TQCA

A Technique for Adding Temporality to Qualitative Comparative Analysis

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As originally developed by Charles Ragin in The Comparative Method *(1987), qualitative comparative analysis (QCA) has been used extensively by comparative and historical sociologists as an effective tool for analyzing data sets of medium-N populations. Like many other methods, however, QCA is atemporal and obscures the sequential nature of paths of causation. QCA ignores the order of events by treating combinations of attributes as though they occur simultaneously rather than as unfolding over time. While preserving the essential strengths of QCA, the authors present a modification that is capable of capturing the temporal nature of causal interactions. This modification involves a hybrid of Boolean algebra and sequence analysis to create a parsimonious set of solutions. This technique is referred to as temporal qualitative comparative analysis, or TQCA.*

Keywords: *qualitative comparative analysis; comparative and historical methodology; time; temporality; sequence*

As originally developed by Charles Ragin in *The Comparative Method* (1987), qualitative comparative analysis (QCA) has proved an effective tool for analyzing data sets of medium-*N* populations. Primarily used by comparative and historical sociologists, the method emphasizes the holistic nature of cases, the interaction of attributes, and multiple paths to an outcome over a traditional statistical emphasis on the strength of individual variables. Cress and Snow (2000), for example, use QCA to chart the different pathways to various outcomes

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for homeless social movement organizations. Other scholars have examined shop-floor resistance (Roscigno and Hodson 2004), political mobilization in nondemocratic countries (Osa and Corduneanu-Huci 2003), political revolutions (Wickham-Crowley 1992; Goodwin 2001), and social spending (Amenta and Poulsen 1996; Amenta and Halfmann 2000).

Considering the context of its application in historical social science research, the method is surprisingly unable to capture the sequential unfolding of events. While it highlights the interactive nature of causation, it tends to obscure the historical paths of causation. The method assumes that each independent attribute is either operating simultaneously or that the order in which they operate is irrelevant. For example, in a reanalysis of Gamson's (1975) social movement organizations data set, Ragin (1989) uses two independent attributes in determining the ability of social movements to gain new advantages: level of bureaucracy in the movement's organization and acceptance of the movement's goals by the target. However, *the temporal order* in which these two attributes occur might provide as much information about the secrets of success for social movements as does the interaction of these variables. For example, social movements that have achieved recognition by the state and then develop bureaucracies may be less effective than those that were bureaucratized to begin with. While this is only a speculative example, there is no reason to rule out sequence a priori, as does the current method.

In this article, we develop a technique to address this limitation. After a review of Ragin's QCA illustrated with a hypothetical example, we present an extension of QCA capable of capturing the sequential nature of causal interactions. The technique involves attending to the sequence of case attributes, thus greatly expanding the number of possible configurations. After accounting for temporality in this way, we show how the researcher then places theoretical restrictions to limit the number of configurations possible to carve the set down to a manageable size. Finally, we develop a modified version of Boolean algebra to find the most parsimonious solution to the QCA equation representation of the causal process. We refer to this method as temporal qualitative comparative analysis, or TQCA.

BACKGROUND

Ragin (1987) developed his qualitative comparative method in an effort to overcome a serious point of methodological division among practitioners of historical sociology. Although a number of methodological issues remain controversial in the young subdiscipline, perhaps the deepest and most seemingly intractable debate is between advocates of ''variable-based'' and ''case-based'' methods (also see debates in Ragin and Becker 1992). Proponents argue that variable methods produce studies that demonstrate how enduring causal processes affect historical outcomes; among their advantages, these methods allow a large *N*, an appreciation of the probabilistic character of causation, and a better chance for inference and comparison, while critics contend mainly that they do violence to the complexity and unique dynamics of individual cases. Case methodologists, in contrast, pay less attention to widely applicable variables, focusing instead on uncovering the coherent (often unique) development of cases. Their critics say that this focus drastically limits the possibilities for valid comparison and generalization (Lieberson 1994; King, Keohane, and Verba 1994).

QCA, according to Ragin, bridges these two approaches by preserving the analytical leverage of variables with the emphasis on the contextual specificity and integrity of individual cases. The method emphasizes configurations of attributes and multiple causal pathways and relies on an in-depth knowledge of each of the cases. We agree that Ragin's method is a significant advance that, given the terms of the methodological debate in historical sociology, does present a viable alternative to case- and variable-based methods that leverages both their strengths. However, we believe that it has a significant shortcoming that undermines its ability to satisfy its stated goals.

The shortcoming, ironically enough for a historical method, is that QCA fails to take account of time. Variables and cases, as Ragin deploys them in QCA, are frozen in time—they are treated neither as containing sequences of events nor as forces that cause changes to occur over time. In other words, whereas QCA hopes to bring about a productive synthesis of case- and variable-based methods, because it does not include time in the analysis, it undermines

them both in two ways: (1) by failing to show how variables really work as causal paths or forces that work over time to bring about sequences of events and (2) by failing to do justice to the "integrity" of cases by showing how they are constituted through their temporal development or unfolding rather than by being merely a collection of variables. To be sure, we make no claim about whether Ragin's method neglects time more than many other standard analytical methods. In the literature, only Goertz and Mahoney (2004) have noted the importance of causal ordering in analyses based on Ragin's methods. Although they include temporal ordering in their theoretical model, they rely on a traditional version of one of Ragin's techniques to implement it.[1] Our effort tackles the neglect of temporality in Ragin's methods more directly—by developing QCA internally to address this shortcoming.

