Understanding Collective Control Processes

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Introduction

Although sociologists often describe people and groups of people as having control over things, resources, or other people, the question of how control processes actually work has rarely been the focus of sociological attention. Theorists of criminology (e.g., Gottfredson and Hirshi 1990) and of organizations (e.g., Perrow 1986) have taken the concept of control as a central concern, but their analyses of the concept have been rudimentary at best. Similarly, social-class theorists in the Marxist tradition have often given the concept of control a prominent place, equating it with domination, without having seen the need for any close analysis of the concept. Wright (1979), for instance, defines social classes in terms of their control of economic surplus, with the "dominant class" (p. 15) exerting "control over money capital, . . . physical capital" and "supervision and discipline within the labor process" (p. 25). He contends, further, that members of the working class experience a corresponding "loss of control over the labor process" (p. 28). Wright then builds his theoretical exposition on these definitions without ever analyzing in any detail how such control processes work.

Control processes have also figured prominently in the theories advanced by rational choice theorists such as Coleman (1990), who grounds his theory in four basic concepts: actors, resources, interests, and control (p. 28). "A minimal basis for a social system of action," according to Coleman "is two actors, each having control over resources of interest to the other" (29). Although the concept of control is evidently an important foundation of Coleman's theory, he describes the process of "exercising control over those resources one is interested in" as a "simple" type of action (p. 32), and his book offers no further analysis of the process of control.

Theorists in the functionalist and interactionist traditions have come closer to an analytic examination of control processes, but even they have only rarely offered a coherently specified theory of control. Parsons, for example, sought to include the notion of a cybernetic control hierarchy in his comprehensive theory of society. Parsons emphasized the importance of shared values as controlling social behavior and argued that when control by means of these internalized values breaks down, thus threatening a loss of social order, social control processes become essential for preventing or curbing deviance (1951). His account of how control processes might work, however, was incomplete and often confusing. In the interactionist tradition, Goffman (1959) discussed such topics as the "maintenance of expressive control" (p. 51) in face-to-face encounters, and his whole opus of work on impression management can be read as a compendium of the interactional techniques people use for maintaining control. Goffman's approach, however, was more descriptive than analytical. Similarly, Garfinkel's breaching experiments (1967:35–75) vividly demonstrated some of the ways in which control of everyday interactions can be disrupted, but his theory of ethnomethodology did not treat the concept of control in any detail. Control may be, as Gibbs (1989) argued, "sociology's central notion", but sociologists have generally been content to work from commonsense notions of control, rather than subjecting control processes to careful analysis.

In this chapter, I argue that control systems theory has made possible rigorous analytical models of control processes that offer new conceptual horizons to sociologists for whom issues of control have theoretical importance. I argue, further, that many social processes not previously regarded as examples of control might fruitfully be reconceptualized in this way. In particular, I reanalyze case studies from two recent sociological works, a study of the escalation of a conflict between farmers in a Bangladeshi village (Roy 1994) and a study of the interactions among members of a family on a holiday having fun in the house of mirrors of a French amusement park (Katz 1999). To lay the groundwork for understanding how collective control processes might be implicated in these settings, I first review findings from a series of simulations of control processes in which control agents are modeled as cooperating or competing to control a single variable. I then apply the lessons learned from these simulations to reinterpret empirical findings from the contrasting case studies.

My conclusion is that the kinds of control models described in this book may have potential applications that are broader than has previously been recognized, our theoretical understanding of collective processes having grown.

SIMULATIONS OF CONTROL PROCESSES

In a recent article (McClelland 2004), I presented simulations based on models of closed-loop feedback control systems (Powers 1973) to show how the generic forms of social processes of control might be expected to work. Here I review the most important of these simulation findings in preparation for discussing empirical examples of control processes. The models used in these simulations are relatively simple—cybernetic systems controlling a single scalar variable—but they provide a basic psychological model of the perceptual processing and behavior that an individual must perform to control some variable phenomenon in the physical or social environment.[1] Such simulation models, despite their simplicity, have repeatedly been shown with great accuracy in laboratory experiments to describe examples of human tracking behavior (e.g., Bourbon 1990; Marken and Powers 1989), and control theorists have taken these models as applicable in broad outline to many other kinds of human behavior.

My object in presenting the results of these simulations is to show what happens when two or more control systems, or agents, as I will call them, seek to control a single variable in their common environment. To set the stage for examining these simulations of simplified social interactions, however, I will begin by describing the control behavior of a single agent working alone. In all of the simulations to be presented, one or more control agents act to maintain at some reference value a variable that is also acted upon by another force tending to disturb its value. Figure 2.1 displays the results of a simulation of a single agent controlling a single environmental variable. The vertical axis in this graph indicates the variable to be controlled in the agent's environment, here measured as positive or negative distance from a zero point on a linear scale. The horizontal axis from left to right indicates units of time.

Two dotted curves appear to dominate the graph in figure 2.1, zigzagging symmetrically across each other, one labeled *Disturbance*, the other, *System Output*. These two curves simulate the forces acting simultaneously upon a variable in the agent's environment. The disturbance, which in the absence of actions by the control agent would completely determine the position of the environmental variable, has

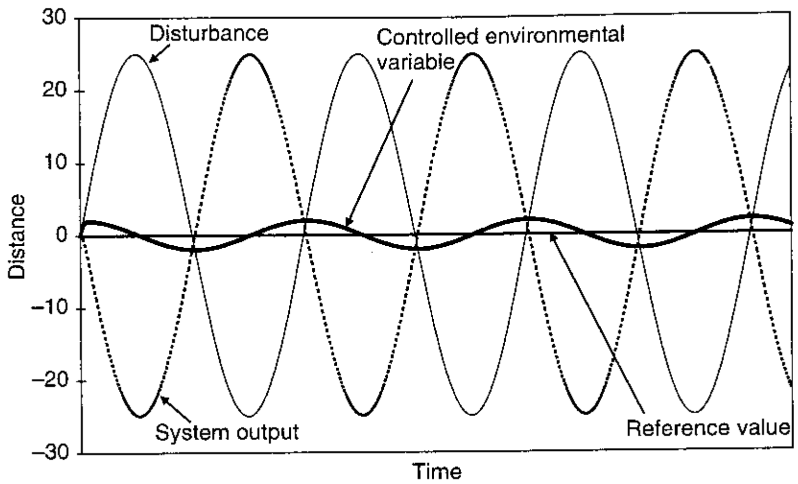

Figure 2.1 Simulation of a Single Control System in Action.

been arbitrarily given the form of a sine curve for purposes of this simulation. Many other smoothly varying disturbance curves would work equally well for simulations such as this, including entirely random patterns,[2] but the regularity of this pattern helps to make clear some important aspects of the results. The heavier dotted curve in figure 2.1, labeled *System Output*, shows the agent's physical actions that impinge on the environmental variable. The disturbance and the system's output are modeled as acting together to determine the moment-to-moment value of the environmental variable.

