A Causal Overview of Formal, Dynamic, Theory-Driven Models of Social Movements

__Name__
__Department__
__University__
__Email__

Abstract

There is growing understanding that collective social behaviors in general and social movements in particular are complex, dynamic systems; and that to fully understand the way social movements evolve over time we must understand the feedbacks that drive their behavior. Formal models can reveal these feedback structures by making explicit the assumed causal pathways by which action in one part of the system influences the remainder of the system. This paper describes a section of the literature of formal dynamic models of social movements by highlighting the causal influences and feedback structures that various authors consider contributory to collective action in this context. The paper reveals how models have built upon one another over the last 40 plus years in an attempt to identify and elaborate the feedback mechanisms responsible for social movement dynamics. The paper also reveals challenges faced in conceiving and constructing representations of these systems, and places where further consideration is warranted.

Introduction

There is growing understanding that collective social behaviors in general and social movements in particular form complex dynamic systems, and that to fully understand the way movements evolve over time we must understand the feedbacks that drive their behavior. (Biggs 2003; Richardson 1983) Formal models can reveal these feedback structures by making explicit the assumed causal pathways by which action in one part of the system influences the remainder of the system. This paper describes a section of the literature of formal dynamic models of social movements by highlighting the causal influences and feedback structures that various authors consider contributory to collective action in this context.

Scope of models considered

My purpose in this overview is to explore causal pathways that have been explicitly identified in the social movements literature and formalized as models. As such I will only consider theory that has been included in formal, mathematical models. There are many mechanisms that have been discussed in literature but are not presented as formal models, and will fall outside the scope of the survey. I thus omit such influential works as those of Olson (1971); McCarthy and Zald (1977); Tilly (1978); and Doug, Tarrow, and Tilly (2001).

Topically, I am interested in models of collective behavior in which a group of individuals mobilize to demand concessions from their government. These dynamics evolve on timescales of weeks to months, and so I omit models of crowd behavior that operate with timescales on the order of hours. Amongst models

excluded by this filter are those by Granovetter (1978), and Johnson and Feinberg (1977).

Models of social behavior can be grouped using Dawe's dichotomy into those following the structuralist pattern of looking first at the behavior of the group, and those following the interactionist paradigm in which macro-level behavior is generated from the interaction of individuals. (Dawe 1970) As I am interested in understanding feedbacks in the system, I will limit investigation to models using the structuralist perspective. In practice, this includes models that represent the behavior of populations and cohorts of individuals, along with aggregate levels of behavioral response. I omit agent-based models and those that derive their results from the aggregation of actions simulated at the individual level. This filter excludes works by Heckathorn (1996), and Oliver (1980) amongst others.

My interest in explicit theory-driven causal mechanisms excludes econometric models or models that attempt to infer relationships between time-series data, such as Aguiar-Conraria (2012) and others.

While I am interested in the general topic of social movements as vehicles for social change, many of the selections in this paper focus on a regime/dissident conflict as one particular manifestation of collective protest behavior. While this segment of the full topic of social movements is not likely to be representative of the space of movements themselves, it seems to have attracted the most interest of causal modelers to date. The models included in this paper do not represent an exhaustive

survey of the social movements literature, but instead explore the way different authors have added new concepts and feedback loops to the literature.

The notation used in this paper

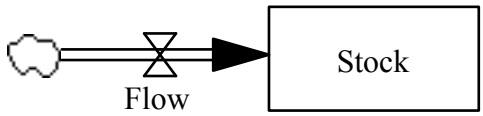
Each of the models described in this paper is illustrated with an expanded diagram of the causal processes contained within the model. For elements in these diagrams that correspond directly to variables presented by the various authors, I have included the variable name following the English language description of the concept in question. In places I have given names to full terms of the various authors equations, drawn as closely as possible from the text description of the models in question. This is to improve the clarity of the diagram, and to help to explain the causal mechanisms postulated. In places I have had to infer these meanings from text and the structure of the equations.

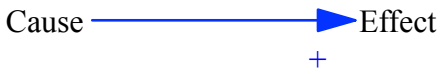
Where authors have presented their models in differential equation format, or other formats which support ready identification of state variables within the model, I use the notation of 'Stocks and Flows' from the System Dynamics tradition.[1] Stocks represent elements of the model that persist from one time step to the next and are modified in a continuous fashion. Here they are drawn in boxes. The values of the stock variables are sufficient to encode the full state of the system and allow for

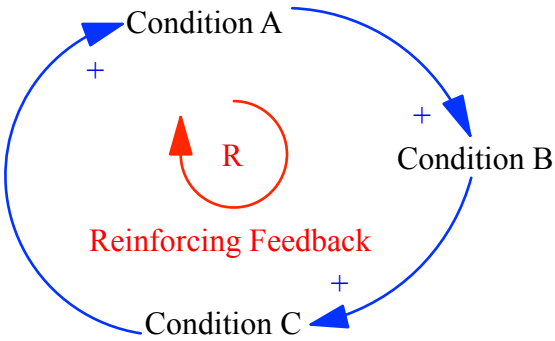
[1] For a full treatment of the System Dynamics paradigm, see (Sterman 2000).

calculation of the remaining model elements. Flows represent the derivatives of these stock values with respect to time, and are drawn as pipes with control valves.

Where authors have not explicitly identified state variables, or when these are presented as a set of recurrence equations without an explicit 'delta' from one time period to the next, I have instead sketched the terms as found in the model as simple variables, to enable analysis of the model's feedback structure.







Causal influences are illustrated with narrow blue arrows, with the assumption that changes to the quantity at the tail of the arrow are assumed to cause changes to at the arrow's head. The arrowheads are labeled with a + or – polarity to describe whether an increase in the influencing quantity leads to an increase (+) or decrease (-) in the affected quantity.

