest offers remarkably useful data for the study of scalar thresholds, particularly of communities or settlements (I'll use the two terms interchangeably; for recent reviews, see Kolb and Snead 1997; REFS). "Community" means the settlement of potential daily, face-to-face interaction. Community does not mean you have to see everyone, every day; rather, there's the possibility of interaction between and among everyone, every day. I'll return to the Southwest's particular charms for this problem at the end of this essay. First, the problem and its solution; then, how that solution connects with larger intellectual issues; then, back to the Southwest to apply the solution.

Here's the specific problem: how big can a community get before it requires governance – specifically, centralized, formal, institutional, hierarchical governance? Cross-cultural studies by me and Kristina Kosse suggest that a hard threshold exists at about 2,500 people. Kosse and I both worked with permanent, independent, single-settlement societies. Permanence is important: It's quite possible for very large aggregations of people to exist briefly – as Col. Custer discovered to his dismay at Little Bighorn.

The actual value varies of course a few hundred people either side of 2,500 – all figures in this essay should be understood as approximate, not absolute. That is, if a permanent settlement or community exceeds (approximately) 2,500 people, it almost always will have permanent, institutional, centralized, hierarchical governance: a chieftain, a mayor, a king, whatever. (Exceptions are discussed below.)

Conversely, some small settlements had kings, chiefs, head honchos. In our cross-cultural analyses, some settlements as small as 500 had governance (but most that size did not), while all settlements of 2,500 or more had governance. So: 2,500 is not necessary, but it is sufficient – and that's important. Settlements with elaborate governance and less than 2,500 people will reappear towards the end of this essay. They are one of the Southwest's particular charm.

I've taken to calling [>2,500 = governance] the "Kosse-Lekson rule" or K-L rule because our two analyses converged and agreed, independently. We did this work at the same time and place: the University of New Mexico in the 1970s. Thanks to Lewis Binford, UNM was a hot bed for this kind of research. Kosse and I were peripheral to the department – she in Maxwell Museum, me in the National Park Service – so Kosse and I were ignorant of each other's research until a third party introduced us. Thus, our work was independent, and – very happily – we reached the same conclusions, which makes me think it might be real.

I published first, but Kosse published better. My work appeared in a student journal (Lekson 1985), in an unpublished dissertation (Lekson 1988) and in a chapter in an obscure volume on vernacular architecture (Lekson 1990—material developed in the early 1980s). Kosse's work was more broadly published (Kosse 1990, 1996, 2000) – appropriately, I think, because her methods were more rigorous and her goals were broader than mine.

(My next contribution to the matter was merely enabling: I organized a session on "Geographic and Demographic Scale" at the 1992 Southwest Symposium, with papers by Kosse, Michael Adler, Suzanne Fish and me (published in Fish and Reid 1996). I revisited both emergent order and the K-L rule in *Chaco Meridian* [Lekson 1999:161-165] – a discussion strangely ignored in almost all recent southwestern discussions of scalar thresholds.)

Kosse and I were certainly not the first to explore the relationship of community/ settlement size and socio-political complexity. In various forms, that correlation has occupied social sciences at least as far back as Naroll (1956), Ember (1963), and Caneiro (1967). Carniero (1967:239; cited in Johnson 1982:390) noted that: "…if a society does increase significantly in size, and if at the same time it remains unified and integrated, it must elaborate its organization." Current interest within American archaeology can be traced from Flannery (1972:423) through Wright (1977) and Johnson (1978, 1982; Wright and Johnson 1975) to Kosse and Lekson, and most recently, Binford (REFS), Feinman (2011). Again, see Dubreuil (2010) for an excellent critical review.

Clive Gamble (1998:436) noted that "interestingly, Bernard and Killworth's sociometric study (1973:183) produced a figure of 2,460 as the maximum group size which has some stability without a formalized hierarchy governing interaction." Bernard, H. Russell and Peter D. Killworth (1973) reached that

figure by beginning with the Rule of Six – or in their case, seven – described below.

The K-L rule gives us a good indicator of political complexity in archaeological situations and I was happy to use it as a tool to understand the ancient past. At the time, I suggested that some sort of mental "hard wiring" – what has been called "social channel capacity" – might underlie the K-L rule, but I didn't pursue that line of thought. Kosse took it further, and theorized that the 2,500 limit was some sort of cognitive threshold or tipping-point: in a community of that size, people's brains overloaded and they required new levels of socio-political structure for things to work.

Kosse explored the emergent order of complexity theory – specifically the work of Stuart Kauffman (Kauffman 1991, 1993, 1995) at the Santa Fe Institute on emergent order or self-organization – "order for free" that developed from underlying principles (which could be described mathematically) within a field of agents or entities which were otherwise non- or minimally ordered (think also of Ilya Priogene REFS and Per Bak REFS).

(Binford [2001: 435], too, was inclined this way: "I strongly suspect that the packing threshold identifies what has been called a point of 'self-organized criticality' (Bak 1969).")

As these interacting, non-linear variables progressed, thresholds were reached in which order emerged; that is, a quantum change from dis-order or lack of order to a more stable, structured order. For Kauffman, the nonlinear and near-chaotic dynamics complemented or even completed the linear concepts of Darwinian evolution, which he finds insufficient for explanation of order observed in the biological universe (Kauffman 2008).

(By another happy accident, I was involved with Kauffman and SFI at that time too – again, independently. In discussions with Kauffman and reading his work, I wondered if something like emergent order underlay the K-L threshold. But all I did was wonder, because I could not discern a trigger or cause that would lead social change to mirror K=2 networks.)

