Sequential Requisites Analysis: A New Method for Analyzing Sequential Relationships in Ordinal Data*

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Objectives. This article presents a new method inspired by evolutionary biology for analyzing longer sequences of requisites for the emergence of particular outcome variables across numerous combinations of ordinal variables in social science analysis. *Methods.* The approach is a sorting algorithm through repeated pairwise investigations of states in a set of variables and identifying what states in the variables occur before states in all other variables. We illustrate the proposed method by analyzing a set of variables from version 7.1 of the V-Dem data set (Coppedge et al. 2017. Varieties of Democracy (V-Dem) Project; Pemstein et al. 2017. *University of Gothenburg, Varieties of Democracy Institute: Working Paper* No. 21). With a large set of indicators measured over many years, the method makes it possible to identify and compare long, complex sequences across many variables. *Results.* This affords an opportunity, for example, to disentangle the sequential requisites of failing and successful sequences in democratization, or if requisites are different during different time periods. *Conclusions.* For policy purposes, this is instrumental: Which components of democracy occur earlier and which later? Which components of democracy are therefore the ideal targets for democracy promotion at different stages?

Sequences are critical to understanding many social processes such as regime transitions, onset of civil wars, economic development, and institutional development. The subject of specific concern to us that has important policy implications is the study of democratization. This is a field of study endowed with persuasive theorists and accomplished area experts (e.g., Dahl, 1971; Diamond, Linz, and Lipset, 1988; Linz and Stepan, 1996; O'Donnell and Schmitter, 1986; Schedler, 2013). They provide us with abundant lessons from both detailed country case studies and comparative analyses. Large-*N* data sets on democracy and democratization emerged already in the 1960s with the purpose of evaluating more general hypotheses. The field has since seen substantial increasing methodological sophistication

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(e.g., Acemoglu and Robinson, 2001; Bollen, 1993; Inglehart and Welzel, 2005; Jackman, 1973; Norris, 2008; Lipset, 1959; Przeworski et al., 2000), but has also become crowded with typologies depicting various semi-authoritarian regimes (e.g., Gandhi and Przeworski, 2007; Geddes, 1999; Levitsky et al., 2002), democratic regimes (e.g., Lijphart, 1999), innumerable subtypes (Collier and Levitsky, 1997), and full typologies from autocratic to democratic regimes (e.g., Diamond, 2002).

A core issue remains, however. Existing studies habitually provide evidence on variables related to democratization (e.g., Acemoglu et al., 2005; Boix, 2003; Coppedge, 2012; Przeworski, 1991; Teorell, 2010) from which causal inferences are attempted. Yet, we have been unable to use large-*N* data to depict the series of requisite conditions that are typical for countries making their way from one regime to another. We "know" that processes of democratization are messy, with many factors interacting over time that eventually produce either good or less good outcomes. However, we have been unable to measure all those aspects systematically across the world and along extended time spans, and even less able to systematically analyze the many sequential and interrelated changes among those variables. The Varieties of Democracy (V-Dem) data set has solved the first issue by providing data on over 350 variables across 173 countries and the period from 1900 to 2012 (Coppedge et al., 2017; Pemstein et al., 2017). A first effort at solving the second issue was presented in Lindenfors et al. (2018) (utilized in Wang et al., 2017; Mechkova, Lührmann, and Lindberg, 2019). The present article takes that framework significantly further and presents what we believe to be a viable solution to the second problem.

On the State of the Field of Democratization

One subset of scholars has focused on which variables *external* to the political system may increase the probability of democratization, such as geography, modernization, colonialism, inequality, and societal/class conflict. Lipset's milestone (1959) sparked a long deliberation on whether, or to what extent, economic development, or more broadly modernization, affects democratization and democratic consolidation (Acemoglu et al., 2009; Bollen, 1983; Burkhart and Lewis-Beck, 1994; Huntington, 1991; Knutsen et al., 2015; Przeworski and Limongi, 1997). Yet, the field seems not to have produced a definitive answer to the question of whether economic development is beneficial for democratic stability but not for transitions (Przeworski et al., 2000); whether it facilitates neither transitions nor stability (Acemoglu et al., 2009); or that it furthers both of them (Boix, 2003).

Another group focuses on research on *endogenous* dynamics of democratization. These are studies analyzing how parts of what we think of as a democratic regime, or autocracy, affect each other in positive or negative ways. Much of the early writing took "big" approaches to democratizations. For example, Rustow's (1970) timeless piece suggested four interrelated stages of democratization: national unity, prolonged political struggle, deliberate accords, and habituation to democratic rules (cf. Carothers, 2002). O'Donnell et al. (2013) find that democratization is more likely when a bargaining between moderate actors (soft-liners) on both sides precedes a "founding" election and projected four transition processes with varying outcomes. Linz and Stepan (1996:57–60) argue instead that there are six alternative pathways of democratic transitions, each with different consequences for democratic consolidation (see also Karl, 1990; Munck and Leff, 1997).

