THE DIFFUSION OF COLLECTIVE VIOLENCE*

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Past explanations of violence have characteristically paid more attention to the issues of social conditions and psychocultural stimuli than to the issue of timing. Timing is the focus of this paper in which a differential equation model of the temporal diffusion of violence is developed. This model is derived from behavioral generalizations which indicate that aggression is both instigated and inhibited via direct and vicarious learning. The parameters of the model provide measures of the instigation and inhibition processes that take place throughout an outbreak. Twenty-five data sets representing a wide variety of collective outbreaks of violence are used to test the empirical fit and to evaluate the credibility of the assumptions of the model. The model describes the overtime distribution of incidents quite accurately and the assumptions and implications of the derivation appear to be consistent with the cultural conditions surrounding the outbreaks.

One basic shortcoming of research on causes of violence is the assumption of independence among incidents. This assumption overlooks the fact that present actions are to a large degree affected by the outcomes of actions experienced in the past, either directly or vicariously. Explanations that simply identify different social conditions which cause violence, such as social disorganization (Downes, 1968), absolute deprivation (Lupsha, 1969), political structure (Lieberson and Silverman, 1965), organizational capacity (Shorter and Tilly, 1974; Snyder, 1975) and social conflict (Sears and Tomlinson, 1968) or that specify different psychocultural stimuli of violence such as relative deprivation (Gurr, 1968; Caplan and Paige, 1968), rising expectations (Davies, 1969), alienation-powerlessness (Kerner, 1968), internal-external control (Gurr, 1970) and normative or value conflicts (Spiegel, 1971) are incomplete. They fail to take into account the time related social learning processes that mediate the impact of these factors.

A number of researchers have analyzed time-series data to investigate cyclical outbreaks of various kinds of violence (c.f. Denton and Phillips, 1968; Huff and Lutz, 1974; Li and Thompson, 1975; Lieberson and Silverman, 1965; Shorter and Tilly, 1974; Snyder, 1975; Snyder and Kelly, 1976; Spilerman, 1970; 1971; Tilly et al., 1975). Some have discussed possible interdependency or contagion effects, and a few (Huff and Lutz, 1974; Li and Thompson, 1975; Midlarsky, 1970) have attempted to measure and evaluate contagion processes. Spilerman (1970; 1971), for example, produced strong evidence that the probability of contagion in the U.S. urban riots was proportional to the population size of relevant units. However, social contagion has not been rigorously conceptualized in terms of social learning processes where individuals are instigated and inhibited by the outcomes of others' violent actions.

The purposes of this paper are to develop a differential equation model of the diffusion process inherent in most outbreaks of violence and to evaluate the adequacy of the model and its implications. The adequacy will be judged by: (1) empirically fitting it to data on a variety of

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outbreaks of violence; (2) comparing the fit of alternative differential equation models derived using different inhibition terms; (3) examining the congruence between the model's assumptions and known facts about particular outbreaks; and (4) discussing the reasonability and meaning of the parameter estimates.

THEORY

Violence may be defined as any activity which results in the nonaccidental physical damage of persons or property. It generally, if not always, occurs in a conflict situation where two or more parties contest to settle an issue in their own favor. There are several kinds of contests (e.g., legal and political, as well as violent). In a violent conflict, the parties damage each other's persons and property until one is destroyed, concedes the issue, or a compromise or stalemate is reached. Some violence is individual as when a husband beats his wife. Other violence may be organized as when two or more armies battle each other. Collective violence is a mixture of the two—unorganized individuals, collectivities or organizations involved in a battle over time against a common foe (the country, the establishment, the government, adults, blacks, or Jews, for example). It involves social contagion wherein the units are instigated and inhibited by the information they receive through time about one another's behavior and its consequences. Hence, the modifier collective here implies a population of units separated in time and space and influencing one another as they act together on the basis of secondhand information and without hierarchical leadership.

Collective Violence as Cultural Diffusion

It has been suggested (Huff and Lutz, 1974) that the logistic model of cultural diffusion (Dodd, 1953; 1955; Griliches, 1957; Coleman et al., 1966) explains why violent incidents usually accumulate in a sigmoid pattern. However, a careful analysis reveals four serious problems with this formulation.

First, the mechanism in the logistic model is communication by salesmen and admen, and people who have already adopted and experienced the benefits and costs (cf. Coleman et al., 1966). In contrast, the probable mechanism for outbreaks of collective violence is much more subtle: imitation or vicarious learning usually based on news media reports of violence and its consequences occurring in other parts of the nation or world (Archer and Gartner, 1976; Spilerman, 1976).

Second, while the cumulative curves of collective violence are sigmoid, many violate an essential condition of Dodd's (1953; 1955) and Coleman et al.'s (1966) logistic theory: the units of the populations which generate them are seldom, if ever, in *direct* communication with one another. Consequently, the redundancy of contacts cannot explain the later slowing of the accumulation that results in the sigmoid pattern. According to the Coleman et al. (1966) theory, without direct communication among units in the population, the data should take a decaying exponential shape, not the sigmoid pattern which all exhibit.

