# Incorporating Reality into Social Choice

Blue Sky Ideas Track

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## ABSTRACT

When voting on a proposal one in fact chooses between two alternatives: (i) A new hypothetical social state depicted by the proposal and (ii) the status quo (henceforth: *Reality*); a *Yes* vote favors a transition to the proposed hypothetical state, while a *No* vote favors Reality. Social Choice theory generalizes voting on one proposal to ranking multiple proposals; that Reality was forsaken during this generalization is, in our view, inexplicable. Here we propose to rectify this neglect and incorporate Reality into Social Choice, distinguishing Reality from hypothesis. We show that doing so: (i) Offers a natural resolution to Condorcet's paradox; (ii) Explains what approval voters approve; (iii) Produces a simple and efficient Condorcet-consistent show-of-hands agenda; (iv) Produces democratic action plans, which start with Reality and proceed in democratically-supported transitions; and (v) Nullifies Independence of Irrelevant Alternatives and hence abdicates Arrow's Theorem. Arrow's theorem was taken to show that democracy, conceived as government by the will of the people, is an incoherent illusion. Incorporating Reality into Social Choice may clear this intellectual blemish on democracy and offer a coherent, simple, efficient, easy to communicate, and trustworthy path forward to democracy.

## KEYWORDS

Arrow's Theorem; Condorcet Criterion; Iterated Approval Voting

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## 1 INTRODUCTION

The standard model of Social Choice does not give any special consideration to the present social state, namely Reality. E.g., neither Arrow [1], nor Sen [17], nor Black [8] incorporate Reality into their models; same for [14]. Here we propose that Reality be incorporated into Social Choice as an ever-present, always-relevant and evolving social state, distinguished from hypothetical social states.

**Ever-present** – since every voter should have the opportunity to prefer the status quo over some or all other proposed alternatives. This opportunity is necessarily available when voting on a single alternative—chosen by voting *No*—and there can be no justification for revoking this right when the number of alternatives increases. More than half a century ago, Clark Kerr has stated that "the status quo is the only solution that cannot be vetoed" [13]. Yet, Social Choice theory, by failing to incorporate the status quo as an ever-present alternative, effectively allows those who set up a vote the choice to veto the status quo. With hindsight, we find it difficult to understand how such a basic desideratum, arguably a basic civic right, could have been bypassed by Social Choice theory.

**Always-relevant** – as the ranking of hypothetical social states critically depends on Reality: Real voters do not rank hypothetical social states in the abstract; they live in a particular Reality, thus when ranking alternatives to it they in fact rank transitions from Reality to the hypothetical social states depicted by the alternatives. Evaluating such a transition rationally requires comparing the utility of the hypothetical social state to that of the present Reality, and estimating the cost of realizing the hypothetical social state given Reality. Furthermore, preference over Reality, or distance from Reality, if known, can be used to naturally resolve Condorcet cycles, giving rise to Reality-aware voting rules that are regular [3] and thus well-behaving, yet do not satisfy Independence of Irrelevant Alternatives and hence eschew Arrow's theorem.

**Evolving** – as the present social state—Reality—changes over time, and could change even though the set of alternatives remain. Democratic communities endeavor that such changes be commensurate with the will of their people. This can be the basis for *democratic action plans* (Section 2.2), which start with the present Reality and proceed only in transitions that have democratic support.

There are ample real-world scenarios where Reality should be taken into account, some reflecting the status quo bias [12]. Here is a concrete example.

*Example 1.1.* Consider choosing a location for a new public building. Ranking of a location must depend on the present availability of public transportation to it, and as this Reality changes, so would the ranking. Incorporating the assumption of future public transportation into each proposed location would not eliminate the impact of Reality: Voters that prefer not to fund new infrastructure for public transportation would downgrade the ranking of locations that presently do not have public transportation. Voters that wish to improve public transportation to a particular location would upgrade the ranking of that location, despite (or because) its present lack of public transport. Either way, Reality cannot be ignored.

*Related Work.* Richelson [15] proposes axioms requiring that a winning state shall win over the status quo by a majority; discusses corresponding voting rules; and considers repeated elections where the status quo might change. Grofman [11] considers the status quo for spatial voting, where people correspond to ideal positions on a line and vote by averaging their ideal position on that line with the position of the status quo; in particular, when Reality changes,

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their preferences change as well. Lastly, in Amendment agenda [14], employed by Anglo-American legislatures, voting is carried out sequentially on each amendment given the status quo, which is continuously updated by each approved amendment.

