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Deliberation, Single-Peakedness, and the Possibility of Meaningful Democracy: Evidence from Deliberative Polls*

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Abstract

Majority cycling and related social choice paradoxes are often thought to threaten the meaningfulness of democracy. Deliberation can protect against majority cycles—not by inducing unanimity, which is unrealistic, but by bringing preferences closer to single-peakedness. We present the first empirical test of this hypothesis, using data from Deliberative Polls. Comparing preferences before and after deliberation, we find increases in proximity to single-peakedness. The increases are greater for lower- versus higher-salience issues and for individuals who seem to have deliberated more versus less effectively. They are not merely a by-product of increased substantive agreement (which in fact does not generally increase). Our results are important, quite apart from their implications for majority cycling, because single-peakedness can be naturally interpreted in terms of an underlying issue dimension, which can both clarify the debate and allow a majority-winning alternative to be interpreted as a median choice and thus as an attractive "compromise."

Deliberation, Single-Peakedness, and the Possibility of Meaningful Democracy: Evidence from Deliberative Polls

Condorcet's and similar paradoxes of social choice have long been seen as serious problems for democracy. Condorcet showed that pairwise majority voting in decisions over three or more alternatives can lead to cyclical majority preferences. If a third of a group (electorate, committee, etc.) prefers *x* to *y* to *z*, another third prefers *y* to *z* to *x*, and the remaining third prefers *z* to *x* to *y*, majorities prefer *x* to *y*, *y* to *z*, and yet *z* to *x*. This illustrates at least three problems with majority rule. First, rational (i.e., transitive and complete) individual preferences may lead to irrational (specifically, cyclical) majority preferences (*collective irrationality*). Second, pairwise majority voting may fail to produce a stable winning outcome (*instability*). Third, when pairwise majority votes are taken sequentially, the outcome may depend on the order in which the votes are taken and may thus be manipulable by agenda setters (*path dependence*, leading to *agenda manipulability*). Arrow's theorem (1951/1963) shows that these and related problems generalize well beyond majority rule,[1] and Riker (1982) has influentially argued that they undermine the meaningfulness of democracy.[2]

What may be said against such counsel of despair? A number of authors have recently argued that majority cycles are empirically rare (Miller 2000, List and Goodin 2001, Tsetlin, Regenwetter, and Grofman 2003, Mackie 2004, Regenwetter et al. 2006). That may well be (the literature as a whole has not yet conceded the point), but we should still wish to understand why they are not more frequent, and what helps minimize their frequency. In this light, it is useful to show the existence of realizable conditions under which democratic institutions can robustly protect against cycles, where "robust protection" means the prevention of cycles for a large class of actual and counterfactual circumstances. It is well known that majority cycles are precluded if individual preferences are "single-peaked," in the original, ordinal sense defined by Black (1948) and Arrow (1951/1963). This requires the existence of a left-right ordering of the alternatives such that each individual has (1) a most preferred alternative and (2) a decreasing preference for other alternatives as they get more distant in either direction from it. The median individual's most preferred alternative then prevails. Here we examine the possibility that deliberation can offer robust protection against cycles by moving preferences toward single-peakedness (as suggested by Miller 1992, Knight and Johnson 1994, Dryzek and List 2003; less explicitly, the idea goes back to Arrow 1951/1963, ch. VII).

Deliberation's effect on the extent to which preferences are single-peaked is important, quite apart from its implications for majority cycling. Single-peakedness stands out among structure conditions for the avoidance of majority cycles.[3] It can be naturally interpreted in terms of an underlying issue dimension and be the result of a form of "meta-agreement" (List 2002)—agreement not about the preference ordering of alternatives but about a dimension on which the alternatives can be arrayed. This can both clarify the debate and allow a majority-winning alternative to be interpreted as the choice of the median voter on the agreed dimension and thus as an attractive "compromise." Further, single-peakedness is sufficient not only for the absence of cycles but for the possibility of strategy-proof collective decision making (Moulin 1980).[4]

In sizeable populations, single-peakedness—a binary property that is either satisfied or violated by any given combination of preferences across individuals—may be hard to attain. Niemi (1969) and List (2001) have therefore suggested measuring *proximity to single-peakedness*, defined formally below. As proximity to single-peakedness increases, the probability of majority cycles decreases (see Niemi 1969, Feld and Grofman 1986, Gehrlein 2004, and our results). But does deliberation actually increase proximity to single-peakedness? And, if so, when and how?

This paper presents the first empirical study of these questions. We focus on deliberation in mass publics, using data from *Deliberative Polls*, which examine deliberation's effects on preferences and other variables (for overviews, see Luskin, Fishkin, and Jowell 2002, Fishkin and Luskin 2005, or Fishkin 2009; on legislative or jury deliberation, see Steiner et al. 2005, Mendelberg 2002). The basic design involves interviewing a good-quality random sample; gathering its members for a weekend to deliberate in randomly assigned small groups; allowing them to put questions arising from the small group discussions to panels of competing policy experts and policy makers; and reinterviewing them at the end.[5]

Our central analysis compares measures of proximity to single-peakedness before and after deliberation. We also advance, and examine the evidence for, some hypotheses about when and for whom proximity to single-peakedness increases most. We contrast the results for high- versus low- to moderate-salience issues, for cases in which there is a more versus less natural left-right ordering of the alternatives, and for participants who seem to have learnt and thought more versus less, judging from the observed knowledge they emerge with. Our results support and refine the hypothesis that deliberation brings preferences closer to single-peakedness.

THEORETICAL BACKGROUND

Individual and Collective Preferences

Consider a set $N = \{1, 2, \ldots, n\}$ of individuals (voters, committee members, etc.) and a set $X = \{x, y, z, \ldots\}$ of alternatives (policies, candidates, etc.). Each individual i has a *preference ordering* R_i over X, where, for any $x, y \in X$, xR_iy means that individual i weakly prefers x to y. When xR_iy but not yR_ix, we write xP_iy ("individual i strictly prefers x to y"). R_i is *rational* if it is *complete* (for all $x, y \in X$, xR_iy or yR_iz) and *transitive* (for all $x, y, z \in X$, if xR_iy and yR_iz, then xR_iz).

An *aggregation rule* maps a *profile* of individual preference orderings $(R_1, R_2, \ldots, R_n)$, hereafter $(R_i)_{i\in N}$, to a collective preference ordering R, defined as in the individual case. In *pairwise majority voting*, for each $(R_i)_{i\in N}$, R is defined as follows: for any $x,y \in X$, xRy if and only if there are as many or more individuals with xR_iy as with yR_ix. A *Condorcet winner* is an alternative that is weakly majority-preferred to every other. *Condorcet's paradox* shows that, for some profiles of rational individual preference orderings, the majority preference ordering is irrational—specifically, cyclical and thus intransitive. If the cycle is at the top of the ordering (no non-cycling alternative is majority-preferred to every cycling alternative), there is no Condorcet winner.