Third, the logistic diffusion distribution results when each unit's adoption or first use of the invention is counted, whereas the sigmoid curves of collective violence are generated by actors who often participate more than once. For example, in the sigmoid outbreak of coups d'etat among countries in Africa, 1960–1975, one of the units (Dahomy) produced at least one coup during each of seven years.

Fourth, while the violence data are more or less sigmoid, they are not all symmetric. This asymmetry excludes the logistic model from serious consideration since it is always symmetric.[1] The suggestion by

[1] The logistic is symmetrical because it is assumed that the rate of adoption is a constant. If, alternatively, it is assumed that this rate changes through time, the model becomes asymmetrical (Hernes, 1972). This necessitates the introduction of an additional parameter. Generally the asymmetric Logistic is not preferred over more parsimonious models, such as the Gompertz, unless the fit to the data is consistently and significantly better.

Hamblin et al. (1973) that a logistic model of innovation describes outbreaks of violence may be rejected for the same reason.

For the above reasons, it appears that the nature and mechanisms of the diffusion of collective violence are not isomorphic with those of general cultural diffusion, and that an alternative model is needed.

Mechanisms of Collective Violence Diffusion

There have been a number of suggestions (cf. Turner and Killian, 1972) regarding specific mechanisms for the spread or diffusion of collective behavior: suggestibility, circular reaction, identification and, as noted, imitation. While all of these may have some merit, the imitation mechanism has enjoyed by far the most theoretical and empirical investigation, with most of the recent developments pioneered by Albert Bandura (cf. 1977) and his colleagues.

Imitation or modeling involves vicarious learning. By watching others working the environment or by talking with them about their experiences, people are made aware of reinforcing consequences, and thereby learn what works and what does not work. However, according to Bandura's (1973) experimental results, learning is not to be confused with behaving. A subject may have vicariously learned that a particular behavior produces a specific reinforcement. Yet, to engage regularly in that behavior the subject ordinarily must frequently encounter the same cues, observe models who legitimate the behavior and personally try the behavior and experience the reinforcing consequences. Evidence from several experiments suggests that overt aggression occurs with substantial frequency only when people are threatened in a conflict situation *and* observe a model successfully aggressing against the source of threat, the other party in the conflict. The threat without the aggressing model or the aggressing model without the threat produces minimal aggression (Wheeler and Caggiula, 1966; Hanratty et al., 1972). Other experimental data (cf. Bandura et al., 1963; Gilmore, 1971) show that in a threatening conflict the observers' aggressive behavior increases as the success of the model's aggression increases (where success is defined as resolving the issue in favor of the model and the model's getting by without punishment).

The Mathematical Derivation

In large scale outbreaks of collective violence much observational learning evidently occurs secondhand, via reports and descriptions in the mass media. By attentively following news media accounts of incidents of violence, units affected by the conflict become familiar with the methods and innovations used by both the units who have thus far participated and by the combatants. The following derivation assumes that a more or less constant proportion of the violent events occurring during an outbreak are reported in the media (see Snyder and Kelly, 1977).

The derivation starts with a definition equating three basic concepts relating to the imitation mechanism. A party in a conflict is composed of a population of behaving units, individuals, groups, collectivities or organizations. Given the assumption that the timing of a unit's participation in collective violence is determined primarily by observational and symbolic learning vis-à-vis others, each violent incident by a unit is both an imitation of previous behaviors and a behavioral model for other units to imitate.[2] Therefore, at any time (t), the cumulative number of violent events (V) in the outbreak equals the cumulative number of imitations (I) by units and the cumulative number of behavioral models (M) for units, or:

$$V = I = M. \qquad (1)$$

The social psychologists involved in the experimental work on imitation have not attempted to develop equations. However, sociologists (cf. Dodd, 1953; 1955; Coleman et al., 1966) in deriving the logistic model of cultural diffusion have

[2] It is assumed that the first unit to start the outbreak is imitating another unit outside the system or, much less frequently, has independently invented the particular kind of violence in question.

used an exponential differential equation which, given epistemic assumptions similar to the above, is an equation for imitation. This exponential differential equation for imitation specifies that the increment in imitations (dI) per increment in time (dt) is some proportion (p) of the number of previous imitations (I):

$$\frac{dI}{dt} = p\ I \text{ or } \frac{dI}{I} = p\ dt. \qquad (2)$$

Because of the equalities in (1), equation (2) implies:

$$\frac{dM}{M} = p\ dt \qquad (3)$$

and

$$\frac{dV}{V} = p\ dt. \qquad (4)$$

The parameter (p) is the rate at which imitation is instigated and is assumed to depend on the costs and benefits of that particular action relative to those of all plausible alternative actions. This is consistent with both experimental evidence on the imitation of aggression (Bandura, 1973) and evidence for the relationship between the rate of diffusion and amount of reinforcement (Hamblin and Miller, 1976).