## 2 REALITY-AWARE SOCIAL CHOICE MODELS

We present four models of Reality-aware Social Choice, from the abstract to the more concrete.

### 2.1 Abstract Reality-aware Social Choice

We designate one of the social states as the distinguished Reality: Consider a set of voters $V$ and a set of social states $S$, one of which is designated as the present Reality, typically denoted by $R$. Voters preferences depend on the identity of Reality, thus, for each $R \in S$, each voter $v \in V$ has a ranking (total order[1]) $v_R$ over $S$, which reflects the preferences of $v$ when the Reality is $R$. We require constancy, so that craving for a particular state of affairs, independently of Reality, implies that once the wish is fulfilled and this state of affairs becomes Reality, the craving should be satisfied.

*Definition 2.1 (Abstract Constancy Axiom).* Let $v \in V$ be a voter and $s \in S$ be a social state. If $s$ is ranked first in $v_R$ for any $R \in S \setminus \{s\}$, then $s$ is also ranked first in $v_s$.

Abstract Reality-aware Social Choice is a formal generalization of the standard model of Social Choice, obtained by limiting votes to be Reality-independent, $v_R = v_{R'}$ ($\forall\, v \in V, \forall\, R, R' \in S$).

### 2.2 Possible-Worlds and Action Plans

In Reality-aware Social Choice, each social state $s \in S$ can be viewed as a *possible world* (see, e.g., [5]), where Reality $R \in S$ is the state corresponding to a possible world that is the actual world, namely the world in which the vote on $S$ takes place. If a social state $s \neq R$ wins, this means that society aims to change Reality from $R$ to $s$. If successful, then the subsequent vote may take place in the possible world (i.e., with Reality being) $s$.

This view gives rise to *democratic action plans*, which are finite sequences of states where (i) the first state is the present Reality; (ii) when Reality equals a state in the sequence, then the following state wins the vote (or ties) in that state. A democratic action plan need not be executed blindly to completion, but should be evaluated at each step, accommodating gaps between estimated and actual efforts of transitioning from one state to another, changes of heart, and recent real-world, external events. Still, a democratic action plan may provide a long term vision and blueprint for a democratic community that is useful and reassuring, while being consistent with the immediate action to be taken at any point in time.

### 2.3 Distance-based Reality-aware Social Choice

Consider the social cost of transitioning from Reality to hypothetical social states. In addition to voters $V$, social states $S$ with changing Reality $R$, and rankings $v_R$, the model incorporates a *distance* $d$ over $S$. Formally, a pseudoquasimetric $d : S \times S \to \mathbb{N}$, satisfying (1) $d(s, s') \geq 0$ for all $s, s' \in S$; (2) $d(s, s) = 0$ for all $s \in S$; and (3) $d(s, s'') \leq d(s, s') + d(s', s'')$ for all $s, s', s'' \in S$. For two social states $s, s'$, the value $d(s, s')$ can be viewed as the distance between $s$ and $s'$ in some abstract metric space, or as the *social cost* of transitioning from $s$ to $s'$. We require that a voter preferring a particular state from afar should prefer it at least as much as it gets near.

*Definition 2.2 (Distance Constancy Axiom).* Let $v \in V$ be a voter and $R, a, b \in S$ be social states. If $a$ is ranked above $b$ in $v_R$, then $a$ is ranked above $b$ in $v_{R'}$ for any $R' \in S$ for which $d(R', a) \leq d(R, a)$ and $d(R', b) \geq d(R, b)$.

Observation 1. *Distance-based Reality-aware Social Choice satisfies Abstract Constancy.*

Distance-based Reality-aware Social Choice is an instance of its Abstract counterpart and a generalization of standard Social Choice (to see this, require $d(s, s') = 0$ for all $s, s' \in S$).