More recently, many scholars have taken a more disaggregated approach and look at specific aspects rather than entire processes of democratization, thus identifying something narrower than "democracy" as their dependent variable. These works are typically associated

with more restricted claims, like if individual rights and institutional checks and balances go before mass suffrage, does democracy have a higher probability of enduring (Berlin, 2002), or that repeated elections—even if not entirely free and fair—are instrumental to spur and sustain processes of expanding civil liberties (Howard and Roessler, 2010; Lindberg, 2006). Again, we find contradictory results such that elections can be a constituent and stabilizing component of dictatorship (e.g., Gandhi and Przeworski, 2007). The literature on the role of civil society has produced more coherent results, generally viewing the mobilization of civil society as critical to the breakdown of authoritarianism and good for democratic consolidation (Bernhard, 1993; Bunce, 2010; Ekiert and Kubik, 1999; O'Donnell et al., 2013; Putnam, 1993), even if it has also been argued that a civil society conveying the interests of society to the regime may promote authoritarian stability (Gandhi, 2010; Magaloni, 2008). The role of political parties suggests that where parties are poorly institutionalized, electoral regimes are likely to lack stability (Bernhard et al., 2015; Hicken and Kuhonta, 2011; Roberts and Wibbels, 1999).

Thus, a great deal of work in political science seeks to investigate the order of events or utilizes historical process tracing of complex sequential relationships to explain political outcomes such as democratization. The sequences of complex social processes usually involve hundreds of related variables with a large number of characteristics, and today's standard techniques for time-series cross-sectional analysis for observational panel data are not very apt for this sort of problems. First, they do not solve the causal inference problem to a greater or lesser degree than the approach suggested here below. Second, they typically force analysts to make very strong assumptions about invariant time-distance between x and y in terms of which lag should be used. Third, they are designed for giving insights into the average effect of xi on y given the conditions zi, sometimes taking interaction effects into account. However, the social and political processes that we as social scientists are typically interested in, such as democratization, are rarely even approximations of such simplifications. Rather, complex and often long series of sequentially related variables are in play and contribute to the outcome.

Finally, large-N research on sequences in political science has been hampered by the lack of appropriate data. The quality, conceptual validity, and reliability of the extant sources on democracy are discussed by others (e.g., Coppedge et al., 2015). For sequential analysis of democratization, one needs long time series covering as many countries as possible. This makes sources such as the BNR Index (Bernhard, Nordstrom, and Reenock, 2001), Bertelsmann Transformation Index (Bertelsmann Foundation, various years), the European Intelligence Unit's index (EIU, 2010), the Democracy Barometer (Bühlmann et al., 2012), or the World Governance Indicators (Kaufmann, Kraay, and Mastruzzi, 2010) less useful. The remaining sources suffer from being highly aggregated and lacking detailed measures of individual aspects of democracy that can be used for sequential analysis, including Freedom House's (2015) political rights and civil liberties ratings (freedomhouse.org), Polity IV's democracy and autocracy scores and their components (Marshall, Gurr, and Jaggers, 2014), the Unified Democracy Scores (Pemstein, Meserve, and Melton, 2014), the Democracy-Dictatorship index (Alvarez et al., 1996; Cheibub, Gandhi, and Vreeland, 2010), the Lexical Index of Electoral Democracy (Skaaning, Gerring, and Bartusevičius, 2015), the Competition and Participation indices developed by Vanhanen (2000), the BMR Index (Boix, Miller, and Rosato, 2013), and the Contestation and Inclusiveness indices (Coppedge, Alvarez, and Maldonado, 2008). In effect, researchers have only had highly aggregated indices of democracy to draw upon, and since there have been no appropriate methods developed for analysis of time-variant, sequential relationships across many variables, it has never been possible to test propositions about more specific relationships in a systematic and comprehensive fashion.

Sequence Analysis of Ordinal Data Customized from Evolutionary Biology

We suggest here a new algorithm—sequential requisites analysis—to enable delineation and testing of long series of requisites involving many variables, while capitalizing on V-Dem's multidimensional understanding of democracy and provision of over 350 highly disaggregated measures of various aspects of democracy for 173 countries from 1900 to 2012. This combination of new data and a new method inspired by evolutionary biology offers an opportunity to evaluate existing theories of failing and successful sequences of democratization in the most rigorous fashion possible, taking full advantage of the complete universe of available data. Perhaps even more significant, unexplored and undertheorized chains of sequential requisites can be investigated with this method. The sorting algorithm we describe here makes it possible to search for sequences not necessarily contemplated by current theory—and do so with regards to long chains of sequential relationships between many factors.

This is a form of descriptive, basic research whose importance should not be underestimated. Description has led to groundbreaking advances across many sciences, including evolutionary biology, from which we adapt methodological approaches. Simply put, we do not know the answers yet to relatively simple questions: When a country transitions from autocracy to democracy (or vice versa), which elements come first? Which are the common patterns, a finite set of sequences for sequences that are failing to lead to democracy, and those that result in democratization?

With a large set of indicators measured over many years, it would become possible for the first time to explore transition sequences.[1] It is quite possible, maybe even probable, that there are varying paths—sequences of conditional relationships (assuming the variables are not independent)—to each of them. This affords an opportunity to disentangle the sequential requisites of failing and successful sequences in democratization. For policy purposes this is also instrumental: Which components of democracy are most exogenous (affecting other components) and least endogenous (dependent on other components) and therefore the ideal targets for democracy promotion at different stages?