Equation (4) involving the collective violence terms (dV and V) is the one of principal interest because of the close correspondence between these terms and the data. However, the others are important because they specify the vicarious learning and imitation processes from which (4) is derived.

Aggression is not only instigated through behavioral modeling but may also be inhibited by costs resulting from failures and the deterrence strategies implemented by opposition units (cf. Bandura, 1973). Increases in the frequency and magnitude of such costs relative to alternatives augment the number of instigated units who are inhibited from engaging in the violence. Inhibition effects are assumed to be cumulative so the relative increase in violence (dV/V) per increment of time (dt) not only varies directly with the instigation rate (p) but also inversely with the accumulated number who are inhibited (i) as in the following equation:

$$\frac{dV}{V} = \frac{p}{i}\ dt. \qquad (5)$$

In outbreaks of collective violence relative costs are observed and talked about and the experimental data show that aggressive behavior by threatened observers is inhibited as they observe the punishment of aggressing models (Bandura et al., 1963; Gilmore, 1971). It is, therefore, assumed that observational and symbolic learning occurs to inhibit violence and that the imitation equation (2) applies so that the increment in numbers inhibited per increment of time (di/dt) is some proportion (q) of the accumulated number of units who have been inhibited (i) up to time (t), or:

$$\frac{di}{dt} = q\ i,\ \frac{di}{i} = q\ dt. \qquad (6)$$

Solving (6) for i via integration yields:

$$i = i_0 e^{qt}, \qquad (7)$$

where q is the previously defined rate at which units are inhibited, e is the base of the natural logarithm and i_0 is the value of i when t = 0. This value of i may be substituted into (5) to obtain:

$$\frac{dV}{V} = \frac{p\ dt}{i_0 e^{qt}} = ce^{-qt}\ dt$$

or

$$\frac{dV}{dt} = ce^{-qt}V \qquad (8)$$

where $c = p/i_0$, or the net rate at which units are instigated to imitate the violence in question, and q is the rate at which they are inhibited. Thus, if this model adequately describes the through-time diffusion of a particular type of violence, the nonlinear regression analysis will provide measures of the rates of the two constitutive processes—instigation and inhibition—for the 25 data sets modeled here.

THE ANALYSIS

The Data

In order to evaluate the descriptive adequacy of the model, we obtained data sets on ten different forms of collective violence: lynchings of blacks, vandalism and swastika painting on Jewish buildings, air hijacking attempts and attempts to deter hijackings, guerrilla warfare, revolutions, purges, coups d'etat, agrarian protests and civil disorders.[3] For a description of the data see Table 1.

The Estimation of Parameters

Because both instigation and inhibition are assumed to approximate continuous rather than discrete processes, the model is stated in differential rather than difference equations. The term (dV/dt) refers to the rate of violence during very small increments of time and V is the accumulated number of incidents of collective violence up to a point in time. The accumulated data correspond to V very much better than data per day, week, etc. correspond to dV/dt, and for that reason, equation (8) was solved by integration for V:

$$V = V_0 e^{(c/q)} e^{(-c/q)e^{-qt}} = A\, e^{kb^t} \quad (9)$$

The right part of the equation was used in fitting the data and c and q were calculated using the following identities: $c = -qk$ and $q = -\ln b$, which are implied above. The intermediate steps required to obtain (9), usually referred to as the Gompertz equation, were omitted because they involve calculus and are quite technical. Those proficient in calculus can derive the equation for themselves; those not would scarcely be helped by the rationale that could be outlined in the space available here. The essential point is that by fitting the integrated equation to the accumulated data, one is able to calculate estimates of c and q as postulated in the model.

The fitting or estimating was done with a nonlinear least-squares regression program based on the Fletcher-Powell (1963) optimization technique. Equation (9) was also fit to most of the data sets using the SPSS nonlinear regression program, with identical results to the fourth significant digit.

RESULTS AND DISCUSSION

Goodness of Fit

The results of the nonlinear least-squares regression analyses are given in Table 1. The integrated equation fits the data very well: r^2 values range from .941 to .999 with a median of .995. Overall, there are no systematic deviations in the residuals. The empirical fit to the accumulated distribution of events is quite acceptable (i.e., $r^2 > .98$) for all but the 1967 U.S. outbreak of civil disorders.

Fit of Alternative Differential Equation Models

Two alternative sigmoid models were considered but rejected. The alternative models were:

$$\frac{dV}{dt} = sVt^m \longrightarrow$$

$$V = \left(\frac{V_0}{e^{s/(m+1)}}\right) e^{(s/(m+1))t^{m+1}} \quad (10)$$

$$\text{and} \quad \frac{dV}{dt} = rV\,(N - V) \longrightarrow$$

$$V = \frac{N}{1 + \frac{N - V_0}{V_0} e^{-Nrt}} \quad (11)$$

Both of these were derived using instiga-

[3] All apparent indications are that the various coders took considerable care to assure the accuracy of each of these data sets. For example, Banks (1971) reports that the intercoder stability averaged .974. However, independently coded data are available for the air hijacking attempt outbreaks and the 1958–66 outbreak of coups d'etat in Latin America. The agreement between the FAA reports on hijacking and the reports in the *New York Times* on worldwide hijacking was over 98 percent. In addition to Banks, data on successful Latin American coups d'etat are also available in Li and Thompson (1975) and Solaún and Quinn (1973). The only discrepency among all three data sets concerned the coding of the Cuban revolution-coup (Banks coded it in 1959, Solaún and Quinn coded it in 1958 and Li and Thompson did not include it). In addition, Li and Thompson coded two events as coups that the others did not—one in Brazil, 1961, where the President resigned under severe pressure and a second in Peru, 1963, where the head of the military junta was replaced by another General. The high overall agreement among data sets is evidence of their accuracy. Also, in modeling, measurement error typically attenuates the r^2. Therefore, the consistently high r^2 values here evidence the data as both reliable and valid.

Table 1. Nonlinear Least-Squares Parameter Estimates and R^2 Values for 25 Collective Violence Outbreak Data Sets

Collective Violence Outbreak	Duration	Equation: $V = V^o e^{(c/q)} e^{(c/-q)e^{-qt}}$				Data Sources
		$V_o e^{(c/q)}$*	c	q	r^2	
Lynching of blacks, U.S.[a]	1882–1956	3483.00	.0007	.0002	.998	U.S. Bureau of the Census, (1960)
Anti-Semitic, U.S., 1958[b]	10/12/58–11/29/58	84.29	.2985	.1395	.982	Caplovitz and Rogers (1961)
Anti-Semitic, U.S., 1960[b]	12/26/59–2/29/60	643.30	3145	.1046	.995	Caplovitz and Rogers (1961)
Air hijacking attempts, U.S.[c]	11/67–12/69	73.01	.0622	.0096	.994	Federal Aviation Agency (1974)
Air hijacking attempts, U.S.[c]	1/70–8/71	53.49	.0232	.0080	.997	Federal Aviation Agency (1974)
Air hijacking attempts, U.S.[c]	7/71–7/73	53.29	.0531	.0148	.995	Federal Aviation Agency (1974)
Air hijacking attempts, L.A.[c]	9/67–10/70	104.20	0332	.0049	.995	Federal Aviation Agency (1974)
Air hijacking attempts, L.A.[c]	12/70–6/73	19.22	.0315	.0083	.992	Federal Aviation Agency (1974)
Air hijacking deterrences, U.S.[d]	11/67–12/69	69.89	.0390	.0074	.985	*New York Times* (1967–1973)
Air hijacking deterrences, U.S.[d]	1/70–8/71	83.47	.0282	.0113	.993	*New York Times* (1967–1973)
Air hijacking deterrences, U.S.[d]	9/71–7/73	151.80	.0576	.0123	.994	*New York Times* (1967–1973)
Air hijacking deterrences, L.A.[d]	10/68–10/70	35.46	.0274	.0079	.981	*New York Times* (1967–1973)
Air hijacking deterrences, L.A.[d]	12/70–6/73	18.62	.0178	.0080	.986	*New York Times* (1967–1973)
Riots, L.A.[e]	1955–1963	188.30	.0031	.0009	.996	Banks (1971)
Guerrilla warfare, L.A.[e]	1955–1963	112.80	.0037	.0009	.996	Banks (1971)
Revolutions, L.A.[e]	1957–1965	78.30	.0025	.0011	.996	Banks (1971)
Purges, L.A.[e]	1958–1966	103.90	.0022	.0013	.999	Banks (1971)
Coups d'etat, L.A.[e]	1958–1966	21.06	.0036	.0010	.993	Banks (1971)
Coups d'etat, Africa[f]	1960–1975	49.01	.0051	.0008	.995	Huff and Lutz (1974), Current History (1972–1975)
Arson, England, 1830[g]	10/4/30–2/3/31	281.31	.7191	.0513	.997	Hobsbawm and Rudé (1968)
Wage meetings, England, 1830[g]	10/23/30–12/21/30	168.20	1.2989	.1009	.994	Hobsbawm and Rudé (1968)
Machinery breaking, England, 1830[g]	11/9/30–12/15/30	249.50	7.4561	.2601	.996	Hobsbawm and Rudé (1968)
Riots, England, 1830[g]	11/15/30–12/10/30	85.71	2.7540	.2930	.996	Hobsbawm and Rudé (1968)
Civil disorders, U.S., 1966[h]	3/15/66–10/19/66	23.67	.8627	.0266	.986	U.S. Senate Committee on Gov't. Operations (1968)
Civil disorders, U.S., 1967[h]	4/1/67–11/21/67	80.12	173.7578	.0724	.943	U.S. Senate Committee on Gov't. Operations (1968)

* This is the upper limit of V, when $q>0$ $\lim_{t\to\infty} V = V_o e^{(c/q)}$

[a] This data set is composed of yearly frequencies. Lynchings of blacks occurred before 1882 but that is when the Chicago *Tribune* began collecting and publishing these data. The collection of lynching data was later taken over by the Tuskegee Institute.

tion and inhibition assumptions analogous to those used in the derivation of equation (8), but with different specifications of the functional form of the inhibition process.