The heavy black curve in the center of figure 2.1 indicates the changing position of the environmental variable over time. This curve is labeled as the *Controlled Environmental Variable*, because the actions of the control agent reduce the scope of this variable's movement to a maximum displacement of only about two distance units on either side of the zero line, as compared to the twenty-five or so distance units in either direction that it would vary, if the disturbance were the only force to act upon it. Notice that the controlled variable's changing position does not precisely coincide with the *Reference Value* being used by the control system, which in this simulation is exactly zero. Although the variation in the position of the controlled variable is considerably reduced, the agent does not succeed in completely eliminating all variation. In other words, controlling a variable in this way means to stabilize the variable in the vicinity of a preferred value or pattern of values, not to fix it in place.

In human terms, control is never perfect, but it can be good enough for practical purposes.

A few other details of figure 2.1 are worth noting. First, it is obvious that the curve of the system output virtually mirrors that of the disturbance, though the output curve is offset a little to the right on the timescale, indicating a slight lag behind the disturbance. This property of control systems, that the physical actions of the system seem to mirror the actions of other physical forces in the system's environment, has often led observers to interpret the behavior of humans and other animals as a matter of responses to stimuli, though control theorists would argue that the animal is just doing whatever is necessary to counteract environmental forces in order to keep some perceived variable under control. Another thing to notice in figure 2.1 is that the control is tightest, that is, the curve for the controlled variable comes closest to the agent's reference value, just after the curve of the disturbance reaches either a maximum or a minimum point, and control then deteriorates as the disturbance crosses the zero line in either direction. This seemingly paradoxical phenomenon of improved control when the disturbance is at its maximum has to do with the sine-curve pattern of the disturbance. When the sine curve approaches a maximum or minimum point, its rate of change in the vertical direction momentarily reaches zero, and the rate of vertical change in the disturbance again becomes increasingly greater until the function crosses the *y*-axis. Thus, the more rapid the change in the disturbance, the less effectively will a control system succeed in maintaining tight control.

Figure 2.2 presents a schematic model of a collective control process in which two agents seek to control a common environmental variable. In these simulations of an elementary social interaction, the two control agents, in effect, "share" the same environmental variable. Thus, every action by one agent has a continuous impact on the state of the environmental variable, which in turn affects the perception and behavior of the other agents, and vice versa.[3] In figure 2.2 a heavy dashed line across the middle of the diagram separates the control systems above the line from their common environment below the line. In this model, the boxes labeled *Input Function* represent the transformation of physical energy from the environment into a perceptual signal, and the boxes labeled *Output Function* represent the transformation of output signals into physical actions in the environment. The heart of the control model is the *Comparison Function*, by which a *Perceptual Signal* is compared to a *Reference Value*, and the resulting error becomes an *Output Signal*. The cybernetic closed loop

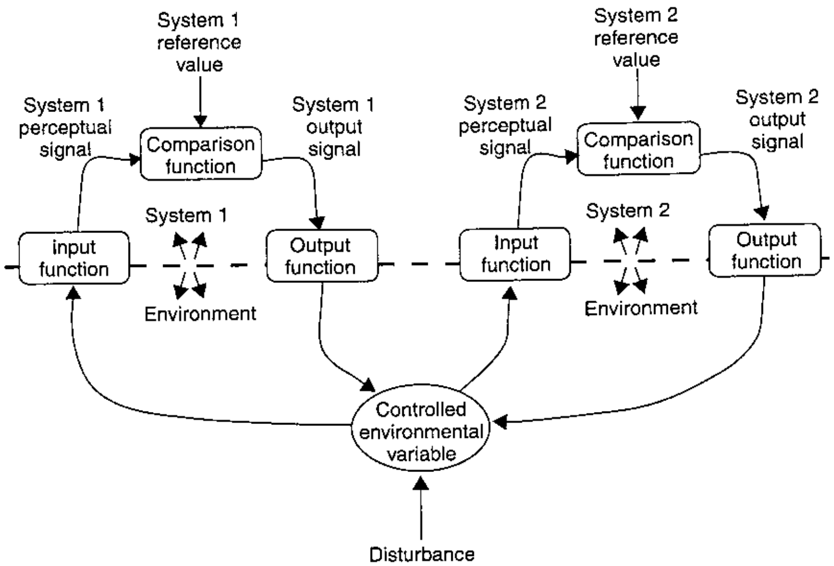

Figure 2.2 A Generic Model of a Collective Control Process.

is completed for both control systems by the feedback of the agent's actions through the *Controlled Environmental Variable*, which is also affected by the *Disturbance*. Although this model shows only two agents, in principle any number of agents, even thousands or millions, could be involved without affecting the mathematics of the simulation or leading to substantive differences in the findings.

My next simulation, figure 2.3, shows two control agents, modeled as in figure 2.2, working cooperatively on the same task. The simulation in figure 2.3 is identical in many respects to that in figure 2.1. The disturbance follows the same sine pattern as in the previous simulation, and the reference values for both agents are set at zero. In this second simulation, however, the task accomplished in the first simulation by one agent is now divided between two. The two agents in this simulation also differ from the agent in the first simulation and from each other in that they have been modeled as having different system *gains*, that is, different rates at which they move to correct perceived errors. The higher the gain of a control system, the more quickly it moves to correct errors and the tighter the control it exerts.[4] The agent in the first simulation was assigned a gain of 500, an arbitrary value that in an earlier study provided a reasonable replication of the results from a laboratory tracking experiment with a human subject (McClelland 2004,

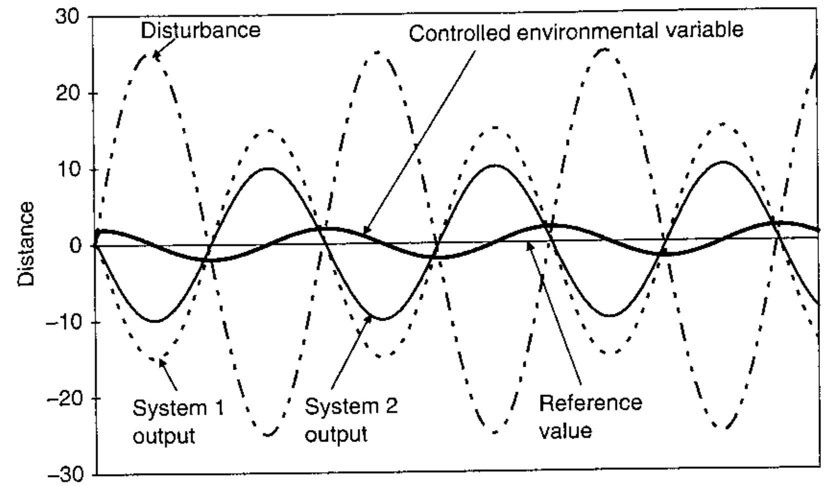

Figure 2.3 Simulation of Two Control System Working Together.

pp. 74–77). In the simulation shown in figure 2.3, Systems 1 and 2 have been assigned gains of 300 and 200, respectively.