The concept of time has received considerable attention recently in the methodological literature of historical sociology.[2] This literature has explored the effects of different ways of conceptualizing time on the logic of cases, variables, and especially explanation in historical methods. The notion of time we propose as a supplement to QCA relies on perhaps the simplest notion of the relationship between time and events in the literature—namely, that of sequence or trajectory. This understanding of the temporal character of causation, one of four concepts of time discussed by Aminzade (1992), holds simply that variables may not work independently of each other and that the *order* in which they influence a case may affect the case's outcome.[3]

Ragin's QCA method advances a compromise between variable- and case-based methods essentially by treating cases as collections of attributes or variables with particular outcomes. QCA groups together cases in terms of their configurations of attributes, regardless of their outcomes, and then uses these groupings to give a quasi-probabilistic account of how particular outcomes are obtained. QCA pays no attention to the sequence in which events (which the method transforms into variables) take place within cases, however. Thus, the method treats a case ABC (where A, B, and C are its variablized attributes) identically to BAC, a case in which the variables unfold in a different order. QCA assumes variables are mathematically commutative.[4] Commutativity usually works in mathematics;

in history, it usually does not. Our extension of this method puts cases back in time by rejecting the commutative assumption and therefore acknowledging that the sequence of events in a case or, put differently, the trajectory of a case matters.

QCA BASICS

Ragin originally outlined the basic methodology of QCA in *The Comparative Historical Method* (1987) and refined the technique in a series of articles (1989, 1994, 1995). More recently, *Fuzzy-Set Social Science* (2000) situates QCA within a larger methodological agenda of set analysis. Our contribution focuses on the QCA agenda outlined in Ragin's earlier work, but in the Discussion section, we address its applicability to fuzzy-set methods. A detailed review of all the steps and justifications involved in QCA is beyond the scope of this article; here we provide a review of the basics.

The researcher begins by ascertaining the population and cases under consideration. This task may be difficult because the method is especially sensitive to the population size and case selection. To take the first issue, QCA works best with a medium *N*. With too few cases, each case may have a unique configuration of attributes, providing little theoretical advantage from this technique. With too many cases, however, log-linear analysis (Goodman 1972) or configurable frequency analysis (von Eye 1990) may be more appropriate. Recent studies have used from 18 (Cress and Snow 2000) to 50 (Amenta and Poulsen 1994) cases quite successfully. The issue of case selection is somewhat more complicated. To date, there has been little work extending QCA to population samples,[5] so researchers tend to work on populations that are universes. Often, this population is easily defined by the data and question or theoretical convention (cf. Ragin's [2000:286-308] analysis of the ''advanced-industrial, democratic countries''). But other times, the population is less clear. The task is crucial because the identification of causes for a certain outcome is dependent on the proper choice of a comparative ''control group'' of negative cases. Ragin (1995, 2000) provides some guidelines for these choices, which revolve around deep empirical and theoretical knowledge of the population under study.

Next the researcher establishes the relevant attributes of the cases she or he will be examining, both what she or he is trying to explain and the factors that, alone or in combination, may lead to the outcome of interest. Amenta and Poulsen (1994) describe a number of different techniques for choosing which attributes to include in QCA models. Since the complexity of a model increases exponentially with each new attribute, the researcher should keep it as parsimonious as possible without sacrificing too much detail. In the basic version of QCA discussed here, each of these attributes should be reduced to two values representing the presence or absence of the trait. While this elimination of variation may seem somewhat crude to many researchers, many attributes are either present or absent and can be easily coded as such. Ragin's (2000) fuzzy-set analysis is in part an attempt to address this issue of reducing variation. The logic of fuzzy-set analysis is different from finding ways to incorporate ordinal or multinomial variation in "variablized" attributes; rather, it constitutes cases as having fractional membership in attribute and outcome "sets." This variable set membership reintroduces variation into QCA without sacrificing the principle of parsimony necessary for workable models. But, again, for the sake of simplicity, we elaborate our example here with binomial attributes.

For the purpose of this explanation, we "analyze" a *hypothetical* data set consisting of 18 cases of unionization attempts by graduate student workers at research universities. The example, which examines the factors that lead to a university's recognition of a graduate student union, illustrate how QCA and our temporal extension work. The cases have the following attributes. The outcome variable we analyze is a union's achievement of recognition by the university (as a valid entity for collective contract and grievance procedures). This factor can be coded dichotomously, demarking cases into those unions that were recognized by universities and those that failed to achieve recognition. For the independent attributes, we select four attributes. The first is whether the unionization struggle takes place at a public or private university. These two settings face different legal and labor relations climates, so this factor could affect the success rate. Following conventional QCA notation, the presence of an attribute will be symbolized by the name in all-capital letters, such as "PUBLIC," and the attribute's absence by all lowercase letters, such

as "public." Second, borrowing from social movement theory, we include the presence of elite allies (ELITE). Third, borrowing from the resource mobilization wing of social movement theory, we have included affiliation with a national union, which would presumably provide resources to the local organizers (AFFILIATE). Finally, drawing from Piven and Cloward (1979), we include the presence of a strike or strike threat as a measure of disruptive potential (STRIKE). All these variables are fairly easy to operationalize in dichotomous categories. The graduate student union at the fictitious University of New York, for example, a private university where the student workers had elite allies, had national affiliation, and threatened a strike, could be represented as follows: public*ELITE*AFFILIATE*STRIKE. (In QCA, a "*" can be read as "and," while a "+" is read as "or.")