How likely Condorcet's paradox is to occur depends on how individual preferences are statistically distributed. If all logically possible preference orderings are equiprobable (an "impartial culture"), the probability of a cycle increases with both the number of individuals n and the number of alternatives k (Gehrlein 1983). For other, non-equiprobable distributions, which may be empirically more realistic, however, the probability of cycles can be much lower (List and Goodin 2001, appendix 3; Tsetlin, Regenwetter, and Grofman 2003; Regenwetter et al. 2006).

Single-Peakedness

Consider an ordering (as distinct from preference ordering) Ω of the alternatives from left to right, with "left" and "right" understood in a purely *geometric* sense. An individual *i*'s preference ordering R_i is *single-peaked with respect to* Ω if i has a most preferred alternative and a decreasing preference for other alternatives as they get more distant in either direction (relative to Ω) from it.[6] For example, the individual preference orderings (x, y, z), (z, y, x), (y, x, z), and (y, z, x) (each listed in strictly decreasing order of preference) are single-peaked with respect to the left-to-right ordering Ω=[x y z]. By contrast, the preference orderings (x, z, y) and (z, x, y) are not single-peaked with respect to Ω = [x y z].

Collectively, a profile $(R_i)_{i\in N}$ of preference orderings is *single-peaked* if there exists at least one geometric ordering Ω with respect to which *every* individual's preference ordering R_i is single-peaked. A geometric ordering Ω with this property is called a *structuring dimension*.

Note the distinction between single-peakedness of an individual preference ordering and single-peakedness of a profile. The former (absent ties) is trivially single-peaked with respect to *some* geometric ordering of the alternatives, for instance the one arraying them in the individual's decreasing order of preference itself (e.g., a preference for *x* over *y* over *z* is single-peaked with respect to [*x y z*]). Single-peakedness is non-vacuous at the individual level only with respect to a *particular* geometric ordering. A *profile* is single-peaked, on the other hand, if and only if *every* individual's preference ordering is single-peaked with respect to the *same* geometric ordering.

As discussed in more detail below, a geometric ordering Ω that renders one or several individuals' preference orderings single-peaked may, but need not, represent an ordering of the alternatives on some *semantic* issue dimension, where, for example, "left" could be most liberal, most secular, or most environmentalist; "right" most conservative, most religious, or most anti-environmentalist.

Single-peakedness is a sufficient condition for avoiding cycles and lends the majority-winning alternative a median interpretation, as previously described.[7] For any single-peaked profile $(R_i)_{i\in N}$, the majority preference ordering is transitive, and the median individual's most preferred alternative (relative to a structuring dimension Ω) is a Condorcet winner (Black 1948, Arrow 1951/1963) (assuming n is odd).[8] That majority voting on domains of single-peaked preferences (relative to some Ω) is a median voting scheme also protects it against strategic voting (Moulin 1980).

Proximity to Single-Peakedness

Single-peakedness is sufficient but not necessary for avoiding cycles. For example, the existence of a large enough subset of the individuals in N with single-peaked preferences may also be sufficient.[9] Consider the largest (or tied for largest) subset M of N such that the preference orderings of all individuals in M—those in the (sub-)profile $(R_i)_{i\in M}$—are single-peaked with respect to *some* geometric ordering of the alternatives. Call such an ordering (it need not be unique) a *largest structuring dimension*. Define the *proximity to single-peakedness* of the profile $(R_i)_{i\in N}$ as $S=m/n$, where m is the size of M (Niemi 1969, List 2001). S equals 1 for full single-peakedness ($M=N$) and is typically bounded below by a value greater than 0. If all individual preferences are strict, the lower bound is $2^{(k-1)}/k!$, which equals 2/3 for k=3, 1/3 for k=4, 2/15 for k=5, and so on, in decreasing fashion.[10]

By Black's theorem, S=1 is sufficient for the existence of a Condorcet winner. But what about S<1? For any threshold α ($0<\alpha<1$), we can determine the conditional probability—call it p—that there exists a Condorcet winner, given $S>\alpha$ (a deviation from an impartial culture).[11] Analytical and computational results suggest that the higher the α, the higher the p (Niemi 1969, Feld and Grofman 1986, Gehrlein 2004). To illustrate, we have randomly generated 1,000,000 profiles of preference orderings over k=3 alternatives for various n. An online Appendix reports the relative frequencies (estimating the probabilities) of the existence of a Condorcet winner for given ranges of S for n=101.[12] We find that the higher the proximity to single-peakedness, the higher the probability.

DELIBERATION AND SINGLE-PEAKEDNESS

Deliberation has been variously defined (see, e.g., Cohen 1989, Dryzek 1990, 2000, Fishkin 1991, Knight and Johnson 1994, Gutman and Thompson 1996, Bohman and Rehg 1997, Elster 1998). For present purposes, we define it moderately thinly, as discussion that is substantive, balanced, and civil (see also Fishkin and Luskin 2005).[13] It focuses on the policy or electoral alternatives and the reasons for preferring some over others; involves the airing of a broad range of perspectives, arguments, and positions; and takes place in an atmosphere of mutual respect. So defined, deliberation can be expected to have a variety of beneficial effects. Most relevantly for present purposes, it can be expected to induce learning and thinking and thus to produce more considered preferences (for evidence, see, e.g., Luskin, Fishkin, and Jowell 2002, Luskin and Fishkin 2002, Barabas 2004).

Our focal claim is that deliberation shapes preferences in ways that robustly protect against majority cycles. One common but naïve hypothesis is that it does so by creating perfect *substantive agreement*. Elster (1986, p. 112) describes this line of thought as follows:

> "Rather than aggregating or filtering preferences, the political system should be set up with a view to changing them by public debate and confrontation. The input to the social choice mechanism would then not be the raw, quite possibly selfish or irrational, preferences …, but informed and other-regarding preferences … There would [then] not be any need for an aggregation mechanism, since a rational discussion would tend to produce unanimous preferences."

Unanimity, in populations of any size, is unattainable. A more realistic claim would be that deliberation increases substantive agreement. Past Deliberative Polls cast doubt on even this more modest claim (Luskin, Fishkin, and Jowell 2002), but in any case substantive agreement is unnecessary for avoiding majority cycles. As already noted, single-peakedness, which does not require substantive agreement, precludes cycles, and proximity to single-peakedness already makes them less probable. Deliberation, in turn, can be expected to increase proximity to single-peakedness (Miller 1992, Knight and Johnson 1994, Dryzek and List 2003). It may do so in either of two broad ways:

Single-Peakedness through Meta-Agreement

Deliberation may increase proximity to single-peakedness by increasing *meta-agreement* (List 2002), that is, agreement on a common semantic issue dimension (like liberal/conservative or secular /religious) in terms of which to conceptualize the choice at hand, as distinct from *substantive agreement* on what choice to make. This involves a three-step process. The first step is for the participants to focus on a common semantic issue dimension. The second is for them to place the alternatives in the same left-right order on it (thereby relating a geometric ordering like [x y z] to the semantic issue dimension).[14] The third step is for each individual to identify a most preferred alternative and to adopt a decreasing preference for other alternatives as they get more distant in either direction from it relative to that common left-right ordering. This process may but need not be conscious.