Elsewhere, we have suggested a set of methods to identify sequences within a set of variables (Lindenfors et al., 2018; used in Wang et al., 2017; Mechkova, Lührmann, and Lindberg, 2019). There also exist a number of other approaches to identify sequences in ordinal and categorical time-series data, many more or less inspired by evolutionary biology. Noteworthy are, for example, social sequence analyses that are inspired by DNA sequence analyses (e.g., Abbott, 1995; Abbot and Tsay, 2000; Gauthier et al., 2010; Casper and Wilson, 2015), set-theoretic approaches such as qualitative comparative analysis (QCA) (Ragin, 1987; Rihoux and Ragin, 2009), and time-series cross-section methods (Beck, 2008). There also exists a more novel approach using Bayesian modeling to construe dynamic systems indicating flow of change (Ranganathan et al., 2014; Spaiser et al., 2014). All these methods have their pros and cons, where method choice is dependent on the format of the data and the specific question of interest. The method presented here sits comfortably in the set-theoretic tradition (see, e.g., Paine, 2016; Thiem, Baumgartner, and Bol, 2016; Schneider and Schmitter, 2004 for discussions on these methods), though we shy away from inferring causation and instead focus on the method's ability to describe historical pathways.

Analyses based on the approach proposed below can in principle be conducted for qualitative data measured at any level (interval, ordinal, binary) but in practice, it requires

[1] Sequencing is explored by Schneider et al. (2004) and Wilson (2014, 2015) with a smaller set of indicators and/or a shorter stretch of time. See also McFaul (2005) and Møller and Skaaning (2010).

ordinal or binary variables in order to be easily interpretable. The analysis is also easier to interpret if all variables in a particular analysis have the same level of measurement, but this is not required.

From the sorting algorithm, combining a series of bivariate analyses (by running all variables against all), one can establish long series of sequences involving many multistate variables. The result is a detailed and empirically based "map" of which aspects of a phenomenon tend to occur before other aspects. In other words, we are now capable of providing the first solution to presenting detailed sequences of democratization and other similar phenomena. Also, the requisite analysis presented below promises to put us in a much better position to answer prescriptive questions with a strong empirical foundation.

Here we present an extended requisite analysis to identify historically realized sequences of events between states of variables. We suggest that the approach detailed below can establish descriptive sequences in terms of conditions among, in principle, an unlimited number of multistate ordinal variables over any stretch of time, given that adequate data are available and that there are, in fact, sequential relationships to be found. To the extent that one can establish that any one sequence across time and space always, or almost always, precedes the outcome, we have arguably come a long way in terms of arriving at a general understanding of and explanation for such a social process compared to where we are today. Until now, we have not been able to provide evidence of such sequences at all across time and a large number of units, other than by individual case analysis found, for example, in historical sociology and in-depth case study approaches.

Data

To explore the temporal relationship between various aspects of democracy utilizing the proposed sequence analysis approach, we use the V-Dem data set v7.1. V-Dem aims to achieve transparency, precision, and realistic estimates of uncertainty with respect to each data point. The v7.1 data set includes 177 sovereign or semi-sovereign states from 1900 to today.[2]

The indicators in the "V-Dem Codebook" fall into three main categories: (1) factual data gathered from other data sets or original sources; (2) evaluative indicators coded by multiple country experts; and (3) aggregated indices constructed by combining several indicators that load on the same dimension based on factor analysis results. The evaluative indicators are produced according to a complex and demanding protocol. Typically, five or more independent country experts code each country-year for each indicator and almost 3,000 experts have been involved in the coding to date.[3] To arrive at the best possible estimates, V-Dem has a team of measurement experts and methodologists who have developed an advanced Bayesian ordinal item-response theory (IRT) model for aggregating and weighting expert ratings and for calculating confidence intervals alongside a series of validity and reliability tests, including tests of intercoder reliability (see Coppedge et al., 2017;

[2]A detailed explanation of the V-Dem approach can be found on V-Dem's website ⟨https://v-dem.net⟩ along with the other V-Dem documents cited in this article.

[3]The coders' considerable knowledge derives from a combination of experience and education: most have lived in their countries of expertise for nearly 30 years, and 60 percent are nationals of that country. In addition, 90 percent have postgraduate degrees. Ratings accorded to a country are therefore largely the product of in-country expert judgments. In addition to providing a rating on each indicator, country experts also assign a "confidence score" (0–100), which measures how certain we can be about the rating. In addition, roughly a fifth of the coders undertake cross-country coding, making it possible for us to calibrate measurements between countries.

Pemstein et al., 2017). This model takes into account the possibilities that experts may make mistakes and have different scales in mind when providing judgments.[4] Indicators in V-Dem are mostly on an ordinal scale from 0 to 4 (originally, the data set also provides other versions). Indices where the original V-Dem scale runs from 0 to 1 have been transformed to ordinal categories ranging from 0 to 4, created and validated by Lindberg (2015) in order to enable the sequence analysis we are aiming for here. Note, however, that the analysis does not require an equal number of steps in the ordinal values utilized, although it does make interpretation easier. If there are an unequal number of steps, then variables can be standardized, or results interpreted "as is."

The New Method: Sequential Requisites Analysis

To explore whether certain states of one variable are systematically conditional on certain states of other variables in existing data, we here extend the method termed "dependency analysis" from an earlier paper (Lindenfors et al., 2018; used in Wang et al., 2017; Mechkova, Lührmann, and Lindberg, 2019). The extension consists of illustrating how dependency tables can be compared using Monte Carlo simulations to test hypotheses. The basic sorting method is inspired primarily by "the contingent states test," which is an established method developed to investigate historical sequences in biological evolution, originally utilized to establish that group living evolved in warning-colored butterfly larvae, not in camouflage-colored species (Sillén-Tullberg, 1993), with reasoning particularly well suited to use on sequence data outside biology. It also has some similarities with QCA (Ragin, 1987; Rihoux and Ragin, 2009) in that the method utilizes the frequency of observations of co-occurrences of variable states. Note that even though variables may covary, the proposed method checks for requisites in the data, not statistical correlations. This is an important distinction since if and when one can establish such requisites—assuming that the data are more or less complete in coverage—this is evidence of actual historical sequences realized in the data.