In particular families of mathematical models – models which mimic important aspects of human society – "order" (or, in this case, governance) simply emerges – intrinsically, mathematically – at particular numerical thresholds. It is an emergent property, "order for free." Kauffman's models behaved much the way our cross-cultural samples behaved. Using Kauffman's K=2 networks (Kauffman REFS; see Kohler, Van Pelt and Yap 2000 for a good introduction). (K=2 means that each element is connected mathematically to two other elements.) Working upward through various Ns, Kosse (2000; a posthumous article) identified likely thresholds or tipping-points at approximately 7, 25, 150, 500 and 2,500.

All correspond to thresholds observed by other researchers in other situations, discussed in the chapter fragment:

7: the Rule of Six – a rule of thumb in business for the maximum number of simultaneous interactions – is actually the Rule of 5-7
25: "Man the Hunter's" 25 for hunter-gatherer band size
150: Dunbar's Number (discussed below)
500: Birdsell's "magic number" (since dismissed) and minimum for governance in cross-cultural studies (discussed below)
2,500: the K-L rule

Kosse's numbers are "real" – that is, they are based on empirical observations or projections from empirical data; and they are "theoretical," derived from Kauffman's K=2 networks. Kauffman's "order for free" suggests that these numbers and the properties they key are emergent; that is, inherent in cognition, social structure, or some other natural property of humans. Sadly, Kosse was unable to follow up her provocative, intriguing research. She died in 1995 and we lost a very talented, very smart archaeologist.

(Note that Clive Gamble (1998) defined sizes of 5, 20, 100-400, and 2,000 – 2,500 individuals as, respectively, "intimate," "effective," "extended" and "global" social networks for an individual.)

Are these "magic numbers"? Rather, think of them as empirical and theoretic value which may work as *constants*. "… like *all* constants, 'Johnson's constant' [Rule of Six] does not explain observable events or patterns. But … knowledge of the existence of a constant—as well as its value—is basic to understanding what the world is like and how it works." (Binford 2001:318)

As with all numbers in this line of research, they should be treated as approximations and first approximations, at that – this is new stuff. Scalar stress (as its called) could kick in well before maxima of 150 or 2,500 were reached; and it's quite possible that scalar stress could be tolerated well beyond those limits, at least for a while. But most cases will, I think, tend around 150 and 2,500 – not as means, modes, or medians but as empirically-based working estimates or approximations.

Clearly, the connections between Kauffman's K=2 complexity networks and the 2,500 K-L threshold lack one or more linking functions, constants or multipliers – quite possibly corresponding to Kosse's number series. They would be easier to handle, too, if there were narrative explanations for why and what happened at those junctures. I will now briefly review Kosse's number series, trolling for likely linking functions.

Rule of Six

The Rule of Six is a business rule-of-thumb for the maximum effective span of control; that is, the number of people a manager can simultaneously manage. Business units of more than six or seven tend to be divided and grouped into small sub-units, leading to dendritic hierarchies branching at nodes of six or seven (REFS). Note that the Rule of Six (or Five or Seven) refers to simultaneous face-to-face interactions, or potentially simultaneous interactions. The Rule of Six applied to direct, personal management before the advent of information technologies that made management more efficient, and therefore broader or "flattened" business organizational structures.

Frederick Taylor (1911) noted empirically that the ratio of producers to non-producers (i.e., managers) in his shop studies was 6 or 7 to 1. Vytautas A. Graicunas (1933) modeled this observation mathematically, demonstrating that while size of an organization increases arithmetically, the potential interactions increase geometrically; Graicunas concluded that "no supervisor can supervise directly the work of more than five or at most six subordinates" (1933:XX). That is, there exists a threshold at 6 (or 7) beyond which management efficiencies decay.

For New Archaeology was heavily influenced by its contemporary, quantitative geography. Six was convenient number, corresponding spatially to the hexagonal grids inspired by quantitative geography, in which a central place was surrounded by six spaces. Art imitating nature?

Gregory Johnson (1978), who introduced the Rule of Six into archaeology cited sources as far back as mid-century Udy (Udy 1959, 1970): "the maximum number of items to which an individual can give simultaneous attention ranges between three and seven with a mode at five." Udy's (1970:50) own data suggest that in activity coordination, this number is probably four." (Johnson 1978:105). Johnson considered cost-benefit analysis of information sources and hierachies, and concluded: "Across the whole organizational range considered, however, the mean number of organizational units integrated by an immediate superior unit in administrative hierarchy generated on an assumption of efficiency maximization is 3.66, with a range of 2.33 to 6.00. This mean of 3.66 is a reasonable approximation of Udy's figure of 4.0, and the range of 2.33 to 6.00 is remarkably close to that of 3.0 to 7.0 reported in the psychological literature." (Johnson 1978 105)

In a later paper looking at small-group studies, Gregory Johnson (1982:392-393) brought this "rule of thumb" to archaeology, when he noted an evident "organizational threshold" at six or seven individuals. Johnson cites studies of "capacity of an individual to monitor and process information" that suggest that "span of absolute judgment of unidimensional stimuli" and "span of immediate memory … simultaneously retained" are "fairly narrow, and average about 7" (Johnson 1982:393-394). "If hierarchy development is related to some kind of

scalar stress, why should it occur at around group size 6? Unfortunately this question is much more easily asked than answered" (Johnson 1982:393).

