Governing Social Bodies:

Affect and Number in Contemporary Cricket

Sivakumar V. Arumugam

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ABSTRACT

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Two recent cybernetics-derived academic disciplines, biomechanics and operations research, have worked to reshape cricket. Liberalization and the consequent large flows of money into the game have resulted in a transformation in how the game is regulated, coached, and played. In this dissertation, I have focused on how cricket is now being produced through an account of the use of biomechanics in the regulating and coaching of cricket and an appraisal of the role that operations research plays in regulating interruptions to individual games of cricket. I argue that these twin developments correspond to Foucault's notion of a contemporary governmentality organized around the body as machine and the species of body, respectively. A consideration of the manner in which cybernetics underpins these practices and theories broadens and deepens accounts of both how the contemporary world is continually being shaped and being studied.

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Chapter 1

Introduction

Cricket is an old sport. The basic form of the game stabilized in the early 18th century. A bowler bowls a ball towards a batsman who in turn tries to hit the ball away from the bowler's teammates—this is the micro-event at the core of any game of cricket. There have been a number of changes in the game and how it has been played, governed, and thought about over the last 300 years. Some of the changes in cricket since World War II can be traced to the imbrication of cricket with the exigencies and imperatives of modern markets. Denis Compton, a professional cricket player before and after the War, as well as a professional football player, was one of the first sportsmen to make a living from advertising—selling his image as a sportsman rather than just from playing sports itself. The compression of the game in time and space in the form of "one-day" cricket in England in the 1960's continued this connection between cricket and commerce. The game was structured to force a result within a single day as spectatorship for multi-day long cricket that often ended in draws dwindled. In the late 1970's, the media mogul Kerry Packer persuaded the Australian Cricket Board to award his television channel exclusive broadcasting rights to Australian cricket by constructing a set of parallel "rebel" national teams and instituting commercially successful games between them. This pattern has continued to the present day via the creation of the Indian Premier League. The monies involved in this league of

city-based franchises in India has enabled it to draw on new sources of cricketing talent both within India and around the world.[1]

In this dissertation, I track some recent changes to how this international game is coached, played, and governed. I will demonstrate that two relatively new cybernetics-derived sciences—biomechanics and operations research—have been applied to cricket since the 1990's. Both sciences have reshaped the regulation of games of cricket. Biomechanics is now woven into the regulation of what counts as "bowling" as well changing how bowlers are coached. And an Operations Research formula that purports to be fair and predictive of results is used to determine the outcome of interrupted one-day games. I will suggest that tracking these particular changes lends some insight into two concepts of some interest in anthropology—affect and number. Insofar as cricket is both a part of the contemporary world and a simulacrum of it, similar processes may be occurring elsewhere.

Cricket in an era of globalization, with India at its center, has been transformed. A much shorter version of the game tailored for evening television viewing has been heavily promoted. Various aspects of the game have been standardized, with the ICC providing the mechanism to enforce those standards. An international league has been instituted to measure national teams' success

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[1]For a recent account of some of these changes, see K.R. Guruprasad (2011).

against one another in the traditional five day form of the game that aligns with a "World Cup" involving play of the short, one day long, form. Such measures have been designed to increase audience sizes in India and around the world. The resulting increase in revenue to all members of the ICC—although it is worth noting that only the cricket boards in India, Australia and England actually make a profit, which is used by the ICC to subsidize the other boards—have in turn been invested in increasing the competitiveness of the individual national teams. Training academies for cricket players now specialize in breaking down playing techniques into series' of minute bodily gestures through computer analyzes of video images. Such televisual technologies, adopted from the visualizations made available to audiences, have made the efficiency of cricket players' bodies rather than individual playing style of overwhelming concern within India and around the world. Furthermore, a concern over increased efficiency, in particular, of overseeing players' physical fitness, has led national teams to replace their system of ad-hoc hiring of players match by match to a contracting of players on an annual basis. Moreover, the laws of cricket have also been reformulated around advances in the statistical analysis of cricket. These new technologies, I argue, collectively make available a novel form of governmentality—or the conduct of conduct—in cricket.

1.1   Science studies and constructivism

Studying the deployment of science in cricket suggests a science studies approach. Science studies as such, as a not quite stable broadly defined discipline in its own right, is part of the story that I think unfolds in cricket. I suggest in chapter 4 that science studies shares a certain similarity to what, after Margaret Mead, came to be called second-order cybernetics, or the study of the engagement of observers of a cybernetic system with that very system. Making that connection between cybernetics and science studies, and a connection between cybernetics and important recent concepts in anthropological theory, does not, however, reduce the latter to the former. Much as demonstrating that something social is constructed does not imply that the writer thinks it ought not to have come into being or could cease to be, suggesting that these connections exist does not by itself undercut the usefulness of cybernetics, science studies approaches, or indeed certain theories of affect and number.

In *The Social Construction of What?* (Hacking 1999), Hacking asserts four theses about social construction work, listed together here:

    0 In the present state of affairs, *X* is taken for granted; *X* appears to be inevitable (Hacking 1999, 12).

    1 *X* need not have existed, or need not be at all as it is. *X*, or *X* as

it is at present, is not determined by the nature of things; it is not inevitable.

2 *X* is quite bad as it is.

3 We would be much better off if *X* were done away with, or at least radically transformed (Hacking 1999, 6).

Hacking suggests that this list comports with grades of (this time, unenumerated) least-to-most demanding varieties of constructivism:

- Historical

- Ironic

- Reformist; Unmasking

- Rebellious

- Revolutionary (Hacking 1999, 19)

It is easy to see the correspondence between these two lists. If only condition (0) obtains, one is most likely an historical constructivist, if (0) and (1) obtain together, one is likely an ironic constructivist and so on, in Hacking's schema.

The point behind these grades of constructivism comes out in his writing on the "science wars." Hacking assumes a disagreement between two parties: con-

structivists and scientists. He lists three "sticking points" between these adversaries. The first concerns the *contingency* of scientific theories. Hacking notes, for example, that Andrew Pickering, in *Constructing Quarks* (Pickering 1984), "holds that the evolution of physics, including the quark idea, is thoroughly contingent and could have evolved in other ways" (Hacking 1999, 31). Here Hacking inserts an empirical claim: "Most physicists, in contrast, think that the quark solution was inevitable. They are pretty sure that longstanding parts of physics were inevitable" (Hacking 1999, 31). The second sticking point concerns classification. Hacking argues that "[c]onstructionists tend to maintain that classifications are not determined by how the world is, but are convenient ways in which to represent it. They maintain that the world does not come quietly wrapped up in facts. Facts are the consequences of ways in which we represent the world" (Hacking 1999, 33). The third, and last, sticking point, concerns the stability of scientific theories. Hacking suggests that "[c]ontrary to the themes of Karl Popper and Thomas Kuhn, namely refutation and revolution, a great deal of modern science is stable. . . Scientists think that the stability is the consequence of compelling evidence. Constructionists think that stability results from factors external to the overt content of the science" (Hacking 1999, 33).

Hacking's empirical claims aside, his account of the three sticking points be-

tween the two groups—scientists and constructivists—makes clear his own understanding of constructivism. The first sticking point, contingency, and the third, stability, are closely related. His argument appears to be that constructivists are wedded to the claim that scientific theories could have been and could be otherwise. This puts them, according to the schemas listed above, in line with thesis 1, matched to an ironic constructivism. These are the minimalist claims of the constructivist side of the science wars. On the other hand, Hacking commits "scientists" to an very strong claim with regard to putative findings in science, and does so explicitly. He states, for example, that "Maxwell's Equations, the Second Law of Thermodynamics, the velocity of light, and lowly substances such as dolomite are here to stay" (Hacking 1999, 33). The extravagance of this claim does not lie in Hacking asserting that some theories are sometimes held to be beyond dispute, but rather in his assertion that some theories will never be disputed. The second of the sticking points is where the real point of this grand claim lies. He argues with regard to practices of classification that they "do not exist only in the empty space of language but in institutions, practices, material interactions with things and other people" (Hacking 1999, 31). However, people—in his example, "individual women refugees"—"can become aware of how they are classified and modify their behavior accordingly." By contrast, quarks "do not form an inter-

active kind" for "[q]uarks are not aware that they are quarks and are not altered simply by being classified as quarks." This, he holds, "forms a fundamental difference between the natural and the social sciences" (Hacking 1999, 32).[2]

This is in fact the "fundamental difference," not between Hacking's scientists and constructivists, but rather between Hacking's and Bruno Latour's accounts of constructivism itself. In "The Promises of Constructivism" (Latour 2003), Latour treats, as he does elsewhere (Latour 1993), science as a parliamentary process. He notes, regarding Hacking's four theses, that "[a]lthough it is an important step forward to reveal the inherently political nature of the argument, Hacking's gradient is too asymmetric. . . he says nothing of the politics of those who should be called 'naturalists,' namely those who need this implied stage -1, which allows for X to be there as a permanent fixture of nature" (Latour 2003, 37). This gives a position to those who wish that particular theories be taken to be beyond (political) dispute. Latour offers, in replacement of Hacking's schema, a series of guarantees meant to placate all participants in the science wars. First, for any given X of Hacking's, "once there, and no matter how it came about, discussion about X should stop for good." Second, "in spite of the indisputability insured by the former, a revision process should be maintained, an appeal of some sort, to

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[2]See also, "Inaugural lecture: Chair of Philosophy and History of Scientific Concepts at the Collège de France, 16 January 2001" (Hacking 2002)

make sure that new claimants. . . will be able to have their voices heard" (Latour 2003, 38). Third, "the common world is to be composed progressively; it is not already there once and for all." Fourth, "humans and non-humans are engaged in a history that should render their separation impossible" (Latour 2003, 39). And, fifth, "institutions assuring due process should be able to specify the quality of the 'good common world' they have to monitor" (Latour 2003, 40). The last guarantee appears to form the core of Latour's argument about constructivism. He suggests that the dispute that matters is one over whether any given *X* is *well* constructed or not; rather than whether it *is* constructed or not.