Equation (10) consistently gave the worst fit and for this reason was eliminated from further consideration. Equation (11) gave a poorer fit but was rejected primarily because of the obvious *asymmetry* of some of the data sets which are known to be complete (especially the two anti-Semitic outbreaks, the third U.S. hijacking outbreak, the outbreaks of purges and revolutions in Latin America and the outbreaks of machine breaking and rioting in England). This asymmetry conflicts with the necessary symmetry of the logistic process specified in equation (11) (see fn. 1).

Validity of Assumptions

Continuity of reinforcement contingencies. Equation (8) assumes relatively stable trends in changes in the reinforcement contingencies. One way to display reinforcement conditions in different epidemics is via collective learning curves, by plotting accumulated successes against accumulated attempts. The usual form for such learning curves—individual, organization or collective—is a power function with an exponent somewhat different from 1.0 (cf. Hamblin et al., 1973). The requisite success data are presently available only for the hijacking epidemics and for the coups d'etat outbreak in Africa. The appropriate plots are given in Figure 1. Data relationships described by power functions become linear on logarithmic coordinates and that is the case here. Note that the r^2 values are all above .98, and the exponents are quite different from 1.0 except for the African coups. These analyses support the assumptions that reinforcement contingencies are typically not constant and that changes are characterized by continuity.

Premature terminations. Since the model assumes that outbreaks of collective violence are characterized by continuities, discontinuities in reinforcement could prematurely truncate an epidemic and set the conditions for a new one. Examples of early terminations are the

Table 1. Continued

[b] These outbreaks of vandalism, and swastika paintings on Jewish homes, stores and institutional buildings were nationwide and lasted respectively seven and nine weeks. According to Caplovitz and Rogers (1961) there was no evidence of an organized plot in either of the outbreaks.

[c] A hijacking attempt was counted every time a person or a group of persons tried to commandeer an aircraft by threat of harm. The data indicated there were three separate outbreaks of hijacking attempts in the United States and two in Latin America during the August 1967–July 1973 interval.

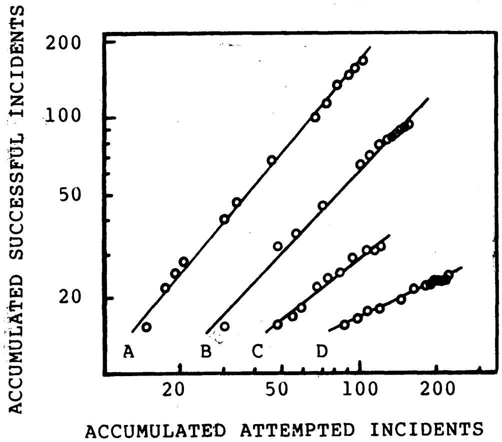
[d] Deterrence attempts are actions taken by combatants which, if successful, might increase potential hijackers' expectations of failure and punishment. These were coded by Miller from the stories on hijacking in the *New York Times* (1967–1973).

[e] Hamblin et al. (1973:126–35) analyzed Banks's data and found, in Latin America, two series of epidemics of various kinds of political violence since World War II. Banks's data for the second series are analyzed here. For definitions see Banks (1971i, xv) and Rummel (1963:25–6).

[f] Huff and Lutz's data on the diffusion of coups d'etat (1960–1972) among 30 contiguous black-ruled countries in Africa were updated through 1975.

[g] These data trace an agricultural labor uprising that occurred throughout the east and south of England in the final months of 1830. The data were collected by Hobsbawm and Rudé from all available newspapers as well as public and private records, and are given by date, type of disturbance, place and target.

[h] These data are from questionnaires completed by the mayors or city managers of all cities reported to have experienced some sort of riot or civil disturbance. Where information could not be obtained from municipal officials, the data were compiled from local news reports.



Plot	Outbreak	Exponent	r^2
A.	1st U.S. Hijacking	1.22	.99
B.	Coups d'etat, Africa	1.04	.99
C.	2nd U.S. Hijacking	.79	.98
D.	3rd U.S. Hijacking	.49	.99

Note: On both the ordinate and the abscissa, the plots were positioned for display by multiplying each with a different constant. This does not change the slope or the fit.