"There appear, then, to be rather severe limits on the maximum size of task-oriented groups that are organized horizontally (nonhierarchically), and these limits may be related to individual information-processing capacity" (Johnson 1982:394; see also Johnson 1982:410-413).

These limits caused "scalar stress" (Johnson 1982) -- cognitive limits on human information processing. Johnson defined "scalar stress" as cognitive limits on human information processing. "Scalar stress" measures the number of potential or real face-to-face interactions among decision makers in group of n people, expressed mathematically by the formula: $(n^2 - n)/2$ (Johnson 1982:394).

"Scalar stress" is still active in the archaeological lexicon – a widely-used and ever-widening-defined term. It's gone beyond $(n^2 – n)/2$. Just what it means is no longer altogether clear: anything that's too big to work smoothly? But too big to fail?

Gregory's work has recently been further developed in a Southwestern example by Wesley Bernardini. "Cross-cultural organizational regularities were argued to be grounded in cognitive constraints, shared by all humans, that limit the number of pieces or channels of information that can be simultaneously processed by the human brain." (Bernardini 1996:372)

Citing the usual suspects " the maximum information processing workload for an individual is exceeded at group sizes of greater than about six people. That is, for consensual group decisions, each person can maximally consider the views of about five other people, plus his own, to arrive at a choice." (Bernardini 1996:374-375).

Applying the rule of 6 to adults (he leaves children out of the mangle), and positing four levels of integration: "… four transition points for a decision-making hierarchy structured by adult-, household-, clan-, and phratry- level decision-making units at population sizes of roughly 9, 36, 170, and 570 adults." (Bernardini 1996:385) Happily, these are not far off Kosse's series, at least up to the K-L rule. Perhaps this is the missing multiplier? Recall Bernard and Killworth's (1973) analysis that began with a factor of 7 and reached a maximum hierarchy-free size of 2,460.

Man the Hunter's band size:" 25

SUMMARIZE BINFORD'S ANALYSIS IN *CONSTRUCTING FRAMES OF REFERENCE*.

Dunbar's Number: 150

"Dunbar's number" is the number of people an individual can actually know effectively as individuals: about 150. It is named for Robin I. M. Dunbar, a central figure in human evolutionary cognitive neuroscience (REFS), and no stranger to archaeology (e.g. Dumbar 2009). Dunbar (1995 and elsewhere) noticed that in primates (apes, monkeys, chimps etc) the size of a social group in the wild was closely correlated with the size of their brain's neocortex, relative to the total brain size. Bigger the neocortex, bigger the group. Humans have really big neocortexes. Extrapolating from his primate data, Dunbar suggested that humans can know – really know, as individuals – only 150 people. (Two thousand cyber friends on Facebook don't count.)

Dunbar sees evidence for a 150-person limit in the size of corporate groups in simple societies, such as clans: "For the twenty-odd tribal societies where census data area available, these clan groups turn out to have a mean size of 153. The sizes of all but one of the village - and clan-like groupings for these societies fall between one hundred and 230, which is within the range of variation that, statistically, we would expect from the prediction of 150." (Dunbar 2010:25 -26)

He goes on to cite examples from archaeology and history: "In traditional societies, village size seems to approximate this, too. Neolithic villages from the Middle East around 6000 BC typically seem to have contained 120 to 150 people, judging from the number of dwellings. And the estimated size of English villages recorded by William the Conqueror's henchmen in the Domesday Book in 1086 also seems to have been about 150. Similarly, during the eighteenth century the average number of people in a village in every English county except Kent was around 160. (In Kent, it was a hundred…)" (Dunbar 2010: 27)

Dunbar (2010:28-29) posits two explanations: (1) "a memory overload problem (we can only remember 150 individuals, or keep track of all the relationships involved in a community of 150)" or (2) "something to do with the information constraint on the quality of the relationships involved?" It is not, according to Dunbar, a question of memory:

> "It seems equally unlikely that the problem lies with a pure memory constraint, though memory capacity obviously must impose some kind of upper limit on the number of relationships that an animal can have. There are three reasons for this claim. First, in humans at least, memory for faces is an order of magnitude larger than the predicted cognitive group size: Humans are said to be able to attach names to around 2,000 faces but have a cognitive group size of only about 150. Second, there is no intrinsic reason to suppose that memory per se is the issue. The social brain hypothesis is about the ability to manipulate information, not simply to remember it. Third, and perhaps most significantly, memories appear

> to be stored mainly in the temporal lobes,42 whereas recent PET scan studies implicate the prefrontal neocortex, notably Brodman area 8, as the area for social skills and, specifically, theory of mind." (Dunbar 1998: 184)

Rather, it is the *quality* of the relationship, the strength and nature of the personal knowledge. We can remember hundreds of names and faces, but we can *really know* only about 150 people, as individuals. Beyond 150, we have to categorize, put people into groups based on kinship (real or fictive), social strata, costume clues, linguistic keys, places of residence, or other dimensions that work in our particular society. "Classifications and social conventions allow us to broaden the network of social relationships by making networks of networks, and this in turn allows us to create very large groups indeed. Of course, the level of the relationship is necessarily rather crude but at least it allows us to avoid major social faux pas at the more superficial levels of interaction when we first meet someone we don't know personally." (Dunbar 2010:80).