Latour makes use of the metaphor of building construction, of architecture, to bring out this aspect of constructivist arguments. He notes that, the authorial claims of architecture notwithstanding, "architects' stories of their own achievements are full of little words to explain how they are 'led to' a solution, 'constrained' by other buildings, 'limited' by other interests, 'guided by the inner logic of material,' 'forced to obey' the necessity of place, 'influenced' by the choices of their colleagues, 'held up' by the state of the art, and so on" (Latour 2003, 31). Further, even this implied notion of constraint is misleading: "What is interesting in constructivism is exactly the opposite of what it first seems to imply: there is no maker, no master, no creator that could be said to dominate materials, or, at

the very least, a new *uncertainty* is introduced as to what is to be built as well as to who is responsible for the emergence of the virtualities of the materials at hand" (Latour 2003, 32). Whereas Hacking "does not want peace between construction- ist and scientist" but rather "a better understanding of how they disagree, and why, perhaps, the twain shall never meet" (Hacking 1999, 31), Latour seeks here to elucidate a constructivism adequate to the peace. The notion of uncertainty is crucial to Latour's understanding of constructivist arguments. It is this which allows him to make central the question of how *well* constructed an object is.

In "Why Has Critique Run out of Steam?" (Latour 2004), Latour gives ex- amples of constructivist arguments put forward for politically conservative, not revolutionary, purposes. Constructivist arguments, in other words, that even fall out of Hacking's conceptual grid. He notes a *New York Times* quote of a Republi- can strategist talking about global warming arguments: "Should the public come to believe that the scientific issues are settled... their views about global warming will change accordingly. Therefore, you need to continue to make the *lack of scien- tific certainty* a primary issue" (Latour 2004, 226).[3] Latour notes that the problem would appear to be no longer "coming from an excessive confidence in ideological arguments posturing as matters of fact... but from an excessive *distrust* of good matters of fact disguised as bad ideological biases!" (Latour 2004, 227) Rather,

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[3]The quote is from the *New York Times*, 15 March, 2003, A16.

constructivism, and with it critique, ought be directed at how well constructed particular objects are. Latour notes, from Heidegger, the etymology of the word "thing": "We are now all aware that in all European languages, including Russian, there is a strong connection between the words for thing and a quasi-judiciary assembly" (Latour 2004, 232-233). Thus, a "thing is, in one sense, an object out there and, in another sense, an *issue* very much *in* there, at any rate, a *gathering*" (Latour 2004, 233). The combination of uncertainty and the relation between objects (things) and parliamentary process allows Latour to mount a successful argument against Hacking's postulation of a difference between nature and social, and natural and social sciences. Hacking's looping effects argument—that natural objects cannot know that they have been named and therefore possibly behave differently—depends on a prior disjunct between the natural and the social. It is this disjunct that a consideration of "things" makes impossible. Latour suggests that the Whiteheadian refusal to force a disjunct between the natural and the social "is an entirely different attitude than the critical one, not a flight into the conditions of possibility of a given matter of fact, not the addition of something more human that the inhumane matters of fact would have missed, but, rather, a multifarious inquiry launched with the tools of anthropology, philosophy, metaphysics, history, sociology to detect *how many participants* are gathered in a *thing*

to make it exist and to maintain its existence" (Latour 2004, 245-6).

Latour's analysis of various natural scientists at work certainly seems congruent with this take on "things" and how they are constructed. This is precisely the approach I undertake here. In this framing, cricket is a thing that gathers together a set of multi-disciplinary endeavors. Telling the story of science in contemporary cricket is to unfold a set of connections between cybernetics-derived disciplines and anthropological theory.

1.2 Cybernetic things and governmentality

Aihwa Ong has suggested that neoliberalism is "a new mode of political optimization" and that it is "reconfiguring relationships between governing and the governed, power and knowledge, and sovereignty and territoriality" (Ong 2006, 3). Ong notes that neoliberal forms of reasoning have two different elements to them: "both economic (efficiency) and ethical (self-responsibility) claims" (Ong 2006, 11). And Ong argues that neoliberal governmentality as a "political technology centered on the management of life oscillates between two poles of development," with one pole centered, quoting Foucault, on "the body as a machine: its disciplining, the optimization of its capabilities, and the extortion of its forces"[4]

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[4]Quoted from Foucault (1978, 37).

and the other pole centering on "the species body as biological machinery and a basis of collective well-being and reproduction" (Ong 2006, 13).

But if Foucault can be situated within the cyborg sciences, as Hacking has suggested (Hacking 1998), then one pressing question that Ong does not attend to concerns the kind of critical work that can be carried out when tracing the impact of neoliberalism on contemporary forms of governmentality using a theory that may itself be closely related to neoliberalism. Put slightly differently, could it be that neoliberalism, as ism, consists precisely in the reordering of elements between the two poles of "the species body" and "the body machine"? What might now count as an element of the species-body rather than the body-machine?

Political scientists working on India have recently framed liberalization as a shift from a centralized interventionist state to a decentralized regulatory state (Kohli 2001). This framing dovetails nicely with anthropological and historical work on the effects of 19th century and early 20th century colonial governmentality on the political present. In the Indian context, it has been argued that governmentality may have superseded popular sovereignty as providing the grounds for a democratic politics (Chatterjee 2004). Certainly, a decentralized regulatory state would have to rely upon the disciplinary effects of already present norms to maintain rule. Taking this argument further, however, would require an in-

vestigation of the ways in which such norms unfold through the body (Foucault 1977, Foucault and Rabinow 1997). Without this crucial step, an accurate understanding of how norms produce and reproduce themselves in a regulatory state is impossible. I will examine the processes through which changes in bodily cricket practices and their regulation make possible a different understanding of the conduct of individual bodies in the contemporary world.

I argue in this dissertation that the science biomechanics speaks directly to what Foucault called the "body as machine." I found in the field that biomechanics is now an integral part of the coaching of fast bowling in cricket. It plays a role in both injury prevention in bowling and a role in optimizing that bowling in cricket matches. In addition, it has come to play a crucial role in regulating the controversial question of "throwing" in cricket.

The usual, longer, form of the game often ends in a draw, however one-day cricket matches are designed to produce a result. I suggest that the discipline of operations research is vital in understanding the connection between what Foucault referred to as "species bodies" and the problem of how to force a result out of a game of one-day cricket that is incomplete. The operations research model that two scholars—Frank Duckworth and Anthony Lewis—derive has been presented by them as a fairer because scientific alternative to the previous attempts

at a "rain rule" that all depended on various cricketing rules of thumb. It works by probabilistic prediction of what a team would have scored if play had not been interrupted, and was very quickly taken up by the International Cricket Council (ICC) as a necessary part of all international one-day cricket games.

1.3   Cybernetics and theory

Norbert Wiener coined the term "cybernetics" to describe the work that he and others had been doing during World War II and shortly afterward. He was of course an important participant in the Macy Conferences after the war that forms a crucial moment in the development of cybernetics. Here I focus on the conceptual moves that Wiener makes in connecting together cybernetics on the one hand and what became later the disciplines of biomechanics and operations research. There is in addition an important overlap for him between cybernetics and developments in economics during and after the war. Wiener chose the Greek term for steersman in part to honor the work by Clark Maxwell in 1868 on governors (Wiener 1948, 11). The feedback mechanism with ship tillers and steam engines alike were, for Wiener, a crucial feature of what he called control and communication in the animal and machine. Feedback enables the twining together of control and communication. Wiener notes on several occasions in his two popular books

on cybernetics (Wiener 1948, 1954) that there were several precursors to the basic concepts underlying this constellation of theories and practices. They tied together several existing academic disciplines, including anthropology, physics, biology, and psychology. However, his own research interests would later fall under entirely new disciplines, in particular biomechanics, operations research, and computer science.

The specific project that Wiener first worked on during the war concerned the automation of anti-aircraft artillery. He presented the problem as one involving the closing of a gap between the speed of the airplane and the shells shot at them: "unlike all previously encountered targets, an airplane has a velocity which is a very appreciable part of the velocity of the missile used to bring it down," from which it follows that it is necessary to "shoot the missile, not at the target, but in such a way that missile and target may come together in space at some time in the future" (Wiener 1948, 5). Wiener's example of steering a ship makes the connection between feedback and a predicting of the future particularly clear. Separately from the problem of any evasive action a pilot might take—subject to the plane's capacities—the underlying issue is that correcting the course of a ship-as-gun to match exactly, say, a compass reading, will not work well because the ship's direction will overshoot the intended compass reading. Correcting that

mistake in turn and so on may result in the ship continually yawing from side to side. What is needed and indeed used, Wiener suggests, is a mechanism that "carries the reading of the wheel to an offset from the tiller, which so regulates the values of the steering engine as to move the tiller in such a way as to turn these valves off." Such an arrangement has the important feature of being a "feedback system [that] tends to make the performance of the steering engine relatively independent of the load" (Wiener 1948, 7).

The twining together of control and communication in such machines on the one hand and in the human body on the other is immediate for Wiener. He moves directly to an account of him reaching out to pick up a pencil. He notes first that perhaps only experts in anatomy might have an account of the muscles and the correct sequences of those muscles firing required to do this. Moreover, that knowledge alone would not make a conscious decision to fire particular muscles in sequence possible: "On the contrary, what we will is *to pick the pencil up*. Once we have determined on this, our motion proceeds in such a way that we may say roughly that the amount by which the pencil is not yet picked up is decreased at each stage" (Wiener 1948, 7). Visual and proprioceptive signals as to success or failure of the act to reach for the pencil themselves inform further attempts to close the gap between hand and pencil. As Wiener notes, "[t]he central nervous system

no longer appears as a self-contained organ, receiving inputs from the senses and discharging into the muscles. On the contrary, some of its most characteristic activities are explicable only as circular processes emerging from the nervous system into the muscles, and re-entering the nervous system through the sense organs, whether they be proprioceptors or organs of the special senses" (Wiener 1948, 8).