Each feedback loop in the diagrams is identified as either reinforcing (R) or balancing (B) with a red loop indicator. Reinforcing feedbacks are those that tend to drive the system away from equilibrium, whereas balancing loops bring the system towards equilibrium. Each feedback loop is labeled with a name, which will allow us to compare feedback processes across models to show how various authors expand

on the same themes as their predecessors with more nuance or detail, and where they introduce structures of their own into the model pantheon.

Throughout the paper, I will use these diagrams to understand not only the way the various authors represent the state of the system, but how they understand the causal pathways which drive behavior and how those pathways work together to create feedback structure. I have chosen not to include the model equations underlying these diagrams, as they are best understood in the original context of their first publication. Each of these models is available for simulation and closer inspection at www.github.com/_removed for review anonymity_.

The layout of this paper

In the sections that follow, I will address one model at a time, describing how each contributes to our understanding of the structure of the social system underlying social movements. I will specifically consider their conception of the system state variables, the causal mechanisms in play, and the feedback loops assumed to be active in each representation of the system. I will attempt to identify some of the limitations of each model structure, especially in places where subsequent authors present innovations to overcome these limitations.

Jackson, Russet, Snidal, and Sylvan (1978)

In 'Conflict and Coercion in Dependent States' (Jackson et al. 1978), the authors present a set of recurrence equations describing the behavior of an authoritarian regime and its conflict with an opposition group. The conflict made manifest by the

opposition is met with coercive force, which for the authors has the effect of increasing the level of conflict the opposition is willing or able to maintain. Figure 1 reveals the causal structure of these recurrence equations elaborated according to their text descriptions.

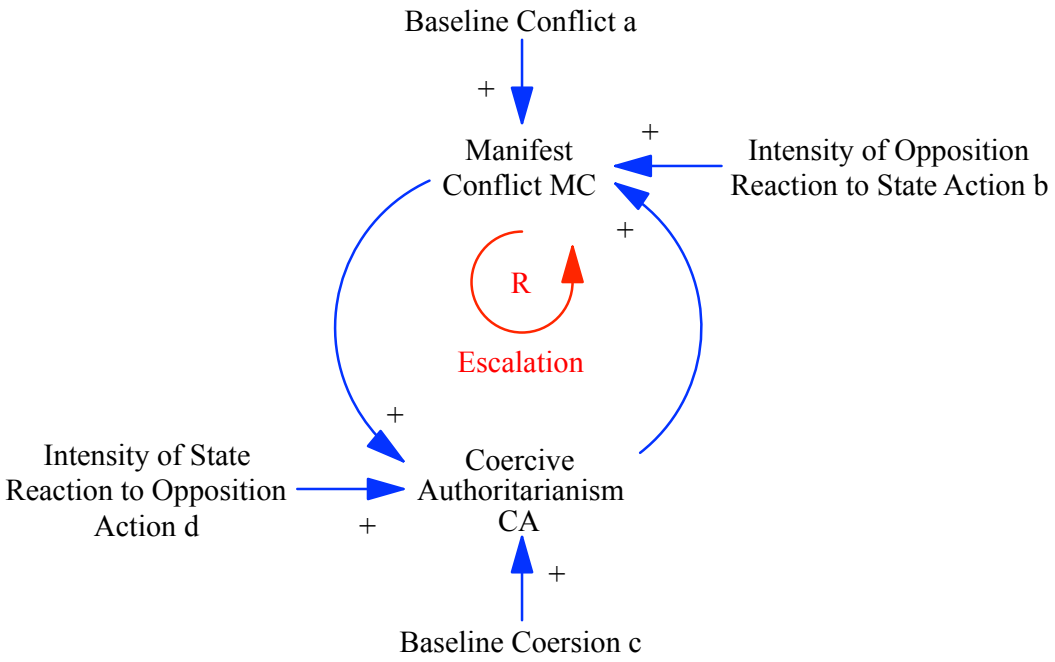


Figure 1: A Causal Loop Diagram of Jackson, Russet, Snidal, and Sylvan (1978)

Concepts of System State

The presentation of recurrence equations does not allow for a strict interpretation of any components of the model as comprising the 'system state', as these are not limited to incremental change. The recurrence is instead built on the values of Manifest Conflict and Coercive Authoritarianism, which are each defined as a function of the previous state of the other, and represent the 'memory' of the system and allow for evolution in discrete time.

Feedback Processes

The dependence of the behavior of each group on the prior behavior of the other creates a reinforcing feedback process R (here in the discrete time of the recurrence equation) that reinforces the initial behavior of the system so long as the reaction parameters d and b are both positive. If the product of d and b is greater than one, the conflict and coercion present will grow exponentially. If between 0 and 1, the conflict will decay to zero.

Limitations

The model presented is quite simple, and while formalizing the authors' hypothesis regarding escalation dynamics for states in conflict, omits much of the discussion in the remainder of the paper. Presented in the paper but omitted from the model are descriptions of the influence of foreign intervention on latent conflict, and nonlinear responses to coercion, which if included would allow for multiple equilibria.

The authors discuss the possibility of oscillatory behavior, which is only possible for the recurrence equations presented in the period of the recurrence itself, as simultaneous growth will always lock in to further growth. Thus oscillation depends on the turn-by-turn fashion of the model. To allow for more interesting dynamics, a true system state, modified incrementally from the prior system state, would be required.

Huckfeldt (1989)

Huckfeld's paper '*Noncompliance and the limits of coercion: the problematic enforcement of unpopular laws'* describes the dynamics of civil disobedience (Huckfeldt 1989). Huckfeldt looks specifically to answer why attempts to enforce unpopular laws succeed or fail, and what are the opportunities and risks associated with a coercive enforcement strategy. Figure 2 illustrates equations from this model.

