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Standards of Good Practice in Qualitative Comparative Analysis (QCA) and Fuzzy-Sets

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Abstract

As a relatively new methodological tool, QCA is still a work in progress. Standards of good practice are needed in order to enhance the quality of its applications. We present a list from A to Z of twenty-six proposals regarding what a "good" QCA-based research entails, both with regard to QCA as a research approach and as an analytical technique. Our suggestions are subdivided into three categories: criteria referring to the research stages before, during, and after the analytical moment of data analysis. This listing can be read as a guideline for authors, reviewers, and readers of QCA.

Keywords

QCA, fuzzy sets, good practice, data analysis, research approach, comparative methods

The American social scientist Charles Ragin introduced the foundations of Qualitative Comparative Analysis (QCA) in three major books (1987, 2000, and 2008b). Together with several other book publications,[1] articles,[2]

[1] Rihoux and Meur (2002), Goertz and Starr (2003), Rihoux and Grimm (2006), Wagemann and Schneider (2007), Rihoux and Ragin (2008).

[2] For a comprehensive list, see www.compasss.org.

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and treatments in general methodology textbooks, these writings have contributed to an increased recognition of QCA as a methodological tool with a potential added value.

As the popularity of QCA broadens, so does the risk of an increasing number of faulty applications. There is a growing awareness for the need not only to lay out QCA's principles, but also to develop standards of good practice. This trend towards more practice-oriented, hands-on instructions has become manifest in the publication of several textbooks (De Meur and Rihoux 2002 in French; Schneider and Wagemann 2007 in German; Rihoux and Ragin 2008 in English) as well as QCA training courses offered across many countries.[3]

What is missing, in our view, is a comprehensive and easily accessible "code of good practice" in article-length form, spelling out which practical tasks are at stake when performing "good quality QCA." Presenting such a code has several advantages. First of all, it helps to make QCA more transparent and, thus, acceptable within the social science community by showing both its capacities and limits and also dispelling some of the most persistent myths and misunderstandings. Second, such a listing of good QCA practice can serve as a guideline both for users of QCA, in getting their work correct analytically and technically, and for readers and reviewers, in having a yardstick for evaluating empirical analyses based on QCA.

Wagemann and Schneider (2009), together with Berg-Schlosser et al. (2008), argue that QCA is not just another (computer-based) data analysis technique. In order to do justice to its underlying epistemology, it needs also to be understood – and applied – as a research approach in a broad sense. *Before* – and, as we will show, *after* – the "analytic moment" (Ragin 2000) of data analysis, QCA is based on specific requirements on core issues of research design, such as case selection, variable specification, and set membership calibration. Our listing of good practices underlines this double nature of QCA and thus is divided into three parts:

- A first part addresses QCA as a research approach, presenting proposals for the phase *before* the analytical moment;

[3] See especially the annual ECPR Summer School in Methods and Techniques in Ljubljana (http://www.essex.ac.uk/ecpr/events/summerschools/ljubljana/index.aspx). For an extended list of QCA courses taught mainly across Europe, check www.compasss.org.

- A second part discusses requirements that emerge *during* the analytical moment and, more generally, when QCA is applied as a data analysis technique; and
- A final part addresses QCA as a research approach with specific requirements for the phase *after* the analytic moment.

Some of our suggestions are inspired by ideas presented in earlier literature (Yamasaki 2003; Ragin and Rihoux 2004; Schneider and Wagemann 2007; Wagemann and Schneider 2007; Rihoux and Ragin 2008), but others are novel.[4] With few exceptions, our suggestions are formulated such that they apply to all variants of QCA (that is, crisp-set, fuzzy-set, and multi-value). Some of our proposals are not even specific to QCA but apply equally to any empirical method. While some of these proposals might seem obvious, evidence from research reality suggests that this is not the case for everybody.

Space restrictions prevent us from providing a thorough introduction to QCA. Readers unfamiliar with this approach might want to read the present article jointly with the one preceding it in the same journal, where we describe QCA as a research approach and a data analysis technique.