Wiener and his collaborator Julian Bigelow approached another Macy participant, Arturo Rosenblueth, to ask if that is "any pathological condition in which a patient, in trying to perform some voluntary act like picking up a pencil, overshoots the mark, and goes into an uncontrollable oscillation?" The affirmative answer, which Wiener reports as "purpose tremor" associated with brain injury led to a jointly written paper between all of them titled "Behavior, Purpose, and Teleology" in the journal *Philosophy of Science* (Rosenblueth et al. 1943). A number of the key concepts Wiener introduces here—feedback, the twining of control and communication, and purpose tremors through failed proprioceptive acts—came to form, I will argue in the next two chapters, key determinates of the attempt to use biomechanics in cricket.

In addition to his interest in the connections between his mathematical work on cybernetics and the nervous system of humans and animals, Wiener also

thought deeply about control and communication at the level of human social being, whether in terms of local interactions with machines in, say, a factory, or across society taken as a whole. Whereas feedback was the key concept in Wiener's examination of individual machines and bodies, *information* and *entropy* were the concepts that linked together those concerns with a cybernetic understanding of society as a whole. Wiener argues that entropy is a measure of disorganization and that the information contained in some messages is the inverse of this: "In fact, it is possible to interpret the information carried by a message as essentially the negative of its entropy, and the negative logarithm of its probability. That is, the more probable the message, the less information it gives. Clichés, for example, are less illuminating than great poems" (Wiener 1954, 21). Wiener, of course, held to the theory that entropy in any given closed system increased over time—what is known as the second law of classical thermodynamics. On the question of what counted as "life," then, Wiener suggested that one might include "all phenomena which locally swim against the current of increasing entropy," even though this would include both certain machines and, for example, astronomical phenomena not thought to be in that category. Wiener reinforces those questions by in fact trying to avoid them in writing that it would be "best to avoid all question-begging epithets such as 'life,' 'soul,' 'vitalism,' and the like,

and say merely in connection with machines that there is no reason why they may not resemble human beings in representing pockets of decreasing entropy in a framework in which the large entropy tends to increase" (Wiener 1954, 32). The very idea that *information* ties together life and machine, invites the notion that society itself is a cybernetic machine, one filled up with all manner of feedback mechanisms that invite the kinds of analysis that individual lives and machines already engender.

Part of the wild popularity of his book lies in the deep skepticism Wiener introduces with respect to the possibilities of the application of cybernetics to society. After noting a considerable wariness with respect to the belief "elevated to the rank of an official article of faith in the United States, that free competition is itself a homeostatic process" (Wiener 1948, 158), Wiener went on to warn against both anarchy, through too many active anti-homeostatic social processes, and the active social enforcement homeostatic processes of the small community (Wiener 1948, 160). The underlying problem is that unlike friends with "hopes… for the social efficacy of whatever new ways of thinking this book may contain," (Wiener 1948, 162) Wiener suggests that "whether our investigations in the social sciences be statistical or dynamic—and they should participate in the nature of both—they can never be good to more than a very few decimal places, and, in

short, can never furnish us with a quantity of verifiable, significant information which begins to compare with that which we have learned to expect in the natural sciences" (Wiener 1948, 164).

The central difficulty, Wiener argues, is that social systems both change as they are investigated and change because they are investigated—"[w]e are too much in tune with the objects of our investigations to be good probes" (Wiener 1948, 164). Feedback processes working at the level of an entire society work against the application of cybernetics because the investigation itself may cause society to change. The point is not that society changes at all, but rather that it may change even before a determined attempt to effect change that comes after a complete investigation. Wiener's denial of this possibility—the application of cybernetic principles to the study of society—underscores precisely that such an application was conceivable. Philip Mirowski has written about the deep influences that these cybernetic principles have had on macroeconomics. As I will make clear in chapter 4 operations research as a discipline has also come to be applied to cricket. Its roots are in military logistics and strategy (Shrader 2006), but it quickly found a secure academic home when it was applied to business practices—the paradigmatic study is of the operations of factories, including perhaps especially the *management* of the people operating in that factory (Gass and Assad 2005).

Hacking has argued, in fact, that Georges Canguilhem had already developed an approach that might be properly construed "cyborg" in an essay by Canguilhem titled "Machine and organism." Hacking notes that Canguilhem "passed from the thought that there is 'no difference between teleology and mechanism' to a more sweeping statement, that 'tools and machines are kinds of organs and organs are kinds of tools and machines.' " (Hacking 1998, 204) And, further, that "he wants us to take seriously the idea that machines too are extensions of the body" (Hacking 1998, 207). It is this move, argues Hacking, that makes Canguilhem an anti-Cartesian; for Descartes, the body is a mechanical device, as are animals: contrawise, "Canguilhem held that...tools and machines extend the body. They are parts of the living organism, not parts with which it was born, but parts which it has made." Hacking notes, parenthetically, that those "who want to know where Bruno Latour and other present-day French iconoclasts are coming from, may want to read more Canguilhem" (Hacking 1998, 205). Canguilhem was, of course, deeply influential to both Deleuze, Foucault, and numerous others.

Donna Haraway's "A Cyborg Manifesto" represents the first serious attempt to think through the implications of Norbert Weiner and others' work on cybernetic organisms. Her central premise is that "[b]y the late twentieth century, our

time, a mythic time, we are all chimeras, theorized and fabricated hybrids of machine and organism; in short, we are cyborgs." Where, a "cyborg is a creature in a post-gender world; it has no truck with bisexuality, pre-oedipal symbiosis, unalienated labour, or their seductions to organic wholeness" (Haraway 1991, 150). Positing this mythic time of the cyborg is, of course, a political move: "Cyborg politics is the struggle for language and the struggle against perfect communication, against the one code that translates all meaning perfectly, on the central dogma of phallogocentrism" (Haraway 1991, 176).

One consequence of Haraway's work, her bringing to attention the possibility that "[o]ur dominations don't work by medicalization and normalization any more; they work by networking, communications redesign, stress management" (Haraway 1991, 245, n. 4) is Philip Mirowski's *Machine Dreams: Economics Becomes a Cyborg Science* (Mirowski 2002). Mirowski takes up the metaphor of the cyborg and suggests that "[e]conomists were present at the creation of the cyborg sciences, and, as one would expect, the cyborg sciences have returned the favor by serving in turn to remake the economic orthodoxy in their own image" (Mirowski 2002, 6). He defines "cyborg sciences" around the "existence of the computer as a paradigm object for everything from metaphors to assistance in research activities to embodiment of research products" for cyborg science "makes

convenient use of the fact that the computer straddles the divide between the animate and the inanimate, the live and lifelike, the biological and the inert, the Natural and the Social, and makes use of this fact in order to blur those same boundaries" (Mirowski 2002, 13). One of the most important consequences of this is, according to Mirowski, that of the "pervasive influence of the cyborg sciences in modern culture, which is to treat 'information' as an entity that has ontologically stable properties, preserving its integrity under various transformations" (Mirowski 2002, 16). The general argument that Mirowski provides in this text is that the cyborg sciences, so construed, were not by any means stumbled upon, but rather that cyborg science is "Big Science par excellence, the product of planned coordination of teams with structured objectives, expensive discipline-flouting instrumentation, and explicitly retailed rationales for the clientele" (Mirowski 2002, 17). The result is that "quotidian distinctions automatically made by almost all Western writers between physics, biology, psychology, and economics are rather unavailing," and, further, that "comprehension of the trajectory of any one of these disciplines requires one to transgress the boundaries of the others with the same abandon and impudence as the cyborgs themselves" (Mirowski 2002, 29).

Mirowski construes the development of the cyborg sciences as springing from thermodynamics' "destruction of the previous clockwork conceptions of order

that had been part and parcel of the eighteenth-century world view"[5] (Mirowski

2002, 43). In particular, the notion of entropic decline, that "we were stuck in

natural circumstances that inexorably running down" seemed to require "some-

thing like 'intelligence' [that] stands as a bulwark against the inexorable grind

of entropic dissolution." Mirowski suggests that Norbert Weiner's invention of

the term cybernetics arose from his asking "[i]f mankind is endowed with this

new kind of 'intelligence,' this ability to process information about the world,

then why wouldn't it also be the case that Nature also possessed that capacity?"

(Mirowski 2002, 44) Alan Turing plays a central role in Mirowski's argument

about such a notion of intelligence—one that makes sense of entropic decline,

but is not unique to humans. Mirowski suggests that Turing, building on Kurt

Gödel's argument that any sufficiently interesting axiomatic mathematics cannot

be rendered decidable, went on to think along these lines: "if man is really a

machine, then we can provisionally equate undecidability with 'noise' and pro-

vide a formal account of what is decidable in mathematics by 'concentrating' our

attention on algorithmic mechanical thought" (Mirowski 2002, 80). It is in this

context that Turing infamous "imitation game," now usually known as the "Tur-

ing test" paves the way for cyborg science theories. Mirowski notes that Turing

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[5]On the role that thermodynamics plays in neoclassical economics, see Mirowski (1989).

wrote his article[6] in direct argument against Michael Polanyi's positing of a tacit knowledge beyond the possibility of systemization by military science and planning (Mirowski 2002, 85, n. 55). That the Turing test is passable is obvious for Turing himself, given his use of Gödel's schema in his own proof that all computers are computationally equivalent to one another: if humans are computational machines, and all such machines are equivalent to one another, then clearly an appropriately programmed machine should be able to pass the test.

Mirowski quite correctly emphasizes that these developments make possible, and comport well with, what he calls methodological cyborgism: "[t]he physically intact and cognitively integrated seat of autonomy—the cohesive locus of responsibility—is rapidly giving way to the heterogeneous and distributed jumble of prostheses, genes, hybrids, hierarchies, and parallel processors" (Mirowski 2002, 441). Mirowski's central historical insight connecting cyborg sciences with the theorization of the cyborg as such is that the "postmodernists who wrought... havoc within the house that solid bourgeois virtues built... was itself an effluvium of intellectual innovations bubbling to the surface from the cyborg sciences, that is, originating in the *natural* sciences and their collateral pursuits" (Mirowski

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[6]Outlining a test for computerized intelligence that revolved around whether contestants communicating through a teletype device to two others might reliably ascertain the genders of the participants responding through the device. If a computer replaced one of the responders and yet managed to "win," i.e. simulate being male or female reliably, that would count as a demonstration of computer intelligence.