### 2.4 Utility-based Reality-aware Social Choice

Assume that the distance $d$ between social states is objective and generally known (which is the case when electing a budget [18], but may not be when electing among candidates). Each voter $v$ has a *state utility* $U_v(s)$ that reflects $v$'s utility for the state $s$, which is oblivious to Reality, and a state ranking, which is Reality-dependent:

*Definition 2.3.* Let $V$ be a set of voters, $S$ a set of social states, $d$ a metric over $S$; and for voter $v \in V$, let $U_v$ be her state utility and $f_v$ a monotone function. Then, the *transition utility* $T_v$ of voter $v$ from state $s$ to $s'$ is defined as $T_v(s, s') = (U_v(s') - U_v(s)) - f_v(d(s, s'))$.

The ranking of a voter $v$ with respect to some Reality $R \in S$ is given by ordering the social states $s \in S$ in decreasing order of their transition utilities from Reality, $T_v(R, s)$. The intuition is that transitioning to a farther social state is more costly and hence less desirable. $f_v$ serves two purposes: (1) it affords the voter a personal way to reconcile the two scales – the subjective utility and the objective distance; and (2) it encodes her subjective *fear factor*: a fully-rational voter might have a linear $f$ while other voter's fear may shoot to infinity when distance surpasses a certain threshold.

Observation 2. *Utility-based Reality-aware Social Choice satisfies Distance Constancy (and hence also Abstract Constancy).*

### 2.5 Reality-aware Economic Social Choice

We associate earnings with social states and costs with state transitions. The profit of a transition from $s$ to $s'$ is the difference between the earnings of $s'$ and $s$ minus the transition cost.

*Definition 2.4.* Let $V$ be a set of voters, $S$ a set of social states; let $d_v$ be a metric over $S$ and $U_v$ a utility function for every voter $v \in V$, where distance as well as utility are both interpreted as amounts in a given currency. Then, the *transition utility* $T_v$ of voter $v$ from state $s$ to $s'$ is defined as $T_v(s, s') = U_v(s') - U_v(s) - d_v(s, s')$.

If $d_v$ happens to be identical for all voters then the Economic model is an instance of the Utility model, with $f$ being the identity function, but in either case Distance Constancy holds. The economic model is open to several interpretations: Both earnings and costs are public, all voters aim to optimize social welfare, namely public profit, and the difference between voters is in their estimates of the objective public earnings and costs. Or, earnings are personal and costs are either public or equally shared, in which case voters

[1] Other elicitation methods are of course possible; here we concentrate on the standard model where voters supply total orders.

aim to optimize personal gain, and the differences between voters reflect primarily their different earnings in different social states, but perhaps also their estimate of the costs of state transitions. Or, both earnings and costs vary between individuals and personal votes again aim to optimize personal gain. If personal costs satisfy the definition of distance, all interpretations satisfy Distance Constancy.

# 3 REALITY SHOCK

## 3.1 Reality-aware Condorcet Criteria

The Condorcet criterion states that a social state preferred to all others by a voter majority shall be elected as a winner, called the Condorcet winner. A winner might not exist due to *Condorcet cycles*. The criterion treats all social states as equal, and hence any method for breaking cycles among them may seem arbitrary. However, once Reality is present as a distinguished alternative, its use as a cycle-breaker can be justified. As support, we enlist Arrow's later-years comment [2, Page 95], acknowledging that: *"... an important empirical truth, especially about legislative matter rather than the choice of candidates: The status quo does have a built-in edge over all alternative proposals."* Arrow's statement supports our general thrust to incorporate Reality into Social Choice, as well as our specific proposal to employ Reality to break Condorcet cycles and ties. All criteria described below indeed generalize the standard, Reality-oblivious, Condorcet criterion.

*Definition 3.1 (Preference-over-Reality Condorcet Criterion).* Let $R \in S$ be the Reality and let $C \subseteq S$ be the top cycle. If $R \in C$, then $R$ is the Condorcet winner. Else, the winner is $W = \{\arg\max_{s \in C} N_R(s)\}$, breaking ties arbitrarily, where $N_R(s)$ counts voters preferring $s$ to $R$ minus voters preferring $R$ to $s$.