To construct the dependency tables that the method uses, for each value of one variable, scan the data set for the lowest value in all other variables. If a particular value in A (say "1" on a scale from 0 to 4) always correspond to a higher "lowest observed value" in B (say "3" on a scale from 0 to 4), it can be inferred that a transition from value 0 to 1 on A is conditional on value 3 on B. If, simultaneously, for each value of B the corresponding "lowest value" in A is its minimum (0), then B is not restricted by A. These two observations in combination indicate that dependencies between the two variables exist only in one direction (Lindenfors et al., 2018:456). To allow some margin of error, a percentile of observations can be specified and treated as the "lowest values," which will slightly relax the criterion of absolute dependencies. We here report dependencies allowing such a 95 percent "wiggle room," following the convention in QCA. Note that whereas a QCA analysis would arrive at a set of prime implicators, the method proposed here instead lists a set of (lowest) requisites—hence the method's name.

Table 1 illustrates the procedure. Table 1(a) indicates that states higher than 0 in A occur *only* together with higher values in B. This means, for example, that A is *never* observed

[4]Simulations and other computational tasks to produce the V-Dem data set were done using resources provided by the Notre Dame Center for Research Computing (CRC) through the High Performance Computing Section and the Swedish National Infrastructure for Computing (SNIC) at the National Supercomputer Centre in Sweden. We specifically acknowledge the assistance of In-Saeng Suh at CRC and Johan Raber at SNIC in facilitating our use of their respective systems.

TABLE 1

Example of Dependency Tables

(a) Variable A	Lowest Value of Variable B	(b) Variable B	Lowest Value of Variable A
0	0	0	0
1	2	1	0
2	3	2	0
3	4	3	0
4	4	4	0

to reach value 1 before B has reached value 2. Thus, B has always reached value 2 *before* A "started moving." At the next level, the same pattern is repeated. Variable A is never observed at value 2 before B has reached at least value 3. At any rate, this is how it has *always been* so far according to the data.

Table 1(b) indicates no such dependency, since A can be 0 at any level of B. Thus, A seems dependent on changes of variable B having taken place at several stages, while in the opposite direction there is no such dependency. In this case, we could conclude that improvements in B are *likely* to be a necessary condition for improvements in A (again without implying that there is a direct causal relationship, or that improvements in B are sufficient in themselves). We can make a firmer statement regarding the opposite direction. There are no dependencies in the other direction, so we can conclude decisively that improvements in B are *not* necessary conditions for improvements in A (Lindenfors et al., 2018:456).

Each such binary relationship can be analyzed across any number of indicators using our algorithm. These can them be summarized in table format. Table 2 shows an example of the described procedure on actual V-Dem data. The sums listed in the right column indicate the sums of requisites from the highest to lowest. The sums listed in the bottom row indicate the sum of states that the other variables are dependent on. Thus, the order bottom to top indicates a sequence where the top variables are more dependent on reformed states of the bottom variables. Likewise, the order left to right indicates a sequence of dependencies where variables in the left column are more contingent on reformed states of the rightmost variables. The two lists, row and column, will be similar by necessity, but need not be identical. Note that the row and column sums need not depend on dependencies of the same variables, so some care has to be taken in interpreting these sums when comparing variables—variables can be compared, if that is deemed desirable, through the use of Euclidean distance between requisite rows. Note also that the method thus far is descriptive rather than hypothesis testing, so no significance values are reported.

The table indicates that the highest state of some variables occurs *only* together with higher values in the others. This means, for example, that "Legislature investigates in practice" only exists in its highest state if "Health equality" is at least 2, "Election free and fair" is at least 4, and all the others are at least 3. Based on data from across 171 countries and 116 years, this suggests that reaching a perfect democratic state on the indicator of whether the legislature in practice investigates the executive when there is reason to do so (e.g., if it is suspected that the executive has engaged in unlawful activities) is highly contingent on several other aspects of democracy being highly developed *first*.

On the other hand, the "Executive bribery and corrupt exchanges" occurs in its highest state regardless of the values of many of the others, and only requires "Harassment of

TABLE 2

Sequential Requisites Table

	Legislature investigates in practice	Health equality	Executive bribery and corrupt exchanges	High court independence	Harassment of journalists	CSO entry and exit	Access to justice for women	Election free and fair	Sums
Legislature investigates in practice		**2**	**3**	**3**	**3**	**3**	**3**	**4**	**21**
Access to justice for women	2	2	2	3	3	3		4	19
Harassment of journalists	2	2	2	3		3	3	4	19
High court independence	2	2	2		2	3	2	3	16
CSO entry and exit	1	1	1	1	2		2	3	11
Election free and fair	1	1	1	1	2	1	2		9
Executive bribery and corrupt exchanges	0	0		0	1	0	1	1	3
Sums	8	10	11	11	13	13	13	19	

NOTE: Example of a sequential requisites table for the highest state of each variable. The highest state of the variables listed in the left column has not occurred in the data if the state indicated by the numbers in the table was not reached for each variable listed in the top row. For example, the variable "Legislature investigates in practice" (highlighted with bold text) has only been observed to exist in its highest state (4) if "Health equality" was at least 2, "Election free and fair" at least 4, and all the others at least 3. Darker green indicates lower state of each individual variable; 0 = white to 4 = darkest green.

journalists," "Access to justice for women," and "Elections free and fair" to be at least 1. We can infer that the absence of "Executive bribery" (its highest state) is something that countries can achieve relatively independent of and *before* many other democratic aspects develop.