I am not aware of many attempts to verify Dunbar's number, experimentally. Dubreuil (2010:158-159) cites a study (you could try this at home!) by "Roberts and colleagues (2009) [who] asked their subjects to list all their relatives and all the unrelated people in their network with whom they felt they had some sort of personal relationship and with whom they had some sort of contact during the course of they year. They found a mean network size of 72 people, and despite important variations between individuals, no network extended beyond 170 people. Their results suggest that there is an upper bound on total network size, which might be determined by people's limited cognitive and emotional capacity to maintain personal relationships with a very large number of people." 170 is acceptably close to Dunbar's Number, 150.

Clive Gamble (1998:435), in a very interesting review of scalar issues, cites another study supporting Dunbar's Number:

> Bernard and Killworth (1973) have examined the structure of groups and sub-groups in terms of the matrix of interactions between individuals. They conclude that a psychological restriction exists on the number of people or units which can be integrated. They conclude with the hypothesis that 'any group of more than at most 140 elements must form its own sub-groups, and in so doing produce its own formalised hierarchy to deal with this' (Bernard and Killworth 1973: 184). A link between a recurrent network size of 150 supported by bonds created through language has been identified by Dunbar (1993: 686).

I think there's evidence of Dunbar's Number at Chaco. Consider Casa Rinconada. Its interior above-bench circumference is 200'. By ergonomic standards (18" seat-width), Casa Rinconada can seat about 125-135 people. Of course those are modern standards; readers who have attended events at Pueblos know that Pueblo proxemics can be tight. 200 people might possibly

jam together around Casa Rinconada's bench; surely that's an absolute maximum, or very close to it. We should, I think, assume that Great Kivas were designed with the thought and planning that typified Chacon architecture. They had a pretty good idea of function, capacity, audience, and so forth before they laid it out. If the buildling was planned – and of course it was! – then it's likely that Casa Rinconada was intended to seat between 125 and 200 people – simple averaging gives us about 160. I suggest that the intended maximum size of the assembly that met in Chacoan Great Kivas was about 150-160, Dunbar's Number.

There are many Great Kivas at Chaco, probably as many as twelve in simultaneous use during the height of the Bonito phase. Another thought experiment: assume that Great Kivas were designed to seate150 heads-of-households/lineages; and those (extended) households numbered between 10 and 20 people; and all Great Kivas were in simultaneous use. We can then extrapolate from 12 Great Kivas X 150 heads-of-households X (10+20 / 2) persons-per-household = 27,000 people. Far too many for Chaco Canyon! But not far off the order of magnitude of Chaco's region (see "Chaco as Altepetl") which, at a guess, numbered 30,000 to 40,000 people. Please note, again, that I am not offering these as "real" figures – I am trying to estimate frames of reference, scales at which we should be thinking about Great Kivas in Chaco Canyon, and Chaco itself. In any event, it seems likely that the Great Kivas of Chaco Canyon serviced a larger region – there are far too many Great Kivas for Chaco itself. (Unless Great Kivas were used in sequence – that is, each had a specific function or use – which is of course possible.)

Ruth Van Dyke (REFS) has suggested that Chaco in effect "captured" Great Kivas from outying settlements, forcing those settlements to come to the Canyon to do whatever happened in Great Kivas. We don't know what happened in Great Kivas – absent whole-sale "up-streaming" from modern Pueblo practices, which I reject. I agree with Van Dyke, and I suspect that Chaco's dozen Great Kivas serviced different constituencies from both inside and outside the Canyon. Half of the twelve Great Kivas are located outside the enclosed plazas of the Great Houses, and surely that placement meant something. Some Great Kivas serviced Chaco Great House residents. Other Great Kivas serviced someone else –leaders from outlying communities? Think about scales, rather than absolute numbers: we know of about 150 Pueblo II Great Houses outside Chaco Canyon (the total is around 200, of which about 50 are pre- or post-Chaco); about 150 people could fit in a Great Kiva; and Dunbar's number is 150. There's something to this numerology, although relations of elements in the preceding sentence are not, at this point, clear to me.

Birdsell's magic number and the lower limit: 500

In *Constructing Frames of Reference*, Binford spent considerable time reviewing Jospeh Birdsell's "magic number" of 500 (Binford 2001:223-224) – which Binford called "Birdsell's important and visionary work" (p. 224)

"Birdsell was interested in whether there was a basic 'self-defining limit' to the size of the extended hunter-gatherer social unit (Birdsell 1953:172)" and determined that limit was around 500 (Binford 2001:223). But Binford's analyses "…challenge Birdsell's argument for the existence of a self-defining unit that he later termed the 'dialectical tribe.' This influential construct was estimated to have a mean size of 500 persons and, at the Man the Hunter conference, it stimulated considerable discussion … (Lee and Devore 1968:245-48)" He continued:

> "…the 'dialectical tribe,' or the 500-person unit within which a single language dialect was spoken. Implicit in Birdsell's discussion of group size was his belief that the mean band size of twenty-five persons – the so-called 'magic number' discussed at the Man the Hunter conference (Lee and DeVore 1968:245-48)—was also 'self-defining.' … Birdsell seems to be referring to the process of self-organization, which proceeds without at directing agency … It is unfortunate that—as Birdsell was well aware—he wanted to investigate properties that in 1958 were inadequately documented. Forty years later it is appropriate to applaud his foresight and, I hope, fulfill his expectations…" (Binford 2001:317).