2002, 448). Thus, Haraway's and others' work on the cyborg has enabled Mirowski to pull together a history of developments in early twentieth century mathematics, Operations Research during World War II, the birth of the computer, and the role of game theory and information processing in economics, as themselves making possible a world of the cyborg theorizations.

For these varied theorists, then, the key reason that cybernetics is interesting is that it gave rise to the "cyborg"—the mangling of human and machine in a range of different fields and, more importantly, as a methodological move. Wiener clearly talked about cybernetics in terms of both its focus on the body and on the possibility of its application to society as a whole. In later chapters, I argue that biomechanics and operations research as academic disciplines have come to be applied to cricket. Tracing these interactions, I will argue, create useful sites for examining two concepts of some concern to anthropologists, namely affect and number, respectively. Some recent work suggests that this connection between cybernetics and anthropological problems is, separately from Gregory Bateson and Margaret Mead's documented involvement with cybernetics, no mere accident. The general argument is that cybernetics has been influential on what has come to be known in the US as French theory, including readings of Lacan, Derrida, Deleuze, and Foucault.

Lydia Liu builds an argument about a contemporary "cybernetic unconscious of the postwar Euro-American world order" in delineating the connections between Lacan and cybernetics (Liu 2010, 288). Liu goes on to suggest that through an initial set of reflections on the game that occurs in Edgar Allan Poe's "The Purloined Letter," Lacan "developed a notion of language that brought him closer to the symbolic language of mathematics that the alleged affinity with Ferdinand de Saussure or modern linguistics" and suggests that we should "credit him for having accomplished for psychoanalysis what the mathematicians have done for economic behavior in game theory" (Liu 2010, 290). Liu establishes this striking hypothesis through an argument about the connection between Lacan and the mathematician Georges Théodule Guilbaud—they were friends from 1950 to Lacan's death in 1981 and attended their respective classes and seminars (Liu 2010, 299). This link is especially interesting given the well-known influence of the formal nature of the pre-war Bourbaki movement in French mathematics on economic theory practices in the US after the war, especially through the mathematician Gérard Debreu. Liu emphasizes the connections between Guilbaud's interest in the new—in the 1950s—game theory of John von Neumann and Oskar Morgenstern, and the heterolinguistic "supersign" *jeu*/game. Briefly, the "game" of game theory entered France as "jeu," only to travel back to the US as "play"

(Liu 2010, 291).[7] This is part of the mechanism, Liu suggests, by which "American game theory and cybernetics became progressively *unseen* and *unmarked* through their Frenchness" when the concepts they generated migrated back into the US (Liu 2010, 293).

Whereas Liu suggests that a cybernetic unconscious is at stake in the suppression of the role of cybernetics in "theory" in the US, in a slightly earlier article Céline Lafontaine points to a rather more understated possible reason: "[cybernetics] carried a new paradigm combining the scientific and technical discoveries of the day." As it carried a variety of such discoveries, "no unified definition of cybernetics has been able to impose itself." This lack of precision or "blurredness," Lafontaine goes on to argue, "combined with a high level of conceptual flexibility, . . . has given the informational paradigm the strength to diffuse widely" (Lafontaine 2007, 28).

Lafontaine's use of "paradigm" here is not accidental—the accent is on cybernetics as an epistemic revolution (Lafontaine 2007, 32), one that played in particular a lasting role in structuralism. The article focuses primarily on Claude Lévi-Strauss and argues that "[n]ot only did Lévi-Strauss draw from the cybernetics universe his 'spirit without subjectivity' model, but the entire project of structural

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[7]See also the translation of "stochastic" into what became and remained "*aleatory*" when it returned to the US. The former is straightforward and mathematical, the latter, Liu argues, is confusing and philosophical (Liu 2010, 305 n52).

anthropology consisted in interpreting society as a whole according to a general theory of communication" (Lafontaine 2007, 32). Lafontaine carefully notes the connection between Roman Jakobson and cybernetics through Jakobson's attendance at the Macy Conferences (Lafontaine 2007, 33). Lévi-Strauss in turn was, of course, deeply indebted to Jakobson. It is worth noting a further connection that Lafontaine does not draw on. In trying to translate Jakobson's new linguistics theory into an account of kinship and society, Lévi-Strauss in turn came to depend on a key contribution by the mathematician André Weil, a leading of the formal Bourbaki movement in pre-war France.[8]

Lafontaine also finds a series of explicit connections between Lacan and cybernetics. As with Lévi-Strauss, Lacan discussed the influence of cybernetic ideas on his own work explicitly. In addition, and importantly, Jacques Derrida also worked directly with and against cybernetic ideas. Derrida, Lafontaine notes, thought of cybernetics as a field of *writing* and criticized Wiener for not having thought through all its philosophical consequences. In particular, Derrida wanted to "purge it of all metaphysical concepts" related to "soul, life, value, choice and memory" (Lafontaine 2007, quoted from *Of Grammatology*, 37). Just as cybernetics is not concerned with the meaning of a message, only its unique-

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[8]On the connections between Bourbaki, Weil, and Lévi-Strauss, see Amir Aczel (2006). On the connection between the latter and Jakobson, see Bernard D. Geoghegan (2011).

ness, so also might one consider Derrida's refusal of the second part of the dyad signifier/signified. The philosophical consequence, for cybernetics and for deconstruction, is meant to be a kind of erasure of the subject. For the latter, this is an erasure that leads to, in Lafontaine's words, the "possibility of for any uniqueness to become a pluralization of a signifying chain that is then open to infinite and unlimited interpretation" (Lafontaine 2007, 38).

Some of this language is likely familiar to scholars interested in Giles Deleuze. Here too Lafontaine finds an important line of influence. Lafontaine notes in particular that the very idea of the plateau comes directly from a Macy Conferences participant in quoting directly from *A Thousand Plateaus*: "Gregory Bateson uses the word plateau to designate something really special: an infinite region of intensities that vibrates unto itself and expands by avoiding any orientation toward a culminating point or an exterior end" (Lafontaine 2007, quoted from *A Thousand Plateaus*, 39). In addition to this explicit citation, Lafontaine puts some weight on Deleuze and Guattari's idea of deterritorialized bodies composed of machines, immaterial and heterogeneous interconnected rhizomes, and so on, as indicators of the deep influence of cybernetics.

The connections between cybernetics and Foucault are, in Lafontaine's hands, also ones of suggestiveness rather than direct citation. Lafontaine argues that

"[i]n defining power as a system of relations and emphasizing its discursive nature, Foucault is well and truly in line with the cybernetic rupture." Moreover, Foucault's notion of power is "strangely similar to cybernetic control" (Lafontaine 2007, 36). Lafontaine draws on a note by Henri Lefebvre to build this connection. Lefebvre wrote against the structuralist notion of system and characterized Foucauldian theory in particular in the following way: "could it not then be cybernetics in the end, until now ignored ... by the 'pure' philosophers, be they even structuralists" (Lafontaine 2007, Quoted from *Position: contre les technocrates*, 37).

The connections that Lafontaine draws here regarding control between cybernetics and Foucault are certainly suggestive rather than firm. However, given the explicit and important lines of influence between cybernetics and Lévi-Strauss, Lacan, Deleuze, and Derrida, as well as Hacking's account of Canguilhem and Foucault on cybernetics (Hacking 1998), it does seem to be worth reflecting on a situation where the ideas of the primary scholar used by anthropologists and others in the US to build critiques of neoliberalism may themselves be partially built out of a set of concepts–cybernetics—that was created at the same moment that neoliberal theory was itself put together.

The question of control that was so central to Wiener's conception of cybernetics comes up in another important context. One of Clifford Geertz's early

articles on the concept of culture was built directly on the idea of control and makes the connection to cybernetics quite straightforward.[9] Geertz explains in "The Impact of the Concept of Culture on the Concept of Man" that "culture is best seen not as complexes of concrete behavior patterns—customs, usages, traditions, habit clusters—as has, by and large, been the case up to now, but as a set of control mechanisms—plans, recipes, rules, instructions (what computer engineers call 'programs')—for the governing of behavior" (Geertz 1973, 44). This passage is compatible with a cybernetic notion of control, precisely in the sense that something that has been programmed is capable, at least in principle, of being programmed differently.

Certainly, Geertz was clear that this notion of control comes from cybernetics. He wrote that this idea of culture as control is not novel, but "a number of recent developments, both within anthropology and in other sciences (cybernetics, information theory, neurology, molecular genetics) have made them susceptible of more precise statement" (Geertz 1973, 45). Geertz introduced the important idea of the publicity of culture as follows: "The 'control mechanism' view of culture begins with the assumption that human thought is basically both social and public—that its natural habitat is the house yard, the marketplace, and the town square. Thinking consists not of 'happenings in the head' ... but of a traffic in

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[9]I owe this observation to Anush Kapadia and Poornima Paidipaty.

what have been called, by G.H. Mead and others, significant symbols" (Geertz 1973, 45).

These two ideas, of culture-as-program and public-thought are exactly a conception of a society that is accessible and reprogrammable over time. Geertz's influence on cognate disciplines like political theory on the one hand, and the return to concerns with tradition and habit that Geertz marked as inadequate in some recent strands of contemporary anthropology on the other, suggest that this early turn to cybernetics continues to exert some effect on contemporary anthropological theory.

1.4   Anthropology of sport and cricket in India

The general literature on the anthropology of sport is sparse (Blanchard and Cheska 1985, Guttmann 1994, Sands 1999, Moore 2004), however some valuable work on sport and techniques of the body is available (Alter 1992, Mills and Sen 2004, Wacquant 2004). This work is not directed at an understanding of the production of techniques of the body, however, and therefore is not readily capable of making connections from the body back to society at large. Work on cricket in India concerns, for the most part, general histories of the game (Guha 2002, Ma-

jumdar 2004).[10] There are two important exceptions here. Ashis Nandy (Nandy 1989) has argued that cricket in India, because particularly suited to Indian culture, enabled Indians to judge their rulers against the supposed ideals of the game and found them wanting. Arjun Appadurai (1996) provides a useful quick survey of the importance of cricket in understanding modern India and suggests that cricket is ideal for the play of nationalist passion because it is a site within which experiments with modernity can safely by conducted by the various interested parties to cricket. The list of such parties is instructive:

1. The state, because cricket "offers the sense of being able to manipulate nationalist sentiment."

2. "To technocrats, publicists, journalists, and publishers... it provides the sense of skill in handling the techniques of televising sports spectacles."