Concepts of System State

The paper introduces two new concepts accounting for the state of the system. The first is a population of individuals engaged in disobedience as a fraction of the total population[2]. This population is built through some form of social recruitment process, and declines as citizens are coerced into compliance with the law. The second state element is the resource base devoted to ensuring compliance, whether those resources are police time, incarceration costs, or forgone economic opportunities. This element of the system state is modified in response to resource

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[2] The model considers only the behavior of the population that is willing to disobey, leaving the determinant of this willingness exogenous to the model. As such, the fraction currently disobeying fully specifies the remainder - the population that is willing to but not currently disobeying. In the sketch, I include this population for clarity, although it is not strictly required.

constraints, political support, and policing decisions.

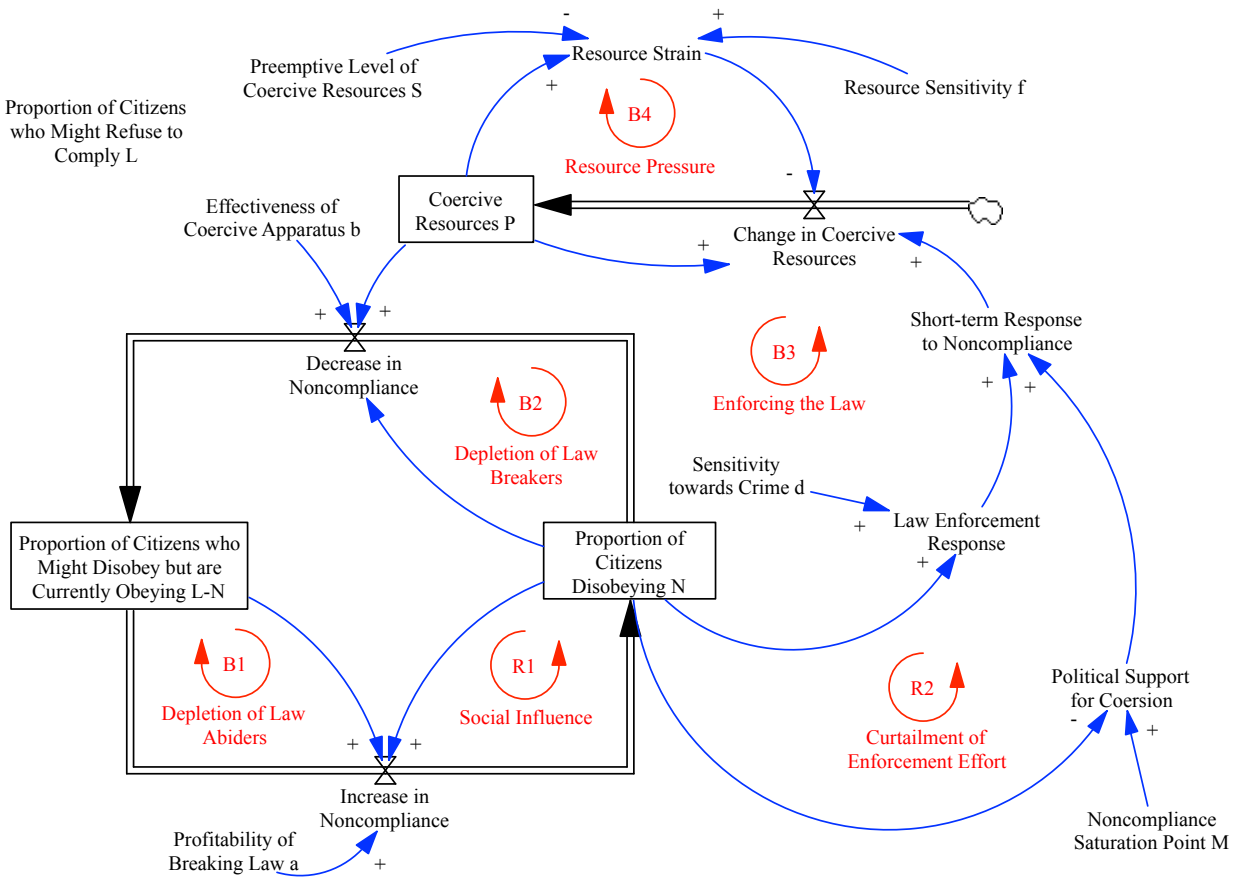

Figure 2: Structural diagram of the equations presented in Hickfeldt (1989), with state variables as stocks.

Feedback Processes

While the model does not include the 'escalation' feedback described by Jackson et al., it introduces a number of feedback processes by which the disobedient population and the level of coercive resources are modified in response to each other.

The first reinforcing loop R1 accounts for social contagion, which encourages recruitment of new individuals to the population of disobeyers in proportion to the current population of disobeyers. This likely works through a 'word of mouth' or

'perception of immunity' mechanism, but intermediating steps are not elaborated in the paper. The second reinforcing loop R2 accounts for the fact that as the population of disobeyers grows, political pressure for enforcement wanes, curtailing coercive resources and slowing the flow of individuals back to the 'obeying' population. Both of these feedbacks work to destabilize the system, encouraging a state of either full obedience or full disobedience as time progresses.

The law enforcement mechanism creates balancing loop B3, which encourages the allocation of more coercive resources in response to an increase in disobedience and works to limit the population of disobeyers to a target dependent on the system's parameter values. As this loop operates through multiple state variables, a delay is introduced into the feedback process, which allows the possibility of oscillation. The ability of this feedback to operate is itself limited by resource pressures, shown in balancing feedback B4, which create a pressure to curtail expenditures.

Balancing loops B1 and B2 arise due to the general assumptions that individuals act independently, and that movement between each population is proportional to the size of the population itself. B1 specifically becomes active as the fraction of disobeyers becomes a significant portion of the population. This allows the model to consider system states in which the opposition group is more than a small fraction of the population, broadening its range of applicability.

Limitations

The model considers political support for coercion to be an instantaneous function of the level of disobedience. While there may be correlation between compliance and support for a law, they are both likely to come from a third, independent variable representing the perception of the legitimacy of the law among the population, which responds without regard to coercive pressure.

The assumption that coercive pressure can yield a proportional decrease in the disobedient population is consistent with a mechanism of intimidation and moral or psychological influence. A system in which coercion is due to physical force alone might be rate limited only according to the resources available for enforcement.