Criteria with Regard to QCA as a Research Approach before the Analytic Moment

a) *QCA Should Be Used for its Original Aims*

Berg-Schlosser et al. (2008; see also Ragin and Rihoux 2004:6) mention five possible aims of using QCA:

- To summarize data;
- To check the coherence of the data with claims of subset relations;
- To test existing hypotheses and theories;[5]

[4] Our suggestions are, in fact, an extension of a listing in the QCA textbook of the authors (Schneider and Wagemann 2007:266ff.). This earlier listing serves simply as a general conclusion of the book, without further explanations or justifications.

[5] For suggestions regarding how to use the intersection function as a means for "testing" theories in QCA, see Schneider & Wagemann (2007:118–127).

- To overview quickly the basic assumptions of the analysis; and
- To develop new theoretical arguments.

To this, we would add the use of QCA as a means for creating empirical typologies (for more details, see Kvist 2006 and 2007).

Of course, it is possible to pursue all or just some or one of these purposes of QCA in the framework of a research project. We also deem it important to highlight that hypotheses should consist of statements about sufficient and/or necessary conditions. QCA is good in detecting these types of set relations and inadequate for others, such as correlations (Ragin 2008b).

b) *QCA Should Be Applied together with Other Data Analysis Techniques in a Research Project*

Different methods should be used in a complementary way, especially if the aim is to draw causal inferences. QCA is particularly useful for combination with conventional (comparative) case studies. On the one hand, case studies help to acquire familiarity with the cases that are so indispensable both for generating the data (concept formation and measurement) and a meaningful interpretation of QCA results (see point c). On the other hand, due to its focus on complex causal structures, QCA solution terms provide more precise information about the analytically relevant similarities and differences between cases, by clustering them into different paths towards an outcome. Those groupings can be a useful starting point for selecting cases for subsequent (comparative) case studies.

Restriction: In general, multi-method research in the form of journal articles faces serious space limitations. When QCA is the only method used, it still remains important to summarize the research process that generated the data and to mention which other methods (case studies, statistical analyses, etc.) should be applied in subsequent analyses and why.

c) *Familiarity with Cases Is a Requirement before, during, and after the Analytical Moment of a QCA*

The basic motivation behind a QCA should always be to learn more about cases. Researchers should try to know as much as possible about their cases at all stages of the analytical process. *Before* the analysis, familiarity with cases makes it easier: to identify analytically relevant conditions, to specify each case's membership in them, and to specify the relevant population. *During* the analysis, it is useful for selecting parameters (such as the consistency values, see Ragin 2006b and points l and z). *After* the analysis, it facilitates interpreting the results. Additional information from "causal process observation" (Collier, Brady und Seawright 2004:252ff.) enhances the possibility of drawing valid causal inferences.

Restriction: QCA can be used to analyze individual level data (e.g. Ragin 2006a and 2008b), where, by necessity, familiarity with a single case is not central. This should be replaced by familiarity with *types* of cases, as defined by different paths towards an outcome. The different types of individuals can be described in more detail by including other analytically relevant characteristics not used in QCA. If, for instance, a sufficient condition for being a conservative voter (the outcome) is "being male *and* living in a remote village in the mountains" and another one is "being wealthy *and* a regular worshipper," it should be analyzed which other factors are shared by individuals in these two types of condition of conservative voters. This might provide cues on why these two different types of individuals – and not others – share the same voting pattern. When analyzing types of individuals, data analysis techniques other than QCA can and should be used (such as statistical procedures like factor or cluster analysis, see point b).

d) *There Should Always Be an Explicit and Detailed Justification for the (Non-)Selection of Cases*

The literature in comparative methods provides a whole catalogue of criteria regarding how to select cases (e.g. King, Keohane, and Verba 1994:124ff.; Collier, Mahoney, and Seawright 2004; Mahoney and Goertz 2004; Morlino 2005:51ff.; Seawright and Gerring 2008; Rohlfing 2008). An explicit rationale for selecting cases and defining a population is all the more important in QCA because here causal inference is not based on notions derived from inferential statistics. As a consequence, results, first and foremost, hold for the cases that have actually been examined. One can only generalize to other cases on the basis of clearly specified *scope conditions* (Walker and Cohen 1985), which delimit the universe of cases for which the causal relation examined is claimed to hold.