3. "To the private sector, cricket affords a means of linking leisure, stardom, and nationalism. . . ."

4. "To the viewing public, cricket affords the sense of cultural literacy in a world sport. . . ."

5. "To the upper-middle-class viewer, it affords the privatized plea-

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[10]For a useful general note on the discipline of history and sport, see Guttmann (2003).

> sures of bringing stardom and nationalist sentiment within the
> safe and sanitized environs of the living room."

6. "To working-class and lumpen youth, it offers the sense of group belonging, potential violence, and bodily excitement. . . ."

7. "To rural viewers. . . [it] gives a sense of control over the lives of stars, the fate of nations, and the electricity of cities." (Appadurai 1996, 112)

The class analysis is rather curious, not least because it is entirely speculative, but the important point is that both Nandy and Appadurai, drawing their inspiration in many ways from C.L.R. James (1963), proceed from the assumption that Indian cricket is a stable entity that represents an engagement with colonialism, nationalism, and modernity. One can draw out the meaning of the former for the latter.

1.5   A summary

Rather than reading cricket for its wider resonances, my project proceeds from the notion that an understanding of contemporary cricket—the community of players, coaches, regulators, and spectators that collectively constitute this game

as a thing—and the role that biomechanics and operations research as cybernetics-derived sciences plays in it, may illuminate the connection between biomechanics and certain arguments about affect—arguments that draw on a theorist, Deleuze, who may himself have been in part informed by cybernetics—on the one hand, and operations research and particular arguments about number, on the other. The emphasis throughout is not on why these sciences have come to play the role they have in cricket, but rather an elucidation of what that role is and the way the technologies they have introduced are shifting as they have been introduced to cricket while simultaneously reconstructing cricket itself.

The next chapter examines the burgeoning role of coaches trained in biomechanics in helping cricket players improve their bowling actions by using ethnographic data from a fast bowling coaching center in Chennai called the "MRF Pace Foundation" (MRF). My fieldwork there took place between January and August, 2007. A large number of past and current fast bowlers who have represented India have been coached at the MRF by T.A. Sekar and Dennis Lillee. I examine the relationship between the biomechanics they employ and the trained to be malleable bodies of such professional cricket players.

Cricket is the only popular sport that is constituted by laws, not rules. In general, umpires do not enforce rules on the field of play, instead they adju-

dicate disputes between players according to the laws of cricket. The ongoing rapid commercialization of the game has compressed the form in which cricket is played and heightened the pressures on players to win matches. One consequence has been substantial changes in the laws of the game and how those laws are enforced. Neoliberalism has been conceptualized by Foucault as a process that drives subjects toward a responsibility to develop one's own "human capital." I argue in chapter 3 that the turn to affect in critical theory and anthropology can be read as an attempt to trace that change and the effects it has had on contemporary governmentality. I suggest that one strand of affect theory can be read as a mechanism that articulates law with society and examine in this chapter how cricket players train bodily affect through, in part, the use of the science of biomechanics. This science—the study of life and the forces that act upon it—has played a crucial role in dealing with an important and controversial question in contemporary cricket—how does an umpire know whether a bowler has thrown the ball, thereby gaining an "unfair" advantage? An examination of the debates on this question and the changes in the laws of cricket driven through the laboratory findings on throwing illuminates, I argue, the entanglement of biomechanics, law and affect on the playing field.

Anthropologies of post and late modernity have offered a wide array grounds

for concern about the contemporary world predicated on crisis, anxiety, apathy, or denial about the modern world, along with a tracing of emerging new modes of discourses, institutions, or modes of being. I argue in chapter 4 that such analyses of the contemporary in cultural anthropology have necessarily been organized around a concern with and prophesies about immanent futures. A paper published in a leading Operations Research journal in 1998 offered a means to, in effect, predict the outcome of games of cricket. This has become important given the popularity of "limited-overs cricket"—games that by construction must end in a win or a loss. The eponymous and proprietary Duckworth-Lewis method introduced in that paper works by reducing the state of a game of cricket to two factors—the number of deliveries remaining and the number of batsmen still available. It now forms a crucial part of the laws regulating cricket through ensuring that the winner of an otherwise rain interrupted game can be calculated statistically.

There are a number of objections that one could make to the Duckworth-Lewis method. On the one hand, on statistical grounds one might point out that the formula it uses was chosen rather arbitrarily and has so many degrees of freedom that it is easy to "fit" it to available data. On the other hand, the claim that it is a mere two-factor model—what matters in assessing the state of an innings

is only how many overs and wickets are remaining—itself seems to run counter to traditional sensibilities about the subtlety of the game. I argue in chapter 5 that more recent operations research articles building upon the Duckworth-Lewis method are not susceptible to these kinds of critique. Indeed, I suggest, these new approaches, employing a simulation of cricket innings in order to build non-parametric models of rain-interruptions, are novel analyses that fall out of the kinds of arguments that scholars have made about the role of statistics in contemporary forms of governmentality.

Chapter 2

Biomechanics and the habits of bowling fast

When I first met Irfan Pathan at the Madras Rubber Factory Pace Foundation grounds in May 2007, he had already been working in the Foundation's gym for some weeks. As with other sports, a large part of the strengthening programs for fast bowlers like Irfan consisted of core strengthening exercises and this was indeed an important focus for him. Irfan had been playing for the Indian national side since 2003, but had struggled to maintain his position in the side as his form waned and by the end of 2006 he was out of the national team. Irfan was familiar with the MRF grounds and personnel because he had started training there well before his international debut and had returned to regain his form.

In this chapter, I demonstrate through an appraisal of Irfan's training methods the imbrication of biomechanics into fast bowling in contemporary cricket. Biomechanics works in coaching fast bowling through making bowlers' bodies just malleable enough to reformulate their bowling actions. This ability to make bodies malleable comes at the cost of isolating the act of bowling from its target—the batsman. I argue that there is an interesting tension between the authority that biomechanics gains—by isolating bowling from batting—and the resulting circumscribing of its usefulness—by not being able to account for why some bowlers continue to fall out of form when playing competitive cricket.

The regular bowlers training at the Foundation were warming up on the field.

I saw the head coach T.A. Sekar in the gym trying to set up his laptop and helped him with that. This became a recurring motif over time—trying to stay useful to the coaches, staff, and players by helping them get on with their work. Sekar was a professional fast bowler himself and had playing for India in the 1980's. As the head coach at the MRF Foundation since the late 1980's, he had coached a number of the fast bowlers who had played for India since then. The interactions between Sekar, training in biomechanics and keen to formulate what he called the science of bowling, and Irfan form the central dynamic of this chapter. Sekar had been setting up his laptop in order to show Irfan some video footage of him in the MRF nets. Sekar was using software called SiliconCoach Pro to demonstrate to Irfan that his bowling action had changed recently and needed to be fine-tuned. The implication was that if he was successful he might be able to get back into the Indian team and bowl successfully. Irfan did in fact regain his place in the side by the end of 2007.

The SiliconCoach company is based in New Zealand but sell their software product and the training to use it to professional sportsmen around the world . They note on their website that "SiliconCoach has committed team of programmers, biomechanists, physical educators and marketing executives who all share a desire to provide simple-to-use products that make a difference."[1] Indeed, the

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[1] Last accessed 9/3/12, `http://www.siliconcoach.com/\#products`

founder of the company—Joe Morrison—is himself trained in biomechanics. At its core the software program simply aids handling video footage, but this alone is no mean programming feat as I discovered in my own amateur efforts later during my fieldwork. The suite of programs produced by SiliconCoach consists of a number of tools to overlay the raw video footage with marks of various kinds. A coach uses these marks across multiple frames to measure the angles of limb and whole body movements, compare one set of slow motion video frames representing one attempt at a particular movement to another set of frames, and so on, in order to help a player improve on their playing technique. The program helps a coach track any degradation of the player's technique over the course of one practice session as they get tired and helps the coach demonstrate differences between two or more different players' technique. Morrison, the founder of SiliconCoach, suggested in an interview with a martial arts coach that:

> Your perception of your movements are from looking outwards from your body but people are actually judging you externally, you need to see what they are seeing in relation to your technique. You need to know exactly where your limbs are not where you think they are. It's also a great motivational tool that accelerates development and that always excites people (Todd 2005).

Sekar's use of the program with Irfan and the other bowlers made it clear that this was the core feature of SiliconCoach at the MRF. It enabled the players to create a feedback loop between what they felt they were doing with their bodies proprioceptively and what they could subsequently see they were doing once "marked up" by their coach. However, the program and the associated equipment—laptop, camera, video and power cables, etc.—were cumbersome to use on a regular basis. In order to operate all of that equipment, arrangements were often made to bring in SiliconCoach specialists for practice sessions. The rest of the time, the methodology at the MRF would have been familiar to any cricket player. Sekar or another coach would simply demonstrate what they wanted a player to do with their bodies. The players would imitate that demonstration and seek the approval of the coach.

An important feature of the approach to fast bowling coaching at the MRF—one that marked it out as different from other coaching venues—was the isolation of the act of bowling itself. The whole panoply of considerations a coach of a team might introduce vis-à-vis bowlers, batsmen, and fielders playing a competitive game of cricket is carefully erased in Sekar's work with individual fast bowlers at the MRF. My arrival at the MRF happened to mark the beginning of active use of the cricket nets at the ground. All the players training there had been working

largely in the gym or doing other kinds of exercises in the cricket field next to

the gym. Using the nets—that is, actually bowling against batsman and using

the netting to keep the batsmen's shots from spreading far afield—was a separate

activity that was just starting after a period of reconditioning of the grass surface

of the nets. Yet even in the nets, Sekar's suggestions were never focused on the

effects of a particular bowling act. He was never concerned explicitly whether

a bowler was bowling a particular line or length—the direction of the ball that

was bowled at a batsman—or the kind of delivery a bowler was working on. His

focus was on the act itself, independently of the effects of the act. Late in my

fieldwork, Andre Coley, the then coach of the Jamaican Under-19 team, who was

there to learn about Sekar's approach said to me that he found this remarkable.