From Table 2, it may seem that improvements in the variables on the left are *necessary* conditions for improvements in the top variables. However, as the observed relationship is historical rather that causal, one should be careful in implying a direct causal relationship (see, e.g., Paine, 2016; Thiem, Baumgartner, and Bol, 2016; Schneider and Schmitter, 2004). A low number of dependencies for all states of a variable, though, indicates that there are very few necessary conditions for it to assume higher states—this can be stated firmly. However, the converse claim of causality is less supported. If a variable has a high number of requisites, this indicates that it historically never has reached higher states before a number of other variables have reached high levels, but any causal claim has to be made very carefully.

So far we have described the method of dependency analysis as first described in an earlier publication (Lindenfors et al., 2018) in order to make the following development of the sequential requisite analysis described here intelligible. Instead of focusing on only *one* state as above (the highest state of variables), Table 3 is an example of a dependency table for *all* states of each variable. So if a variable has five states (0, 1, 2, 3, and 4), it can

TABLE 3

Sequential Requisites Table

	Legislature investigates in practice	Health equality	Executive bribery and corrupt exchanges	High court independence	Harassment of journalists	CSO entry and exit	Access to justice for women	Election free and fair	sums
Legislature investigates in practice 4		2	3	3	3	3	3	4	21
Access to justice for women 4	2	2	2	3	3	3		4	19
Harassment of journalists 4	**2**	**2**	**2**	**3**		**3**	**3**	**4**	**19**
High court independence 4	2	2	2		2	3	2	3	16
CSO entry and exit 4	1	1	1	1	2		2	3	11
Election free and fair 4	1	1	1	1	2	1	2		9
Harassment of journalists 3	**1**	**0**	**1**	**1**		**1**	**1**	**2**	**7**
Legislature investigates in practice 3		0	1	1	2	1	1	1	7
Access to justice for women 3	0	1	0	1	1	1		1	5
CSO entry and exit 3	1	0	0	1	1		1	1	5
Election free and fair 3	0	0	0	1	0	1	1		3
Executive bribery and corrupt exchanges 4	0	0		0	1	0	1	1	3
Harassment of journalists 2	0	0	0	0		1	1	1	3
High court independence 3	0	0	1		0	0	1	1	3
CSO entry and exit 2	0	0	0	0	0		1	1	2
Health equality 4	0		1	0	0	0	1	0	2
Legislature investigates in practice 1 & 2		0	0	0	0	0	1	1	2
CSO entry and exit 1	0	0	0	0	0		1	0	1
Election free and fair 2	0	0	0	0	0	0	1		1
Executive bribery and corrupt exchanges 2	0	0		0	0	0	0	1	1
Health equality 2 & 3	0		0	0	0	0	1	0	1
High court independence 2	0	0	0		0	0	0	1	1
sums	10	11	15	16	17	18	27	31	
Access to justice for women 1 & 2	0	0	0	0	0	0		0	0
Access to justice for women 2	0	0	0	0	0	0		0	0
Election free and fair 1	0	0	0	0	0	0	0		0
Executive bribery and corrupt exchanges 1 & 3	0	0		0	0	0	0	0	0
Harassment of journalists 1	0	0	0	0		0	0	0	0
Health equality 1	0		0	0	0	0	0	0	0
High court independence 1	0	0	0		0	0	0	0	0

Occurs later ↑ / ↓ Occurs earlier

NOTE: Example of a dependency table for the highest state of each variable. The highest state of the variables listed in the leftmost column has not occurred in the data if the state indicated by the numbers in the table was not reached for each variable listed in the top row. For example, state 4 of the variable "Harassment of journalists" (highlighted with bold text) has only been observed to exist if all the variables listed at the top have reached at least a value of 2 and in some cases 3 or 4. Contrast that with state 3 of the same variable (also highlighted with bold text) where only "Election free and fair" was at least 2 and all almost all other variables at least 1.

appear five times in the table. This does not happen in Table 3 since we have omitted state 0 for all variables.

The state indicated of the variables listed in the left column has not occurred if the states indicated by the numbers in the table were not reached for each variable listed in the top row. For example, state 4 of the variable "Harassment of journalists" (highlighted with bold text) has only been observed to exist if all the variables listed at the top have reached at least a value of 2 and in some cases 3 or 4. Contrast that with state 3 of the same variable where only "Election free and fair" was at least 2 and almost all other variables at least 1, while "Health equality" has been observed at its lowest level. This indicates a sequential order of requisites where no country of the 171 between 1900 and 2016 has managed to move from state 3 (journalists are relatively rarely harassed by political agents for writing critically about the government) to state 4 (such harassment never happens) without a series of improvements on other democratic aspects *first*. Table 2 is summarized graphically in Figure 1.

Table 3 is the outcome of the new algorithm we have developed, summarizing hundreds of bivariate dependency analyses. Using these new methods, we can get a good sense of which variables come first, middle, and last in processes, as illustrated with the discussion above. This example of looking at the state dependencies is of particular interest when one is analyzing, for example, what conditional relationships look like for achieving democratization.