e) *The Number of Conditions Should Be Kept at a Moderate Level*

It is tempting to run an analysis including every possible condition in order to have an allegedly exhaustive view of sufficient and necessary conditions. However, just like in garbage-can statistical models, where too many independent variables "destroy" the results because coefficients will not become significant and their strength and direction become unstable, high numbers of conditions are also dysfunctional for QCA. For one, the number of logical remainders will grow considerably, making the problem of limited diversity ever more pronounced (see Ragin and Sonnett 2004; Schneider and Wagemann 2006 and point n). In addition, with many conditions, QCA produces very complex results, making theoretically meaningful interpretations a daunting task.[6] In short, it is a myth that just because no statistical assumptions are violated QCA is not subject to the "many variables – few cases" problem (Lijphart 1971 and 1975) and the challenges this poses for drawing causal inference.

Several mutually non-exclusive strategies exist for reducing the number of conditions (Amenta and Poulsen 1994). For instance, higher order constructs can be created (Ragin 2000:321–328) through so-called master or macro-variables (Rokkan 1999; Berg-Schlosser and De Meur 1997); or a two-step QCA approach can be applied (Schneider and Wagemann 2006; Schneider 2008:chap 5–6).

Restriction: When micro-level data is analyzed, the ratio between conditions and cases can be tilted slightly more towards the former. Usually, micro-level analyses operate on data that is both more heterogeneous and numerous than macro-level analyses. Both features, in tendency, reduce the number of logical remainders. At the same time, using more conditions help to reduce the number of contradictory rows (in csQCA) and to raise the consistency values (in fsQCA), respectively. This, in turn, is a positive asset, for the better specified a truth table is (less logical remainders and contradictions and higher consistency), the stronger the (causal) inference.

[6] See Marx (2006) for a methodological experiment on the acceptable proportion between the number of cases and the number of variables.

f) *The Conditions and Outcome Should Be Selected and Conceptualized on the Basis of Adequate Prior Theoretical Knowledge as well as Empirical Insights Gained throughout the Research Process*

Like case selection, in QCA also the selection and definition of conditions and an outcome is subject to changes based on preliminary findings throughout the research. Such a re-specification of the cases, the conditions, or even the values of cases in certain conditions stands in marked contrast to best practices in statistical research. Here the data are said to be inviolable once they have been collected. In qualitative research, in general, and QCA, in particular, an ongoing adaptation of the data set is the rule, not the exception.

Restriction: The iterative process of data and case specification cannot, of course, be continued *ad infinitum.*

g) *The Calibration of Set Membership Scores Should Be Discussed in Detail*

The data processed in crisp and fuzzy-set QCA consists of membership scores in sets. These scores for cases need to be generated via the so-called calibration of sets. In the process of set calibration (Ragin 2008b:ch. 4 and 5; Wagemann and Schneider 2009), it is particularly crucial to specify qualitative anchors (the set membership scores of 0 and 1 in csQCA and the scores 0, 0.5, and 1 in fsQCA). Theoretical, not empirical, arguments are needed in order to determine which empirical evidence qualifies for set membership scores above and/or below these anchors.

In other words, the specifying of qualitative anchors cannot be derived exclusively from the empirical information at hand. It primarily rests on prior knowledge external to the data. In fact, a mechanical application of mathematical operations on the data (such as operating with the statistical median or mean) is almost always wrong when calibrating sets. These procedures only take into account properties of the data and are void of any theoretical meaning or reasoning.

Both theoretical reasons and the quality of empirical evidence should also be the basis for the more general decision regarding whether to apply crisp-set or fuzzy set-based QCA. It is a myth that this choice should be driven by the number of cases, with csQCA allegedly being more appropriate for smaller N research and fsQCA for larger N designs.

h) *The Appropriate QCA Terminology Should Be Followed*

QCA is based on the principles of set theory, formal logic, and Boolean and fuzzy algebra; as a result, QCA has developed a terminology of its own. This is a crucial yet often overlooked difference to standard statistical techniques. The latter use: values on variables rather than set membership scores; correlations rather than set relations; and linear rather than Boolean algebra.