The process may occur through discussion, with individuals influencing one another. As the participants talk, learn, and think about the alternatives, they consider the reasons for or against them, out of which a semantic issue dimension can be constructed. In deliberating about energy choices, for example, the participants may come to realize that some alternatives are cheap but dirty, others clean but expensive. To the extent that they focus on these attributes in evaluating the alternatives, they will have constructed a semantic issue dimension defined by the trade-off between cost and the environment. That is the first step. As the participants learn more about the attributes of specific alternatives, moreover, they can see how to place them in some geometric order corresponding to the semantic dimension they have constructed. They learn, for example, that coal is cheap but dirty, natural gas cleaner but more expensive, and wind power still cleaner but still more expensive. That is the second step. Then, as each participant considers the semantic issue dimension, the geometric placement of the alternatives on it, and his or her weighing of the underlying reasons, he or she may arrive at a most preferred alternative and rank other alternatives according to their distance in either direction from it. Someone who favors environmental over cost considerations may come to support wind power as a first choice, followed by natural gas and coal (assuming there are no other alternatives). That is the third step. The same three-step process can also occur through excogitation, any discussion aside, with individuals independently arriving at a similar conceptualization of the alternatives.

The semantic issue dimension and geometric ordering in this process may be more or less *natural*, in the sense that the reasons out of which the issue dimension is constructed may be more or less salient for the relevant population, and the geometric placement of the alternatives on it more or less obvious. The salience of given reasons and the obviousness of given placements, of course, will depend on the population in question. The three-step process we have described does not require the existence of any particularly natural issue dimension. All it requires is that some reasons become sufficiently focal to allow the construction of a common issue dimension. The resulting approach to single-peakedness, however, can be expected to be more pronounced to the extent that there is a natural issue dimension and geometric placement of the alternatives on it.

Single-Peakedness without Meta-Agreement

Deliberation can also increase proximity to single-peakedness without increasing meta-agreement. A profile's single-peakedness is a matter of the aggregate coherence or patterning of preferences across individuals, not necessarily the cognitive organization of each individual's preference ordering. Individuals may simply adopt preference orderings they come to recognize as typical of political elites with whom they identify, and to the extent that elite preference profiles are close to single-peaked (presumably due to meta-agreement at the elite level), the resulting public preference profiles will also be close to single-peaked. This second, cue-taking mechanism requires shallower learning and thought than the mechanism involved in meta-agreement.

HYPOTHESES

We expect deliberation's effect on proximity to single-peakedness (S) to be nonlinear. Since S cannot exceed 1, while deliberation is presumably unbounded above, further increases from high-enough levels of deliberation should bring only small increases in the (correspondingly high) value of S. Thus we expect S to be an increasing, strictly concave function of deliberation, approaching 1 as deliberation increases. A testable implication is that deliberation's effect should vary with the salience of the issue. For highly salient issues, which have usually already received a good deal of casual deliberation in the participants' everyday environments, preference profiles should already be relatively close to single-peaked, and the effect of the more formal onsite deliberation should be small. It is for issues of low to moderate salience that we expect the onsite deliberation to make an appreciable difference.

As noted above, the effect should be greater to the extent that there is a natural issue dimension and geometric ordering of the alternatives for the participants to adopt (whatever they may have started with). The effect should also be mediated by the learning and thought deliberation induces. The greater the learning and thought, the greater the expected increase in proximity to single-peakedness. This hypothesis is normatively important. It suggests that deliberation's effect stems at least partly from meta-agreement produced by learning and thought, not just from cue-taking.

To sum up, then, our principal hypotheses are:

H1: Deliberation tends to increase proximity to single-peakedness, subject to the constraints in H2, H3, and H4.

H2: The rate of increase diminishes, eventually becoming negligible, at high enough levels of deliberation.

H3: The increase is greatest among those deliberating most "effectively," in the sense of learning and thinking the most.

H4: The increase is greater, *ceteris paribus*, to the extent that there is a natural issue dimension and geometric ordering of the alternatives.

We cannot test H2 directly, but a testable corollary is:

H2′: Deliberation's effect is smaller for higher- than for lower-salience issues.

It should also be noted that while we have no quantitative measure of the naturalness of issue dimensions or geometric orderings of the alternatives, some of the issue dimensions and orderings we encounter below do seem distinctly more natural than others, affording at least a rough test of H4.

EMPIRICAL CASES

We have already described the basic design of Deliberative Polls ("DPs"). Members of a random sample are interviewed, then invited to attend a weekend discussing the issues at a common site. Between the first interview and the weekend, they are sent carefully balanced briefing materials laying out arguments for and against policy alternatives. During the weekend, they alternate between discussions in randomly assigned small groups and plenary sessions in which they put questions generated by the small-group discussions to panels of experts or policy makers. The discussions are led by moderators trained to intervene as little and as neutrally as possible, steering the participants neither toward nor away from particular alternatives, and neither toward nor away from consensus. They also try to ensure that no-one dominates, that everyone participates, and that all sides are considered. At the end, the participants answer the same questions as at the beginning. Some DPs also involve control groups.

The "treatment" is thus broadly deliberative, revolving around discussions—in the small groups; in the corridors and over meals, coffees, and drinks; in the dialogues with the plenary session panelists; and in casual exchanges with family, friends, and co-workers in the interval between the initial interview and the onsite proceedings. The discussions also entail and occasion much thinking and learning (as documented, at least with respect to learning, below).

Data and Alternatives

Our data come from nine DPs, eliciting preference orderings over three or more alternatives on a total of thirteen issues.[15] The DPs, issues, and alternatives (numbered as in ensuing analyses) are:

- Six regional DPs commissioned by Texas electric utility companies (SWEPCO, CPL, WTU, Entergy, HL&P, SPS) sought orderings of four *policies for meeting electricity needs*: (1) conservation, (2) building new fossil fuel facilities, (3) building new wind or solar facilities, (4) buying electricity from elsewhere (SWEPCO, CPL); or (1) building new coal facilities, (2) building new wind or solar facilities, (3) conservation, (4) building new natural gas facilities (WTU); or (1) generating electricity using renewable technologies, (2) conservation, (3) building new fossil fuel facilities, (4) buying electricity from elsewhere (Entergy, HL&P, SPS).
- Three of these DPs (SWEPCO, CPL, WTU) also sought orderings of four or five broader *goals*: (1) minimizing cost; (2) maintaining environmental quality; (3) ensuring adequate present and future supply (WTU) / avoiding dependence on any one resource (SWEPCO) / creating jobs (CPL); (4) ensuring that everyone's basic electricity needs are met (WTU) / using renewable re-

sources (SWEPCO, CPL); and (5) minimizing outages (WTU) / maximizing flexibility to increase or reduce production quickly (SWEPCO).