Both Kosse and I (and many others REFS, REFS, REFS) noted that hierarchy appears in many societies well below the 2,500 K-L rule. In Kosse's and my analyses, hierarchy was present in a few societies as small as 500; but in no societies smaller than 500. I suggest that 500 marks the lower scalar limit, as it were, of population size which can support (or tolerate) a king, or leader, or hierarchy. More on this, below.

Kosse (1996:90) looking at a "nonrandom sample of 103 societies notes that 500 is a threshold for "CAN be" complex; 2,500 is a threshold for "MUST BE" complex. Note that she is referring to the total population of a single settlement polity. "With so much ambiguity and variability of behavior [between 500 and 2,500] it is not surprising that the material evidence for middle-range societies is less than clear-cut." (Kosse 1996:90)

500, I think, marks a population scale at which governance becomes possible, sustainable – but not really necessary, in the everyday use of that word. (To twist logical terms: at 500, governance may be necessary but not sufficient.) As discussed at more length below, I think governance below K-L (perhaps at 500?) appears en route to the Southwest's K-L triumphs: Chaco and Paquimé. Both ultimately reached or exceeded the K-L rule. Chaco grew gradually, from three Great Houses at about 850-900 to 1000-1020 when Great House construction boomed (discussed below). Chaco, I think, became political long before it

reached K-L. Paquimé, in contast, appeared more-or-less entire sometime around 1300 (with a local run-up, to be sure; but the city itself dates to 1300 and later).

The K-L rule and Kosse's later work with K=2 networks suggest that hierarchy may be an emergent property of settlements larger than 2,500. That is, 2,500 people is sufficient for governance. But formal governance happened in much smaller settlements, presumably NOT as an emergent property. Kosse and I found hierarchical institutional governance in communities of 500. Cautionary tales: one-third of Aztec altepeme central clusters/capitals had less than 3,000 and of those, many had less than 2,500 – significantly less, from 800 to 1,400 people. Of course those Aztec settlements were part of much larger, very complex political system – the king-over-the-hill situation. But, more importantly, they were all *secondary states*. Complexity had not emerged or evolved at small *altepeme*, it had been imported or adopted. This has implications for the Southwest, discussed below.

The K-L rule: 2, 500

I've discussed the K-L rule above. In this section, I look at exceptions and applications. Recall that K-L rule suggests that settlements over 2,500 will have (must have?) hierarchical, formal, permanent governance. Is it possible to dodge the K-L rule? Three possible examples: (1) large peasant villages; (2) sequential hierarchies; (3) alternative leadership.

(1) Large peasant villages: Kosse and I both were looking at independent, single-settlement societies. It is quite possible for a peasant village to exceed 2,500 and lack an obvious mayor or king; but in that case, there's usually a ruler over the hill. The peasant village is part of a larger polity. So the rule holds: over 2,500 indicates governance; but governance can be internal or external: a mayor running the town itself, or a king in a distant city providing rules and controls. That's handy, because in archaeology we can't always tell if a settlement is independent or in a polity. For the 2,500 threshold, it apparently does not matter.

(2) Sequential vs. simultaneous hierarchies: Gregory A. Johnson (1982) suggests that "simultaneous" hierarchies might not be the only solution to scalar problems, and offers "sequential hierarchies: an egalitarian alternative" (1982:396). A "sequential hierarchy" is "difficult…to characterize" (403) but appears to involve consensus decisions on several levels (nuclear family, extended family, group). "…sequential hierarchy is unlikely to be the only social mechanism allowing large aggregations among egalitarian groups. Ceremony, ritual, or what might be called 'generalized feather-waving' is probably another" (Johnson 1982:405).

Johnson developed the concept of "sequential hierarchies" with data from !Kung hunter-gatherers with maximum group sizes of about 125. He then applies the concept to highland New Guinea groups, with "maximum population of largest political unit" ranges from 180 to 2400 (Johnson 1982:Table 21.6); only 2 of 12 groups approach the upper limit; the other 10 are less than about 1000 (max = 1072). Note that his largest group is 2,400 people.

"…it would appear that sequential hierarchies should be a basic feature of egalitarian societies" (Johnson 1982:404). For Bernardini (1996), "sequential hierarchy" becomes some sort of representational government with a council of representatives at the head (his Figure 1); "simultaneous hierarchy" is the typical conical structure with a leader at the top substituting for the council of representatives (his Figure 2). I'm not sure this is what Johnson had in mind… Johnson was thinking of distributed, situational leadership. But Bernardini's version of "sequential hierarchy" will resurface (below) in my model of political development and the K-L threshold. "The development of sequential or simultaneous hierarchies as alternate paths to reducing scalar stress are governed by the same cognitive constraints, so that scale-based. transition points in the social organizations of both types of groups should occur with equal regularity." (Bernardini 1996:377)

(Note that Bernardini's analysis – like the analyses leading to the K-L rule –holds only for single settlement communities: " The mechanics of (re-)constructing inter-site decision-making systems (e.g., dispersed communities) do not necessarily follow the structure outlined below." (Bernardini 1996:374).)

Most notably, sequential hierarchies are very rare: "We have garden-variety 'chiefdoms' and 'early states' stacked ten deep under the lab table, but elaborate sequential hierarchies may have been a rare phenomenon" (Johnson 1989:386 – citing Catal Huyuk, which we revisit below). Indeed, much like the *rara avis* "corporate hierarchy", the Southwest's remarkable (and remarkably stereotyped) Pueblos are the constant, over-worked reference.