The two control agents in figure 2.3 have been assigned different gains to make their output curves easily distinguishable: System 1, the higher-gain system, has greater output in both directions. Because the gains assigned to the two agents add up to 500, their outputs taken together add up to the same total output as was produced by the single simulated agent shown in figure 2.1. Furthermore, acting jointly (together with the random disturbance) the two agents have an impact on the environmental variable that is equal to that of the single agent in figure 2.1. A careful comparison of figures 2.1 and 2.3 shows that the curves for the *Controlled Environmental Variable* in the two simulations are, in fact, identical.

The principle illustrated by this simulation is that two or more agents working collectively can control a variable as effectively as a single agent can. Furthermore, when two agents are working together, neither has to work as hard as a single agent would. In technical terms, the system gains of the participating agents are additive, so that several low-gain systems working together can achieve control that is as tight or even tighter than that achieved by one high-gain system.[5] This finding accords with common sense when we relate it to a simple human task such as lifting a heavy object, in which two or more people generally prove to be stronger than one. Collective control processes, I will argue, can take on a variety of complicated forms in human social life, but the principle that collective control is more powerful than individual control almost always holds true.

In a previous article (McClelland 1994), I asserted that social power is generated by the alignment of reference values among people engaged in controlling the same perceptual variables. The simulation in figure 2.3 provides an example of perfectly aligned reference values: Both control agents make use of a reference value of exactly zero, and though they are individually "weaker" in terms of system gain than the single agent in figure 2.1, their collective control actions prove to be as powerful as those of the single agent. Perfect alignment of reference values, however, is by no means the rule in collective control processes. As McPhail, Schweingruber and Ceobann note (this volume), in many cases the reference values of actors involved in collective action are only "loosely coupled."

A series of simulations reported in McClelland (2004) explored the behavior of agents engaged in collective control processes in which the reference values are *not* aligned. The counterintuitive finding from those simulations was that, though agents with misaligned reference values engaged in collective control processes are by definition in conflict with each other, the misalignment does not necessarily reduce the level of control two agents can have over a shared variable in the environment.

Figure 2.4 provides an example of this conflictive control, in which two agents control their perceptions of a single variable but use different reference values. The disturbance pattern used in the simulation in figure 2.4 is the same as that used in previous simulations (figures 2.1 and 2.3), and the control agents are like those shown in figure 2.3, except that instead of agreeing on a reference value of zero, they use reference values that are slightly divergent: 1.0 for System 1 and -1.5 for System 2. Because the agents in this simulation are modeled as having relatively high system gain (300 for System 1 and 200 for System 2), even this small difference in their reference values leads to sharply diverging output curves, as System 1 soon begins to pull one way while System 2 pulls in the other. In comparing figure 2.4 to figures 2.1 and 2.3, notice that the vertical scale of the graph has had to be extended by a factor of five in each direction to accommodate the wide divergence in outputs; such divergence is a characteristic mark of control-system conflict.

Although the change in the vertical scale of the graph prevents it from being immediately obvious, the curve for *Controlled Environmental Variable* in figure 2.4 is precisely the same as in the earlier simulations. In this simulation the control exerted by two conflicting agents proves to be just as effective as it was in the earlier

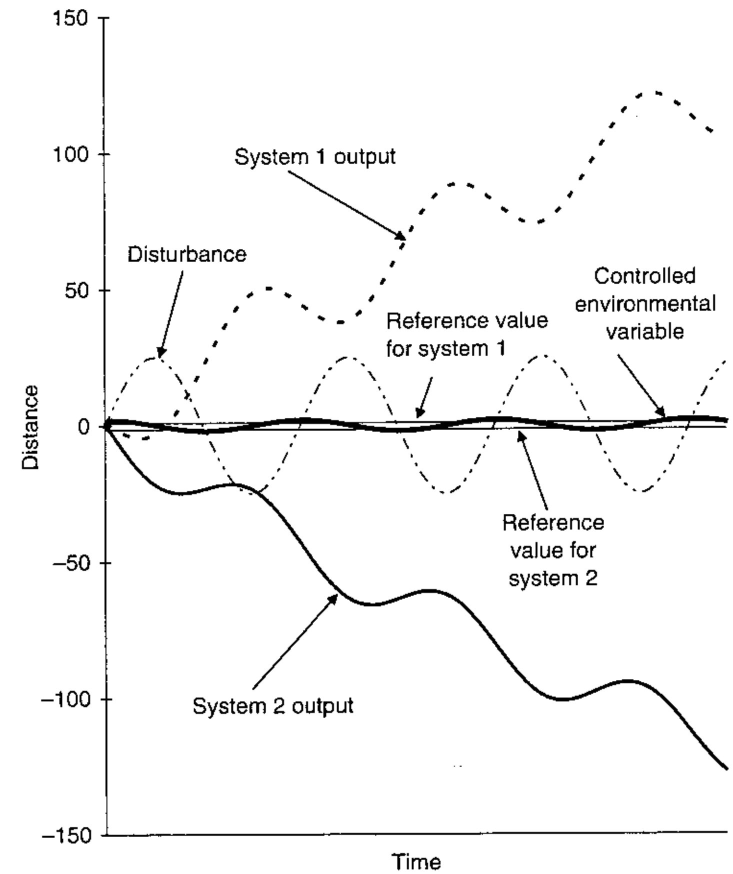

Figure 2.4 Simulation of Two Control System Working in Conflict.

simulation in which the two agents agreed on a reference value (figure 2.3). From the wavy pattern of output for both agents, one can see that, even as they tug in opposite directions, they are in effect cooperating to oppose the sine-wave pattern of disturbance. Whenever, in fact, the disturbance causes the environmental variable to begin crossing the reference line for one or the other of the agents, that agent temporarily reverses the direction of its output and pulls in concert with the other agent. The conclusion to be drawn from simulations such as this is that cooperation and conflict are not necessarily separate phenomena for interacting control systems. Contrary to my own prior assertions about the importance of alignment (McClelland 1994), collective control processes may occur without precise alignment of reference values of the people engaged in the control process. When the reference values of participants are not aligned, conflict inevitably occurs, as well, but these simulations demonstrate that conflict and control may take place simultaneously.