Tsebelis, Sprague (1989)

In their paper *'Coercion and Revolution: Variations on a Predator Prey Model'* (Tsebelis and Sprague 1989), Tsebelis and Sprague construct a model based on the Lotka-Volterra predator prey structure (Lotka 1920) that attempts to account for the periodic nature of protest and revolutionary movements. The paper also works to include concepts of relative deprivation as elaborated by Davies (1962) and Gurr and Leggewie (1970). In this concept, revolution fills the role of the prey species in relation to predatory coercion, and the role of the predator species in relation to Relative Deprivation, as seen in Figure 3.

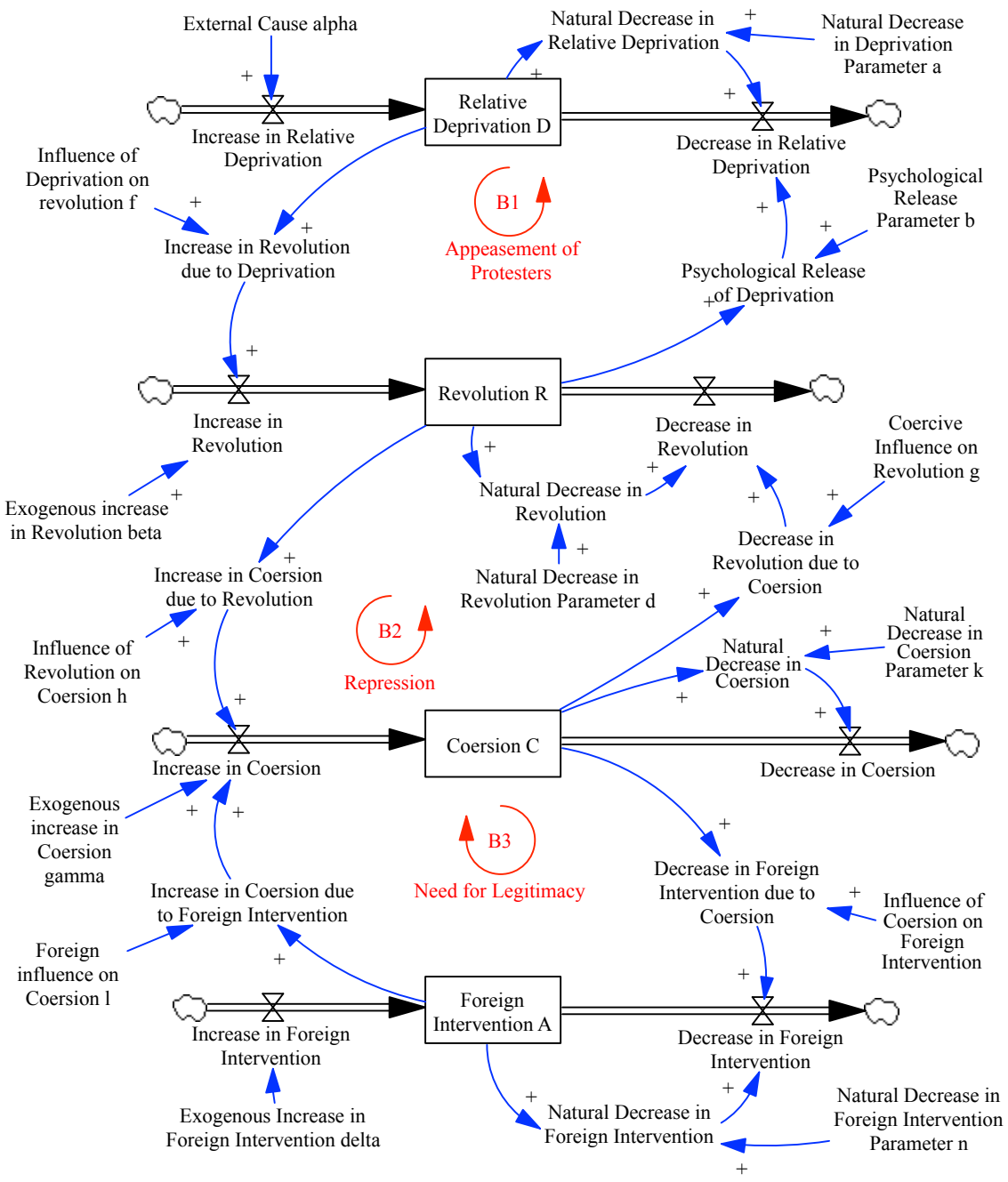

Figure 3: A diagram of the full equation model in Tsebelis and Sprague (1989)

Concepts of System State

Tsebelis and Sprague abstract the concepts of disobedient population and coercive resources into general states of 'Revolution' and 'Coercion'. They add to these states

the concepts of 'Relative Deprivation', capturing concepts of the perception of justice and legitimacy missing from Huckfeldt's presentation; and 'Foreign Intervention', which in some ways accounts for the need for independent measures of the political support for coercion, here described in terms of foreign pressure. The model supposes that in addition to their interactions through 'predation' type relationships, each of these components has a natural tendency to exponential decline, and exogenous growth forcing.

Feedback Processes

In addition to the natural decay processes (not labeled), the predator prey relationship provides balancing loops which intermediate between the various system state variables. As each of these balancing loops incorporates multiple system states, the feedback operates with a time delay, creating the conditions necessary for oscillatory behavior.

The 'repression' feedback loop B2 in this model is structurally equivalent to the 'Enforcing the law' feedback in Huckfeldt's presentation, and again responsible for limiting the extent of revolution. The balancing 'Need for Legitimacy' feedback loop B3 parallels Huckfeld's 'Resource Pressure' limiting feedback in that it serves to constrain coercion somewhat endogenously, in this case intermediated by foreign intervention. This additional stock creates the opportunity for an overshoot and collapse dynamic in the coercion dynamic, which may be a pathway for state failure.