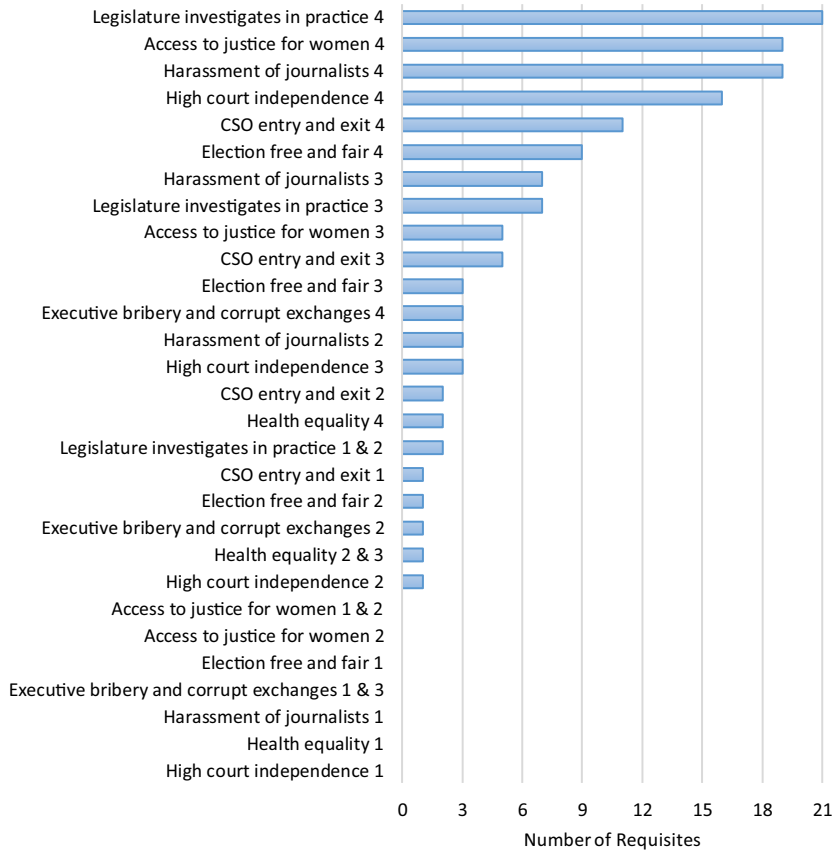
The proposed method can be made to fail through analyzing variables with very skewed distributions, for example, if all observed states for one variable are in the same state, or very few exceptions exist. Misleading results can also be the product of analyses where there are very few observations in total.

The sequential requisite analysis method can also be used to compare the dependency order for different outcomes. For example, we here compare dependencies in two scenarios: (1) country reform sequences occurring during the first wave of democratization, 1930 and earlier, and (2) country reform sequences occurring during the third wave of democratization, 1974 and later. This produces two tables ("Additional Results," Tables A1 and A2), which are then used to compute Kendall's rank correlation coefficient τ (*tau*) comparing orders (comparing the orders of variables in the leftmost column of both tables to each other (Abdi, 2007). The results are also illustrated graphically in "Additional Results" (Figure A1) that shows which variables differ the most between the first and third waves of democratization in terms of when—relative to all other democracy variables—they reached their highest state. For example, the difference is stark when it comes to harassment of journalists, which disappeared relatively early in the process during the early democratization wave 1900–1930, whereas during the third wave of democratization since 1974 it has been highly contingent on high values on a large number of other indicators. Perhaps this is indicative of the larger influence and therefore perceived threat of journalists writing critically about the ruling government in the more recent times.

For significance testing, membership into the groups "1930 and earlier" and "1974 and later" country sequences are then randomly assigned to the events and new τs calculated, a process repeated, for example, 10,000 times. This produces a null distribution of τ estimates arising from random permutation with which to compare the original τ, indicating how disparate the original τ is from the distribution. A result indicating 5 percent or less can be taken as a significant difference the between contingency orders. Here, $p = 0.0362$, indicating a significant difference between first- and third-wave contingencies ("Additional Results," Figure A2).

FIGURE 1

Graphical Representation of the Ordering of Variables as Depicted in Table 2



NOTE: The larger the number of requisites, the later in the process a given state of a given variable is generally observed. Thus, for example, harassment of journalists ends after free and fair elections have been fully instituted but simultaneously as women have been given full justice. In Figure 1, this is represented by Harassment of journalists level 4 having a higher number of requisites (19) than Election free and fair level 4 (9), but the same number of requisites as Access to justice for women level 4 (19). This means that there exist countries in the data where journalists are harassed and women do not have full access to justice even though elections are free and fair.

Conclusions

This article details a new approach to the study of sequences in ordinal data in social science: requisite tables. The usefulness of this analytic tool is illustrated with a simple sequence analysis of eight ordinal values from the V-Dem Electoral Democracy Index (as per the v7.1 of the V-Dem data set). A significance test is included for comparing outcomes of different scenarios. We believe this sorting algorithm has great potential for the analysis of many types of pressing issues that social science confronts, not the least the sequences of democratization. We hope to use this method in the near future to be able to answer critical questions about successful and unsuccessful reform sequences, as well as what democracy support should focus on at various stages of democratization, in ways that can directly inform policy and practitioners' priorities.