After identifying the cases and attributes, the researcher lists all possible combinations of independent attributes. There are 2^k possible configurations, where k is the number of independent attributes. For our example with four independent attributes, there are 16 possible combinations. These are shown in Table 1.

Each row represents one of the different possible configurations that could exist for the hypothetical graduate student union data set. In this table, "1" denotes the presence of an attribute and "0" its absence. All these configurations need not exist in the data set; it is the set of possible combinations. Each of the cases should then be matched up with the appropriate configurations. We have assigned our 18 hypothetical cases as shown in Table 1, where the "Cases" column indicates the number of cases that fit into that row's configuration and "Recognition" shows the fraction of the number of cases that were successful in achieving recognition. We insert "?" in the Recognition column whenever there are no cases since the fraction is undefined.

For simplicity's sake, we have assigned membership in the Recognition column with fractions equaling 1, 0, or that are undefined. Real-world data that share a configuration of attributes need not share an outcome, so fractional results for recognition could exist. When this is the case, there are two possible ways to address the situation. One option is to reevaluate the groupings of cases into configurations by asking whether they make sense together. For example, do our three cases in the first row fit together, or are there

TABLE 1: Qualitative Comparative Analysis (QCA) Configurations for Union Recognition

Number	Combination	PUBLIC	ELITE	AFFILIATE	STRIKE	Cases	Recognition
1.	PUBLIC*ELITE*AFFILIATE*STRIKE	1	1	1	1	3	3/3
2.	PUBLIC*ELITE*AFFILIATE*strike	1	1	1	0	2	2/2
3.	PUBLIC*ELITE*affiliate*STRIKE	1	1	0	1	1	1/1
4.	PUBLIC*ELITE*affiliate*strike	1	1	0	0	0	?
5.	PUBLIC*elite*AFFILIATE*STRIKE	1	0	1	1	2	0/2
6.	PUBLIC*elite*affiliate*STRIKE	1	0	1	0	0	?
7.	PUBLIC*elite*affiliate*STRIKE	1	0	0	1	3	0/3
8.	PUBLIC*elite*affiliate*strike	1	0	0	0	1	0/1
9.	public*ELITE*AFFILIATE*STRIKE	0	1	1	1	1	1/1
10.	public*ELITE*AFFILIATE*strike	0	1	1	0	0	?
11.	public*ELITE*affiliate*STRIKE	0	1	0	1	0	?
12.	public*ELITE*affiliate*strike	0	1	0	0	1	0/1
13.	public*elite*AFFILIATE*STRIKE	0	0	1	1	0	?
14.	public*elite*affiliate*STRIKE	0	0	1	0	0	?
15.	public*elite*affiliate*STRIKE	0	0	0	1	1	0/1
16.	public*elite*affiliate*strike	0	0	0	0	3	0/3

fundamental differences between cases in the group? This moment of methodological reflection might spur the researcher to rethink the attributes used in the analysis and perhaps to look for hidden attributes to help resolve the "contradiction" of fractional membership in the outcome set. Alternatively, it is possible to code fractional results with qualitative designations—for example, Ragin (1995) codes his outcomes as "uniform" (for fractions equaling 1), "likely," and "possible." This inclusion of ordinal outcome variables greatly improves Ragin's original scheme, and it allows the researcher to create different models to represent different stringency conditions for the outcomes.

Pointing toward two strategies for interpreting these contradictory outcomes, Ragin (1995) distinguishes between "conservative" and "optimistic" models. A "conservative" model of the outcome denotes only the causal configurations that "always" lead to the given outcome—but this condition is of course partly dependent on the definition of the population. An "optimistic" model might add the configurations where at least one positive outcome was registered, thus capturing all the conditions in which the outcome is possible. This improvement on the method accommodates the contradictory or probabilistic nature of outcome data without a search for hidden variables. For the simplicity of our hypothetical example, we chose not to include contradictory configurations. It is important to note, however, that our extension of QCA is fully consistent with this aspect of the method.

While our example leaves out configurations with contradictory outcomes, it does feature configurations without cases representing them. This situation will almost always occur once the researcher starts investigating settings with three or more attributes. The most straightforward approach is to treat these configurations with absent cases as having neither positive nor negative outcomes. Ragin, however, suggests that at times, the researcher, who knows the data best, might choose to input likely values for outcomes. This is most appropriate for cases where, based on theory and other cases, a positive or negative outcome seems overwhelmingly likely. In our example, we have chosen the first approach, to treat unknowns in our hypothetical data set as failures.

Once cases, configurations, and outcomes are properly assigned, the researcher uses Boolean algebra to uncover the logic of the conditions under which outcomes occur by stringing together equations representing each of the positive outcomes. It is important to note

that, from the perspective of this logical algebra, it does not matter how many cases match up with each configuration. Whether 20 cases represent a configuration or just one, it is still a path to success. In situations where the population is the universe, the phenomena being modeled will not happen again, and there are no contradictory cases, so this logic holds. But for situations when any of these assumptions is violated, Ragin (1998, 2000) has developed statistical tests that take into account both the number of cases and the "degree" of membership in attribute or outcome sets to give a probabilistic analysis of configurations and outcomes. Returning to our hypothetical example and the data listed in Table 1, the four paths to union recognition can be combined as in Table 2, which are taken from lines 1, 2, 3, and 9 in Table 1.