Figure 1. Collective Learning Curves for the Three U.S. Air Hijacking Outbreaks (11/67–12/69, 1/70–8/71, 9/71–9/73) and the Black African Coups d'Etat Outbreak (1960–1975)

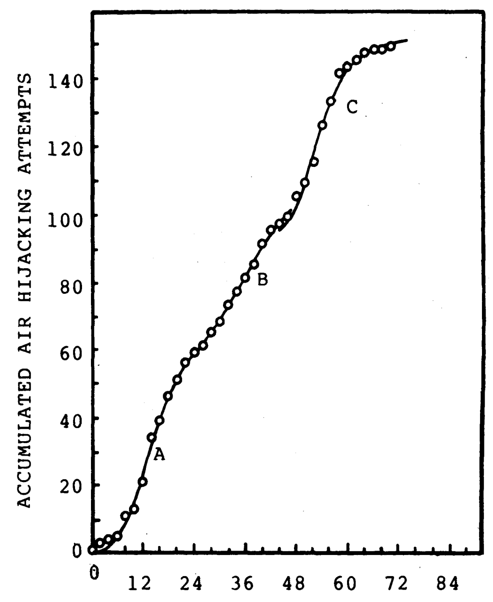
first and second U.S. epidemics of air hijacking attempts and the first Latin American air hijacking epidemic, all five counter epidemics of deterrence attempts and the Latin American epidemics of riots, guerrilla warfare, and coups d'etat.

The authors analyzed abstracts of all the stories in the *New York Times* on each hijacking so we have rather detailed knowledge of these events and can, at least, suggest a likely source of the premature truncations in these data.

The first U.S. outbreak mostly involved political migration, hijacking attempts to Cuba which at that time was romanticized as a socialist haven, with imagery of leftist hijackers receiving a hero's welcome. However, that epidemic ended prematurely shortly after six U.S. hijackers returned voluntarily from Cuba to certain prison terms in the United States. They complained bitterly about housing and food. Blacks charged racial discrimination, and escaped criminals reported they were put into terrible prisons. These stories, given wide coverage in the media, evidently created a discontinuity, enough of a jump in the inhibition process to cut off the outbreak.

The second U.S. outbreak came to a premature end when D. B. Cooper accomplished what appeared to be a successful extortion hijacking by parachuting into the night over Oregon or Washington with $200,000 from Northwest Airlines. Consequently, the third outbreak began vigorously, with most hijackers attempting extortions and with increased levels of counterviolence.

However, the data suggest overlaps rather than abrupt transitions from one outbreak to another. This is depicted in Figure 2 where the U.S. data are accumu-



Plot	Outbreak	$V_0 e^{c/q}$	c	q
A.	11/67-1/70	70.62	.0677	.0100
B.	1/70-9/71	61.50	.0197	.0066
C.	7/71-9/73	55.91	.0625	.0139

The lines represent the least squares fit of the Gompertz equation to each of the outbreaks with the transition points from one epidemic to another included in both outbreaks.

Figure 2. Air Hijacking Attempts in the U.S. Accumulated over the Entire Period of the Outbreak

lated over the entire period and the transition points are included in both epidemics. The parameters are slightly different from those in Table 1 which were calculated without assumed transitions, and the fit is slightly better.

A discontinuity may also account for the unsatisfactory fit of the model to the 1967 U.S. civil disorder data. In July 1967 a dramatic, massive disorder occurred in Newark, New Jersey. Partly because of the sheer severity of the disorder and partly because it occurred across the river from Manhattan, the U.S. media center, this event received intensive coverage for several days (Spilerman, 1976). This greater than usual media coverage evidently produced a discontinuity, a jump in the instigation process. Over one-half of the 83 disorders in 1967 occurred in the two-week period immediately following the Newark coverage.

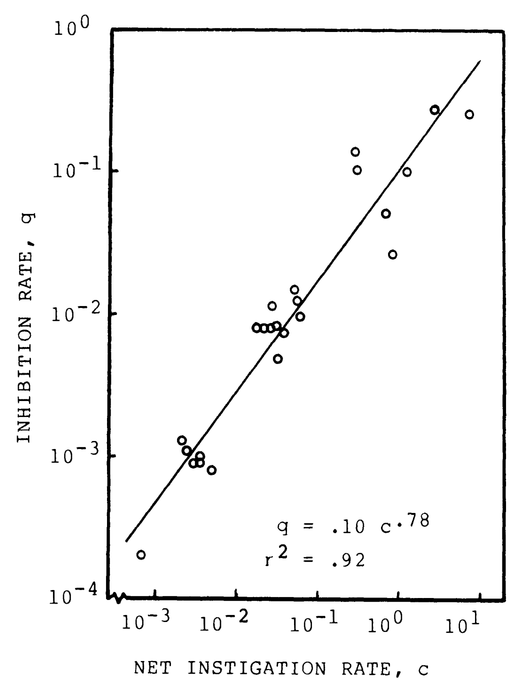
The Parameter Estimates

When time is measured using the same unit, as in Table 1 where t is in days, the c and q parameters can be compared across outbreaks. Such comparisons are useful in evaluating the model, since parameters may or may not behave as predicted from the underlying theory. Because of the unsatisfactory fit of the model, the parameters for the 1967 U.S. civil disorder outbreak were not included in the following analyses.