The 'Appeasement of Protesters' loop B1 introduces a feedback we have not seen in previously considered models which allows for the possibility that protest may be

effective in achieving concessions from the regime, or at least cathartic to the population.

Limitations

All of the state variables presented in the model are somewhat abstract concepts, for which it would be difficult to identify a set of units, or to construct a conservative metric. While this does not invalidate the idea that these concepts are in competition with one another, or the nature of the feedback structures, they would need to be operationalized before the model could be expanded.

In the conception of the model as it is presented in the paper, there is no true process for the self reinforcing growth of any of the prey elements, as would be necessary to strictly parallel the Lotka-Volterra system and would correspond (for example) to Huckfeldt's 'Social Influence' feedback. This is fundamentally due to an ambiguity in the interpretation of first order terms on each state variable.

Relative deprivation is here portrayed to respond only to revolutionary activity, and has no provision for proactive intervention by the regime. To be useful for policy analysis, the model could be expanded to include the weighting between decisions to invest in coercive resources verses political concessions.

Karmeshu, Jain, Mahajan (1990)

In 'A Dynamic Model of Domestic Political Conflict Process' (Karmeshu, Jain, and Mahajan 1990), the authors build explicitly on the work of Jackson et al. and Salert

and Sprague, and the structural equation modeling of Lichbach and Gurr (1981) to understand the conditions in which conflict will settle into a steady state or evolve more dynamically. The equations of their model are diagrammed in Figure 4.

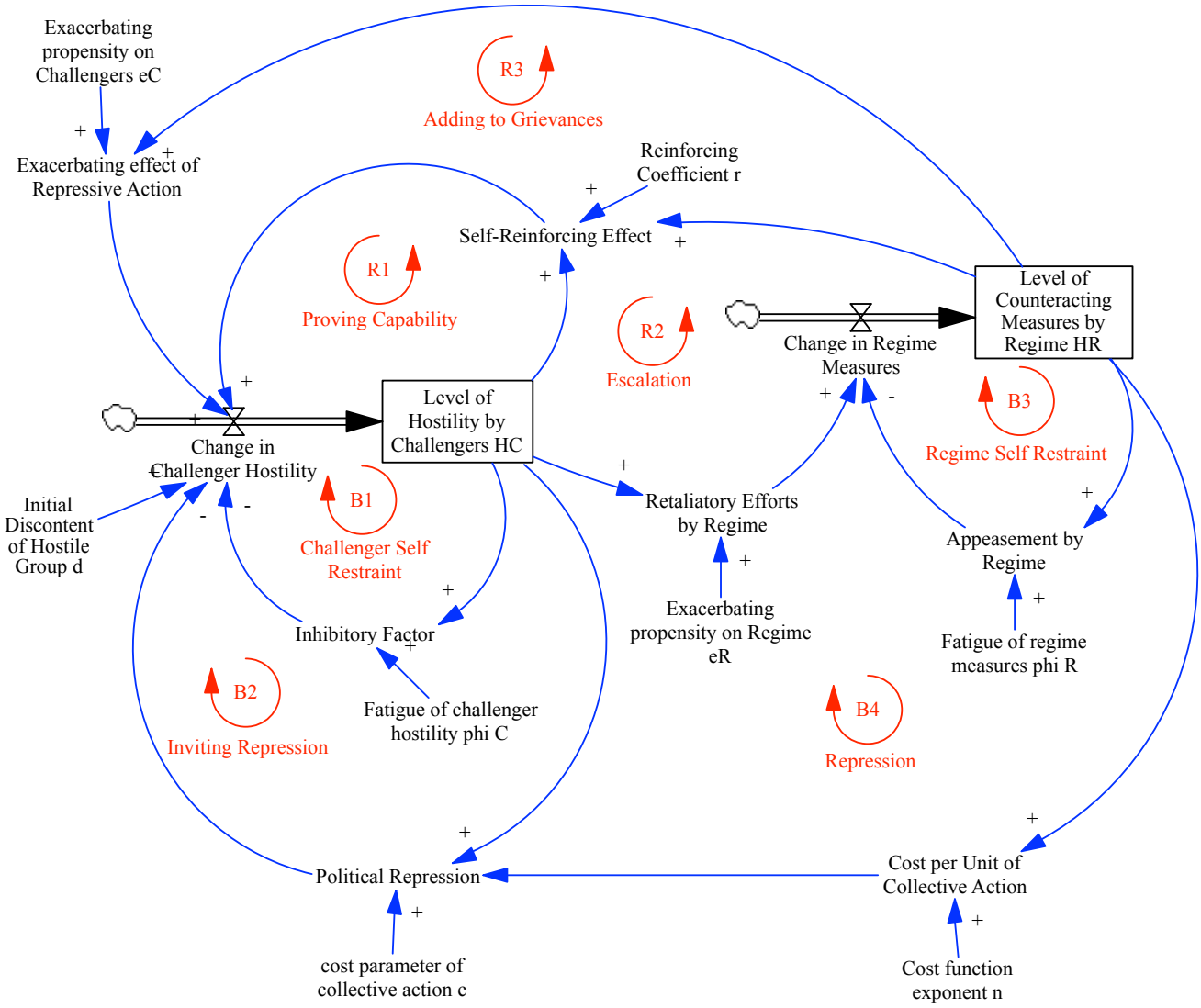

Figure 4: The equations of Karmeshu et al. are laid out and feedback loops identified.

Concepts of System State

The model presented retreats from Tsebelis and Sprague's more elaborated system state to the familiar levels of conflict and coercion. The model adds endogenous

causal mechanisms for both the growth and decay of each of these stocks as influenced by the other factors in the model.