Reviewing the most important findings from this series of simulations reported here, I conclude that collective control processes can be expected to have the following characteristics:

1. The tightness of control will be proportional to the sum of the gain of all participating control systems. In human terms, to the extent that we can assume that the amounts contributed to a collective effort by any two human beings will be approximately equal, we can infer that the overall power of a collective control process will grow roughly in proportion to the number of participants.
2. A misalignment of the reference values used by the participating agents does not necessarily reduce the overall tightness of the collective control effort. In human terms, people who are cooperating in an action need not be in precise agreement about the reference values to be used in order to get things done.
3. Any misalignment of the reference values used by the participating agents inevitably results in some degree of conflict. In human terms, because there is no guarantee that reference values will be aligned, we can expect that most collective control efforts will involve, at minimum, an undercurrent of conflict.

Simulations reported in McClelland (2004) also explored the behavior of interacting control systems when they encounter limits to their output and when misalignments of reference values are brought back into alignment. Briefly, these simulations showed that, if limitations are imposed on the output of interacting agents, they may sometimes get caught in a deadlocked conflict, in which neither is able to establish control over the disputed variable. In a deadlocked conflict, as long as the value of the variable remains in the contested zone between their reference values, the variable simply follows the path dictated by disturbances, which in a situation such as this may include the actions of a third party to the dispute. The simulations also showed that when the reference values of two conflicting agents are brought back into alignment, the relaxation of overt conflict in their outputs happens at a much slower rate than the original divergence, so that conflicts between control systems typically escalate more rapidly than they diminish (pp. 82–86).

While these principles of collective control will in theory apply to all kinds of control processes, empirical examples of collective control

processes may often be much more complicated than my simulations would indicate. In particular, these simulations have dealt only with the control of perceptions of a scalar variable in a single dimension, whereas the hierarchical theory of perception put forward by Powers (1973, and see chapter 1 of this volume) suggests that interacting humans are capable of controlling many different variables in different orders of perception simultaneously. It is theoretically possible, for instance, that the intentions of participants in a control process may be conflictive at one level of perception but closely aligned at another. Such complex situations are beyond the scope of my simulations, but they indicate the complications that can arise as we turn to empirical applications of the principles of collective control.

APPLICATIONS OF A MODEL OF COLLECTIVE CONTROL PROCESSES

These simulations have provided simplified theoretical models of the ways that processes of collective control might be expected to unfold in human social life. But because of the considerable abstraction of the models and because of the unfamiliarity of thinking in terms of collective control processes, it may be difficult to imagine how such models can apply to concrete social situations. This section presents two contrasting case-study examples in which these models are used to reinterpret the findings of empirical studies done by other sociologists. My purpose is to suggest the potential utility of the collective-control-process perspective as a theoretical tool.

A study of conflict in a South Asian village (1994) by sociologist Beth Roy offers both a detailed examination of an episode of escalating conflict between two groups and a strikingly memorable image of the kind of conflictive stasis that can emerge from a deadlocked collective control process. In *Some Trouble with Cows*, Roy tells the story of a communal conflict in 1954 between Hindu and Muslim residents of an obscure village in the delta of the Ganges River in East Pakistan (now Bangladesh). Roy interviewed villagers, both Hindu and Muslim, who participated in an incident that began when a Muslim farmer's cows were eating the crops in the field of his Hindu neighbor, who retaliated by seizing the cows. Although accounts of the conflict differ in many details depending on the religious allegiances of the informants, all accounts agree that within a matter of days the conflict that began as *Some Trouble with Cows* had escalated into a massive confrontation between Hindus and Muslims, involving many thousands of men armed with primitive weapons such as swords and scythes. Some of the participants in the conflict came from the local community, which Roy calls Panipur, but others came from neighboring communities scattered for miles around. The episode ended abruptly when the police, who had been summoned to restore order, shot into the crowd and killed at least two of the combatants.

If we take Roy's richly detailed ethnographic account of the conflict in Panipur as an example of a collective control process, we note first that, as expected, the overall power exerted in the collective control effort intensified in proportion to the number of participants in the conflict. The incident started as a conflict between two neighboring farmers, but the number of participants on each side quickly grew, as relatives and friends from the two religious communities joined into the hostilities. When Golam Fakir, the Muslim farmer whose cows caused the trouble, went out to bring his cows home on the first night of the incident, he was confronted not just by Kumar Tarkhania, the Hindu farmer whose crop had been eaten that day, but also by several of Kumar's relatives, who announced that they had seized the cows and intended to keep them. Golam managed to free his cows and run home, and that night he recounted the story of the quarrel to his own kinsmen and several neighbors (1994, pp. 51–53). What started as a quarrel between two farmers had turned into a more serious incident involving groups of men on both sides.

The next day saw a series of increasingly serious encounters involving a growing number of participants, with Golam again tethering his cows near Kumar's field, Kumar and his family retaliating by taking the cows and tethering them where they could eat the crop in Golam's field, Golam protesting and getting hacked on the arm by a Hindu scythe, groups of Muslims seizing Hindu cows and vice versa, and even some hand-to-hand fighting (Roy 1994, pp. 53–56). During the second day, bands of Muslims and Hindus from neighboring villages began joining the fray. News of the fighting had quickly spread as messengers on both sides rode from place to place on horseback, carrying mikes and loudspeakers to broadcast their calls to arms (pp. 56–57, 67–68). Meanwhile, councils of village elders from both religious communities met among themselves and with local authorities to find ways to handle the growing disturbance (pp. 58–64). By the end of the second day of the confrontation and the start of the third, large numbers of men on both sides were involved. In line with the theory of collective control processes, as the number of active participants grew, so did the intensity of the conflict.

From a theoretical point of view, a second important observation is that this struggle for control over cows and fields exhibited the classic pattern of a twosided conflict, as was shown in figure 2.4: Each side's attempt to control their own perceptions by intensifying their output was matched by an intensification of opposing actions from the other side. The numbers of men gathering on each side appeared to be roughly comparable, and each aggressive action by one party was parried by a counterthrust from the other, so that no decisive action took place. By the end of day two, a stalemate was developing.