Appendix: Additional Results

TABLE A1

Dependency Table for Country Reform Sequences Occurring During the First Wave of Democratization, 1930 and Earlier

	Health equality	Legislature investigates in practice	CSO entry and exit	High court independence	Access to justice for women	Harassment of journalists	Executive bribery and corrupt exchanges	Election free and fair	sums
Legislature investigates in practice 4	2		3	3	3	3	4	4	22
Health equality 4		2	4	3	3	3	2	4	21
Access to justice for women 4	1	3	3	3		3	3	4	20
High court independence 4	2	3	3		3	3	3	3	20
CSO entry and exit 4	1	2		3	2	3	3	3	17
Health equality 3		2	0	2	2	2	1	3	12
Access to justice for women 3	0	0	0	1		1	3	3	8
Election free and fair 4	0	1	1	1	1	2	2		8
Harassment of journalists 4	0	1	2	1	1		2	1	8
Legislature investigates in practice 3	0		1	2	1	2	1	1	8
Harassment of journalists 3	0	1	1	1	1		1	2	7
CSO entry and exit 3	0	1		0	1	2	1	1	6
Executive bribery and corrupt exchanges 4	0	0	1	1	1	0		3	6
Election free and fair 3	0	1	1	1	1	0	1		5
CSO entry and exit 2	0	0		1	1	1	0	1	4
Health equality 2		0	0	0	1	0	1	2	4
Legislature investigates in practice 2	0		0	0	1	0	1	1	3
Election free and fair 2	0	0	0	0	1	1	0		2
Harassment of journalists 2	0	0	0	0	1		0	1	2
High court independence 2	0	0	0		0	0	1	1	2
High court independence 3	0	0	0		0	0	1	1	2
Access to justice for women 1	0	0	0	0		0	0	1	1
Access to justice for women 2	0	0	0	0		0	0	1	1
CSO entry and exit 1	0	0		0	1	0	0	0	1
Election free and fair 1	0	0	0	0	0	1	0		1
Executive bribery and corrupt exchanges 1	0	0	0	0	0	0		1	1
Executive bribery and corrupt exchanges 2	0	0	0	0	0	0		1	1
Executive bribery and corrupt exchanges 3	0	0	0	0	0	0		1	1
Harassment of journalists 1	0	0	0	0	0		0	1	1
Health equality 1		0	0	0	0	0	0	1	1
High court independence 1	0	0	0		0	0	0	1	1
Legislature investigates in practice 1	0		0	0	0	0	0	0	0
Sums	6	17	20	23	26	27	31	47	

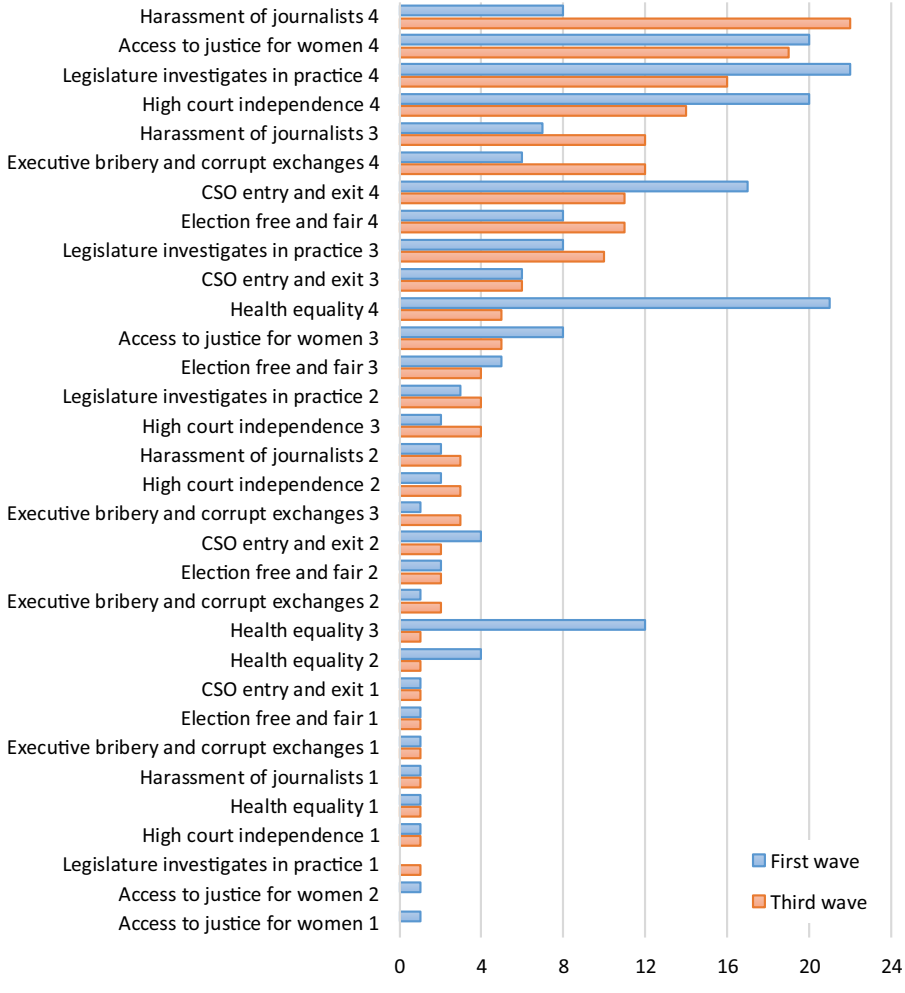
TABLE A2

Dependency Table for Country Reform Sequences Occurring During the Third Wave of Democratization, 1974 and Later