This criterion is not only logically sound but has psychological appeal. All alternatives, except Reality, relate to hypothetical social states. A comparison of a hypothetical state to Reality is more trustworthy than a comparison among two hypothetical states, as the latter requires more hypothesizing and imagining. Our criterion breaks cycles and ties by employing only comparisons with Reality, hence it can be argued to be psychologically more sound than criteria that rely on comparisons among hypothetical states, as well as more stable mathematically. We note that it is possible that all members of a top-cycle are equally preferred over Reality. In such an extreme case, we feel that it is quite justified to resolve the tie among them arbitrarily, as indeed the voters will be equally happy with a transition from Reality to any of them.

In case the distance metric is generally known (Section 2.4), distance from Reality can also be used to break Condorcet cycles:

*Definition 3.2 (Distance-from-Reality Condorcet Criterion).* Let $R \in S$ be the Reality and let $C \subseteq S$ be the top cycle. If $R \in C$, then $R$ is the Condorcet winner. Else, the winner is $W = \{\arg\min_{s \in C} d(s, R)\}$, breaking ties arbitrarily.

Note that the distance-based criterion does not rely on subjective voter judgments to break cycles, but only on the (presumably) objective distance measure, if available.

Arrow noted that in candidate elections, Reality does not play the same role as in voting on issues. Dodgson [7], however, suggested to add a fictitious Protest candidate, to allow voters an to protest against an inadequate list of candidates. Clearly, a winner of an election must at least win over the fictitious Protest candidate; if not, the elections are nulled.

*Definition 3.3 (Protest-based Condorcet Criterion).* Let $R \in S$ be the Protest candidate and let $C \subseteq S$ be the top cycle. If $R \in C$, then the elections are nulled. If $R \notin C$, then the Condorcet winner is $W = \{\arg\max_{s \in C} N_R(s)\}$, breaking ties arbitrarily.

These Reality-aware Condorcet criteria naturally correspond to Reality-aware Condorcet-consistent voting rules, which are sufficiently simple to be stated in one sentence and to be computed manually. Their simplicity means that they are easily communicable and therefore more trustworthy by the voters.

Remark 1. *In a sense we face a multiobjective optimization problem, with one dimension being the tournament graph–the closer a state is to a Condorcet winner the better, and the second relates to Reality, e.g., the number of voters preferring a state over Reality. Other instantiations of the second dimension might lead to different Reality-aware Condorcet criteria. Further, while we perform a lexicographic multiobjective optimization, one might consider, e.g., the Pareto curve and weighted average.*

## 3.2 Reality-aware Iterated Approval Voting

While approval voting is attractive for its simplicity and advantages over plurality voting [4], it suffers from a lingering and vexing question: What do approval voters in fact approve, when they mark an alternative? The lack of a definitive answer to this question puzzled voters and theoreticians alike, casting doubt on the foundational significance of approval voting as well as on the moral authority of its outcome. Reality offers a simple resolution to this ambiguity: When voters mark an alternative, they in fact attest to their preference of this alternative over Reality.

If this Reality-aware interpretation of approval voting is adopted, then (i) a marked alternative should be interpreted as a "yes" vote and an unmarked alternative as a "no" vote on the question "Do you prefer this alternative over Reality?", and (ii) the vote result should be based on the net preferences ("yes" votes minus "no" votes) for each alternative. Only alternatives with a positive net preference over Reality should be considered, where the one with the highest score wins. If none exist, then Reality wins. This voting rule can be easily realized by a show-of-hands, where each alternative undergoes a "yes/no" vote independently, and the results are tallied.

Next, we present a show-of-hands agenda that iterates Reality-aware approval voting to elect a Condorcet winner, if one exists.

*Definition 3.4 (Iterated Approval Voting).* Set $T$ to the present Reality and mark all alternatives as active. Proceed in rounds. In each round, active alternatives are voted against $T$, with losers and ties marked inactive. If active alternatives remain, set $T$ to an alternative most preferred over $T$, breaking ties arbitrarily, and continue. Else declare $T$ as the winner and stop.

Assuming that voters cast approval votes based on their implicit rankings, then Iterated Approval Voting elects a Condorcet winner with respect to these rankings, if one exists, else a member of the top cycle. While it might need one iteration per alternative and a quadratic number of show-of-hands in the worst case, our

simulations, done for Impartial Culture elections selected uniformly at random, suggest that with 4 alternatives, less than a total of 6 show-of-hands approval votes in two rounds are needed to elect a winner, and within the practical range of up to 12 alternatives, on average, the number of approval votes needed is less than twice the number of alternatives.