A third interesting point from a theoretical perspective is that although the conflict had two clearly defined sides, the participants on a given side were not necessarily well aligned among themselves in their reference values for the conflict. In fact, Roy's account suggests a considerable lack of alignment (1994, pp. 78–81). Roy describes how village leaders who had been inciting the villagers to resist were taken aback on the third morning, when they saw that their calls to action had attracted thousands of armed strangers. The leaders then began trying to mitigate the conflict, but without success. Although the Muslim leaders, and later the Hindu, as well, persuaded their followers to make a gesture of conciliation by releasing the cows they had seized, groups of Muslim men nevertheless advanced on the Hindu neighborhood, somebody set fire to a cow shed and a haystack at Kumar Tarkhania's farm, and thereafter the leaders "were not in complete control of events" (p. 81). Even Golam, the farmer whose cow started the trouble, had by this time lost his enthusiasm for the quarrel, but his own efforts to restrain the other Muslim fighters were unavailing. In Golam's words, as transcribed by Roy, "[T]hey paid no heed to what we said. They even came and tried to strike me with a weapon. They said they would murder me if I did not move out of their way" (p. 77). Thus, the ranks of the men on the two sides were far from unanimous in their determination to pursue the conflict—or putting it theoretically, much less than perfectly aligned in their reference values.

In analyzing a collective control process, one must ask what perceptions are being controlled, and the perceptions being controlled had evidently shifted by the third day of the conflict. What had started as a quarrel over cows and crops soon assumed symbolic importance for the participants as a struggle for dominance between the Hindu and Muslim communities. Roy describes how the recent political history of partition of India and establishment of the Muslim state of Pakistan encouraged local Muslims to begin asserting their rights vis-à-vis the Hindus, who during colonial days had been in majority and had the upper hand in their village as elsewhere in India, and she offers this interpretation of what Muslims were thinking:

> The ideological steps between cow-eats-plants and all-out war were plain to see on the Muslim side. They, both local Namasudras [low-caste Hindu farmers and fishermen] and caste Hindus, had oppressed us for years. We could not protest because they enjoyed protection from the state. Now the state is ours. It is our turn. Now we'll teach them a lesson. To translate power on a state level into power on a local level was the task of the day. (1994, p. 65)

In theoretical terms, the perceptions under control had shifted from a lower order to a higher order, in which the original pretext for the dispute had become merely a symbol for more abstract but more emotionally resonant and meaningful perceptions linked to group identity; it seems reasonable to assume that as more people become involved in a collective control process, the likelihood of higher-order perceptions becoming the focus of control will increase.

Assuming that one of the high level perceptions controlled by the Muslim participants was the extent to which their religious community should assert its claims to dominance, by the third day there was a clear disagreement between the community leaders, the groups of armed men, and individuals such as Golam over the reference value to be using. The control actions that emerged as a de facto consensus were more extreme than Golam and the village elders wanted, but their participation nevertheless lent force to the event, even if they disagreed to some extent with the others on their side. In spite of the misalignment of reference values, the increasing number of participants had increased the overall power of the collective control process to the point that the original participants themselves had very little leverage over subsequent events.

The conflict came to a climax in the middle of the third day, and the climactic episode provides us with a particularly striking visual image of a collective control process operating conflictively. Participants later described the event as a "riot," but, as Roy notes, by American standards it was a remarkably orderly riot (1994, p. 72). Thousands of armed men from each side staked out positions in a field and then sat down in long lines opposite each other in an "aggressive face-off" (p. 80). To quote Golam, "It was as if there were a canal, with two parties sitting on the two sides of it. A group sat on that side of the canal, a group sat on this side of the canal, and the space between them was empty" (p. 79).[6] Although there was some "chasing and counter-chasing" (p. 81), and some men were injured, nobody was killed, and the "main form of the battle was sedentary" (p. 80). This arresting image of intense conflict coupled with virtual immobility can serve as an apt metaphor in thinking about other conflictive control processes in which the forces arrayed against each other are almost equally balanced. The combination of high tension and relatively little change over time is exactly what theory would predict as the number of people involved in a collective control process goes up and the alignment of their reference values for the control effort goes down; historical examples of long-lasting entrenched conflicts are numerous, from the trench warfare of World War I to the cold war to conflicts in Northern Ireland and between Israelis and Palestinians.

The conflict that had started with the trouble over cows and had become deadlocked by the third day of hostilities did not go on indefinitely. By late afternoon on the third day, the police, who did not usually maintain a presence in small rural villages, had finally arrived on the scene, and the officer in charge gave the order to fire on the crowd if they didn't disperse at once. Accounts differed about exactly what happened next, but Roy's informants consistently reported that the police opened fire on the groups of combatants, and that at least two men, and perhaps as many as four, died (1994, pp. 96–101). After the shootings, the rioters quickly disbanded and went home. Roy notes that none of her informants blamed the police for having fired on the crowd, and she speculates that this abrupt ending to the conflict—before a bloody battle could be joined in earnest—had actually suited the purposes of the participants: "[T]he villagers had few options for how to bring the conflict to an end . . . [F]ood was running out and ponds were drained of water. Something had to give" (p. 102).

The quick end to this conflict through the intervention of the police illustrates the way that third-party actions can create disturbances that may determine the course of a conflict, especially when the conflict is deadlocked and neither side can by increasing its output decisively tip the balance. In this case the intervention of the police was evenhanded—they aimed their fire at men on both sides (Roy 1994, pp. 98–99)—and the conflict ended not because of police support for one side or the other but because combatants did not want to get shot. The important theoretical idea here is that people are controlling many perceptions simultaneously, and although at any given moment their focus of attention may be on maintaining control of just one perception, if control of that perception begins to jeopardize other perceptions that are more fundamental—in other words, higher in the hierarchy of control—attention shifts back to maintaining these more fundamental perceptions. The mere fact of engaging in a conflict with someone else does not necessarily create perceptual errors for an individual. If one is playing a competitive game, for instance, conflict is part of the fun, because it is integral to the perception that both parties are trying to experience. It is only when a conflict is internalized and begins to create incompatibilities within one's own perceptual hierarchy (if, for instance, you really want to win but are afraid of what might happen if your opponent loses) that perceptual errors occur. My argument, then, is that the intervention of the police into the escalating conflict over cows effectively ended the conflict by shifting attention away from the main perception being controlled—defense of the honor of one's own religious group—to other incompatible but equally compelling goals—such as maintaining a reference value of zero for being shot—which, when combined with additional sources of internal conflict—the shortages of food and water (Roy 1994, p. 102) and the perception that one's compatriots were abandoning the field—provided individuals with persuasive reasons for a quick retreat.