(3) Alternative leadership. Uniquities: ritualities, coomunitas, etc. Anything to keep the ancient Southwest in that Pueblo Space… See Chapter 4.B. SUMMARIZE LEKSON 2010 "THE GOOD GRAY INTERMEDIATE" IN *ANCIENT COMPLEXITIES*

Exceptions to the Rule

Are there real-world examples of communities by-passing the K-L rule? (A key question, which will resurface in the discussion of Roland Fletcher's [1995] C- and T-limits in urbanism, Chapter 3.B.; and critical to Fletcher's analysis of low-density urbanism [Fletcher 2009].) There are anecdotal exceptions to the K-L rule: permanent, (presumably) independent settlements of more than 2,500. By-

pass is usually accomplished by segmentation into clearly defined neighborhoods or wards (Smith REFS). Several examples:

"Yako in SW Nigeria are settled in towns of between 2,000 and 11,000 inhabitants. Every town is subdivided into almost self-governing wards whose structure is based on territorial patriclans, but at the same time a town is governed by a council whose composition is based on non-territorial matriclans. There is no central government, and the leaders of the clans do not possess the power and the personnel b which they can enforce the accepted norms" (Hansen 2000:15, 26-7; citing Forde 1964: 1-6, 135-6, 165-209). "Each village was subdivided into wards with clearly marked boundaries between the wards. Each ward had an assembly place for meeting, rites, and festivals" (Hansen 2000:26)

Umor had 11,000; five (later four) wards: "The ward was almost a self-governing community, and fighting between two wards in Umor had resulted in emigration of all members of one ward and the subsequent foundation by that ward of a new village" (Hansen 2000:26)

WEST AFRICAN CITIES: Jenne-Jeno and Hambarketolo in Mali: "Conurbation" of two huge sites and many smaller sites within 1km radius. First cent BC to 8th cent AD. 41 hec and pop of "at least 5,000" "No trace of an urban elite was found…a stateless urbanized community" (Hansen 2000:15; citing McIntosh 1995:372-98)

CATAL HUYUK: Deconstructing *The Leopard's Tale*

What to do with Catal Huyuk? No elites – how do they know? Tiny sample of a huge site! Bee hive, primitive communalism. It's big enough it should have had hierarchy. MAYBE A DIFFERENT MENTALITY…different cognition, Joh Hoffaker's super-brain? My original interests in cognitive evolution was sparked by Julian Jayne's (1976) *The Origin of Consciousness in the Breakdown of the Bicameral Mind.* Jaynes is not highly regarded today, but contra Mithen et alia, it's interesting to think how LATE 'modern' mentalities developed rather than how far back we can project 'modern' mentality… Catal Huyuk might be a great case.

Resolving Scalar Thresholds

How do we get from Dunbar's Number to the K-L rule? We need a function, or multiplier, or divisor to get from 150 to 2,500.

Here are two working assumptions (mine, not Dunbar's) and one conundrum: (1) small groups make decisions through consensus: councils, assemblies, etc., with situational leadership, but without permanent ruler roles; (2) consensus requires some degree of mutual social knowledge among all actors; it's hard to reach

consensus with strangers. And the conundrum: Dunbar's Number suggests that the largest group in which everyone could know everyone else was about 150 people. We might expect governance to appear above 150, but the real number is the K-L rule of 2,500.

Not all 2,500 people in a community "matter," politically. Kids, for example, don't have a lot of political clout. How many people are actually involved in community decision-making? How many "players" in the pool?

I will assume that governance is normally a matter for adults (despite recent events in Washington, which suggest the contrary). And usually, sad to say, governance is very often the business of adult males (which may, in part, explain recent events in Washington).

(Of course political "players" could be female, but sadly that's rare. To cite a familiar case, Pueblos are more or less matriarchal, but when it comes to governance, it's a man's world – as the hardest working man in show business once put it. For those annoyed by my gender assumptions, feel free to substitute "adult female players.")

How many adult male (or female) "players" could there be? Let's start with a community of 2,500, the K-L threshold. Southwestern populations averaged about 60:40 adult:kids, so we reduce 2,500 to 1,500 adults. For this exercise, let's assume 50:50 male:female, so that reduces 1,500 to 750. Of course it's not that simple. At Paquimé, the ratio of men to women was 40:60; Chaco was more balanced, but for a key age range of 15 to 25 years, there were far more women than men, two males to nine females. (Gender imbalance of this kind probably indicates slavery.) A 40:60 ratio would, of course, further reduce the number of potential male "players." But let's work with 750: that's the pool of all adult males. An assembly 750 equals would be unworkable. But all adult males are not equal. There are elders, for example; and at the other end of spectrum, there are young adults who have yet to prove themselves. I think we can assume that not all 750 were "players." Again, we need a multiplier – or in this case, a divisor.

Let's work from the bottom up: families, lineages. Maybe players didn't need to know everybody, they needed to know families, the basic social units. Indeed, players need to know only the heads-of-households, heads-of-families, heads-of-lineages. (This insight came from my colleague Dr. Catherine M. Cameron, who actually knows astonishing details about many more people than Dunbar would have expected…really big neocortex, perhaps?) How many heads-of-households in a community of 2,500? That depends on how big a family was. Our typical family – a "nuclear family" – is 2 adults, 2.5 kids and a dog. Families in many societies are much larger and more inclusive, with a head couple, multiple nuclear families of their offspring, an odd uncle or aunt, some kids picked up from relatives who had too many kids, etc. Extended families range from 10 to 20 people (again, approximations!). Wes Bernardini (1996) estimated

that a 13th century unit pueblo – a household – was, on average, about 13 people: 8 adults and 5 kids. That's an extended family. If families averaged 13 people, then a community of 2,500 would have around 200 heads-of-households – about one-quarter of the total pool of 750 adult males; that is one in four of adult males. That does not sound unreasonable.