- The Australian national DP on the 1999 referendum on making Australia a republic (Luskin et al. 2000) sought orderings of three *constitutional possibilities for the Australian head of state*: (1) a republic with a directly elected president, (2) a republic with a parliamentarily appointed president (the referendum proposal), and (3) the status quo, with the Queen as head of state.
- The 1996 British national DP on the future of the Monarchy sought orderings of three possible *changes to the British monarchy*: (1) a monarchy with a more ordinary royal family, (2) a republic with a head of state with the same duties as the Queen, and (3) a republic with a head of state with the combined duties of Queen and Prime Minister.
- The 2002 regional New Haven DP (Farrar et al. 2010) sought orderings of three possible policies for the *level of commercial passenger service at the New Haven regional airport*: (1) maintaining it as is; (2) expanding it, offering more flights to more places; and (3) ending it.
- The New Haven DP also sought orderings of four possible arrangements for *sharing property-tax revenues* across the towns of greater New Haven: (1) full local control, (2) voluntary agreements between towns, (3) state-provided incentives to share, and (4) state requirements to share.

Salience and Naturalness

These issues differ both in salience (of the issue as a whole) and in the extent to which there is a natural geometric ordering of the alternatives. Consider first salience. Electric utility policies in Texas and revenue sharing in New Haven had received little public attention before the DP. The Monarchy in Britain, the airport in New Haven, and the Constitutional Referendum in Australia had received incomparably more. These latter three were highly salient. Since values and goals typically receive some thought, the electric utility goals were presumably in between—more salient than the electric utility policies but less salient than the three high-salience issues.

Now consider the extent to which there is a natural ordering of the alternatives. This is not something that can readily be measured, but our sense is that the fairly explicit phrasing of the alternatives as matters of degree, rather than in merely categorical terms, gives the alternatives in each of the two New Haven cases a more natural ordering than those in any of the others. The airport alternatives can be obviously ordered from no commercial passenger service to increased service, with the status quo in-between; the revenue-sharing alternatives from no revenue-sharing (local control) to mandatory revenue-sharing, with voluntary sharing and incentivized sharing in-between. Plausibly, the electric utility policy alternatives can be ordered on some environmental-to-economic benefits dimension. By contrast, the electric utility *goals*—explicitly including not only minimizing cost and maintaining environmental quality but such other alternatives as diversifying the energy resource portfolio, avoiding outages, meeting everyone's basic electricity needs, creating jobs, and being able to cope with short-term spikes or plummets in demand—seem less naturally orderable on any one dimension. The same is true of the alternatives in the Australian and British cases, each including two very different departures from the status quo. To be sure, these assessments are rough and relative. The alternatives for the two New Haven cases can also be ordered on dimensions other than the level of commercial passenger service or the compulsoriness of revenue-sharing, and there could be circumstances in which other cases admit a more natural ordering, for instance, in Australia, in terms of the degree to which citizens can participate directly in choosing the head of state.

ANALYSIS

Table 1 describes the preferences on these issues before and after deliberation. The first seven rows contain the low-salience cases (electric utility policies in Texas and revenue sharing in New Haven), the next three contain the moderate-salience cases (electric utility goals in Texas), and the last three contain the high-salience cases (the Australian referendum, the British monarchy, and the New Haven airport). The columns give the number of individuals in the sample (*n*), the number of alternatives (*k*), the largest structuring dimension (*D*), the Condorcet winner (*C*), and the proximity to single-peakedness (*S*) at both T1 (before deliberation) and T2 (after deliberation).[16] The subscripts "1" and "2" distinguish the T1 and T2 values. A final column gives the change in proximity to single-peakedness from T1 to T2 ($S_2 - S_1$).

Statistical inference in this context (to what we should see if the whole population received the DP treatment) is difficult. The definition of *S*, the proportion of individuals with single-peaked preferences on the largest structuring dimension, depends on the identity of that dimension. Thus neither S_1 nor S_2 has a known sampling distribution. As a rough guide, however, we may estimate the standard errors conditional on the obtained structuring dimensions. The difference S_2–S_1 presents an additional difficulty, since the obtained structuring dimension may change from T1 to T2. For S_2–S_1, therefore, we present worst-case estimates of the standard errors, on the assumption of zero covariance between S_1 and S_2.[17] Table 1 presents these estimated standard errors in parentheses.

(Table 1 about here)

Consistent with earlier results on non-ranking attitudinal and choice variables (in, e.g., Luskin, Fishkin, and Jowell 2002, Fishkin and Luskin 1999, and Luskin, Fishkin, and Hahn 2007), deliberation seems to induce considerable preference change. The Condorcet winner changes in eight of the thirteen cases, as does the largest structuring dimension (in not quite the same eight).[18] But our concern here is with proximity to single-peakedness, reported in the rightmost three columns.

Proximity to Single-Peakedness

A first point is that the proximity to single-peakedness at T1 is largely consistent with our sorting of the issues by salience. The mean S_1 is 0.751 among the three high-salience cases, but only 0.486 among the seven low-salience cases. True, it is still lower, at 0.308, among the three moderate-salience cases (all electric utility goals), but two of these have more alternatives and thus a lower minimum S. In addition, the electric utility goals arguably afford less of a natural left-right ordering of the alternatives than the electric utility policies, not to mention New Haven revenue-sharing.

But could the high-salience cases have the highest mean S_1 simply because they have only k=3 alternatives? Recall that S's lower bound, given strict preferences, is highest for k=3.[19] A rough way of addressing this possibility is to calculate how far S exceeds its minimum as a fraction of how far it could do so. Call this adjusted index $S' = (S – S_{min})/(1 – S_{min})$, where S_{min} is the lower bound. S' ranges from 0 (when $S = S_{min}$) to 1 (when S=1). The adjustment is only rough because the formula for S_{min} assumes strict preferences. As many respondents are indifferent between given pairs of alternatives, S is occasionally lower than S_{min}. For what it is worth, however, this adjustment leaves the three high-salience cases displaying the highest T1 proximity to single-peakedness. The mean S_1' is 0.268, 0.138, and 0.229 for the low-, medium-, and high-salience cases.[20]

More importantly, Table 1 supports H1, H2′, and H4. (We consider H3 below.) Regarding H1, the mean increase across all thirteen rows is 0.101. If normally distributed, the observed $S_2 – S_1$ would be statistically significant by conventional standards (by a two-tailed test at the 0.05 level against the null-hypothesis value of 0) for nine of the thirteen cases.

Regarding H2′, the increase is confined to the ten low- and moderate-salience cases, for which the mean increase is 0.134. The mean increase is also larger for the low-salience cases (0.141) than for the moderate-salience cases (0.116). For the three high-salience cases, the mean increase is -0.006. Two of the latter actually show *decreases*. Again, the observed $S_2 – S_1$, if normally distributed, would be statistically significant for every low- to moderate-salience issue except electric utility policies in the Entergy DP and statistically insignificant for all three high-salience issues. Here too, this pattern could be an artefact of differences in the number of alternatives. In the low-salience cases, coincidentally involving more alternatives, S could simply have more room to increase. But

S' shows mean increases of -0.014 for the high-salience cases,[21] 0.149 for the moderate-salience cases, and 0.212 for the low-salience cases—still consistent with H2′. So at least on issues that are not extremely salient, deliberation does seem to increase proximity to single-peakedness.