### 3.3 Reality Abrogates Arrow's Theorem

Arrow's theorem [1], abstractly and particularly, shows that the Condorcet criterion is not satisfactory as a foundation of democracy, since, as Condorcet cycles exist, no social welfare function (which returns aggregated rankings of the social states) can break those cycles in a non-dictatorial way. Arrow crucially uses the axiom of Independence of Irrelevant Alternatives (IIA), which requires that whether one alternative is ranked higher than another in the aggregated vote shall not depend on other alternatives, which Arrow deems irrelevant. If Reality is taken into consideration then this axiom does not hold. Intuitively, this is so because the preferences of voters among any pair of alternatives (neither of which is Reality) crucially depend on the ever-present and always-relevant "other" alternative – Reality. Specifically, in all four Reality-aware Social Choice models presented, the ranking of any two alternatives may depend on the identity of a third alternative – Reality.

Furthermore, recall the Reality-aware Condorcet-consistent voting rules described above: As these voting rules use Reality's "built-in edge over all alternative proposals" (to use Arrow's words) to break Condorcet cycles non-dictatorially, they, in some informal sense, violate Arrow's theorem.

More formally, we revisit Bordes and Tideman [3], who define Regularity, a natural requirement of any reasonable voting rule, and proceed to show that in their model any voting rule that satisfies Regularity also satisfies IIA, thus justifying this axiom and validating Arrow's theorem in their model. To follow their approach, we generalize their model to include Reality as a distinguished alternative, accept Regularity as a reasonable requirement of any Reality-aware voting rule, and confirm that our proposed rules are indeed Regular. The analysis and theorem of Bordes and Tideman justifying IIA as a condition in Arrow's theorem are valid for Reality-oblivious Social Choice. However, this changes when Reality is incorporated. The counterexample below shows that, while Preference-over-Reality satisfies Regularity, it does not satisfy IIA. Hence, the theorem of Bordes and Tideman that Regularity implies IIA does not hold in Reality-aware Social Choice. Reality-aware voting rules, while being Regular, abrogate Arrow's theorem as they do not satisfy IIA for the fundamental reason that Reality is always relevant to the choice among alternatives.

*Example 3.5.* Consider a vote profile: $v_1 : a \succ b \succ c \succ d \succ e$, $v_2 : c \succ d \succ a \succ b \succ e$, $v_3 : b \succ e \succ c \succ a \succ d$. Alternatives $a, b, c$ form a top cycle. Applying a Preference-over-Reality rule, if Reality is $d$, results in $c$ winning, while $b$ wins if Reality is $e$. Thus, the preferences over the so-called "relevant" alternatives $a, b, c$ are identical independently of whether Reality is one of the "irrelevant" alternatives $d$ or $e$, however, a Preference-over-Reality rule would resolve the cycle differently depending on whether Reality is $d$ or $e$, thus contradicting IIA, as the preferences of the "relevant" alternatives over the presumed "irrelevant" Reality are different.

That Reality-aware Social Choice satisfies Regularity but not IIA captures its fundamental difference from classical Social Choice: Theoretically, Arrow's theorem is irrelevant to this model and it would be exciting to find out what other parts of classical Social Choice theory do not hold once Reality is incorporated. Practically, Regular Reality-aware Condorcet voting rules reckon with the Condorcet paradox without much ado, opening the way for their practical application, including Iterated Approval Voting, democratic budgeting [18], and democratic document editing [19].

Gibbard et al. [10] and Yanovskaya [20] also show that in a model with always-present alternatives (e.g. the status quo), different from ours, Arrow's theorem does not hold as well. Riker [16] and his followers take Arrow's theorem to show that democracy, conceived as government by the will of the people, is an incoherent illusion. We view the ability of Reality-aware Social Choice to repeal this criticism as one of its major strengths.