Feedback Processes

The model introduces several new feedback processes, and adds detail to feedback mechanisms already explored by other models. The reinforcing loop R1 builds upon the social contagion construction of Huckfeldt's model, characterizing the demonstrated level of hostility, mediated by the reaction of the regime, as proof of the capability and efficacy of the challengers. The mechanisms comprising the escalation feedback loop described by Jackson et al. are elaborated as comprising two different causal pathways. In R2, escalation occurs as regime coercion intensifies existing conflict, and in R3 as coercion adds new motivation for protest.

The authors likewise elaborate the causal mechanism by which the repression/enforcement loop found in Huckfeldt, and Tsebelis and Sprauge serves to limit protest activity: balancing loop B4 describes the mechanism as raising the cost of collective action. As before, this loop allows the possibility of oscillatory behavior. Huckfeldt's 'Resource Pressure' balancing loop is described as a form of self-restraint in balancing loop B3 as the regime experiences fatigue. The balancing loop B2 parallels Huckfeld's 'Depletion of law breakers' feedback, in that the growth of opposition increases the per-unit efficacy of government repression. The model adds a parallel self-restraint balancing feedback loop B1 for the resistance party.

Limitations

There is discussion in the paper about the need for regime legitimacy, and several of the feedbacks (B2 and B3) seem as if they should interact with the concept directly. However, the model lacks an explicit way of tracking regime legitimacy and its influence in the system.

Chong 1991

The book 'Collective action and the Civil Rights Movement' (Chong 1991) contains a formal model of multiparty conflict expressed as a set of recurrence equations. To the regime/dissident paradigm so far explored, the paper adds concepts of government concessions and popular counter-mobilization. The motivating case in Chong's work is the U.S. Civil Rights movement, and this shifts his emphasis away from mobilization against the state towards protests for specific legal change. Equations for Chong's model are diagrammed in Figure 5.

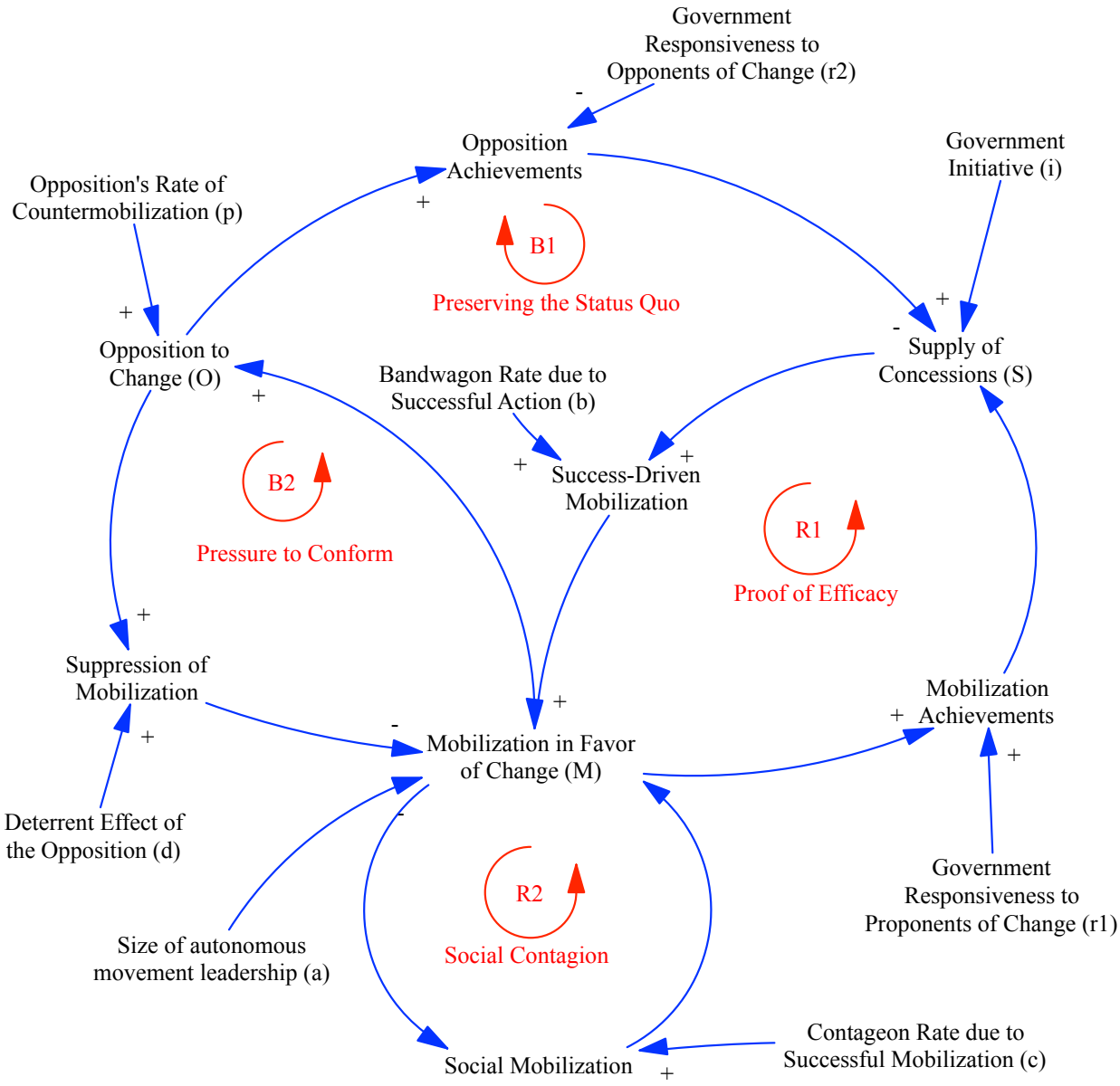

Figure 5: A causal loop diagram of Chong (1991)

Concepts of System State

As with Jackson et al., the system state is here less strictly defined. Mobilization, opposition, and concessions each form part of the system 'memory' and form the basis for each party's reaction in subsequent time steps.