Roy's own theoretical interpretations of the riot in Panipur, though not informed by control systems theory, are in many ways compatible with the perspective offered here. Her book strongly emphasizes the autonomy of the individual actors in choosing to riot, in making communal decisions about what to do, and in understanding their local conflict in the wider context of national history and politics (1994, pp. 135–136). Reexamining her results with attention to collective control processes alerts us to the dynamic mixture of conflict and cooperation occurring simultaneously between and within the communal groups; helps explain the orderliness that emerged during this conflictive episode, even when the intentions of the participants were not well aligned; and shows how this episode of conflict in a seemingly exotic locale shares features that might be expected to occur in collective control processes anywhere else.

My second example is taken from Jack Katz's provocative book, *How Emotions Work* (1999). His study, like Roy's, offers a wealth of detail about the behavior of individuals in social interaction and thus provides readily accessible material for a control systems reinterpretation. In the chapter "Families and Funny Mirrors," Katz reports on an observational study of family interactions in a hall of mirrors at a French amusement park. Katz used an unobtrusive camera to videotape visitors to the fun house—usually family groups of adults and children—as they posed and laughed in front of mirrors that gave them back distorted images of themselves.

One sequence that Katz analyzes in detail involves a family of four, a father, mother, a school-age daughter, and a son about four years old.[7] The episode begins with the father and son standing in front of a mirror, and the father, repeatedly attempting to make the boy laugh, finally grabs the son under the arms and lifts him up so that they can both see the same image. The boy sticks his arms out straight as he is lifted. Quickly putting the boy down, the father sticks his own arms out in imitation of his son and at the same time calls for the mother and daughter to join the group (1999, pp. 101, 117). They arrive to see both father and son posed in front of the mirror with their arms out "like an airplane" (p. 117). With all four now gazing together into the mirror, the mother leads a chorus of laughter at the images they see. After their "collective act" (p. 118) of laughing in concert, they quickly move on to another mirror.

In interpreting this and the other episodes described in his chapter on funny mirrors, Katz argues that the impulse to laugh at a distorted image comes from the "dynamic tension" between the distortions seen in the mirror and the person's "presumptively normal identity" (1999, p. 91). By laughing, one implicitly rejects the perception of a distorted self in favor of a perception of oneself as normal. Katz's argument implies that the force of this rejection is enhanced when shared by another person and that family members, who can be assumed to know that one is not *really* like the image in the mirror, are particularly well placed to help resolve the tension by getting the joke and thus affirming one's normality (pp. 91–93). Katz sees families as doing more, however, than just having a good laugh together. He argues that the shared merriment can provide an opportunity to "construct the family as a spiritually vivid entity," producing "a powerful if tacit narrative about the family," and celebrating the "capacity of the family to make transcendent sense of the distorted images that the outside world makes of one's identity in everyday life" (p. 93).[8]

From a control systems perspective, Katz's presentation makes it obvious the individuals finding humor in their reflections in the mirrors are controlling a complex perception. In his words, the humor depends on perceiving the "juxtaposition" of the "conflicting images" of the relatively normal-looking person in front of the mirror and a grotesquely misshapen reflection. Katz reports that adults, like the father in the episode described above, often have to "work hard" to help young children understand the link between the curious shapes appearing in the mirror and the people standing in front. Until they "get it," very young children may just stare at the mirrors, "soberly absorbed" by the unusual shapes and movement (1999, p. 105).

Furthermore, Katz's evidence suggests that this perception of conflicting images becomes more powerfully funny when shared than when experienced independently. As Katz tells us, "People usually do not laugh alone" (1999, p. 93). He reports numerous examples of people summoning family members, like the father calling his wife and daughter in the example above, to come and look at a reflection. Vigorous laughter does not usually develop until the person succeeds in getting other family members to join in looking at the mirror (pp. 94–96, 120). Evidently, the power of the control process increases with the increasing number of participants, just as theory would predict.

In his interpretation of these episodes, Katz argues that a "presumption of shared viewing" is crucial to the experience (1999, p. 93). "Even when two people are 'with' each other, moving as companions to stop before the same mirrors at the same times, laughter typically will not emerge unless both can assume that they are observing the same reflection" (p. 94). He notes, however, that this assumption of "intersubjective seeing" is often problematic, since the images appearing in the mirrors can change drastically depending on one's angle of perspective (p. 97). A tall person and a short person looking together at the same curved mirror, for instance, may see entirely different images, and Katz offers several examples of an adult, like the father above, picking up a small child to establish a common eye level for the two of them (pp. 98–99). Katz goes so far as to assert that the problems created by differing perspectives ultimately make the presumption of shared viewing "a myth." In his comments on the episode of family laughter described in the example above, he concludes that "none of the members has firm grounds to assert confidently that all share the same focus" (p. 120), because a careful examination of the videotape record and written transcript reveals that the adults and children are looking at different things from different perspectives even as they laugh together (pp. 118–120).

In control-theory terms, before two people can share the same reference value for the relatively high-level perception that is involved in recognizing the incongruity between the reflection in the mirror and what a person is "really" like, the two people must also share the lower-level perceptions from which it is constructed—a perception of a distorted image in the mirror together with an idealized perception, in mind's eye perhaps, of the person's true essence. Family members can perhaps be assumed to agree in holding positive mental images of each other;[9] however, if they do not share the same perception of the distorted image in the mirror, then their sharing of the higher-level perception would be problematic. But as we have seen from the simulations, a lack of alignment in the reference value for a shared perception does not necessarily prevent a collective control process from going forward, though some degree of conflict between the participants inevitably occurs.

Katz's observations are interesting from this theoretical point of view, because he documents a variety of ways that the adult members of family groups appear to be trying to manage the conflicts in making sure that all are looking at the same "funny" thing. In addition to lifting children up so that they can share the grown-ups' view, adults try to tell children exactly what to see both by using words to describe the humorous images and gestures to indicate where and how to look (1999, pp. 97–104, 127). Katz also makes the intriguing suggestion that collective laughter can prove useful as a conflict-management tool, both because of its ambiguity and because of the way it tends to hamper the individual's ability to monitor others. Laughter is, as Katz puts it, "an expressive device that does not bother with the substantive content of language" (p. 113), so that "people can laugh at the right time and in a decorously fitting way even while they don't know what they are laughing about" (p. 114). Thus, laughter's ambiguity of reference can serve to make developing conflicts fuzzier. What is more, the bodily actions involved in laughter—the "noisy outbursts with rapidly jolted head movements" (p. 120)—can also make it harder to pay close attention to others' actions. In short, when people laugh together, misalignments matter less.