He detailed his surprise that there was no real discussion about the tactics of

bowling to particular kinds of batsmen, work on different kinds of deliveries, and

other discussions about the strategies and tactics of fast bowling in cricket—the

staple conversation, in short, of most cricket coaching venues.

It is not, of course, that Sekar thought these matters to be unimportant. Rather,

these were matters best left to the bowler and the particular coaches he worked

with when not at the MRF. Why is this the case? What does winnowing done

the dynamics of bowling fast in this way achieve for Sekar? And how did biome-

chanics come to form the central coaching method for fast bowling at the MRF?

I argue that the biomechanics expertize produced at the MRF is based precisely

on this limiting of its field of action. Biomechanics at the MRF isolated the act

of bowling by looping it through a feedback process either through an imitation

of the coach's gestures or through a video representation of the bowler's own

body. Michel Callon, in theorizing economics as a form of expertize, has argued

that "economics, in the broad sense of the term, performs, shapes, and formats

the economy, rather than observing how it functions" (Callon 1998b, 2). With

respect to the question of expertise, the pertinent term here is "shapes." I argue

through my account of biomechanics that much of the work that science does in

producing expertise over a domain has to do with shaping what may enter into it

and what may not. I suggest that biomechanics at the MRF has established itself

by shaping and limiting its field of application to the act of bowling. To bring

other forms of expertise to the MRF is in fact to try to reshape a preexisting field

of application. Describing a domain of activity helps define, shape, and limit it.

Formulating a critique of that domain, therefore, must be intimately tied to this

act of description. I argue that attending to the successes and failures in which

particular reformulated domains gather together expertise, and the seductions of

those sets of expertise is a valuable exercise. I use the term seduction here from

Dominic Boyer to highlight that this interaction involves a kind of prior acceptance of the relevant doctrine (Boyer 2008). I will suggest that this is not so much a question of access to experts—that an expert will not talk to an anthropologist who is openly opposed to their research agenda, for example—but rather that it is a question of language. Producing mastery of the relevant language or jargon is already to enter into a kind of seduction of other experts. At a minimum, it would evince a desire to belong to that group. More importantly, possessing a facility with that language will already format the kinds of critique one might be able to grasp.

There are various groups of fast bowlers who attended the MRF Foundation while I was there. The key group were young fast bowlers—in many cases they had yet to start their professional careers but their very attendance at the MRF had resulted in or was caused by an earmarking of them as future professional players. A second group were the regular squad of the MRF team itself. This professional team competed locally in Chennai against other teams with similar corporate patronage. A third set of groups—a recent addition to the MRF set up—were players who had paid to receive some coaching at the MRF. Lastly, there were players who were already successful at the highest levels of international cricket who came back to the MRF to receive further coaching. Irfan Pathan,

along with fellow international level bowlers Sreesanth and Munaf Patel, spent varying amounts of time at the MRF during my fieldwork there.

This fact raises an interesting question. Why was Irfan a regular attendee of the MRF? What was it that he was learning during his various workouts there or is it that there was something he was failing to learn? As head coach, Sekar was enormously influential at the MRF. Indeed, the lack of a formal association with the BCCI—the private regulatory authority of cricket in India—notwithstanding, I am sure that a positive word from Sekar about some young player would certainly improve the odds of them being given a chance at a professional level. Sekar himself played professional cricket as a fast bowler, including a few games for India. However, a story often repeated at the MRF and told to me first by Sekar himself centered on the role that Dennis Lillee plays at the MRF. Lillee, a well known ex-player for Australia with a fast bowling record that places him amongst the best who have ever played the game, had been coming to the MRF several times a year since the late 1980s.

The Foundation's importance to cricket in India rests largely on its employment of Dennis Lillee as a pace bowling consultant. Lillee was a fast bowler for Australia in the 1970s and 1980s, but his career was marked by a sharp change in bowling technique brought on by a severe back injury. Working with an athlet-

ics coach and then a biomechanics expert, he remodeled his bowling action and regained his position in the Australian team. Up until that moment, Sekar told me, fast bowlers who damaged their backs as a result of having a "bad" action rarely made any kind of professional level re-entry into the game. Consequent biomechanical work on fast bowlers in laboratories—detailed below—worked on this same kind of injury to the lumbar vertebrae, but focuses on younger players who have yet to make a name for themselves at the highest levels. Sekar's argument was that young talented players were unable to continue their nascent careers because they were injuring themselves.

There was, in short, a self-selection bias at work historically. The best professional players were precisely the players who did not have the kind of problem of technique that might lead to such injuries. Lillee was unusual in that respect. Reworking his bowling action through the application of biomechanics and therefore rehabilitating his bowling career, Lillee was, in this telling, the main conduit of the entry of biomechanics into cricket. Lillee's training in biomechanics comes from sports science work in Australia, particularly in Melbourne and Adelaide. Given his stature within the game as a former player and his access to training by the best of cricket biomechanics experts, he is, unsurprisingly, the primary route for transfers of biomechanical knowledge from laboratories in Australia to

fast bowlers in India in particular. The best of the compliments Sekar paid Lillee, again repeated several times in varying contexts, was that Lillee had a "mind like a computer"—a mind that did not need video footage and laptops—in analyzing and suggesting corrections in a bowler's action. Lillee is certainly famous in cricketing circles as an ex-fast bowler. That alone would lend a certain authority to anything he had to say about other, current, fast bowlers. This particular compliment, however, adds to that authority a picture of Lillee as an expert not just in the science of biomechanics but also in the manner of its application. He is so advanced that he does not need the computer device prostheses that other coaches rely on.

Within this story about how biomechanics came into cricket, the reason why biomechanics has been successful is meant to be straightforward. It is effective. This claim is not just about injury prevention—although that was certainly a recurring claim at the MRF—but also about the effectiveness of biomechanics as a method of analyzing and improving bowling actions. I suspect that the implicit claim is that the gap between the best and worst players has narrowed along with a general improvement among contemporary pace bowlers as a whole. This claim is probably more likely to strike cricket followers as false, but it is difficult to prove or disprove given all the other changes that have occurred in cricket that pertain

to the other parts of a cricket game—batting and fielding. As I shall demonstrate in the next chapter biomechanics also came to play a role in regulating cricket performances, not just in trying to improve such performances.

Leaving aside how biomechanics came to be applied to cricket and why it was accepted, there remains the question of what kind of domain biomechanics carved out for itself. I will argue in this chapter that Irfan and players like him are in part the product of a biomechanics that authorizes itself by shaping a particular field of application, yet precisely for that reason also produces a limit on its effectiveness as a sports science. It both works and does not work because it limits its field of application. The particular kind of boundary it puts in place for itself raises, I will argue later, an interesting anthropological problem about human movement.

2.1 Liberalization and expertise of the body

Broadcasting deregulation in India in 1991 resulted in the creation of a market for televised cricket. Audiences for some international matches involving India sometimes run into the hundreds of millions. Although there are some other cricket playing countries that have significantly richer individual consumers available—principally England and Australia—India's population is large enough that the value of access to its nascent "middle-class" consumers has made it the new fi-

nancial center of world cricket. One striking marker of that change is the Indian Premier League—a league instituted in 2008 that is composed of city-based teams in India. These local teams can draw on leading players from around the world because the salaries the teams can afford dwarf payments that those players can garner playing for their own national teams (Cricinfo 2008).

This was a new *market* for cricket because televised cricket in India before 1991 was broadcast solely on Doordarshan—a public television channel—and the concept of *selling rights* to cricket did not exist. In fact, on occasion, the organization in charge of cricket in India would pay Doordarshan to help defray the broadcasting costs. Such a system of payments could come across as surprising to Indians now, given the evidently close and deep imbrication of global cricket and the demands of television advertising derived money from this new Indian market.

The extra money available in cricket over the last 20 years has had an important effect on the game. To succeed at the highest levels, players need access to a whole infrastructure of training such as that found at the MRF that was simply not available earlier. Cricket is a predominately visual and tactile team game played over long quiet periods of time punctuated by repeated quick actions. As with baseball, a hard ball is struck with a wooden bat in order that the batsman

may score "runs." In professional cricket the ball is projected by a bowler from a distance of approximately 20 yards at speeds sometimes in excess of 90 miles per hour. When the ball is struck well, it can fly at similar speeds towards the fielders. The result is that playing cricket has come to require both a high degree of attention (Crary 1999) and a set of instinctive habituated skills (Bourdieu 1990). Cricket training is targeted precisely at the development of the level of attention and correct habits needed to play well. Furthermore, visual technologies such as the SiliconCoach programs are being deployed in this training of attention and habit. I examine here the role of attention and habit in the formation of cricket bodies at one important venue in contemporary cricket.

The new forms of expertise developed in cricket in India are being strongly opposed by some other participants within the game. The example I give in this chapter concerns the development of biomechanics in pace bowling. By experts I refer, simply, to practitioners of a kind of securitization of life who are frequently all too eager to pursue their craft. Here I mean "life" in the sense that Wiener tried to capture with a cybernetic understanding of the overlapping connections between machines and biological organisms. And by "securitization," I refer to the sets of techniques that Mirowski argues post-war economics has made available in contemporary financial markets that work to break up and reformulate

prior market products. Experts have come to play a variety of roles in cricket. They are involved in the creation and operation of markets for both broadcasting rights for television (Raj 2004) and for the players themselves in the form of player auctions in the newly formed private club-based and compressed "Twenty20" version of the game (Kidd 2008, Richards 2008); and to the development of novel visual (Scott-Elliot 2001, Pringle 2008) and statistical technologies to help both audiences and players alike improve on their understanding of the game.