Recall Dunbar's number: 150. 750 is far beyond the cognitive comfort level; 200 is much closer, but still too high. Consensus among strangers is hard to reach, and with 200 players one-quarter of the assembly are strangers. I suspect when the number of players significantly exceeded 150 – say, pushing 200 – things fell apart. Time for a king.

There are endless permutations and possibilities for theoretical family size and theoretical number of adult male/female players. I've assumed that single heads-of-households or lineages were the only players; that's a dangerous assumption, since other social roles, not defined by kinship, no doubt "played" as well: priests, warrior, whatever. I suspect that the pool of players in a community of 2,500 was often (perhaps always) well above Dunbar's number.

I do not claim that these thought experiments and number games "solve" the K-L rule, but I think they "resolve" it a bit. The addition of other functions and factors (perhaps a role for the Rule of Six?) may lead us, ultimately, to a workable mathematical model of the K-L rule and the rise of hierarchical governance. I side with Carniero: when a few people could make decisions for a community (or other collective), a key evolutionary tipping point had tipped – towards the state. I continue to work on this, but I am hopeful that younger minds will turn to the problem, or some version of it, and solve it.

K-L in the SW

Chaco and Paquimé were two Southwestern sites for which we can safely assume centralized, formal, elaborate, institutional, hierarchical governance. How big were they? Decades ago, I estimated Chaco's peak population, beginning with the assumption that small "kivas" were in fact domestic structures, with one "kiva" per family. I multiplied the number of Pueblo II "kivas" at Chaco by 6.5 – a family size calculated from the floor area of "kivas" and pit structures. With those assumptions, I estimated 2,100 to 2,700 permanent residents at Chaco – conveniently straddling the K-L rule, before that rule was discovered. Of course, if we use Bernadini's extended family figure of 13 – derived from the floor area of the "pueblo" portion of "single kiva sites" – that figure doubles: 4,200 to 5,400! (Of course it's more complicated…etc.)

Paquimé, according to Charles Di Peso (who excavated the site) had a peak population of about 4,700 – well over the K-L rule. Michael Whalen and others (2010) recently argued that Paquimé was, in fact, only half as big as Di Peso

claimed. I tend to trust the excavator; but maybe Di Peso was wrong and Whalen is right. That might drop Paquimé's population to around 2,350 – bumping up against the K-L rule threshold! In fact, 2,500 is Whalen's published number, but it's an approximation. Whalen halved Di Peso's estimate, to illustrate the effect of halving Paquimé's size; he made no claims of great accuracy for the figure.

I think that Chaco and Paquimé both closely approached or exceeded 2,500, larger than any other Pueblo settlement of their times, and almost all Pueblo towns that followed (more on this, below). In both cases, governance might have "emerged" as a function of the K-L rule. But there is excellent and abundant evidence that both polities were heavily influenced by Mesoamerica; that is, both were almost certainly secondary states (see Chapter 4.B).

Governance at Chaco may have developed – or rather, was purposefully, intentionally developed, by leaders following southern models – at smaller, earlier population levels. Here's a K-L history for Chaco: (1) Chaco represents the last in a string of theretofore unsuccessful attempts by Great House families (nobles manqué) to establish polities in the northern San Juan; (2) at relatively low population totals – perhaps 500, perhaps 1000 – the polity "takes" in Chaco Canyon during the early and middle 900s, with three major noble families (Pueblo Bonito, Penasco Blanco and Una Vida); (3) starting around 1000, new noble families join Chaco and build their Great Houses (and attached commoners build unit pueblos) until Chaco approached the K-L threshold; (4) political life then becomes locked-in, fixed: governance becomes both sufficient and necessary.

Recall that 2,500 is not necessary, it is sufficient. With in situ growth to 2,500, order will emerge and governance becomes necessary. But 500 people can support (or at least abide) a king. I think the Chaco polity started – as a secondary state – well below the K-L threshold, in the Pueblo I period (Al Hayes estimated 1,600 for Pueblo I at Chaco, but of course this figure is contested), and became essential when Chaco reached 2,500. Thus, the Chaco polity was not "emergent" – it was in every sense artificial. Remember that both Chaco and Paquimé were secondary states, borrowing from Mesoamerican traditions of governance and rulership – and history/agency may trump emergent complexity. Chaco succeeded (i.e., persisted), however, because it reached the K-L threshold, at which point governance was no longer optional.

Paquimé was both secondary and big – as far as we can tell, very close to the K-L rule early in its history. There was a local run-up (and a lot of outside help) but when the city itself appeared, it rose in a hurry. Again, scale "locked in" the need for political structure, early and often.

Two broke through. One of the Southwest's most interesting assets are several score very large Southwestern towns which bumped up against the T-L rule but

kept the playing field level. That is, they got big without becoming polities. More than a few towns approached T-L (and, indeed, a few actually topped it; discussed below). But they kept their worlds safe for democracy (sort of) and avoided the T-L trap. That's worth studying!