In order to highlight the distinct logic underling QCA, the following terminology has been developed:

- The term "condition" is used, not "independent variable;"
- The phenomenon to be explained is called "outcome," not "dependent variable;" and
- The results of a QCA are called "solution formula" or "solution term," not "equation."

The use of this vocabulary is not only more correct formally but also diminishes the risk of confusing the underlying logic of QCA with that of other data analysis techniques, such as regression analysis. These might look similar on the surface, but they are based on different mathematical procedures and epistemologies.

Restriction: In multi-method studies, terminological differences might lead to stylistic problems and substantive confusion.

Criteria for the "Analytic Moment"

i) *Necessary and Sufficient Conditions Should Be Analyzed in Separate Analytical Steps, with the Analysis of Necessary Conditions Going First*

Standard analyses of truth tables in QCA are geared towards unraveling sufficient conditions. Only under very peculiar empirical conditions does such an analysis of sufficient conditions also correctly reveal the presence or absence of necessary conditions (Wagemann and Schneider 2009). Because of this, statements about necessity should only be made if necessary conditions have been identified in a separate and adequate analysis.

The data analysis should always start with the necessary conditions (for a justification of this point, Schneider and Wagemann 2007:112ff.).

j) *Contradictory Truth Table Rows Should Be Resolved prior to Minimizing the Truth Table Algorithm*

Contradictory rows can defined as a configuration of conditions (that is, a truth table row) containing cases with different outcomes values. The difference in the outcome, thus, is not be explained by the conditions used. Several ways of solving such logical contradictions can, and should, be applied: the case selection should be changed; other conditions should be added; and/or the outcome should be re-conceptualized.

If contradictory rows still exist, outcome values of these rows (either 1 or 0) need to be assumed when logically minimizing a truth table. These assumptions can either follow a purely mathematical logic, or be informed by theoretical arguments or empirical evidence (Ragin 1987:113ff.; Schneider and Wagemann 2007:116ff., and point m of this list). In fsQCA, contradictory rows are usually operationalized through less than perfect consistency values. However, the same strategies for resolving contradictions, as in csQCA, can also be applied.

Restriction: Any of the possible ways of addressing contradictory rows comes at a price. Adding conditions increases the problem of limited diversity. Excluding cases or reconceptualizing the outcome, and thus recalibrating the outcome set, require firm theoretical justifications that are not always at hand. Excluding contradictory rows from the logical minimization procedure of a truth table (that is, assuming that this combination of conditions does not lead to the outcome), leads to lower coverage values of the QCA solution term. That is, cases with the outcome to be explained are not captured by the solution. Inversely, including contradictory rows produces lower consistency values of the solution term, because it covers cases that do not display the outcome.

k) *Truth Tables Should Be Minimized with the Help of Appropriate Computer Software*

The great majority of QCA is based on truth tables that exceed a level of complexity that can be managed by hand. Several pitfalls await those who set out and try to minimize complex truth tables. In the best case, only logically redundant prime implicants are overlooked so that the minimized solution term is still logically correct. But this is not the most parsimonious formulation of the information contained in the truth table. In worse cases, logical mistakes are made so that the solution term misrepresents the truth table information. An additional argument for using appropriate software is that it produces the coefficients of consistency and coverage (this is true for the packages fsQCA 2.0 and Stata, Longest and Vaisey 2008).

Restriction: In case of exceptionally short truth tables, a logical minimization is also feasible by hand. Moreover, while the minimization generally should be done with a computer, scholars should still always engage in eyeballing a truth table, in order to become more familiar with the underlying evidence. They should ask questions, such as: Are there any rows particularly populated by cases? How much limited diversity exists? Are there many rows with just one ore a few cases?

l) *The Choice of Appropriate Levels of Consistency and Coverage are Research-Specific, and Need to Be Supported with Arguments*

The appropriate levels for consistency and coverage are research-specific. They vary with the number of cases studied, the knowledge the researcher has about the cases, the quality of data gathered, the specificity of theories and hypotheses at hand, and the research aims. When choosing thresholds for consistency and coverage in QCA, researchers cannot rely on commonly accepted thresholds that are applicable to any and all QCA.