The problem presented by such experts and the field of application that they shape that is not primarily about the possibly deleterious effects of that expertise on the world but merely the manner of its production of a field of application. They

The chapter explores the grounds and limits of growing expert knowledge in cricket. But this is not an argument that is concerned primarily with examining the negative effects of new knowledge forms on an old and storied sport. Such a focus may simply re-circulate a familiar anxiety amongst an older and elite cricket-watching public that cricket, with all itâĂŹs recent growing pains, might cease to be the leisurely and gentlemanly sport it once was. In other words, I want to guard against a certain nostalgia for non-commercial cricket. Instead, I offer an account of how certain experts work so as to construct a new thing—

biomechanically inflected fast bowling—and in doing so draw together processes and people that were not imbricated with each other before.

Cricket followers could argue quite plausibly, for example, that the West Indian bowlers of the 1970's and 1980's were far superior to current bowlers from various teams around the world. One kind of response might try to track the variance of international pace bowling quality and pace, suggesting that the gap between the worst and slowest bowlers on the one hand and the best and fastest bowlers on the other has narrowed considerably with the advent of biomechanics in cricket. My focus here is rather different from this kind of debate. I will argue that regardless of the successes or failures of biomechanics with respect to the changes it has introduced into cricket, its application to fast bowling is necessarily limited by the manner of its interventions. Biomechanics is limited in effectiveness precisely it needs to limit its field of application in order to intervene in cricket.

2.2 Biomechanics

Biomechanists could trace their discipline's history back to Aristotle's *De Motu Animalium* given how broadly the discipline is defined. The more typically cited candidate for a founder of retrospectively derived story of biomechanics is Gio-

vanni Alfonso Borelli and his work in the 17th century on animal mobility and the forces generated within bodies by the activities and functions of life (Brand 2002). However, given that biomechanics as a discipline did not exist in the United States or in Australia until the 1960s (Drewlinger 1996), it is more useful to think of it as an important part of cybernetics derived sciences as they were formulated during and shortly after World War II. Certainly for Wiener there is a clear relationship between his work on cybernetics and what became the discipline of biomechanics shortly afterward. With such sciences, the accent is on the set of techniques used to analyze and optimize the operations of not just particular organizations, but also and in similar fashion particular organisms and the machines they may interact with. The emphasis in this case is on using engineering principles and theory to understand how living beings move. Subfields of biomechanics include soft body dynamics (animal tissues, for example), locomotion and gait analysis, and ergonomy. I concentrate here on human movement, specifically sports biomechanics, which targets both improved performance and injury avoidance.

Biomechanics as a science deployed within cricket works on the first of the poles of development that Aihwa Ong writes about. As I suggest in the Introduction, the idea that the body is a machine is constitutive of this discipline. Specifically, in biomechanics the body is a machine that consists of articulated bones

and the muscles acting upon those bones. It is principally organized around the linear and angular kinetics—the Newtonian mechanics—of the "musculoskeletal system." Biomechanics as a discipline in sports in particular works by separating a player from their own muscles and joints. The players, along with coaches, join with biomechanists themselves to become experts in the movement of individual limbs relative to one another. For all these participants, becoming an expert is to carefully and continuously monitor the relationship between the experience of having a body and the knowledge one gains of the biomechanics as a science.

In order to help players do this, I found that Sekar would continually both explain the basic principle behind a change in habit that he suggested they employ and also demonstrate what that change looks like to the player. I discovered that it was quite impossible to follow Sekar's discussions with the players about their technique without mimicking his gestures myself. Over time, he would on occasion use me as a model for the particular movement that he wanted to highlight to a player. In other words, these discussions about particular muscles and when to activate them in the act of bowling inevitably threw up a "motivation" attached to that speech. This performative aspect of expertise at the MRF was crucial to its deployment. To be able to demonstrate an action and, perhaps even more importantly, respond to subtle changes in the attempts of a player trying

to mimic that demonstration was a key part of the dynamic between Sekar and the players he was coaching. The importance of this gestural aspect of coaching bowlers will form an important part of the argument I build about the limits of the biomechanical expertize that Sekar is able to deploy.

To understand how those limits are formed requires a knowledge of the fundamental features of biomechanics as a science applied to sports. An important textbook in the field by Duane Knudson explains that "Biomechanics has been defined as *the study of the movement of living things using the science of mechanics.*" (Knudson 2007, 3) In relation to sport, which is the principal focus of this textbook, Knudson notes that the "applications of biomechanics to human movement can be classified into two main areas: the improvement of performance and the reduction or treatment of injury" (Knudson 2007, 5). Knudson's account is useful because it lists nine fundamentals of biomechanics. The fundamentals, that is, of the use of biomechanics in sports. Knudson states that they are "general rules that currently fit what we currently know about the biomechanics of human movement." They were selected because they "constitute the minimum number of core principles that can be applied to all human movements and because they provide a simple paradigm or structure to apply biomechanical knowledge" (Knudson 2007, 30). The first three—"force-motion," "force-time," and "inertia"—are restatements of

Newton's three laws of motion. The general theme is that a change in position—movement—of a human body can be studied through examining the forces that must have acted over some period of time on that body to create that movement. The fourth is the "range of movement" of a body which "can be specified by linear or angular motion of the body segments." The fifth is "balance" and the sixth is"coordination continuum"—the varying quantities of sequential or simultaneous recruitment of muscles acting on joints to execute some movement (Knudson 2007, 33-4). Knudson's seventh principle of "segmental interaction" states that the "forces acting in a system of linked rigid bodies can be transferred through the links or joints." However, Knudson notes, the "exact mechanism of this principle of biomechanics is not entirely clear, and common classification of movements as open or closed chains is not clear or useful in analyzing movement." The eight and ninth principles, "optimal projection" and "spin," are really more about the motion of projectiles released by players in certain sports and form little part of biomechanical research in cricket (Knudson 2007, 34).

At the moment a bowler releases the ball, the body, in this frame, is best conceptualized as a series of articulations—for a right-handed bowler, the series starts at the toes of left foot, to the left ankle, knee, and then hip, and along the vertebrae to the right shoulder joints, and then the right wrist and finger joints. If this

sequence is concatenated with one another correctly, the pace bowler will release the ball both at high speed and with sufficient control to make that speed useful on the playing field. Knudson's first three principles are straightforward applications of Newton's Laws on human bodies, subject to the range of movement that such physical bodies can undertake. The next three are the ones where bodies become rather more than mere physical objects—coordinating the segmental interaction of a player's limbs seems exactly to correspond to what sports players commonly call "technique." As I shall demonstrate, very little biomechanics research addresses the problem of how one's technique might change over time, much less purposively improve it.

Moreover, the sixth and seventh principles that Knudson lists—precisely the ones that he discusses the least—are I argue the most important part of the application of biomechanics to cricket. These two principles, the coordination continuum and segmental interaction, concern the manner in which the timing and coordination of how muscles are recruited into rotating a series of joints is crucial to powerful movement. They help define the difference between pushing—what Sekar called "putting" in discussions with players—the ball towards a batsman and either bowling or throwing the ball at great pace on the cricket field (Blazevich 2012, 196–98). Consider standing in an open field, holding a ball in your hand

and "wind-milling" your arm forwards as fast as possible but at an even angular velocity all the way around. If you release the ball on one of the occasions when your arm reaches its highest point, the ball will fly forwards. As bowlers run up to the wicket before releasing the ball, one might add your running speed to whatever you can generate from simply rotating their arm repeatedly and evenly as fast as possible. But this resulting total speed, whatever it is, will never be as fast as what you can achieve when using proper technique. From a biomechanics perspective, the angular velocity achieved by windmilling your arm over and over is limited by the speed with which you can contract the complicated series of muscles associated with rotating the shoulder joint forward. In general, the more "fast-twitch" muscle fibers you have and the more of them you can successfully "recruit" into this exercise, the faster your shoulder joint will rotate. The key to actually bowl fast lies rather in the tendons that connect those muscles to the skeleton. Tendons are typically both much more elastic than muscles and they can recoil from a stretched state much faster than a muscle can contract (Blazevich 2012, 201). The key to bowling fast is in fact to stretch those tendons using the muscles they work with and use the recoil from them as you relax those muscles to propel the ball forwards. The segmental interaction Knudson lists as a fundamental principle of biomechanics is crucial here. To bowl well is to stagger in just

the right coordinated way a series of stretches of the tendons of your joints from,
for a right-handed bowler, the left foot all the way up to the right hand so that
they work in concert to propel the ball forwards at the batsman.

Although there were some earlier articles on biomechanics and cricket, the first
noticeable cluster of findings were all on fast bowling in the late 1980s and early
1990s. Some of these authors are precisely the scientists Lillee consulted as he
attempted to rebuild his bowling action. A review of the then existing literature
in 1996 lists two possible reasons why fast bowling had drawn the attention of
biomechanists: first, that it "may be because of the importance which this element
of the game has acquired, particularly in the last decade or so" and, second,
possibly because "it is widely considered that fast bowling in cricket is one of
the non-contact activities most susceptible to injury, as evidenced by the almost
epidemic proportions which injuries to the lower back have reached among fast
bowlers" (Bartlett et al. 1996, 403). Bartlett et al go on to argue that:

> Success in fast bowling is determined by a combination of many fac-
> tors, one extremely important variable being the speed at which the
> ball is released. A fast ball release speed reduces the time available
> for the batsman to make correct decisions about the path of the ball,
> thus increasing the demands on the effector mechanisms responsible

for executing the correct shot. (Bartlett et al. 1996, 403)

They go on to list swing bowling—that is, a particular type of delivery involving the ability to move the ball laterally in the air as it approaches the batsman—as another important factor, but this is downplayed in the remainder of the article as there has not been "any quantified, systematic research into the association between aspects of the bowler's technique and success in bowling in-swing or out-swing" (Bartlett et al. 1996, 418).