Regarding H4, the increase is greatest, among both low-to-medium and high-salience cases, for the one case in each set that has a relatively natural left-right ordering of the alternatives (the New Haven revenue-sharing and airport cases, respectively). It is worth noting, however, that at least for low-to-moderate salience cases the presence of a relatively natural ordering of the alternatives is not necessary for a major increase in proximity to single-peakedness. Seven of the other eight low-to-moderate salience cases also show an appreciable increase. This supports our earlier claim that shared issue dimensions can be *constructed* (when there is no relatively natural ordering of the alternatives), as well as *discovered* (when there is).

Proximity to Single-Peakedness and Substantive Agreement

Perfect substantive agreement (unanimity) implies single-peakedness, and high substantive agreement may be expected to produce high proximity to single-peakedness. Could the story of our results be simply that deliberation is producing increased substantive agreement, with increased proximity to single-peakedness as a byproduct? That is what Shapiro (2005), for instance, would suppose. But proximity to single-peakedness, as noted, need not rest on substantive agreement.

To examine this question, we adopt the inverse of the Laakso-Taagepera index of fragmentation (Laakso and Taagepera 1979, Taagepera and Grofman 1981) as a simple measure of substantive agreement. We focus on each individual's most preferred alternative. Writing n_j for the number of individuals most preferring the j^{th} alternative (where $j = 1, 2, \ldots, k$), the index of substantive agreement is $A = (n_1/n)^2 + (n_2/n)^2 + \ldots + (n_k/n)^2$. $A = 1$ when all individuals have the same most preferred alternative (perfect substantive agreement), and $A = 1/k$ when equal numbers of individuals most prefer each of the k alternatives (maximum substantive disagreement).

(Table 2 about here)

Table 2A reports the raw frequencies (n_1, n_2, …, n_k) of the most preferred alternatives, the index of substantive agreement, A_1 and A_2, at T1 and T2, and the change $A_2 – A_1$. It is clear from these results that the observed increases in proximity to single-peakedness are not just a by-product of increased substantive agreement. Indeed, substantive agreement does not generally increase. It increases in only four of the thirteen cases, and the average "increase" (actually a decrease) is -0.046.[22] Furthermore, the changes in substantive agreement are only modestly—and negatively—associated with the changes in proximity to single-peakedness. The Pearsonian correlation between the two across the thirteen cases is -0.308. At least on these particular issues, increased proximity to single-peakedness tends to be associated with *decreased* substantive agreement; the more those deliberating come to disagree, the more they come to agree about what they are disagreeing about.

Learning and Thinking

So far, we have established support for H1, H2′, and H4. But the "how" of deliberation's effect is important. The participants could simply have been taking cues, adopting ready-made preference orderings held by political elites. If that were all they did (as suggested by Aldred 2004), the deliberation behind the increased proximity to single-peakedness would have been quite shallow.

This leads us to consider the mediating effect of learning and thinking about the issues. By "learning" we mean the T1-T2 increase in relevant knowledge—knowledge not just of facts but of arguments for and against the alternatives and of other people's circumstances, beliefs, goals, and capacities, among other things. Of course, knowledge in all this variety is difficult to measure. So is "thinking." Operationally, therefore, we focus on factual knowledge, which is more readily measurable (as the proportion of factual questions answered correctly), is important in its own right, and can serve as a proxy for other sorts of knowledge and thought. Knowledge is positively correlated with the cognitive organization resulting from thought (Neuman 1981, Luskin 1987, Price 1999);

knowledge of any one topic in a given domain is positively correlated with knowledge of other topics in the same domain (if for no other reason than that they are all affected by cognitive ability, controlling for interest; see, e.g., Brody 1997); and different sorts of knowledge are positively correlated (as in, e.g., Schneider, Rittle-Johnson, and Star 2011).[23]

For ten of our thirteen cases (all but the three based on the Entergy, HL&P, and SPS DPs), the questionnaires afford enough factual knowledge items to construct a usable index. Both New Haven indices include four general New Haven items, plus two specific to the topic (the airport or revenue sharing). The Australian referendum index includes four general Australian politics items, plus eight specific to the referendum. The SWEPCO index is confined to the five knowledge items shared with the CPL and WTU questionnaires. The indices range from 0 (no items answered correctly) to 1 (all answered correctly). The online Appendix describes the ingredients.

Table 2B reports the mean T1 and T2 knowledge and mean T1-T2 knowledge gains. The table contains only seven rows because three of the electric utility DPs provide six of our original cases. The first three rows (CPL, WTU, SWEPCO) are a mix of low-salience (for policies) and moderate-salience (for goals), the fourth (New Haven revenue sharing) is low-salience, and the last three (the New Haven airport, the Australian referendum, and the British Monarchy) are high-salience. In every case, the participants learned a great deal. The knowledge gains are a first indication that more is going on than mere cue-taking. The mean increase, across all rows, is a sizable 0.218, akin to the mean score on an exam’s increasing by 22 points on the familiar 0 to 100 scale.

Note that Table 2B lends further support to our characterizations of salience. While comparisons of different knowledge indices must be taken with some caution, resting as they do on an implicit assumption of equal average difficulty, the pattern is clear. The mean *T1 knowledge* is highest in the high-salience cases (averaging 0.524) and lowest in the low-salience case (0.362 for New Haven revenue sharing). The mean *knowledge gain* is lowest in the high-salience cases (averaging "only" 0.191) and highest in the low-salience case (0.245 for New Haven revenue sharing).

The next step is to show that the previously observed increases in proximity to single-peakedness are at least partly learning-driven. Since proximity to single-peakedness is intrinsically aggregate, our strategy is to partition the sample into low- and high-learning subsamples and then to perform the same analysis as above separately within each. In practice, this means dividing the sample by observed T2 knowledge, which can be shown, under a broad range of plausible conditions, to be more highly correlated with actual knowledge gain than is observed knowledge gain (T2 observed knowledge minus T1 observed knowledge).[24] Participants who emerge knowing a lot at T2 have typically learned a lot—either observably, if they scored low on knowledge at T1, or unobservably, if they scored high on knowledge at T1 and thus could show little gain. The threshold dividing "high" from "low" knowledge is always drawn so as to divide the sample as equally as possible.[25] Table 2B gives the details. We expect the gain in proximity to single-peakedness to be greater in the high T2 knowledge subsample, in accordance with H3. The results, in Table 3A, support this hypothesis in spades. Even in the low T2 knowledge subsample, proximity to single-peakedness generally increased. In the high T2 knowledge subsample, it always increased. In every case, moreover, the increase is greater for the high T2 knowledge subsample than for the low T2 knowledge subsample. The mean increase is 0.147 for the former, but only 0.052 for the latter.[26]

(Table 3 about here)

Here, too, salience is an important conditioning factor. For the high T2 knowledge subsample, the mean increase is 0.209 in the low-salience cases (electric utility policies and New Haven revenue sharing), 0.130 in the moderate-salience cases (electric utility goals), and 0.081 in the high-salience cases (the New Haven airport, the Australian referendum, and the British Monarchy). For the low T2 knowledge subsample, the mean increases are similarly consistent with the sorting by salience: 0.133 in the low-salience cases, 0.103 in the moderate-salience cases, and -0.106 (not merely smaller but negative, a *decrease*) in the high-salience cases.