Theory also suggests that the misalignments in a collective control process can also be managed by the collective control of a higher-order perception. Katz, as noted earlier, makes the point that families at the fun house are doing more than just laughing together; through moments of shared laughter, he argues, families are building a sense of unity (1999, pp. 117–121). In theoretical terms, family members are collectively controlling a perception of family identity and belongingness, which is a yet higher-order perception than the perceptions involved in seeing humor in the comparison between the mirror's distorted images and the normal images of family members. At higher levels of the hierarchy, perceptions by definition become more complex, since they are assembled from combinations of lower-order perceptions, and the ways of satisfying their reference values, and thus of keeping the perceptions in control become more numerous. It also becomes increasingly difficult to tell what another person is really thinking, because the perceptions of such complexity and abstraction are harder to put into words. Finally, higher-order perceptions always unfold slower than the lower-order perceptions from which they are made up, and, consequently, the control of high-order perceptions tends to be intermittent. For all these reasons, conflicts emerging in higher-order collective control processes can often be ignored or temporarily papered over, and lower-order conflicts can sometimes be discounted by assuming the presence of a higher-order consensus, whether or not it is actually there.

Thus, family members of different ages posing and laughing in front of funny mirrors need not be seeing the same images in the mirrors in order to control their higher-order perceptions of belonging to a unified family. Moreover, their collective control process of "doing family" does not require absolute convergence in their reference values for how much unity their family should have. For most families, chances are good that the members may differ in how much togetherness they prefer. In theory, such misalignments must inevitably produce conflict, but with the slow pace of development of collective control processes involving high-order perceptions, the control process may go forward for a long time before the tensions become too noticeable. Moreover, if the family is functioning reasonably well over the long haul, memorable experiences of relative harmony, such as those in the fun house, may allow people to recalibrate their reference values in the direction of greater convergence, while the conflicts and tensions that are experienced may initiate in the individuals a process of perceptual reorganization that also increases the likelihood of convergence among family members.

These theoretical speculations move us considerably beyond the specifics of the episodes reported by Katz. Though his analysis has many other interesting details to offer, this brief review should be sufficient to indicate how one can reinterpret his findings to uncover collective control processes in operation. French families having fun in a hall of mirrors may seem worlds away from Bangladeshi farmers fighting over cows, but we have seen that essential principles governing collective control processes can apply in both settings. The striking contrasts between these two examples suggests that collective control processes may also be at work in numerous other social settings, and thus that an understanding of the principles of collective control may prove informative to social scientists with a wide variety of substantive interests.

DISCUSSION

This chapter has reviewed the principles of collective control processes, as revealed in a series of simulations in which independent control agents, modeled as negative-feedback control systems, control the perceptual input derived from a shared environmental variable in the presence of a disturbance factor. Some basic principles derived from these simulations—that the control efforts exerted by agents involved in a collective control process are additive, that the reference values used by the control agents need not be perfectly aligned, and that misalignments inevitably result in conflict between the agents—have been shown to be useful for reinterpreting results from two dissimilar studies of human interaction: an escalating dispute between Bangladeshi farmers and the clowning and laughing of French families in a house of mirrors. In both of these contrasting examples, we can identify collective control processes in operation, which lends weight to the conclusion that collective control processes may be widely distributed in other settings, as well.

While the simulation models and empirical examples presented here are intended to suggest the usefulness of the theoretical concept of collective control processes, the simulation models have been of the simplest kind, and much remains to be done to develop this elementary conceptual approach into a well-honed theoretical tool. For one thing, the models presented here deal only with the control of a single variable in one dimension. Further theoretical development of this approach will require the construction of models that show the operation of collective control processes in multidimensional perceptual fields. While many real-world controversies can be conceptualized as contests over just one variable—disagreements about how much money is owed, for instance—in many other cases the struggle may be for control of several variables at once, and single-variable models of such processes are clearly insufficient.

The idea of collective control processes in a multidimensional space raises an important conceptual point. *Alignment* in the context of these models can mean more than one thing. In a collective control process, the reference values used by participating parties may be aligned (or not), but misalignment is also possible in the perceptual variables being controlled by the different parties. Consider a collective control process that involves two variables and two parties, and imagine that the process takes place in what can be conceptualized as a two-dimensional space (a plane surface). Suppose that one party perceives and controls a variable in the east–west direction, while the other perceives and controls a variable in the north–south direction. No conflict will ever occur, whatever the reference values chosen by the parties, since the variables they are controlling are orthogonal. In effect, they are neither cooperating nor interfering with each other.

To the extent, however, that the variables perceived and controlled by the two parties are correlated, conflict becomes a possibility, as does cooperation, and the greater the correlation, the greater the chances both for conflict and for consolidation of effort. Thus, for intense conflict to occur the parties need to be controlling well-aligned variables but with misaligned reference values, while cooperation without conflict requires the alignment of both the variables to be controlled and the reference values to be used.[10]

Closely connected to the question of collective control in multidimensional perceptual fields is the challenge of building models of collective control processes that involve multiple levels of the perceptual hierarchy. The models presented in this chapter pertain only to a single order of perception, but in my analysis of empirical examples of collective control, I sometimes found it necessary to discuss multiple levels of perception, as when the conflict in Panipur shifted from the control of cows and fields to the control of the relative political positions of religious communities in the village, or as when families in the French fun house appeared to be controlling both the perception of gazing together at the images in the mirrors and the of perception of belonging to a family. Implicated in these multiple levels of perception were the processes of communication and persuasion, processes by which people seek to align their reference values for collective actions, and processes which are far beyond the scope of my simple simulation models. Thus, at this stage of theoretical development, constructing a detailed model that could encompass all of the various control processes occurring simultaneously in those examples remains a formidably challenging task.[11]

Nevertheless, the construction of complicated models such as these, with hierarchical levels of control over multidimensional perceptual variables, may be necessary for addressing some of the kinds of control discussed by the prominent sociological theorists enumerated in my introduction to this chapter. Take, for instance, the foundational concept of "control of resources" in James Coleman's rational choice theory (1990). In the framework of Coleman's theory (see Fararo 1993, pp. 295–297), a resource is a set of rights defined by some group of people with respect to some set of physical objects or human actions. To control a resource means to possess this set of rights, together with the right to transfer these rights to another person. In framework of control theory, however, the focal concept in this formulation—rights—turns out to be a perception relatively high in the perceptual hierarchy, while lower-level perceptions of objects or actions must also be modeled as part of the process. Given the fact

that conflicts over resources are pervasive in everyday life, readers of this chapter may be easily convinced that collective control processes must somehow be involved in the control of resources, but the task of constructing a multidimensional, hierarchical model to describe these processes will present future researchers with substantial theoretical challenges. Although Coleman described the exercise of control over resources as a "simple" type of action (1990, 32), it appears after all that the process is not so simple.