Thus, rather than justifying thresholds by referring to alleged conventions, thresholds must be explicitly justified. By contrast, when certain levels of significance have reached a doctrine-like status in some areas of applied statistical social science research, this arguably has negative consequences for discovering correct estimates of true effects (Gerber and Malhotra 2008).

Restriction: While no generally valid and exact threshold values for the parameters of fit can exist, some lower boundaries for consistency might be spelled out. No consistency values lower than 0.75 should be accepted (Ragin 2008b: 118). In the case of necessary conditions, the consistency value should be set much higher (see Schneider and Wagemann 2007: 213 for a detailed discussion of this point).

m) *The Treatment of Contradictory Rows (in csQCA) and of Inconsistent Truth Table Rows (in fsQCA) in the Logical Minimization Process Should Be Transparent*

If all attempts to eliminate contradictory rows fail, the rules for their treatment are similar to those for logical remainders specified under n. A researcher needs to be explicit about: whether such rows exist in the truth table; how many of them there are; which cases deviate from a broader pattern; and how these rows are treated in the process of logical minimization.

If the so-called (crisp or fuzzy) truth table algorithm is used, explicit reasons must be provided regarding which threshold value is chosen above which a given truth table row is considered to be a sufficient condition for the outcome (Ragin 2008a and Schneider and Wagemann 2007:chap 3). As mentioned (see point 'n'), no reference to any specific, commonly agreed, and universally applicable consistency value can be made. Such a value does not and should not exist, since the appropriate level of consistency varies with research project specific characteristics, such as the number of cases, the researcher's intimacy with the cases, the quality of the data, and the precision of existing theories. Empirically, in fsQCA, consistency values across all logically possible truth table rows often display a gap between very high and very low values; using this empirical gap for setting the threshold can often be an appropriate choice.

n) *The Treatment of Logical Remainders Should Be Transparent*

The treatment of limited diversity should be transparent. This requires, in a first step, to specify whether or not logical remainders exist in the truth table and, if so, what type(s) of logically possible "cases" are not observed empirically. Such a specification (best to be done in the form of a Boolean expression) of the type of limited diversity on which the empirical study is based is a useful starting point for formulating the scope conditions (Walker and Cohen 1985) under which subsequent empirical results are claimed to be valid (Ragin 1987).

In addition, it must also be justified explicitly which of the different strategies were applied for dealing with logical remainders during the logical minimization process (see point 'r'). This information is indispensable for other researchers who want to reproduce the analysis. In this context, Ragin and Rihoux point out (2004:7) that it is helpful to list the simplifying assumptions that have been made, especially if they were generated by the computer but also when only easy counterfactuals were used.

o) *Based on One Truth Table, Several Solution Formulas of Different Complexity Should Be Produced and Presented*

Limited diversity and, thus, logical remainders are omnipresent in comparative social research based on observational data. Different treatments of these logical remainders lead to different solution formulas (Ragin 1987:104ff.; Ragin and Sonnett 2004; Schneider and Wagemann 2007:101ff.). All of these results are logically equivalent and true because they do not contradict the available empirical information contained in the truth table. The formulas simply differ in their degree of complexity, or better, precision.

The suggestion is to produce at least three solution formulas (Ragin 2008b):

- One based on simplifying assumptions (performed by the computer) for the logical remainders, which will always lead to the most parsimonious solution;
- Another one without any such simplifying assumption, which will always lead to a more complex solution term; and
- A third solution term based on so-called easy counterfactuals (Ragin and Sonnett 2004), which will lead to a solution term of intermediate complexity.