This breakdown sheds further light on the failure of overall proximity to single-peakedness to increase in the three high-salience cases. It *does* increase for the high T2 knowledge participants (those who emerge knowing relatively much). There is no overall increase because it *decreases* for the low T2 knowledge participants (those who emerge knowing relatively little). We are unsure of the reason in the British monarchy case, but in the other two high-salience cases, a major reason seems to be that, at least for the low T2 knowledge participants, the largest structuring dimension changes, as Table 3B shows. Recall that S registers only the proportion whose preferences are single-peaked with respect to the largest structuring dimension. If many low T2 knowledge participants continue to hold preferences that are single-peaked with respect to the *old* largest structuring dimension, the T2 proportion whose preferences are single-peaked with respect to the *new* one can easily be lower than the T1 proportion whose preferences were single-peaked with respect to the old one—in which event S_2 will be lower than S_1. This is in fact exactly what happened in the cases of the New Haven airport and the Australian referendum (as detailed in the online Appendix).

DISCUSSION

We have argued that deliberation increases proximity to single-peakedness—at least on low- to moderate-salience issues, where there has not been too much prior deliberation and where proximity to single-peakedness is not already high. We have also argued that deliberation's effect should be greatest among those who are learning and thinking the most, suggesting that it is not just a matter of thoughtless cue-taking. Our analysis, based on Deliberative Polling data, supports these claims.

Controlling for salience, the increases in proximity to single-peakedness are greatest for the issues that have a relatively natural left-right ordering of the alternatives. Where there is a relatively natural ordering, deliberation appears to help people see that. But the increases are appreciable even for the issues that do not have one. In those cases, deliberation appears to help people construct a shared ordering.

Our analyses bear some third-cousin-ish relationship to those based on factor-analytic and co-variance-structure models of responses to non-ranking policy attitude items (as, e.g., in Judd and Milburn 1980, Jackson 1983, Peffley and Hurwitz 1993). The dimensionality and fit do not directly reflect attitude organization inside the minds of individual respondents (Luskin 1987, 2002) but do register the degree of aggregate patterning of opinion. The fewer the dimensions and the better the fit, the greater the patterning. Stratifying these analyses by variables like knowledge generally produces results akin to ours: the number of dimensions decreases and the fit increases as knowledge increases (Stimson 1975, Delli Carpini and Keeter 1996). That said, the specific form of patterning we examine here—the proximity to single-peakedness of preference profiles—is distinctive, not only in conceptual detail but in social-choice-theoretic significance.

A skeptic may wonder how much of the increase in proximity to single-peakedness is due to the actual deliberation (and consequent thought and learning) between the initial interview and the post-event questionnaire. But an experiment enfolded in the New Haven DP provides reassurance on this score. Half the participants discussed the airport first and revenue sharing second, and the other half the reverse. The results (recounted more fully in Farrar et al. 2010, in this respect a follow-up to this paper) suggest that the great bulk of the increase in proximity to single-peakedness stemmed from the onsite deliberation (consisting of both small-group and plenary discussions), rather than from anything between the first interview and the onsite deliberation. On the airport, an extremely salient issue, there is little increase in S to apportion, but on revenue sharing, the increase in each treatment group occurs largely or entirely during the interval bracketing the group's discussion of revenue sharing (earlier in the one, later in the other).

Still, the full story is doubtless more complex than the one told here. The issue's salience and the individuals' learning are probably not the only conditioning or mediating factors. Much may also depend, for example, on the broader quality of the deliberation. The more focused, serious, and reflective the deliberation, the more it should promote proximity to single-peakedness. As the number of DPs with suitable ranking questions increases, we hope to examine these and other hypotheses.

There also remains, as ever, some causal mediation to explore. This is not just a question of the extent to which the movement toward single-peakedness is attributable to the deliberation in the DP treatment (as discussed in Farrar et al. 2010), but of what it is about deliberation that is responsible. Two sorts of disaggregation are of interest: the first to apportion deliberation's effect as between various possible intervening social and psychological mechanisms, the second to apportion its effect as between the various components of the DP treatment. To what extent, for example, is it thinking versus learning that increases proximity to single-peakedness? To what extent is it the small-group discussions versus the plenary sessions with experts and policy makers? The argument above suggests some possible answers, as do the results regarding knowledge, whose effect may be mediating as well as conditioning. Closer examination must await future studies, with finer measurement or experimental manipulation aimed at disaggregation of either sort. But for now it is an important advance to show, as we have done here, that there *is* an effect to be parsed—that, at least under widely prevalent conditions, deliberation does move preferences closer to single-peakedness.

This implies that deliberation *can* robustly protect against majority cycles, in the sense explained above, by moving preferences toward single-peakedness. Ironically, it was Riker (1982, p. 128) who first raised this possibility, writing that "[i]f, by reason of discussion, debate, civic education, and political socialization, voters have a common view of the political dimension (as evidenced by single-peakedness), then a transitive outcome is guaranteed." He immediately added, lest too much hope be drawn from this remark, that he expected this only for "issues of minor importance".

Here we see that deliberation has the posited effect only on issues of low to moderate *salience*. But salience and importance are hardly the same. Many issues are important, but only a few, at any moment, are salient. Salient issues, moreover, need not be important. It is not unknown for relatively frivolous issues to be salient. Thus the domain of deliberation's effect on proximity to single-peakedness is broad. And when unattended but important issues become more salient, the "discussion, debate, civic education, and political socialization"—in short, the deliberation—they then receive will move preferences toward single-peakedness, thus helping to ensure that "a transitive outcome is guaranteed."