In QCA, the final step is to "algebraically reduce" or simplify the equation (Ragin 1995). In the reduction process, paths that differ by only the presence or absence of one attribute are treated as equivalent, with the differing attribute removed from the path. In our example, both PUBLIC*ELITE*AFFILIATE*STRIKE and PUBLIC*ELITE*AFFILIATE*strike are combinations that lead to recognition. Since they differ only on the strike threat variable, we can say that every PUBLIC*ELITE*AFFILIATE union drive will result in recognition. The two original subsets can be thought of as subsets of the new combination, as it logically includes all cases regardless of strike status. Ragin, Drass, and Davey (2003) developed a program to simplify automatically QCA equations with both dichotomously coded attribute and outcome data or fuzzy-set data.

The complete reduced statement for the right-hand side of our equation is presented in Table 2. As stated above, this equation assumes that we treat the configurations with no cases (lines 4, 6, 10, 11, 13, and 14 in Table 1) as instances of nonrecognition; thus, the reduced statement represents something like the minimal set of conditions for a university's recognition of its graduate student union. These results indicate that to achieve union recognition, elite support is a necessary but not sufficient cause. Graduate students must also have two out of three of the other attributes: public university setting, national affiliation, and a strike threat.

As noted above, however, this reduction relies on the commutative property in that it assumes the equivalence of configurations in which the attributes are listed in different orders. But outcomes occur

TABLE 2: Reduced Qualitative Comparative Analysis (QCA) Configurations for Union Recognition

Paths to recognition
Recognition = PUBLIC*ELITE*AFFILIATE*STRIKE + PUBLIC*ELITE*AFFILIATE*strike + PUBLIC*ELITE*affiliate*STRIKE + public*ELITE*AFFILIATE*STRIKE.
Reduced paths to recognition
Recognition = ELITE*(PUBLIC*AFFILIATE + PUBLIC*STRIKE + AFFILIATE*STRIKE).

as a result of historical processes, so attributes are often events whose temporal character matters. That is, the sequence of causal events or attributes may affect the ultimate outcome. Schematically, the sequence in which *A* occurs, then *B* occurs, then an outcome *X* occurs may not be the same as *B* then *A* then *X*. QCA treats all independent attributes as either occurring at the same time or as occurring in a sequence that is irrelevant to the casual outcome.

In many cases, sequence may not matter for outcomes. It may not matter whether elite allies or national union affiliation comes first. But that is a matter to be sorted out using the data, rather than established through the tacit assumptions of the method. Other times, sequence clearly will matter. Some attributes will precede other independent attributes such as whether a university is public or private, as in our example, or whether a country had a weak or strong state during movements for democracy. They set the context for which all the other attributes interact and thus should not be handled in a way that treats all attributes as temporally equivalent. We present a technique for getting around this problem.

TEMPORAL QUALITATIVE COMPARATIVE ANALYSIS

TQCA is an extension of QCA that allows modeling of the sequence of events. As such, the technique largely follows the logic and process of its predecessor while only selectively applying the

commutative property in Boolean algebra. Below, we outline the steps where TQCA differs from QCA.

While QCA requires that the researcher establish the theoretically relevant attributes, TQCA also requires the researcher to know the sequence in which events unfolded and to have a sense of which attributes temporality affects. Based on her or his familiarity with the cases through theorizing and induction, the researcher must decide whether certain factors always come first, always come last, always come in a specific order, or whether the attributes could come in any order.

In conventional Boolean QCA analysis using two attributes, there are four possible configurations (*AB*, *Ab*, *aB*, and *ab*). However, if the order of *A* and *B* matters, there are four additional cases (*BA*, *Ba*, *bA*, and *ba*). In principle, recognizing the sequence of attributes, and thus recognizing the noncommutativity of historical configurations, can result in a drastic expansion of the number of cases to consider. While in binomial QCA, the number of configurations is 2^k, where k is the number of attributes, in TQCA, the number of possible configurations is $k! * 2^k$—in our four-attribute example, this represents an expansion from 16 configurations to 384. As a result, the researcher must make pragmatic and theoretical restrictions on possible sequences to make the analysis manageable.

In most cases, only the presence of a variable and not its absence will affect the temporal order—it is difficult to specify the timing of a nonoccurrence. In the two-attribute example, there would then only be five configurations (*AB*, *Ab*, *aB*, *ab*, and *BA*, with $Ab = bA$, $ab = ba$, and $aB = Ba$). But it is important to note that, sometimes, the researcher will be able to ascertain the sequence of nonoccurrence of some elements, and in some cases, it will matter, so she or he might find it necessary to include some of these other configurations.

As another limiting strategy, the researcher ight fix certain variables as occurring first, last, or setting the context for the other variables. For example, in our hypothetical union data set, we postulate that whether a university is public or private is a condition that precedes all other action. We could also say that based on our examination of the data and on labor theory, strikes or strike threats always occur after all of the other factors. Furthermore, since it is difficult to establish the timing of the nonoccurrence of either elite

allies or national affiliation, we can simplify the configurations even further by saying that the timing of these attributes does not matter. Researchers using TQCA will have to make similar restrictions on their data to limit the geometric explosion of possible configurations.

For our hypothetical set of cases, we then impose these restrictions, with university setting preceding other events, the ordering of affiliation and elite allies being allowed to vary, and the strike threat fixed as last. The resulting list of 20 configurations for our hypothetical union data set is presented in Table 3.

Here we introduce a notational convention: a dash "—" should be used whenever there is a temporal/causal break. A dash should be read as "then," just as the "+" symbol is read as "or." *A—B* would be read as "*A* then *B*." This convention makes it clear where the sequential breaks occur and clarifies which of the parts of the statement can be reduced, as outlined below.