One additional challenge for the development of the theory of collective control processes is the construction of models that apply these principles at a more macro level. In terms of the theory, scale is irrelevant. Whether the control process operates at the level of a family, a small business, a community, a "million-man" social movement (see McPhail, Schweingruber, and Ceobanu, this volume), a national political party, or a multinational organization, the principles of collective control should remain the same. In fact, it may be easier to model applications of this theory to macro phenomena than to the smaller-scale settings that have been the main focus of this chapter. A perception that is shared by thousands of millions of people who are all participating in its control cannot be overly complicated. Public discourse is often conducted in simplistic terms, and many public controversies revolve around how far to go along some well-defined continuum. Thus, relatively simple models that focus on single-level perceptions and omit any detail about participating individuals may still provide an informative picture of these macro processes of collective control.[12] Whether we are looking at micro or macro settings, then, further development of the theory of collective processes holds promise for increasing our understanding of the inextricable linkage between conflict and cooperation in the creation of social order at many levels of the social world.

NOTES

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1. The control systems used in these simulations are described in the following mathematical model, with five variables and two constants:

   p The perceptual input signal for the system.
   r The reference signal for the system.
   o The output signal for the system, a function of the difference between r and p.
   v The value of an environmental variable which is affected by the output of the control system.

d The disturbance acting on the environmental variable, that is, the sum of all other environmental forces affecting v.
g The "gain" of the control system, a constant proportional to the speed at which the system corrects its perceptual errors. In the first simulation, g is set to 50.
s A constant "slowing factor" introduced to allow the accurate representation of a continuous (analog) process in the form of a discrete (digital) simulation. In these simulations, s = 0.001.

The simulation is iterative, calculating the values of all the variables in the system over 500 equal-time intervals from t = 0 to t = 500. Formulas for each of the variables at time t are as follows:

$p_t = v_{t-1}$

$r_t = 0$ [While r is a variable, it is set to zero in the first two simulations and reset to other constant values in the third.]

$o_t = o_{t-1} + s\{g(r_t - p_t)o_{t-1}\}$

$v_t = o_t + d_t$

$d_t = D$ [The disturbance used in the simulations reported here is a sequence of numbers representing sequential positions on a sine curve.]

The simulations in this chapter have been implemented using a *Microsoft Excel®* spreadsheet, available from the author on request.

2. Because a simple control model like the one used in this simulation acts only the basis of instantaneous differences between the model's perception of the variable and its reference value for the variable, the model has no "memory" of what has occurred previously. Thus, the model works in the same way whether the disturbance is patterned or completely random. If the disturbance were to vary too rapidly, however, as, for instance, if the disturbance were a jagged curve rather than a smooth one, the model would be unable to maintain control, and the simulation would show transient behavior rather than stable control behavior. Humans, of course, are assumed to have more complex multilevel control systems capable of controlling higher orders of perception, so that a person encountering a regularly patterned disturbance would be expected to remember and improve his or her performance by anticipating the pattern, or in other words, controlling a higher-order perception. However, like the control system modeled here, a person would be likely to lose control if the disturbance changed too abruptly. Robertson and Powers (1990, p. 21) describe a series of simple experiments that illustrate these principles of multilevel control.
3. In mathematical terms, if the output of agent j at time t is designated as o_{jt}, the common value of v at time t is computed as follows:

$$v_t = o_{1t} + o_{2t} + \ldots + d_t$$

In these simulations, each of the simulated agents makes use of this common value of the environmental variable v in computing the value of p for the next iteration. Otherwise, the systems use only their own previous values of variables and constants for the iterative computations. Thus, the link between the control systems in these interactional sequences is modeled as taking place entirely in the environment.

4. *System gain* is a term coined by engineers who developed radio amplifiers and other machines based on control systems models. For a discussion of how the concept of gain is used in psychological control systems models, see McClelland 1994, p. 474.
5. Another simulation, not shown here, uses a model identical to that in figure 2.3, except that both agents are assigned gains of 500, like the agent in figure 2.1. The collective control exerted on the environmental variable is proportionately tighter. Though still following a sine-wave pattern, the curve for the *Controlled Environmental Variable* deviates by no more than 1.0 units on either side of the reference value of 0.
6. Roy points out that canals are the only straight-line waterways in this river-delta countryside laced with meandering streams and river channels, where transportation from one village to another often requires a boat (1994, p. 40).
7. Katz calls this episode *T'es bellle* [*sic*] after one of the things said by the participants, which can be roughly translated as "You're bee-oo-tiful" (1999, pp. 108, 110–111, 117–121, 124, 126, 132–133).
8. In this chapter, Katz also examines what happens when individuals get carried away by the intensity of their laughter, experiencing a bodily shift, as Katz puts it, "from 'doing laughter' to . . . being 'done by' humor" (1999, p. 92). Throughout the book, Katz's overriding theoretical concern is to interpret emotional experiences from the point of view of a "phenomenology of the body" (p. 7) based on the works of Maurice Merleau-Ponty.
9. As Katz points out (1999, p. 106), however, the laughter can evaporate quickly if one family member remarks on seeing the other's reflection that the other really needs to go on a diet.
10. This discussion of alignment in reference values and variables controlled highlights the extent to which conflict and cooperation are inextricably linked. When cooperation is possible, so is conflict, and vice versa, and the theory suggests that most collective control processes will involve both.
11. Adding additional complexity to the challenge of constructing hierarchical models of collective control is the fact that the perceptual variables controlled may not always be scalar. At some levels of the perceptual hierarchy, a dichotomous (yes/no) variable describes the perception to be controlled. Marken's spreadsheet model of a hierarchical control system (1990) provides an example in which a higher-order variable is modeled as dichotomous.
12. Heise's chapter in this volume shows one example of how control systems models can be applied in macro settings.

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