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Table 1: Before-After Results: Largest Structuring Dimension, Condorcet Winner, and Proximity to Single-Peakedness

Issue	DP	N	K	D_1	D_2	C_1	C_2	S_1	S_2	$S_2 - S_1$
Electric Utility Policies	**SWEPCO**	232	4	[2314]	[2314]	3	1	0.405 (0.032)	0.556 (0.033)	0.151 (0.046)
	CPL	216	4	[2314]	[3124]	3	1	0.389 (0.033)	0.519 (0.034)	0.130 (0.047)
	WTU	230	4	[2314]	[2134]	3	3	0.374 (0.032)	0.496 (0.033)	0.122 (0.046)
	Entergy	175	4	[3124]	[3214]	1	2	0.640 (0.036)	0.691 (0.035)	0.051 (0.050)
	HL&P	192	4	[3124]	[3124]	1	1	0.521 (0.036)	0.677 (0.034)	0.156 (0.049)
	SPS	222	4	[3214]	[1234]	2	2	0.559 (0.033)	0.649 (0.032)	0.090 (0.046)
Revenue Sharing	**New Haven**	132	4	[1234]	[1234]	3	2	0.515 (0.043)	0.803 (0.035)	0.288 (0.056)
Electric Utility Goals	**SWEPCO**	232	5	[21435]	[12345]	4	3	0.237 (0.028)	0.362 (0.032)	0.125 (0.042)
	CPL	216	4	[1423]	[3124]	4	2	0.444 (0.034)	0.579 (0.034)	0.135 (0.048)
	WTU	230	5	[12435]	[13425]	4	3	0.243 (0.028)	0.330 (0.031)	0.087 (0.042)
Airport Expan-sion	**New Haven**	132	3	[213]	[213]	2	2	0.773 (0.036)	0.811 (0.034)	0.038 (0.050)
Australian Head of State	**Australian Referendum**	343	3	[213]	[123]	1	2	0.828 (0.020)	0.776 (0.023)	-0.052 (0.030)
Changing the British Monarchy	**British Monarchy**	258	3	[213]	[213]	1	1	0.651 (0.030)	0.647 (0.030)	-0.004 (0.042)

Note: n is the sample size; k the number of alternatives, numbered as in the text; D_1 and D_2 the largest structuring dimensions at T1 and T2; C_1 and C_2 the Condorcet winners at T1 and T2; and S_1 and S_2 the proximity to single-peakedness at T1 and T2. The parenthetical entries in the S_1 and S_2 columns are estimated standard errors.

Table 2: Before-After Substantive Agreement and Knowledge

A. Substantive Agreement

Issue	DP	$n_1, \ldots, n_k$		A_1	A_2	$A_2 - A_1$
		T1	T2			
Electric Utility Policies	**SWEPCO**	25, 16, 103, 5	115, 29, 65, 15	.519	.369	-0.150
	CPL	16, 16, 99, 15	96, 61, 32, 17	.494	.336	-0.158
	WTU	11, 18, 112, 15	69, 37, 79, 40	.543	.276	-0.267
	Entergy	99, 29, 18, 13	65, 88, 16, 4	.440	.409	-0.031
	HL&P	110, 30, 21, 13	112, 39, 33, 5	.450	.425	-0.025
	SPS	40, 107, 52, 16	31, 107, 63, 14	.346	.359	.013
Revenue Sharing	**New Haven**	43, 14, 48, 15	23, 51, 44, 12	.318	.308	-0.010
Electric Utility Goals	**SWEPCO**	53, 31, 34, 83, 22	45, 37, 104, 37, 9	.247	.291	.044
	CPL	45, 29, 41, 94	63, 73, 19, 58	.306	.287	-0.019
	WTU	59, 24, 34, 93, 11	46, 36, 76, 60, 11	.286	.246	-0.040
Airport Expansion	**New Haven**	33, 82, 4	30, 83, 13	.553	.501	-0.052
Australian Head of State	**Australian Referendum**	170, 69, 91	67, 209, 51	.385	.475	.090
Changing the British Monarchy	**British Monarchy**	136, 41, 33	128, 46, 24	.482	.487	.005

Note: $n_1, \ldots, n_k$ (at T1 and T2) are the numbers of respondents with first preferences for alternatives 1, …, k, numbered as in the text; and A_1 and A_2 the index of substantive agreement at T1 and T2.

B. Knowledge

Issue	DP	# Items	K_1	K_2	$K_2 - K_1$	Threshold for "High K_2"	Low-K_2 n	High-K_2 n
Electric Utility Policies/Goals	**SWEPCO**	5	.435	.638	.203***	≥ 0.80	122	110
	CPL	5	.360	.580	.219***	≥ 0.80	144	72
	WTU	5	.399	.687	.288***	≥ 0.80	102	128
Revenue Sharing	**New Haven**	6	.362	.607	.245***	≥ 0.66	56	76
Airport Expansion	**New Haven**	6	.407	.588	.182***	≥ 0.66	61	71
Australian Head of State	**Australian Referendum**	12	.520	.764	.243***	≥ 0.83	179	164
Changing the British Monarchy	**British Monarchy**	9	.646	.794	.148***	≥ 0.88	122	136

Note: #Items is the number of questions in the knowledge index; K_1 and K_2 the mean knowledge at T1 and T2; Threshold for "High K_2" the dividing line between high and low T2 knowledge; and Low-K_2 and High-K_2 n the numbers of "high" and "low" T_2 knowledge participants. *** $p < 0.01$.

Table 3: Before-After Results Conditional on T2 Knowledge

A. Single-peakedness

		Low K_2		High K_2		$S_2 - S_1$	
Issue	**DP**	S_1	S_2	S_1	S_2	Low K_2	High K_2
Electric Utility Policies	**SWEPCO**	.393	.525	.418	.591	.132	.173
	CPL	.382	.479	.431	.597	.097	.166
	WTU	.382	.490	.367	.508	.108	.141
Revenue Sharing	**New Haven**	.518	.714	.513	.868	.196	.355
Electric Utility Goals	**SWEPCO**	.246	.361	.236	.364	.115	.128
	CPL	.410	.535	.514	.667	.125	.153
	WTU	.235	.304	.281	.391	.069	.110
Airport Expansion	**New Haven**	.787	.754	.789	.859	-0.033	.070
Australian Head of State	**Australian Referendum**	.860	.682	.793	.878	-0.178	.085
Changing the British Monarchy	**British Monarchy**	.582	.475	.713	.802	-0.107	.089

Note: Low-K_2 S_1 and S_2 are the proximity to single-peakedness at T1 and T2 for the low T2 knowledge subsample; High-K_2 S_1 and S_2 the proximity to single-peakedness at T1 and T2 for the high T2 knowledge subsample.

B. Largest Structuring Dimension in the High-Salience Cases

		Low K_2		High K_2	
Issue	**DP**	D_1	D_2	D_1	D_2
Airport Expansion	**New Haven**	[1 2 3]	[2 1 3]	[2 1 3]	[2 1 3]
Australian Head of State	**Australian Referendum**	[2 1 3]	[1 2 3]	[2 1 3]	[1 2 3]
Changing the British Monarchy	**British Monarchy**	[2 1 3]	[2 1 3]	[2 1 3]	[2 1 3]

Note: Low-K_2 D_1 and D_2 are the largest structuring dimension at T1 and T2 for the low T2 knowledge subsample; High-K_2 D_1 and D_2 the largest structuring dimension at T1 and T2 for the high T2 knowledge subsample. The alternatives are numbered as in the text.

NOTES

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[1] No 'universal,' 'Paretian,' 'non-dictatorial,' and 'pairwise independent' aggregation rule guarantees rational collective preferences. Although more controversial than the other desiderata, independence precludes agenda manipulation (Riker 1982) and strategic voting (Gibbard 1973, Satterthwaite 1975). Other generalizations of Condorcet's paradox include McKelvey (1979) and Schofield (1976).

[2] Although cycling may also arguably have some benefits (McGann 2006, building on Miller 1983).