First we consider the expected relationship across violence outbreaks between c, the net instigation rate, and q, the inhibition rate. As noted, past research on the imitation of aggression suggests that instigation rates increase as the benefits of reinforcement to aggressing models increase and inhibition rates increase as their punishment and other costs increase. Violence usually begets violence in equal magnitude—"an eye for an eye and a tooth for a tooth." And, in a violent conflict what is beneficial to one side is usually costly to the other. While the conflict through time continues, the benefits and costs are ordinarily more or less balanced. All of this implies a matching function which in turn implies a positive relationship between the net instigation and inhibition parameters across outbreaks. In general, power functions describe behavior-reinforcement relationships and that is the prediction here.

The c and q parameters from Table 1 are plotted in Figure 3 on logarithmic coordinates. The relationship is linear, indicating the data are described by a power function, and positive, with a least-squares exponent of 0.78. The .78 exponent indicates that outbreaks of violence are generally characterized by undermatching—i.e., relative increases in the instigation rate are greater than the corresponding relative increases in the inhibition rate. The relationship may seem somewhat less than perfect, but an r^2 of .92 is quite high for cross-modality comparisons over such broad continuums of time, culture and violence. In general, these results are very supportive of the model and auxiliary theory.

Second, we consider the relationship between the magnitude of the instigation and inhibition processes and the duration of a violence outbreak. It might be argued

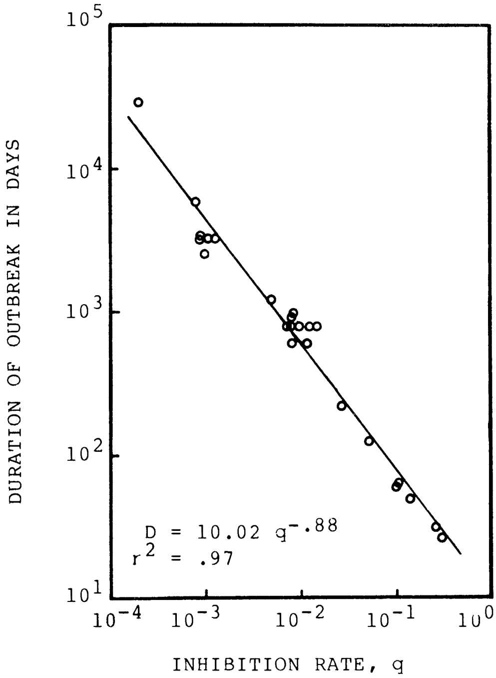


[a]The solid line represents the least-squares power function given in the figure.

Figure 3. Inhibition Rate (q) for 24 Outbreaks of Collective Violence Plotted on Logarithmic Coordinates by the Net Instigation Rate (c)[a].

that the lower the net instigation rate *and* the lower the inhibition rate, the longer an outbreak will last. On the other hand, according to the model incidence of aggression is slowed only by the inhibition rate which functions to terminate the outbreak of violence and thus determine its duration. The hypothesis is that q is the best predictor of duration although c is expected to be highly related because it is a determinant of q. The relationship should be negative and should be described by a power function.

A number of analyses were done, but the one pictured in Figure 4 gives the essential finding: a strong negative relationship between the inhibition rate and the duration of an outbreak. It is described by a power function with an r^2 value of .97 and an exponent of .88. The first order correlation between c, the net instigation rate, and duration was negative and the r^2 value was .90. When c was added as a second independent variable in a multivariate power function, the variance already explained by q was not improved. Other plausible functional forms of these relationships were also tried but their explained variance was substantially lower. Thus, the hypothesis derived from the model is again supported by the data.



[a]The solid line represents the least-squares power function given in the figure.

Figure 4. Duration in Days of 24 Outbreaks of Collective Violence Plotted on Logarithmic Coordinates by the Inhibition Rate (q)[a].

Generality

Tilly (1975:514, 519) suggests that the study of collective violence ought to be limited to damage to persons or property by groups of fifty or more in conflict with other such groups, that violence by smaller groups or individuals is either not important or not measurable at a suitable level of accuracy. Contrary to Tilly's (1975) measurement assumption, the size of unit makes no difference in the fit of this model. Since unreliability attenuates relations, this indicates the reliabilities are consistently high for outbreaks with units of all sizes—individuals (e.g., most hijackings), small groups (most hijacking deterrence), crowds (riots) and organizations (revolutionary battles, coups).

The analysis here also questions Tilly's (1975) assumption that small-scale violence is not important enough to study. The data relationships suggest that lesser forms of violence often prelude more serious forms as part of an escalation process. For example, the four agrarian labor outbreaks were nested one within another, with the outbreak of arson starting first and ending last, the wage meetings outbreak starting second and ending next to last, then the machine breaking and the riots. The seriousness of the outbreaks may be gauged by the inhibition rates the counterreactions generated: 0.0513 for the arson, 0.1009 for the wage meetings, 0.2610 for the machine breaking and 0.2930 for the riots. The unemployed farm laborers, realizing their earlier strategies were not working, evidently escalated the level of violent conflict in the hope of winning. Hamblin et al. (1973: 129–33) also have published analyses which evidence an escalation process relating the different outbreaks of political violence in Latin America. Snyder (1975:275) has called for the investigation of the life history of collective violence; tracing such escalation processes seems to be a fruitful way to go about it.