We insert a dash after each "PUBLIC" or "public" because we have assumed that this attribute, whether or not the case occurs at a public university, precedes all the others. Similarly, we include a dash before each "STRIKE" or "strike" since we have assumed that the strike or strike threat is the final step for the graduate student union. Finally, we add a dash between each "ELITE" and "AFFILIATE" whenever both are present but not when either or both are absent. We eliminate the sequential notation from absent attributes because we determined for this example that a temporal order could not be assigned to either one of these when they were not present.

While 16 of these configurations are similar to the combinations presented in Table 1, 4 additional ones are now included. These are the 4 configurations in which both national affiliation and elite alliances are present, but with affiliation coming first (lines 2, 4, 12, and 14). We add them because now the 4 "ELITE—AFFILIATE" configurations represent elite alliances *preceding* national affiliation, not just the presence of both.

With the addition of these configurations, the researcher must then reassign cases into them. The Recognition column in Table 3 represents our "reanalysis" of the hypothetical unionization data. To understand the possible routes to recognition, we next make a

TABLE 3: Temporal Qualitative Comparative Analysis (TQCA) Configurations for Union Recognition

Number	Combination	Cases	Recognition
1.	PUBLIC—ELITE—AFFILIATE—STRIKE	2	2/2
2.	PUBLIC—AFFILIATE—ELITE—STRIKE	1	1/1
3.	PUBLIC—ELITE—AFFILIATE—strike	2	2/2
4.	PUBLIC—AFFILIATE—ELITE—strike	0	?
5.	PUBLIC—ELITE*affiliate—STRIKE	1	1/1
6.	PUBLIC—ELITE*affiliate—strike	0	?
7.	PUBLIC—elite*AFFILIATE—STRIKE	2	0/2
8.	PUBLIC—elite*AFFILIATE—strike	0	?
9.	PUBLIC—elite*affiliate—STRIKE	3	0/3
10.	PUBLIC—elite*affiliate—strike	1	0/1
11.	Public—ELITE—AFFILIATE—STRIKE	0	?
12.	Public—AFFILIATE—ELITE—STRIKE	1	1/1
13.	Public—ELITE—AFFILIATE—strike	0	?
14.	Public—AFFILIATE—ELITE—strike	0	?
15.	Public—ELITE*affiliate—STRIKE	0	?
16.	Public—ELITE*affiliate—strike	1	0/1
17.	Public—elite*AFFILIATE—STRIKE	0	?
18.	Public—elite*AFFILIATE—strike	0	?
19.	Public—elite*affiliate—STRIKE	0	0/1
20.	Public—elite*affiliate—strike	3	0/3

list of configurations in which union recognition was an outcome. These five paths are lines 1, 2, 3, 5, and 12 in Table 3 and are presented in Table 4.

MINIMIZATION

As with the setup of the case combinations, minimization in TQCA is similar to its predecessor. Researchers first test to see whether any temporal boundaries can be removed. Then QCA minimization rules are used within each temporal block. Finally, some factoring can occur across temporal blocks but with restrictions.

First, when two combinations differ by only the order of two attributes separated by a dash, the temporal boundary marker can be removed and replaced with an *, the symbol for ''and.'' The theoretical implication is that the ordering of these two events does not matter. If both A—B and B—A lead to success, it can be rewritten as $A * B$. This minimization cannot take place if the combinations

TABLE 4: Reduced Temporal Qualitative Comparative Analysis (TQCA) Configurations for Union Recognition

Paths to recognition
Recognition = PUBLIC—ELITE—AFFILIATE—STRIKE +PUBLIC—AFFILIATE—ELITE—STRIKE +PUBLIC—ELITE—AFFILIATE—strike +PUBLIC—ELITE—affiliate—STRIKE +public—ELITE—AFFILIATE—STRIKE.
Reduced paths to recognition
Recognition = PUBLIC—ELITE—STRIKE +PUBLIC—ELITE—AFFILIATE—strike +public—AFFILIATE—ELITE—STRIKE.

differ by other attributes, even if the difference is in another temporal block.

In our example, the first two statements, PUBLIC—ELITE—AFFILIATE—STRIKE and PUBLIC—AFFILIATE—ELITE—STRIKE, can be written as PUBLIC—ELITE* AFFILIATE—STRIKE. Because both ELITE—AFFILIATE and AFFILIATE—ELITE were present along with PUBLIC and STRIKE, we deduce that within this context, the order of receiving elite support and aligning with a national union is unimportant to the outcome. If, however, the two statements were PUBLIC—ELITE—AFFILIATE—strike and PUBLIC—AFFILIATE—ELITE—STRIKE, this same reduction could not be made because the two differ by more than just the order of the two attributes. We would not know if there was something unique about the occurrence of elite alliance before national affiliation that then obviated the need for a strike or strike threat. One could imagine, for example, that elite alliances forged directly by the local union exert greater pressure than those elites who give mainly symbolic support only after pressure from a national union. Thus, the additional pressure of a strike threat is necessary to secure recognition in the second case. One would presumably need to revisit theory and data to come up with a plausible explanation for this kind of arrangement.

Second, paths that only differ within a temporal block (i.e., bounded by dashes) by the presence of an attribute in one and the absence of it

in the other can be reduced by removing the attribute, following QCA logic. For example, PUBLIC—ELITE*AFFILIATE—STRIKE and PUBLIC—ELITE*affiliate—STRIKE differ only by national affiliation and thus can be reduced to PUBLIC—ELITE—STRIKE. In other words, within a temporal block, the normal rules of QCA operate.