### 3.4 Game-Theoretic Consequences

Reality-aware Social Choice allows a more realistic study of strategic behavior of voters. E.g., Reality-aware, Utility Social Choice suggests an iterative game, which might be thought of as a strategic game on top of a democratic action plan. It is pictorially played on a complete directed *game graph* $G$ that has a vertex $a$ for each social state $a \in S$ and the weight of the arc $(a, b)$ equals the distance from $a$ to $b$. Reality is represented by a pebble placed on a vertex and each voter is a player who knows the metric $d$ and the state utilities of all players. In each turn, all players specify their strategic rankings which might not correspond to their real transition utilities, as the pay-off of each player equals the state utility of that player from the Reality at the end of the game. Alternatively, the game might be played until convergence; or, players' pay-off is averaged over the course of the game. In such a game, behaving strategically may, e.g., help shift society tentatively to a social state this player prefers less, in the hope of more easily being able to then shift the society to a more preferable state.

## 4 DISCUSSION

Incorporating Reality invalidates classic results of Social Choice and necessitates rebuilding its foundation. We have proposed four models of Reality-aware Social Choice and presented new axioms and voting rules, which break cycles in a principled ways, including a show-of-hands agenda, termed Iterated Approval Voting, which identifies a Condorcet winner efficiently. We find it particularly satisfying that more than seven hundred years after Ramon Llull has proposed a principled show-of-hands agenda [6], it is still possible to offer a novel and improved computer-less agenda. Further Reality-inspired research should include: axiomatic properties of Reality-aware voting rules; domain restrictions [9]; novel elicitation models; and game-theoretical models.

We hope that Reality-aware Social Choice will not only offer improved foundations for democracy but also produce simple, easy to communicate and trustworthy Condorcet voting rules and agendas, as well as egalitarian democratic processes for, e.g., participatory budgeting [18] and deliberative legislation [19].

## REFERENCES


[1] K. J. Arrow. 1951. *Social choice and individual values* (first ed.). Yale university press.

[2] K. J. Arrow. 1963. *Social choice and individual values* (second ed.). Yale university press.

[3] G. Bordes and N. Tideman. 1991. Independence of irrelevant alternatives in the theory of voting. *Theory and Decision* 30, 2 (1991), 163–186.

[4] S. Brams and P. C. Fishburn. 2007. *Approval voting*. Springer.

[5] B. F. Chellas. 1980. *Modal logic: an introduction*. Cambridge university press.

[6] J. M. Colomer. 2013. Ramon Llull: from "Ars electionis" to social choice theory. *Social Choice and Welfare* 40, 2 (2013), 317–328.

[7] C. L. Dodgson. 1873. A discussion of the various methods of procedure in conducting elections. *Privately printed in Oxford* (1873).

[8] B. Duncan. 1958. The theory of committees and elections. (1958).

[9] E. Elkind, M. Lackner, and D. Peters. 2016. Preference Restrictions in Computational Social Choice: Recent Progress. In *Proceedings of IJCAI '16*, Vol. 16. 4062–4065.

[10] A. Gibbard, A. Hylland, and J. A. Weymark. 1987. Arrow's theorem with a fixed feasible alternative. *Social Choice and Welfare* 4, 2 (1987), 105–115.

[11] B. Grofman. 1985. The neglected role of the status quo in models of issue voting. *The Journal of Politics* 47, 1 (1985), 230–237.

[12] D. Kahneman, J. L. Knetsch, and R. H. Thaler. 1991. Anomalies: The endowment effect, loss aversion, and status quo bias. *Journal of Economic Perspectives* 5, 1 (1991), 193–206.

[13] C. Kerr. 1963. *The uses of the university*. Harvard University Press.

[14] H. Moulin, F. Brandt, V. Conitzer, U. Endriss, A. D. Procaccia, and J. Lang. 2016. *Handbook of Computational Social Choice*. Cambridge University Press.

[15] J. T. Richelson. 1984. Social choice and the status quo. *Public Choice* 42, 3 (1984), 225–234.

[16] W. H. Riker. 1982. Liberalism against populism. (1982).

[17] A. Sen. 1986. Social choice theory. *Handbook of mathematical economics* 3 (1986), 1073–1181.

[18] E. Shapiro and N. Talmon. 2017. A Condorcet-consistent Democratic Budgeting Algorithm. *arXiv preprint arXiv:1709.05839* (2017).

[19] E. Shapiro and N. Talmon. 2018. Deliberative Drafting of a Condorcet-Winning Legislation. (2018). Unpublished manuscript.

[20] Y. Yanovskaya. 1991. Social choice problems with fixed sets of alternatives. *Mathematical Social Sciences* 21, 2 (1991), 129–152.