Restriction: When it comes to the theoretical and substantive interpretation of the results, a researcher is free to choose which formula(s) to put into the center of attention. Most likely, not all three solution formulas are used extensively for substantive interpretation.

p) *The Outcome and the Negation of the Outcome Should Always Be Dealt with in Two Separate Analyses*

The analysis of a truth table provides sufficient conditions for the occurrence of an outcome. However, from this alone, the sufficient conditions for the *non*-occurrence of the outcome cannot be inferred. Even if the negation of an outcome is often not part of the theories to be examined, an analysis of the negation of the outcome is recommended. Such analyses can help to grasp the causal logic driving the positive cases and/or generate substantively interesting insights in their own right.[7]

The solution formula for the non-occurrence of an outcome can be derived either by applying De Morgan's law (Klir, Clair, and Yuan 1997:37) or by performing a separate analysis in which the negation of the outcome is specified as the phenomenon to be explained. When analyzing both the occurrence and the non-occurrence of an outcome, careful attention must be paid to the danger of having made contradictory simplifying assumptions (Vanderborght and Yamasaki 2003). These are logical remainders which are assumed, in one analysis, to produce the outcome and, in another analysis, to produce the negation of the outcome. Researchers must check and report whether such contradictory simplifying assumptions were made, as opposed to inadvertently relying on solution formulas that rest on such contradictory assumptions (see Schneider and Wagemann 2007:167ff. for an adequate procedure).

Restriction: De Morgan's law can only be applied meaningfully if the truth table does not contain logical remainders or contradictory rows (Schneider and Wagemann 2007:112ff.). Since such a situation is more the exception than the rule in empirical social science based on observational data, the default option should be to run a separate analysis for the negation of the outcome. Researchers should also consider whether a (slightly) different set of theories and thus conditions should be used when shifting from the analysis of the occurrence of the outcome to its non-occurrence.

Criteria Concerning Presentation of QCA Results

q) *Different Presentational Forms of QCA Results Should Be Used in order to Depict both the Case- and Variable-Oriented Aspects of QCA*

QCA stands out as a method that puts equal weight on achieving three aims simultaneously. First, it seeks to understand single (groups of) cases. Second, it attempts to unravel the relationship between sets of conditions and the outcome. Third, it assesses the degree to which these analytical results reflect the underlying data structure.

7) On the general importance of negative cases for drawing inferences in social science research, see Ragin 2004:130ff. and Mahoney and Goertz 2004.

In order to fulfill these three aims, researchers should resort to the full repertoire of presentational forms. These forms include: graphical (Venn diagram, YX-plot, tree diagram), tabular (truth tables), and numerical (measures of fit) (Schneider and Grofman 2006).

Restriction: Space limitations often make it impossible to use all forms of representation in a single publication. While a selection of presentational forms should be driven by the primary goals of the research project, it is also true that researchers learn more about their data by producing all presentational forms without necessarily including them in their publication.

r) *QCA Should Always Be Related back to the Cases, Not Be Applied in a Mechanical Way*

Software packages have greatly facilitated QCA. However, they have also increased the temptation to feed the computer with some ready-made data and to run a QCA on it, bypassing the crucial phase of acquiring intimacy with the cases under study. This habit, also known in superficial statistical applications, is particularly damaging in the case of QCA, because one of its principal epistemological aspects consists in capturing accurately the characteristics of cases. If cases disappear behind computer-based algorithms and parameters of fit, the method looses one of its major strengths.

Restriction: In QCA, the explorative element of approaching the data is stronger than it is in statistical techniques. Ragin (1987) calls this the "dialogue between (theoretical) ideas and (empirical) evidence." As a consequence of this, QCA is rarely ever applied with the main purpose of testing ready-made hypotheses distilled from the literature.

s) *Solution Formulas Should Be Linked back to the Cases, Preferably through Graphical Representation Tools*

Researchers should make clear which cases – mentioned with their proper names – are covered by which of the paths in the solution formula. This is the ultimate test of whether or not the results generated by the logical minimization make sense, both theoretically and empirically. Only if the results are useful for understanding the cases has the primary goal of QCA been achieved.

If fsQCA is performed, X-Y-plots are particularly useful in displaying either the entire solution formula and/or different paths towards the outcome. X-Y-plots show straightforwardly where single cases fall on the fuzzy scales of the outcome and the (conjunctural) condition. They also provide a series of information relevant for assessing the quality of the fsQCA results (Schneider and Wagemann 2007:197ff.).