Third, reductions cannot take place across temporal boundaries. Doing so would imply that the temporal ordering of the events does not matter. In certain circumstances, however, attributes can be factored out across temporal boundaries. For example, $A—B*C$ and $A—D*E$ could be presented as $A—(B*C)+(D*E)$, which would be interpreted as A, then B and C or D and E. For the union data set, the combinations PUBLIC—ELITE—STRIKE and PUBLIC—ELITE—AFFILIATE—strike can be factored to PUBLIC—ELITE—(AFFILIATE—strike) + STRIKE.

Based on these procedures, the final reduced statement is presented in Table 4. Note that although the factor ELITE is present in all three cases, it cannot be factored out because of its changing temporal position.

We can now compare our final reduced equation from Table 4 with the QCA equation in Table 2.

TQCA:

$$\begin{aligned}\text{Recognition} = {} & \text{PUBLIC—ELITE—STRIKE} \\ & + \text{PUBLIC—ELITE—AFFILIATE—strike} \\ & + \text{public—AFFILIATE—ELITE—STRIKE.}\end{aligned}$$

QCA:

$$\begin{aligned}\text{Recognition} = {} & \text{ELITE*(PUBLIC*AFFILIATE} \\ & + \text{PUBLIC* STRIKE} \\ & + \text{AFFILIATE*STRIKE).}\end{aligned}$$

The most important apparent change is that the ordering of elite support and national affiliation really does matter, at least for public university unions. There is only one route to recognition that does not involve a strike or strike threat, and that occurs when graduate workers acquire elite support early and then get national affiliation. Receiving affiliation first or not receiving affiliation after receiving elite support both require a strike or strike threat to achieve recognition. This relationship is obscured in the original QCA analysis and equation.

DISCUSSION

The concept of temporality that TQCA represents—that is, the sequence of events—is perhaps the simplest in a historical analyst's repertoire. In this section, we make some suggestions for ways other versions of temporality might be included in TQCA. Aminzade (1992) distinguishes four concepts of time in historical analysis: trajectory, duration, pace, and cycle. TQCA's sequential analysis essentially resembles Aminzade's "trajectory," and it is important to distinguish this concept from the tempting language of "path dependency." As Mahoney (2000) has argued, "path dependency" is a more specialized concept that refers to the possibility that one sequence of events could be completely derailed into an alternative sequence following the occurrence of some intervening event.[6] The most important reason our extension of Ragin's method introduces trajectory and not path dependence is that it preserves Ragin's emphasis on a limited number of variables that can be calculated for each case. A simple sequence of events with two different trajectories might look like this:

$$A—B—C—D \text{ and } A—b—D—C,$$

where B/b indicates, respectively, the presence and absence of some variable or event. This contrasts with a path-dependent sequence that might look like this:

$$A—B—C—D \text{ and } A—b—X—Y.$$

Path dependence is not in principle impossible to represent with our TQCA method. After all, *A—b—D—C* could be represented something like the following:

$$A—b—D—C\ (x, y),$$

where lowercase x and y indicate the path not taken. The problem is a pragmatic one. As we showed above, QCA and TQCA suffer greatly when variables proliferate because there will be a huge number of possible configurations with many configurations lacking cases and very few configurations that are represented by more than one actual case. As such, TQCA is only suitable for very simple instances of path dependency. We leave it to interested researchers to develop appropriate conventions for recording these situations.

Just as path dependency could in principle be accommodated with TQCA, so could many other conceptions of time. Aminzade's (1992) "duration" and "pace" and, conceivably, even some of the different "qualities" of time (in holistic, narrative approaches) discussed by Abbott (1990) could be approximated in a TQCA analysis. This would be done, somewhat crudely, by representing these types of time as attributes of cases. For example, in a collection of cases, the researcher might include a "pace" attribute that tried to capture the momentum of a series of events. The researcher could code the pace attribute dichotomously ("events did/did not follow each other quickly") or multinomially (although this contributes to the proliferation of possible configurations) to represent the character of time. It would also be possible to include one or more temporal attributes as fuzzy sets, which we discuss below. In the stage of TQCA when the researcher places restrictions, these attributes would have to be represented as context-setting factors (much as we placed the private/public university attribute outside of the temporal paths). To reiterate, however, we believe that the sequential or trajectory variety of time will be viable most practically in applications of TQCA.

This strategy for objectifying time might not satisfy strong proponents of narrative (over variable) methods in historical sociology. Admittedly, "variablizing" time in this fashion could be seen as a crude reduction from the historian's point of view. But we would suggest that it is not necessary to view narrative and TQCA as opposed. Rather, TQCA might be useful to historical sociologists as a means for organizing information and structuring narrative accounts of historical events.[7] In this way, TQCA dovetails with two concepts Ragin stresses frequently. First, QCA or fuzzy-set methods are not ends in themselves but should help researchers generate and assess theories—the TQCA/narrative relationship is analogous. Second, if Ragin's chief epistemological concern is to overcome and transcend the opposition between nomothetic and idiographic methods, TQCA can help extend this mission to inherently temporal analytic settings.