Feedback Processes

The model's social contagion feedback R2 parallels Huckfeld's Social influence feedback in which protest is assumed to spread through the population. This social influence is aided by a new feedback R1, in which concessions gained by the opposition lead to more mobilization for change, through proof of the efficacy protest as a tool for eliciting change. This is counter to the assumption by Tsebelis and Sprague that protest consumes the source of its own motivation through a process of appeasement or catharsis.

The balancing loops modeled by Chong both present new dynamics. The first, B1, illustrates the efforts of proponents of the status quo working to minimize the supply of concessions to protestors. A pressure to conform creates balancing loop B2 as counter to the social contagion loop, and creates social pressure against mobilization.

Limitations

The actual level of grievance (as distinct from concessions) makes no appearance in the model, and so both the rate of mobilization and counter-mobilization are motivated not by a gap between the state of the world and either party's goal for that state. Motivations instead are assumed to be endogenous to the levels of mobilization and concession.

The addition of a counter-mobilization introduces the possibility for some very interesting dynamics, as the system now comprises three groups of actors. This model could be fruitfully combined with a construction similar to Huckfeldt's in order to track the recruitment of the general population into each of these categories.

Simon 1994

Simon's paper 'Hawks, doves, and civil conflict dynamics: A "strategic" action-reaction model' (Simon 1994) attempts to treat regime response to protest as a product of both a hawkish anti-protestor faction and a more conciliatory 'dove' cohort, which advocates for less forceful crackdown. The equations of Simon's model are diagrammed in Figure 6.

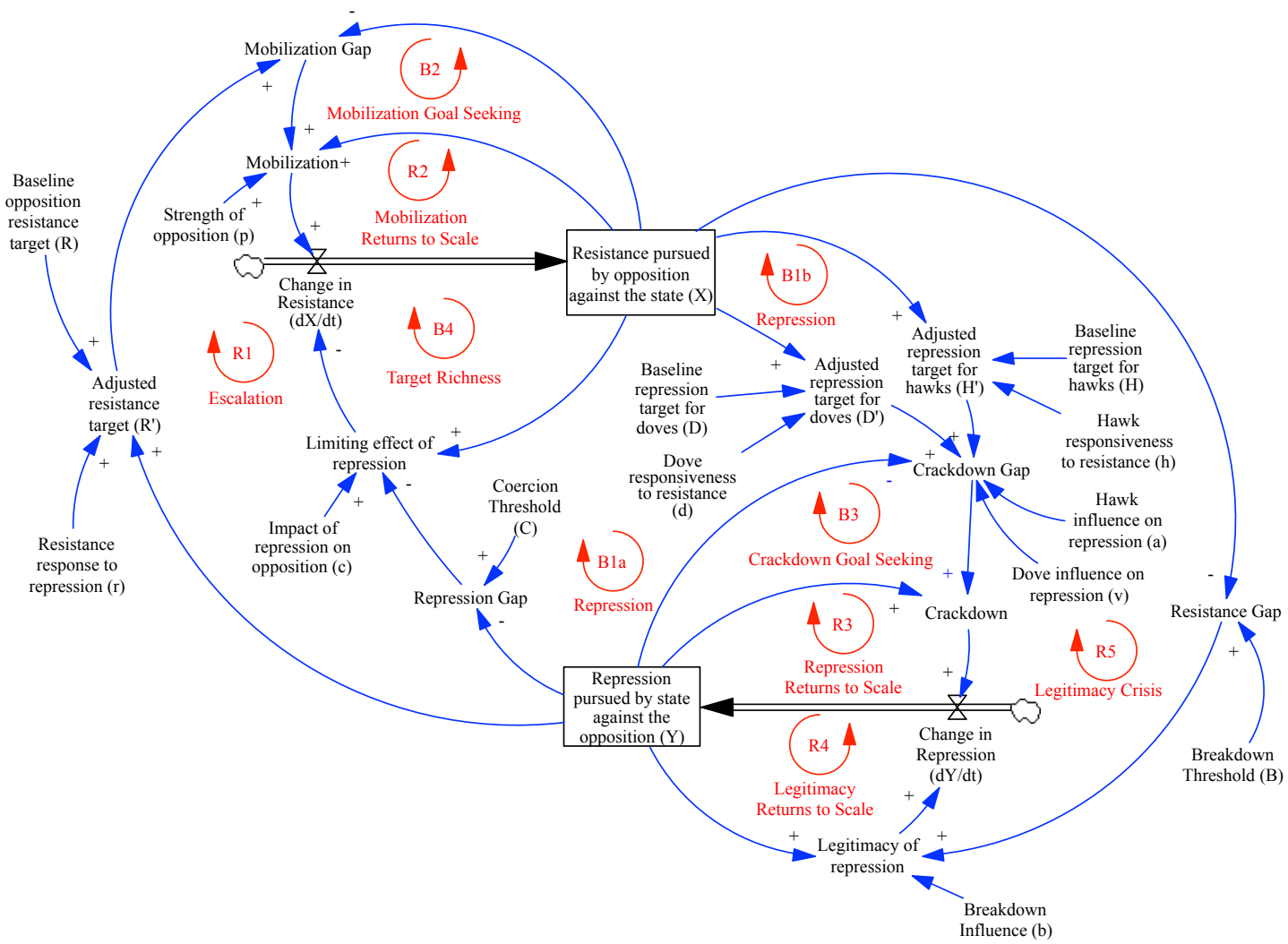

Figure 6: Diagrammatic representation of the model presented in Simon (1994)

Concepts of System State

The system state is characterized following the pattern of Karmeshu et al. It is notable that this should be the case, given that Simon adds a number of new feedback loops to the overall structure. We should expect that increasing the complexity of the model in a real way will at some point require addition of new system states, and so we might suppose that maintaining the simplified

representation was an intentional modeling choice, possibly intended to maintain continuity with prior work.