First, X-Y-plots show whether a specific condition is necessary (lower triangular plot) or sufficient (upper triangular plot). Second, they give an impression how consistent a given condition is with the statement of being a necessary or a sufficient condition, respectively. Third, X-Y-plots offer graphical insights regarding how relevant empirically a sufficient condition is,[8] and whether or not a necessary condition might be trivial empirically (and thus also often theoretically) (Goertz 2006).[9]

t) *Individual Conditions of a Conjunctural and Equifinal Solution Term Should Not Be (Over)Interpreted*

QCA is a configurational method. It rests on the assumption – and, in fact, almost always produces results that show – that the *interplay* between conditions explains an outcome. Therefore, when interpreting the results, an overt focus on the role of individual conditions in isolation from other conditions is not in line with this epistemological foundation of QCA.

Restriction: If in a given research field strong consensus prevails that a particular condition alone and in isolation from any other condition is indispensable for producing (or preventing) an outcome, then a researcher might want to pay attention to this prominence when interpreting QCA results. Often (obviously depending on the patterns in the empirical data), a researcher is able to conclude from a QCA that an allegedly important condition does not show up either as a necessary or sufficient condition. Instead, this particular condition might be simply an INUS condition (Mackie 1974, Mahoney 2008, Wagemann and Schneider 2009), that is,

[8] For instance, in order to be a 'good football player', 'being of short stature, Argentine, and named Diego Maradona' is a sufficient condition – empirically speaking a not really important one, though, for there are many other good players who have no membership in this condition. The graphical representation in a X-Y-plot makes evident conditions for which little empirical evidence exists.

[9] A trivially necessary condition would be, for instance, "air to breathe" for the "occurrence of war." While this statement qualifies empirically as a necessary condition, it is substantively trivial because air to breathe is a condition for literally every type of human action.

causally relevant only in some cases and only in combination with other conditions.

u) *The Researcher Should Always Provide Explicit Justifications When One (or more) of the Paths towards an Outcome Is Deemed more Important than Others*

One possible argument that one path is more important than others can be based on its empirical weight. This can be expressed by the coefficient of coverage, a measure that expresses how much of the outcome is covered, or explained, by a particular solution term. Another approach to importance is that of theoretical relevance. Sometimes an empirically less important path (a path covering only a few, probably even only one case) can nonetheless be more interesting and important theoretically and substantively than other paths covering many cases. A low coverage path might provide an explanation for cases that hitherto have remained deviant or misunderstood. At the same time, high coverage paths might simply state the obvious, contributing little to theoretical and empirical knowledge.

Restriction: An alternative to treating some paths as more important than others is to make sense of the solution formula by moving up the ladder of generality (Sartori 1991, Goertz and Mahoney 2005). If theoretical arguments are at hand, all sufficient conjunctions could be interpreted as functionally equivalent empirical representations of one and the same more abstract concept. While the different sufficient conjunctions are the observed causes, the true theoretical reason for the occurrence of the outcome is the more abstract concept (see Schneider 2008 for an application of this strategy).

v) *Solution Formula alone Should Not Be Taken as Demonstrating an Underlying Causal Relationship between the Conditions and an Outcome*

Similar to any other data analysis technique in the social sciences, the task for researchers using QCA consists in spelling out the causal link (or causal mechanism) between the condition and an outcome in a narrative fashion. Usually, this causal link cannot be derived from the data analysis but instead must be developed theoretically. Often times, detailed discussions of cases are very useful when trying to make sense of the empirical results and to induce theoretical meaning. In particular, such in-depth analyses of a few cases are likely to bring to the fore the causal relevance of the time-dimension in understanding social phenomena.

w) *The Raw Data Matrix Should Be Published*

We assent to the proposition by Yamasaki (2003:3, see also Schneider and Wagemann 2007) that the raw data be presented. Not only should authors of QCA studies know their cases, but this knowledge should also be passed on in a clear and understandable way to recipients. In addition, publishing the raw data, together with the calibration functions (see point g), allows for replicability of a QCA.

Restriction: Some data sets might be too large to be published. In this case, the original data should be made available on the internet or on demand.

x) *The Truth Table Should Be Reported*

Truth tables are a powerful heuristic tool and are at the core of any type of QCA. One of their most important features is that they represent the most complex answer to the main question, namely which combinations of conditions are sufficient for a given outcome. In addition, they provide a straightforward indication of which cases are analytically identical and how much and what kind of limited diversity is in the data (see Schneider and Wagemann 2006; Schneider and Wagemann 2007; and Wagemann and Schneider 2009 and point 'n'). The publication of truth tables allows others to replicate the logical minimization leading to the QCA solution terms.