	Executive bribery and corrupt exchanges	Legislature investigates in practice	High court independence	Harassment of journalists	Health equality	CSO entry and exit	Election free and fair	Access to justice for women	sums
Harassment of journalists 4	3	3	3		3	3	4	3	22
Access to justice for women 4	1	2	3	3	3	3	4		19
Legislature investigates in practice 4	1		2	2	2	3	3	3	16
High court independence 4	2	2		2	1	2	3	2	14
Executive bribery and corrupt exchanges 4		2	0	1	3	1	3	2	12
Harassment of journalists 3	1	1	1		1	3	3	2	12
CSO entry and exit 4	1	1	1	2	1		3	2	11
Election free and fair 4	1	2	1	2	1	2		2	11
Legislature investigates in practice 3	1		1	2	1	1	2	2	10
CSO entry and exit 3	0	1	1	1	1		1	1	6
Access to justice for women 3	0	0	1	1	1	1	1		5
Health equality 4	2	0	0	0		0	2	1	5
Election free and fair 3	0	0	1	1	0	1		1	4
High court independence 3	0	0		0	1	1	1	1	4
Legislature investigates in practice 2	0		1	0	0	1	1	1	4
Executive bribery and corrupt exchanges 3		0	0	0	1	0	1	1	3
Harassment of journalists 2	0	0	0		0	1	1	1	3
High court independence 2	0	0		1	0	0	1	1	3
CSO entry and exit 2	0	0	0	0	0		1	1	2
Election free and fair 2	0	0	0	0	0	1		1	2
Executive bribery and corrupt exchanges 2		0	0	0	0	0	1	1	2
CSO entry and exit 1	0	0	0	0	0		0	1	1
Election free and fair 1	0	0	0	0	0	0		1	1
Executive bribery and corrupt exchanges 1		0	0	0	0	0	0	1	1
Harassment of journalists 1	0	0	0		0	0	0	1	1
Health equality 1	0	0	0	0		0	0	1	1
Health equality 2	0	0	0	0		0	0	1	1
Health equality 3	0	0	0	0		0	0	1	1
High court independence 1	0	0		0	0	0	0	1	1
Legislature investigates in practice 1	0		0	0	0	0	0	1	1
Access to justice for women 1	0	0	0	0	0	0	0		0
Access to justice for women 2	0	0	0	0	0	0	0		0
Sums	13	14	16	18	20	24	36	38	

FIGURE A1

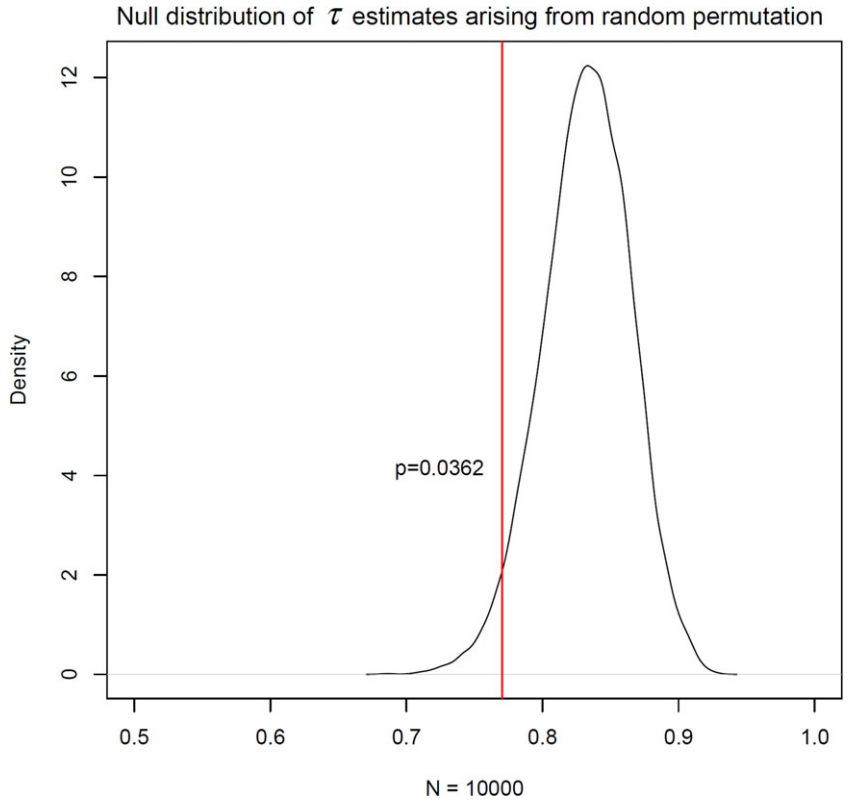
Graphical Representation of the Ordering of Variables as Depicted in "Additional Results" (Tables A1 and A2)



NOTE: The larger the number of requisites, the later in the process a given state of a given variable is generally observed. Note, by comparison, the difference between the first (pre-1930) and the third (post-1974) waves. For example, harassment of journalists ended earlier in democratization processes initiated before 1930, while health equality was implemented comparatively later.

FIGURE A2

Null Distribution of τ Estimates Arising from Random Permutation and the Placement of the Original τ (red line)



NOTE: The $p = 0.0362$ indicates that the probability of observing the current τ given the data is approximately 0.0362. This indicates a slight difference between the contingency orders (the order in the leftmost columns in Tables A1 and A2).

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