TQCA may also complement the methodological agenda Abbott (see 2001) has been developing in recent years. Although the methods Ragin and Abbott have been developing differ greatly, they

both share a skepticism about the hidden assumptions in "standard" methodologies with their assumptions about the independence of variables, the linear and atemporal character of causation, and so forth. Abbott, in particular, has emphasized the importance of considering sequence in social analysis and understanding the ways events and causal chains affect those that occur after them. Until now, Ragin's methods did not incorporate sequential development, so TQCA may help build connections between these two agendas. However, it is important to note the differences between TQCA and Abbott's optimal matching methods. TQCA is primarily a casual technique linking different attributes to a specific outcome, whereas optimal matching is largely for descriptive clustering of different paths of one variable, such as an individual's career. TQCA meshes well with Abbott's calls for "narrative positivism." Although, as mentioned above, TQCA tends not to nourish the thickly described narrative usually favored by historians, it does encourage building structured historical narratives across cases and comparing those narratives between cases—especially when there are different outcomes but also when there are different sequences or configurations of causal factors. Thus, TQCA would seem to fit Abbott's agenda at least enough to stimulate new thinking in ways to combine these directions.

Pierson's (2004) recent work represents a serious rethinking of the way social analysts have used temporal arguments in the study of historical sequences. One might see his explication of the confused way many analysts treat sequence arguments—in particular, the way they often muddle the mechanisms that make sequences matter—as an indictment of the relatively simplistic notion of sequence we employ in this article. But it is worth pointing out that TQCA makes no assumptions about the mechanisms by which temporality affects outcomes; it only allows the researcher to keep track of and analyze temporality in order to theorize about mechanisms. Thus, Pierson's book can be a useful tool for the analyst employing TQCA, both for these theoretical guidelines and as a source of more conceptualizations of time that might be possible to represent using one of the strategies we suggest in this discussion.

As we have outlined here, TQCA is only partly compatible with Ragin's (2000) program of fuzzy-set analysis. Perhaps the most obvious difference between TQCA and fuzzy-set analysis is the use

of dichotomous attributes in the former, while fuzzy-set analysis understands attributes as sets in which cases have varying degrees of membership. Concomitant with these framings is the privileging of the configuration in TQCA, in which cases stand as representatives, as opposed to the privileging of the case in fuzzy-set analysis, in which each case is "coded" for set membership individually. However, this difference between the methods is not a critical one. TQCA logic could work with the case-oriented, nondichotomous set membership of fuzzy-set analysis. In de-emphasizing the logic of configurations, the problem of configurations that are unrepresented by cases (e.g., Table 3, lines 4, 6, 8, 11, 13-15, and 17-18) would be eliminated and replaced by the fuzzy-set analysis problem of identifying negative cases (see Ragin 2000). One twist would be the need to search out cases that exhibited sequential variation as well as variation in membership in the outcome and attribute sets.

The real incompatibility between TQCA and fuzzy-set analysis comes in the "operations" described by Ragin (2000:171-80). Ragin has defined logical operations for fuzzy-set analysis; in addition to the "and" and "or" operations we have used above, he discusses "concentration," "dilation," and "negation." These operations are used both to explore the qualities of the data set but, more important, to evaluate the necessity of causal attributes and the sufficiency of combinations of them (as well as the requisite levels of set membership) for the outcome under question. To make TQCA and fuzzy-set analysis completely compatible, it would be necessary to define the temporal operator "then" and work out how it would meld with the analysis of necessity and sufficiency. In other words, this operator would have to be able to account for situations in which the sequence of combinations of fuzzily defined sets contributed to the necessity or sufficiency of those combinations causing the outcome. A "then" operator, however, has a fundamentally different logic from those Ragin has developed so far. Whereas fuzzy-set analysis avoids the issue of configurations using variable set membership, accounting for sequence would reintroduce it, thus threatening to make the method unwieldy—not to mention how the operator would work is not immediately clear. We thus defer the task of developing rules for the "then" operator for the future.

For the time being, we supply a work-around for this problem. To include temporality in fuzzy-set analysis, researchers could define one or more fuzzy sets that account for some quality of time. For example, as we mentioned earlier, the researcher might seek to characterize the speed with which a social movement acted, so she or he would seek to assess the membership of the different cases in the set of "quickly acting movements." In contrast to TQCA, the types of temporality easiest to define in a fuzzy-set fashion will be ones that refer to temporal attributes that could be captured in set categories. Duration and pace characteristics seem like the most obvious candidates, but perhaps ones referring to the repetition or cyclicity of events or actions could be devised as well.

We also believe that it is possible for a creative researcher to define a *sequential* fuzzy set as long as she or he uses a precise and limited sense of sequence. Let us take Ragin's (2000:261-86) reanalysis of his earlier analysis of International Monetary Fund (IMF) protests (Walton and Ragin 1990) as an example to think through what we mean. Two of the factors in that analysis are "economic hardship" and "government activism," and Ragin rates each case with respect to its membership in these two sets. But perhaps the order of these two factors matters for protest—if a government is perceived to have made a number of policy decisions before economic hardship, these actions might be blamed for the hardship and therefore exacerbate protest, whereas the reverse sequence might make the government look like it is more aligned with the interests of the people, thus cooling protesters' passions. To test this hypothesis, a researcher might define a set called "activism then hardship." A high score would reflect the set's name, and a low score indicates either the lack of this sequence or the reverse sequence. With this new set in the analysis, the researcher would then conduct the various tests of necessity and sufficiency to determine whether sequence was an important factor in the IMF protest. Note that we described this temporal hypothesis in terms of activists' perceptions of the government (whether or not the government gets blamed based on the temporality of its actions), but strictly speaking, this is not the case. The set "government blamed for economic hardship" is both theoretically distinct from and would require quite different empirical evidence than the definition of the sequential set.