Feedback Processes

The model presented includes the escalation feedback loop R1 present in the models of Jackson et al. and Karmeshu et al., elaborated as an adjustment to some baseline level of desired conflict. The baseline is given as exogenous, but represents a place where policy concessions by the regime could interact with the remainder of the model. As the escalation works by influencing a desired level of conflict, a goal-seeking loop B2 acts to bring the level of resistance in line with the desired level, mediated by a return to the scale of the existing resistance R2.

The repression feedback is broken into two loops, the repression pursued by the hawk fraction B1b and that pursued by the doves B1a. These loops are structurally parallel, and from a mathematical perspective could be combined. The repression target is manifest as crackdown through a goal seeking adjustment loop similar to that for mobilization, B3, mediated again through the economies of scale loop R3. The direct effect of repression on resistance depends upon its level – there being an inhibiting and an encouraging effect modeled together, and mediated with a return to scale on the level of resistance that could be described as 'target richness' B4, which will be either reinforcing or balancing to the level of mobilization depending on the manifest level of repression.

The model also considers the influence of opposition in delegitimizing the use of repression R5, in a feedback similar to the political influence in Huckfeldt's model,

again mitigated by returns to scale on the repression, and the threshold mechanism described above.

Limitations

Simon's model includes threshold terms that change the polarity of a component's influence from negative to positive when the threshold is crossed, for example the Coercion Threshold in loop B1. For values of repression above the threshold, the effect is inhibitory, and for values below it is encouraging. These make direct interpretation of the feedback structures difficult, as they essentially conflate two different causal mechanisms into the same elements of model structure. Reformulating the model to make these explicit would improve the model's clarity.

While the model explicitly separates the government response into a party of doves and another of hawks, the model treats these two groups as structurally parallel, and so the distinction does little to add to the system's behavioral possibilities. The hawk and dove distinction could be functionally replaced with a weighted average of the preferences of the two without compromising the model's ability to explain the phenomena in question, or to make policy recommendations for any party. If structural distinctions separate the two parties, however, these should be added to the model explicitly.

Observations on the set of considered models

While authors may disagree on the specific mechanisms that constitute feedbacks in the system, they are by and large consistent in the way they represent the state of

the system, and the general set of feedback loops they assume to be active therein. In Table 1 I have summarized the similarities in choice of state variables, giving each category the most generally descriptive name. The table shows that generalized scales of resistance and oppression are present in almost all models, with a scattering of additional system states. Although each of these levels is described slightly differently, the structural similarity in state variable selections between models is remarkable.

Table 1: State variable presence across models considered

	Jackson et al. (1978)	Huckfeldt (1989)	Tsebelis, Sprague (1989)	Karmeshu et al. (1990)	Chong (1991)	Simon (1994)
Scale of Resistance	x	x	x	x	x	x
Scale of Oppression	x	x	x	x		x
Scale of Compliance/Regime Support		x			x	
Relative Deprivation			x			
Foreign Intervention			x			
Supply of Concessions					x	

In Table 2 I have summarized the overlap between various structural feedbacks presented in each model, giving each category the most generally descriptive name found in the set of models containing it. The table shows that all but two of the basic reinforcing feedback loops present in any of the models considered are replicated in at least one other model. While the repeat rate for balancing feedbacks is lower, the three most popular – that of repression, resource pressure, and target richness - are present in half of the models considered. In contrast to Lichbach's assertion that

'Nobody cites nobody else' (Lichbach 1992), this analysis is suggestive of a literature that builds upon the conceptual developments of previous work.

Table 2: Feedback loop presence across the models considered

	Jackson et al. (1978)	Huckfeldt (1989)	Tsebelis, Sprague (1989)	Karmeshu et al. (1990)	Chong (1991)	Simon (1994)
Reinforcing Feedbacks	**1**	**2**	**0**	**3**	**2**	**5**
Escalation	R			R2		R1
Social Contagion		R1			R2	
Influencing Political Support		R2				R5
Adding to Grievances				R3		
Proving Efficacy				R1	R1	
Returns to Scale of Mobilization						R2
Returns to Scale of Repression						R3,4
Balancing Feedbacks	**0**	**4**	**3**	**4**	**2**	**4**
Repression		B3	B2	B4		B1
Regime Resource Pressure or Fatigue		B4	B3	B3		
Saturation		B1				
Target Richness		B2		B2		B4
Appeasement or Catharsis			B1			
Opposition Restraint or Fatigue				B1		
Pressure to Conform					B2	
Preserving the Status Quo					B1	
Mobilization Goal Seeking						B2
Repression Goal Seeking						B3

Limitations of models in the literature

While the models seem to build on one another, they do not seem to be well connected to the remaining body of theoretical literature on the causal mechanisms influencing collective action. Of the theories surveyed by Buechler in his overview of theories of social movements (Buechler 2011), few are mentioned in the modeling literature and even fewer mathematically formalized.

From a theoretical perspective, counter-mobilization is excluded in all but one of the models here considered, but ties in strongly with implied concepts of support for the regime and regime legitimacy. It would be inappropriate to assume that those individuals who are not mobilized against the regime would be in favor of it, as this conflates the issues of opinion and action.

It would be instructive to consider a breadth of additional state variables as contributory to movement activity – for example, modeling resistance resources as independent from resistance activity, or modeling attitudes in the general population. Bringing the models closer to the physical realities of the system would allow for investigation of more interesting phenomena, and could lead to more actionable lessons.

Conclusion

The paper has described how models have built upon one another over the last 40 plus years in an attempt to identify and elaborate the feedback mechanisms responsible for the dynamics of collective action. I have also discussed the challenges faced in conceiving and constructing representations of these systems, and places where further consideration is warranted.

Future work in this vein would examine the literature of models of collective action that do not take an aggregate perspective on the social system, but instead infer aggregate behavior from the collection of behaviors of individual actors. It is expected that while some overlap would exist with the models considered here,

alternate modeling paradigms may promote different thinking about the causal mechanisms involved in collective action. Work to identify feedback processes would be more difficult to accomplish, but a similar typography of influence mechanisms could be usefully constructed.

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