[3] Other conditions include *value restriction* (Sen 1966) and some necessary and sufficient conditions (e.g., Miller 2000, Elsholtz and List 2005, Regenwetter et al. 2006). Since these are less demanding than single-peakedness, the hypothesis that deliberation induces structure in individual

preferences is stronger and more interesting when formulated in terms of single-peakedness. On domain restrictions in social choice, see Gaertner (2001) and Dietrich and List (2010).

[4] Single-peakedness lends majority voting a natural interpretation as a median voting scheme (Black 1948, Arrow 1951/1963), and as famously shown by Moulin (1980), median voting schemes on domains of single-peaked preferences are *strategy-proof*, meaning that truthful expression of preferences is a dominant strategy for every individual. Penn, Patty and Gailmard (2011) have recently challenged this claim, though their findings do not logically contradict the classic result, since the opportunities for manipulation they identify involve departures from the single-peaked domain.

[5] The use of random samples of the mass public sets this study apart from most research on the occurrence of cycles, which typically examines narrower and more homogeneous groups like professional associations, clubs, or committees (for a critical overview, see Mackie 2004).

[6] Formally, R_i is *single-peaked with respect to* Ω if, for any triple $x,y,z \in X$ with y between x and z relative to Ω, it is *not* the case that xR_iy and zR_ix (so there is no "cave" between x and z, at y).

[7] Our ordinal definition of single-peakedness is the social-choice-theoretic one of Black (1948) and Arrow (1951/1963), not to be confused with the cardinal definition in spatial voting theory. There, preferences are a function of the alternatives' Euclidean (or other) distances from an individual's ideal point, which requires identifying alternatives with points in a Euclidean space, a restriction not made here. Spatial single-peakedness is sufficient for avoiding cycles only if the Euclidean space is one-dimensional, but then the condition is stronger than classical single-peakedness.

[8] The *median individual* is the one with an equal number of others to the left and to the right, with individuals arrayed according to their most preferred alternatives relative to a structuring dimension.

[9] Other sufficient conditions for the avoidance of cycles are mentioned in an earlier note.

[10] The formula is stated without proof by Niemi (1969). A proof for k =3 is available on request.

[11] Taking an impartial culture as a Bayesian prior, p is the probability we would obtain through Bayesian updating given that $S > \alpha$. This probability coincides with the proportion of profiles for which there exists a Condorcet winner among all possible profiles satisfying $S > \alpha$.

[12] More extensive simulations, in collaboration with Susan Holmes, show similar results for $k > 3$.

[13] These properties may also entail some other, non-definitional properties, including increasing the frequency of appeals to the common good, for reasons sketched by Mill, Rawls, and others.

[14] They need not arrive at the same preference ordering, nor agree on the most preferred alternative.

[15] Respondents ranked their top k-1 choices, from which their bottom choice could be inferred.

[16] There need not generally be a Condorcet winner, but in all these cases there happens to be one.

[17] This is very conservative. As always, $V(S_2–S_1)=V(S_2)+V(S_1)–2C(S_2, S_1)$, where V and C are variance and covariance, and $C(S_2, S_1)$ should not actually be 0 but (highly) positive, implying $V(S_2–S_1) < V(S_2)+V(S_1)$. To see this, note that (a) S_1 may be taken as proxying T1 salience and thus (casual) T1 deliberation, (b) issues with higher S_1 should also tend to have higher S_2 (on account of lower numbers of alternatives, residually higher salience, and/or more natural left-right orderings), and (c) since the DP can be expected to shrink initial differences in salience, differences in S_1 should be associated with smaller differences in S_2 (consistent with H2′). So, if $S_2=\alpha_0+\alpha_1 S_1+u$ and, equivalently, $S_2–S_1=\alpha_0+(\alpha_1–1)S_1+u$ (where u is a disturbance), $0<\alpha_1<1$ and $-1<\alpha_1–1<0$. The results in Table 1 confirm all this: the OLS estimates of α_0, α_1, and $\alpha_1–1$ are 0.229, 0.747, and -0.253, and the correlation (covariance normed to the [-1, 1] interval) between S_1 and S_2 is 0.890.

[18] The quasi-control groups in the Australian DP suggest that these observed changes can indeed be attributed to the deliberative treatment. In the treatment group, the Condorcet winner changes from a directly elected president (1) to a parliamentarily appointed one (2), and the structuring dimension changes from [2 1 3] to [1 2 3] (3 is the status quo). Among the original interviewees who did not

participate in the deliberation but were later reinterviewed (n=227), the Condorcet winner remains 1, and the structuring dimension remains [2 1 3], just as it is among a fresh random sample (n=3439) questioned by the Australian national election study immediately after the referendum.

[19] The lower bound for S is 2/15≈0.133 for k=5, 1/3≈0.333 for k=4, and 2/3≈0.667 for k=3.

[20] The 0.268 figure counts the British monarchy issue, where S_1 fell slightly short of S_{min}, as 0. If instead we count S_1' as -0.047, the 0.268 falls to 0.252, still the highest of these figures.

[21] The figure is -0.018 if we do not cut S' off at 0.

[22] Similarly, the number of first preferences for the alternative drawing the most first preferences (the maximum among n_1, n_2, …, n_k) increases in only six of the thirteen cases.

[23] We write of "knowledge," the aptest, in our view, of several related concepts, including "information," "sophistication," and "expertise" (see Luskin 2002).

[24] Three phenomena underlie this result: (1) learning (knowledge gain) is facilitated by, and thus an increasing function of, prior knowledge (e.g., Bransford and Johnson 1972, Recht and Leslie 1988, Hambrick 1993); (2) observed knowledge, defined as the proportion of the survey's knowledge items answered correctly, is ceilinged at 1.0; (3) the knowledge items on any survey are far from a random draw from the universe of potential such items, including many that only experts, if anyone, would know (Converse 2000, Luskin, Helfer, and Sood 2011). The selection is biased toward easy items, lest the observed knowledge index have almost no real variance, departing from zero only via lucky guessing. Under assumptions formalizing these phenomena, (1) the correlation between true and observed knowledge gain can be negative; (2) the correlation between true knowledge gain and observed T2 knowledge is always positive; and (3) the former is less than the latter for most plausible configurations of parameters. For proofs, see Luskin, Helfer, and Sood (2011). In analyses relat-

ing learning to other variables, observed T2 knowledge can therefore yield sharper results, although in the present case we get essentially the same results if we use observed knowledge gain.

[25] This would be a bad idea at T1, as in ordinary surveys, where the distribution of knowledge is severely right-skewed, so that dichotomizing at or near the median would yield a "high knowledge" group containing many respondents not much more knowledgeable than the members of the "low knowledge" group. Here, after deliberation, it is reasonable.

[26] Although T1 and T2 knowledge may be correlated—those high at T2 tend already to have been high, and thus to have been closer to single-peaked, at T1—the difference in proximity to single-peakedness between the high and low knowledge subsamples grows from 0.026 at T1 to 0.121 at T2.