A researcher could thus use sequential fuzzy sets to test relationships between the attribute sets in the cases under study. Although in many instances, it would be difficult or even nonsensical to collect sequence information for the different pairs of attributes under analysis, this task might reveal relationships between the attributes that would otherwise remain uncaptured. In addition, it might allow the researcher to connect narratives about the cases (from, say, a span of newspaper coverage about a protest movement) to the explanatory attributes used in analysis. In other words, pairwise testing of the sequence of attributes in a fuzzy-set analysis could help the researcher structure and compare narratives of social settings.

Sequential fuzzy sets defined this way would seem only to make sense in pairwise analysis of the temporality of attributes. Say, in addition to economic hardship and government activism, we wanted to consider the sequential impact of level of mobilization. For example, maybe mobilization that preceded economic hardship and government activism would allow movements different kinds of political options than protests (such as running opposition candidates), whereas mobilization that followed hardship and government activism as a reaction could only result in public protest. To test these hypotheses, the analyst might seek to define a set called ''mobilization follows hardship and government activism'' and then test its necessity and sufficiency for protest outcome set membership. This sounds straightforward and indeed may be depending on the actual cases, but the difficulty may emerge in ascribing set membership. Say mobilization occurred after hardship and activism in two cases, but the sequence of activism and hardship differed. How should membership be ascribed? What if mobilization occurred between hardship and activism in two cases, but the sequence of those variables differed? In some empirical settings, it might not be difficult to define complex sequences as fuzzy sets or to assign cases clear set memberships. But in most cases, the proliferation of possibilities that occurs when more than two elements are to be ordered would seem to make this technique unusable. Despite these limitations, researchers should be emboldened to seek creative applications of temporality and sequence in fuzzy sets. It seems likely that in many instances, even a series of pairwise sequential analyses of attributes could give the researcher substantial leverage for testing

temporal hypotheses and understanding new relationships between attributes under study.

We conclude with a few broader thoughts on the implications of TQCA for historical and comparative sociology. Ragin's QCA and now fuzzy-set analysis, with their combination of qualitative and quantitative methods, have constituted a truly novel response to longstanding dilemmas of medium-*N* comparative social research. We can only hope that more researchers find ways to apply these innovative techniques more broadly. To date, researchers employing QCA seem not to have been bothered about the atemporal character of the methodology. We hope the introduction of TQCA encourages researchers to think more directly about the role of sequence and other qualities of time in social outcomes. We cannot definitively say that seriously attending to temporality would affect existing studies that have employed QCA because we would need detailed knowledge about their specific empirical conditions. However, we have highlighted this possibility in a number of examples above, and it is not difficult to think of temporal hypotheses in other QCA studies. In addition to encouraging researchers to think about temporality in existing comparative studies, TQCA might open up types of social settings or aspects of social action that have so far been neglected by comparative analysts. We are thinking in particular of analyses of contentious politics (e.g., Wickham-Crowley 1992), although other social settings exhibiting a strong temporal organization would qualify. Social movements have been a chief focus of QCA studies, but we would argue that QCA has directed attention toward stable attributes of the movements and away from the political action itself and thus away from a more realistic depiction of the workings of power (Panofsky 2002).

Finally, while Ragin's QCA and fuzzy-set analyses have helped address the longstanding debate in comparative/historical sociology between case-based and variable-based methods, it has done little to address the other great debate in that field about temporality and causation.[8] Analogous to the former debate, but typically pitting those with historians' sensibilities against those with sociologists', this debate has concerned the role of narrative in the genesis and final form of sociological theories. We decline to take a substantive position here but would submit that TQCA offers a bit of a pragmatic,

methodological response to the debate. For those concerned that historical sociology builds general theory about causes, TQCA offers the ability to compare cases to test hypotheses about temporality. For those wanting to attend to the richness of the narrative and temporal unfolding of social settings, TQCA offers ways to introduce these elements into the analysis and possibly even to structure and compare sets of narratives about different cases. Thus, while TQCA will not settle the debates, it does provide one more tool for researchers working at the crux of this critical issue.

NOTES

1. Goertz and Mahoney (2004) use Ragin's fuzzy-set analysis, not the qualitative comparative analysis (QCA) we discuss here. Despite this difference, our point remains the same. We address the temporal extension of fuzzy-set analysis in the Discussion section of this article.

2. For a sample of the work theorizing the role of time in the methods of historical sociology, see Abbott (1990, 1992, 1998, 2001), Abrams (1982), Aminzade (1992), Calhoun (1998), Griffin (1992), Mahoney (2000), and Pierson (2004).

3. In the Discussion section, we explore some possibilities for using temporal qualitative comparative analysis (TQCA) with other conceptions of time.

4. The commutative principle states that $A * B = B * A$.

5. Ragin's (2000; see also 1995) efforts to include inferential statistics for analyzing "necessity" and "suffiency" of causal conditions attempt to account for variation (of "fuzzy"-set membership, not variablized traits) based on the N of the population under study, but they do not rest on the understanding that the cases under consideration represent a larger, unstudied population.

6. Although Pierson's (2004) version of path dependence, which emphasizes positive feedback loops and the lock-in of initial moves, is arguably more realistic than the one we apply, it is more difficult to represent using our notation.

7. We thank an anonymous reviewer for highlighting this point for us.

8. For an overview of this debate, see Calhoun (1998).

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