Restriction: In the case of particularly large truth tables, the representation of logical remainders can be suppressed, that is, logically possible combinations of conditions for which no empirically observed cases are at hand are not displayed. In this case, however, the kind and extent of limited diversity should be described via a Boolean expression (Ragin 1987:108ff.).

y) *Every QCA Must Contain the Solution Formula(s)*

Results of a QCA should not only be presented in a narrative, but also in a formal Boolean notation. Solution formulas are a powerful way to express the underlying data structure in a parsimonious and logically correct way.

The predominant current convention is to use capital letters for the presence of a set, small letters for its negation, the + sign for a logical OR, and a * sign for a logical AND. For expressing a sufficiency relation, an arrow (→) should be used running from the sufficient conditions towards an outcome.[10] A necessary condition relation should be expressed by using an arrow (←) running from an outcome to a necessary condition. As noted earlier (point *i*), the result of a QCA should be called a "solution term" or a "solution formula," and not "equation."

Restriction: Only under certain (rather rare) empirical conditions is the use of the = sign appropriate. This is the case when the result of the analysis is based on a fully specified truth table, that is, absent contradictory rows, and when the logical remainders are substantially irrelevant, logically possible but substantially impossible, or treatable as "easy counterfactuals" (Ragin and Sonnett 2004).

z) *The Consistency and Coverage Measures Should Always Be Reported*

The coefficients of consistency and coverage provide important numeric expressions for how well the logical statement contained in the QCA solution term fits the underlying empirical evidence and how much it can explain. Both pieces of information help to improve the interpretations of the solution formula.

Restriction: The fact that empirical measures of fit exist and should be reported in QCA should not lead researchers either to assign theoretical relevance a second-order role in the interpretation of results or to hide 'deviant' cases behind the measures of fit (also see point *c*).

Conclusion

One teething problem of QCA is the lack of some rules of good practice, broadly defined. Readers, reviewers, and often even users struggle to make the most of this new methodological tool and to present analytic findings

[10] Alternatively, an unequal sign (≤) can be used. This is based on fsQCA notation (Ragin 2000) and stems from the fact that necessity and sufficiency denote subset relations between the condition and outcome.

in a formally correct, theoretically clear, and substantively compelling manner. With our listing of recommendations we have aimed at tackling this problem.

We have followed a broadly shared understanding (Berg-Schlosser et al. 2008, Wagemann and Schneider 2009), namely that QCA should be perceived of both as a research approach and a data analysis technique. We have divided our suggestions accordingly, in the hope that this contributes to understanding that knowing how to apply QCA requires both: knowledge of the technical and mathematical underpinnings of QCA and of its roots in qualitative social science research. Reducing QCA to pure data manipulation clearly violates the "Q" ("qualitative") in QCA. At the same time, if adequate *technical* knowledge regarding how to apply QCA is missing, this method cannot avoid producing meaningless results.

We conclude with some caveats. First of all, our suggestions should be seen as a "work in progress." Some of the proposals are subject to future changes, due to the simple fact that QCA is still undergoing further developments. Second, it is important not to turn any of our suggestions into unreflected dogma. Any useful guideline for good practice loses much of its positive effects if it is converted into mindless, mechanically applied operations. Finally, we are aware that our listing from A to Z assumes a perfect world in which researchers who try to incorporate our suggestions are not restricted by either time or space. In practice, it is more likely that not each and every QCA publication will (or can) fully achieve the high standards we outline.

We nevertheless consider it important to initiate a debate on what, under ideal conditions, a QCA should look like. This, we hope, will foster an increased (self-) consciousness and create an understanding that deviations from standards of good practice should, at minimum, be justified. This article was designed to sharpen attention to methodological problems when using (not only) QCA. A critical reflection about the methodical necessities, the readiness for adapting methodological possibilities, and a conscious application of a methodological repertoire are healthy attitudes towards any approach to the analysis of social science data.

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