And not just that remarkable non-emergence, but the whole run-up to village and town formation. How did towns get that big to begin with? Southwestern archaeology has a marvelous data base of communities. One thing we do well in the Southwest is villages: how they formed, where they are, what they looked like, how long they lasted. Many we map, in detail, without excavation. We have a sizable library of towns, and a long history of estimating their populations. Many (most?) of these towns can be assumed to be communities – that is, the daily face-to-face groups that form the basis of the K-L rule. And what do those towns – not the cities of Chaco, Aztec and Paquimé – tell us?

Long ago, Art Rohn (REFS) remarked that both ancient towns and modern Pueblos never exceeded 2,500. If they approached that size, they splintered or split into smaller, more manageable daughter communities. I think Dr. Rohn was perhaps over-generous in his size estimates. Even the very largest Southwestern settlements seldom exceeded 1,500. A quick survey:

Beyond Chaco Canyon, the largest 11th century towns were in the Mimbres area. Mimbres towns were typically only a few hundred people: Anyon and LeBlanc (1984: 192) 0estimated "a maximal Galaz village size of 300 people." That figure agrees reasonably well with the scale proposed by Shafer (2003:133) for NAN Ranch Ruin: "24-plus" "extended family households" or perhaps 240 to 480 people (my estimate, not Shafer's).

For Pueblo III (12^{th}-13^{th} centuries), Michael Adler (1996:97) says the largest MV settlements were 1,500. Adler, using "momentary population" estimates, notes "empirical support for a demographic size limit of between 1,000 and 1,500 people in Anasazi communities of the Mesa Verde region" (p. 105). Thus: "We are stuck in that grey area described by Kosse (1990) and Lekson (1988), in which community size can be used to argue for either emergent sociopolitical complexity or the lack of complexity." (p. 105)

Yellow Jacket was the very largest Mesa Verde town in the 13^{th} century. Kristin Kuckelman estimates Yellow Jacket's maximum population at between 850 to 1360 people. http://www.crowcanyon.org/publications/yellow_jacket_pueblo.asp

Scott Ortman has produced the most sophisticated estimates of northern Rio Grande (Tewa Basin) sites. The largest population and the largest of these sites was at Sapawe in the Terminal Classic, at which time Ortman calculates had a population of 2,304 (Ortman 2010: Appendix A).

In a review of late (PIV) Pueblo settlement size, Adams and Duff (2004:11-12) ask (and answer): "So what does village size mean? As Johnson (1989), Kintigh (1994), Bernardini (1996), Duff (2002), and Adams (2002) have noted, village and regional population size is almost certainly an index of the organizational complexity of the groups occupying them. … Additionally, several have extended this to regional aggregates, predicting that populations above about 2000 (Adler 1990) or 2,500 (Kosse 1996) people are usually associated with hierarchical organization, though Upham (1990) suggests this requires on the order of 10,500 people. [almost all PIV towns stayed well below the K-L rule] … The brief jumps to enormous sizes of some villages at Zuni in the late 1200s probably failed because the associated social organization changes were not yet fully in place, resulting in fission (Kintigh 1985)."

Scott Ortman (2009:Appendix A) has studied the population of the largest northern Rio Grande towns in detail; for Sapawe (the largest northern Rio Grande town), Ortman estimates a maximum population of just over 2,300. Very close! But apparently no cigar: Sapawe was occupied for a maximum of 150 years, apparently fragmenting into smaller daughter communities. http://village.anth.wsu.edu/sites/village.anth.wsu.edu/files/publications/Ortman%20Dissertation%202009.pdf

HOHOKAM: The best estimates for large Hohokam towns hover around 1000, as well (it's harder to develop these figures for Hohokam sites).

"The ten most populous Rio Grande Pueblos averaged about 400 residents each during the eighteenth and nineteenth centuries; the western New Mexico Pueblos averaged about 1000 residents during the same period ([my analysis of data in] Simmons 1979:Table 1; Zubrow 1974:Table 2). After the Revolt of 1680, no Pueblo was ever larger than about 1500, except Zuni which occasionally peaked at about 2500 (but which averaged about 1500)." (Lekson 1984:272). Schroeder (1979:246) suggests that Acoma had 6,000 people at the time of Coronado, but this is surely incorrect. The estimate is based on an estimate of 500 houses atop Acoma's mesa; currently there are fewer than 100 houses (mostly unoccupied, or occupied only on special occasions) and the mesa top is pretty crowded.

Pecos was reputed to be the largest Rio Grande Pueblo when the Spanish arrived; their accounts say 2,000 people. But archaeological data support only half that size. http://www.cr.nps.gov/history/online_books/pecos/cris/chap7.htm

A few Southwestern towns exceeded the K-L threshold, usually under particular circumstances and often with interesting results. Zuni was the largest of all Pueblos: five Pueblos jammed together for defense; its Native government (as described by Cushing) was centralized in a small council of leaders who ruled from a special house, at the center of the (Zuni) world (REFS). It's not clear if Zuni still works that way; probably not, since Spain, Mexico and the United States assumed over-all control. Awatovi, after Spanish contact, exceeded 2,500; and it

was crushed by the other Hopi towns, its people scattered among the other Hopi towns. Various reasons are given for Awatovi's destruction; almost all involve behaviors outside Hopi norms. Oriabi flirted with 2,500 and famously split into two smaller communities. With the imposition of outside political controls – Spanish, Mexican, American – all bets are off. Pueblos could get big (although few did) without formal hierarchies because there was a Viceroy in Mexico City, or an Indian Agent in Santa Fe representing centralized governance at a distance. The king over the hill.

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