Inhibition Effects

The results here suggest that social condemnation can have a very strong inhibitory effect. The perpetrators of the anti-Semitic violence were never caught and, therefore, never subjected to vigilante violence nor prosecuted. Yet those inhibition rates are among the highest exhibited in the outbreaks investigated here. Part of the reason for these high rates seems to have been the rather unanimous and severe condemnation of these acts in the mass media. Memories of Nazi atrocities were still fresh and the outrage against these Nazi imitators was nearly universal. The causes of inhibition are evidently complex and social condemnation may be as important as other counterreactions.

Certainly counterviolence is often not the most productive way of managing violent outbreaks. When the authorities in Latin America and the United States opted for shootouts with hijackers, about as many passengers and flight personnel were killed as hijackers. In contrast, 10, 16 and 26 percent of the hijackers were talked into surrendering in the first, second and third U.S. outbreaks, respectively. Generally crew members or passengers discussed the options with the hijackers and persuaded them that surrendering was the least noxious alternative.

As noted, most of the violence investigated here involved basic conflicts where the members of both sides were doing physical damage to one another's persons and properties in efforts to settle the issue in their favor. Much of the violence and counterviolence might have been avoided if the conflicts were somehow turned into either legal contests where the facts were considered and the issues adjudicated to effect justice, or political contests where the issues were settled via discussion, debate, compromise and a vote.

Some of the more bizzare outbreaks like the hijackings do not tend to lend themselves to these kinds of solutions, but in most instances that kind of violence is felonious, clearly against the law. In the first U.S. hijacking outbreak, the airlines asked law enforcement agencies to do nothing—to allow the hijacked airliners to proceed to Cuba without resistance. In the later outbreaks, when the hijackers were forcing pilots to fly them transoceanic and were extorting huge sums, the airliners reversed that policy and law enforcement personnel became quite innovative. As can be seen from the learning curves in Figure 1, they also became much more effective. The hijackings were turned off completely in 1973 when the F.A.A. finally instituted a nonviolent solution: the electronic screening of all passengers for weapons.

CONCLUSIONS

Cumulative distributions of outbreaks of violence are generally sigmoid, some skewed to the right. Our purpose was to develop a model to predict, if possible, the mathematical form of these distributions and to specify the generative processes which could explain these outbreaks. Three models were developed (one detailed), assuming that the benefits and costs to units engaged in a violent outbreak up to any point in time respectively instigated and inhibited subsequent participation by others. It was assumed that a differential equation supported in prior research on logistic models of cultural diffusion is, in fact, a general imitation equation and it was used to predict the form of the instigation process through time. We assumed further that the inhibition process was cumulative and the three models involved different inhibition terms. The model from which the Gompertz function was derived used the imitation equation to describe the inhibition process.

The Gompertz turned out to predict the empirical distributions of violence better than the other equations. The fit was virtually perfect: the median r^2 being .995. There was one deviant case and in that outbreak an essential assumption (i.e., a relatively stable rate of mass media reporting of the violent events) appears to have been badly violated.

The preliminary tests eliminated the alternatives, including application of the logistic diffusion model suggested by Huff and Lutz (1974) and the logistic innovation model suggested by Hamblin et al. (1973). Still, it must be pointed out that the Gompertz might be derived from alternative premises and assumptions. The premises chosen here, however, were empirical generalizations from previous research which were thought to apply in these situations. Also, a number of analyses were done to further evaluate the premises and auxiliary assumptions. Learning curves support the model's assumption that reinforcement contingencies generally exhibited continuity. Early terminations of some of the outbreaks were apparently a function of massive, well published changes in reinforcement contingencies—as would be predicted by auxiliary theory. The inhibition rates were highly related ($r^2 = .92$) to the net instigation rates, a predicted result. The duration of the outbreaks were predicted quite accurately by the value of q ($r^2 = .97$), another predicted result. Because unpredictable variation in parameters can be a prime reason for rejecting a model (cf. Hamblin et al., 1977), these positive results are important corroboration.

This diffusion model has a number of interesting features. First, it appears to be very general: it describes and explains equally well a wide range of violence perpetrated in a number of cultural and historical contexts by units of varying size and type (individuals, small groups, crowds and large organizations). Second, it predicts and explains institutional and dissident violence equally well and thus escapes Firestone's (1974) criticisms that theory and research on violence (a) have focused on dissident violence neglecting institutional violence and (b) have failed to conceptualize a set of processes that account for both.

Finally, the purpose here has been to specify and investigate the processes involved in the timing and contagion of violence, unlike most earlier research which has investigated variables related to the location of violence, the motivation of units engaging in violence, and the social, political and economic conflicts which generate violence. The relative successes here in terms of explained variance, replication and generality suggest these other questions might be profitably investigated in the context of this diffusion model. The constitutive imitation processes as well as the interactive nature of conflict appear to be too powerful to ignore.

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