The key point for Bartlett is that listing speed of release as the main factor justifies the relevance of a mechanical understanding of fast bowling. The further implicit claim is that the faster the ball, the less time the batsman will have to make a correct decision about the likely path of the ball and execute an appropriate shot. As I will note in the next chapter, I found in the field that this assumption is not necessarily true. The authors list "three main techniques prevalent in cricket fast bowling, although the boundaries between them are not fixed and they exist within a continuum of techniques" (Bartlett et al. 1996, 404). This is the biomechanics research that has subsequently become a mainstay of cricket coaching, codified in manuals and cricket coaching syllabi (Woolmer et al. 2008). The first, the "side-on technique," the authors state "has been advocated as the correct and most effective way to bowl." A little before a right-handed side-on bowler re-

leases the ball, the bowler's right foot will be perpendicular to the direction the ball will be released and both shoulders will lie in roughly that same plane that the ball will follow between the bowler and the batsman. At the equivalent moment in action, a "front-on" bowler will have their right foot point towards the batsman and the shoulders will be "open chested," i.e. pointing away to the left of the batsman and the ball's flight path. This, the authors state, is the "technique often used by the West Indian fast bowlers" (Bartlett et al. 1996, 404). These two different methods were already well-known. Coaches outside the West Indies felt obliged to teach bowlers *not* to bowl with a chest-on action, yet were faced with a West Indian team that had dominated world cricket over the previous 20 years with a seemingly inexhaustible supply of fast bowlers with exactly that kind of action. Bartlett's framing of a discussion of the biomechanics of fast bowling by reference to West Indian bowlers suggests the possibility that one of the initial motivations for studying fast bowling in Australia and in England was out of a desire to produce more injury-free fast bowlers in those countries.

The signal contribution of biomechanics to fast bowling comes from an identification of a "mixed" bowling action. As the name suggests it consists of a mix of the first two bowling action techniques. Typically, the lower half of the bowler's body is as with an open chested action, but the upper half of the body is side-

on. So the bowler's back foot points down the pitch towards the batsman, but the bowler's shoulders are in the same plane with each other and the batsman. But this, as with the descriptions of the other actions, is just a snapshot of one moment somewhat before the ball is released. The key point about the mixed action lies in its dynamics. A mixed action is "characterized by bowlers adopting a front-on foot and shoulder orientation at back foot strike, which is followed by a realignment of the shoulders to a more side-on position during the delivery stride" (Bartlett et al. 1996, 405). Yet in all three cases, at the moment in which they release the ball, bowlers are in a chest-on position. So a mixed action bowler has started chest-on, rotated to a side-on position to some extent, and then rotated back again. All along, their feet have been pointing at the batsman. As the article notes: "This technique is believed to be more likely to lead to a high incidence of lower back problems (bony abnormalities such pedicle sclerosis, spondylolysis and spondylolisthesis; disc degeneration and bulging)" (Bartlett et al. 1996, 405).

In a continuation of description that is near impossible to imagine unless one is already familiar with cricket, the article divides up the act of fast bowling into four stages of run-up, pre-delivery stride, the delivery stride, and the follow-through, and they write that a "[p]articular emphasis will be placed on the effect of various kinematic parameters upon the ball release speed" (Bartlett et al. 1996,

405). Given the importance of idea of segmental sequences in biomechanics, the article lists only two studies, one of which they deemed rather inadequate. The remaining study, measuring "peak linear speeds of important joints in the kinematic chain from right hip to right (bowling) hand" found only, and rather unsurprisingly, that adult bowlers had higher peak speeds than the teenagers they studied (Bartlett et al. 1996, 414). The authors conclude that "[m]ore research is needed into segmental contributions to ball release speed, including energy transfers between segments and aspects of segment kinetics" (Bartlett et al. 1996, 414-5). The key finding, however, seems to be independent of this particular lack of data: "[f]ast bowling has been implicated in a multitude of injuries, which include a few to the upper extremity" and to the far more common "lower extremity" such as "groin strains, hamstring strains, wear and tear of the front knee" and so on down to "chronic bruising of the big toe, its nail and the heel" (Bartlett et al. 1996, 418). The greatest impact of biomechanics on injury research in cricket is undoubtedly about the lower back: "[m]any elite fast bowlers have been reported to have had serious lower back injuries, including stress fractures of the third, fourth or fifth lumbar vertebrae... A research team at the University of Western Australia has identified spondylolisthesis, pedicle sclerosis, disc degeneration and bulging as serious and common problems for the fast bowler" (Bartlett et al. 1996,

418).

The article identifies overuse at a young age as a contributory factor, suggesting that "a possible reason for the high incidence of injuries was that young athletes were being forced to train longer, harder and earlier in life to excel in their chosen sports, and that the hours of repetitious practice may produce gradual deterioration in specific parts of the body" (Bartlett et al. 1996, 419). Aside from over-training, there is the question of technique. Here the research, principally from one study, is treated as unequivocal:

> Finally, bowlers who used a technique that combined a front-on back foot placement and a side-on shoulder alignment (the mixed technique) were more likely to show abnormal radiological features in the lumbar spine. These findings provide the most conclusive evidence the mixed technique is dangerous and places the spine in an unnecessarily awkward and potentially injurious position at a time (front foot strike) when ground reaction forces are at their greatest." (Bartlett et al. 1996, 419)

In their conclusion, the authors highlight this finding, arguing not only that "[s]cientists and coaches should avoid young bowlers acquiring this technique and should seek to eliminate it when it is found in a bowler" but also that the

"same collaborators should ensure that the cricket coaching manuals and litera-ture are rewritten to feature the front-on technique as an acceptable alternative to the side-on one, but to caution very strongly against the mixed technique and provide clear guidelines on this" (Bartlett et al. 1996, 422).

This initial and signal moment of the entry of biomechanics into cricket has been very effective. Coaching manuals do indeed now give equal weight to side-on and front-on bowling techniques, whilst admonishing coaches and bowlers from adopting a mixed technique (Pont 2010, Woolmer et al. 2008). Furthermore, a number of countries now have formal policies in place to actively limit the amount of bowling a young player can deliver in matches—in England a 15 year-old bowler, for example, is not allowed to bowl more than 2 6-over spells (England and Wales Cricket Board 2009). The article makes no mention at all of the *performance* of fast bowlers on the cricket field. That is, the findings on fast bowling all look to the problem of injury or merely collect data on how current bowlers bowl. It is not clear how a bowler looking to biomechanics to improve on their speed might do so. More importantly, there is little in this arena of cricket biomechanics on how to manage changes in bowling technique, nor on the relationship be-tween bowling technique as a manipulation of coordinated segmental interaction of a bowler's body and performance on the field of play. The claims that Sekar

and Lillee make at the MRF on behalf of biomechanics are in fact not directly supported by the key biomechanics articles on fast bowling, yet they do garner a great deal of support from them by emphasizing, first, the findings on injury prevention and, second, by making use of the principles that authors like Knudson have put together as forming the fundamentals of biomechanics in sport.

2.3   The MRF Pace Foundation

The Madras Rubber Factory was established over fifty years ago and is primarily involved in the production of rubber tires. In cricket, the company is probably best known for having sponsored Sachin Tendulkar over a number of years—Tendulkar was one of India's major cricket players during the 1990s and remains so today. They put their logo on his bat, so it was impossible to watch him play without being reminded of them. The corporation also sponsors a professional club team in Chennai. This form of corporate patronage links the company to the very beginnings of cricket in India. Princely patronage of cricket formed the bedrock of "native" Indian cricket (Cashman 1980). I write here instead, however, about the MRF Pace Foundation which has been in operation for more than twenty years. The Foundation coaches young fast bowlers who have been selected from around India for their potential as professional fast bowlers. They

do so without charging the players any fees. And although the Foundation is wholly unconnected to the formal organization that controls cricket in India, it nevertheless plays a central role in the production of fast bowlers for the Indian cricket team. To give one example, Gatorade India's "Pacers" promotion which consisted of an all-India talent search for young pace bowlers with nearly 4000 participants had as its prize a "specialized training programme" at the MRF Pace Foundation for the top 10 winners (Veera 2008).

As I noted earlier in this chapter, Dennis Lillee is an important source of prestige for the MRF Pace Foundation. But Lillee only comes to the MRF Pace Foundation a few times a year and each visit is usually for a fortnight or so. During my fieldwork, T.A. Sekar was the head coach and in charge of day-to-day training. I was introduced to Sekar through Rahul Mammen. Mammen is the eldest son of the chairman of MRF, K.M. Mammen, and a key executive in the business.[2] Sekar met me in his office at the MRF headquarters. I told him that I was interested in the use of biomechanics in cricket and he immediately started looking for what he called a "pamphlet" on cricket that he thought would answer my questions. Worried that he was looking to end the conversation as quickly as possible, I started speaking a little about the biomechanics literature I had been reading as he con-

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[2]MRF is a large family-owned business house typical of the interaction between business-oriented groups (in this case Mappillais) and colonial-era corporate governance structures. See Birla (2009).

tinued to rummage through his desk. He stopped, looked a little surprised and then started talking me through the intricacies of the various findings on "mixed" actions and the like. Sekar is a very tall ex-fast bowler who had played briefly for India in the early 1980s. Now, perhaps frustrated by my inability to follow what he was saying he got up and demonstrated a couple of different actions in his office.

It is nearly impossible to convey what these matters are about without the appropriate accompanying gestures. Indeed the term "gesture" seems inadequate because it privileges speech—gesture is used to illuminate or express the emotions associated with speech, but here the motions of his body were the things he wished to communicate. Throughout my stay at the Pace Foundation, Sekar would repeatedly use speech to illustrate his gestures in coaching the players who sought out his advice. Indeed, his coaching related speech in the playing field "nets" was largely hortative. In this context, writing and speech are always estranging forms of communication. To convey how to bowl without gesture is an exercise in immense frustration, as perhaps the previous section of this chapter on biomechanics demonstrates.

On some continued prompting from me, Sekar went on to explain that by the late 1980s, he had already started coaching (while still playing professionally) and

that Lillee had already told him about the dangers of mixed actions—principally bowlers trying to force themselves into a sideways-on upper body position with their feet and hips in a front-on position. By the early 1990s, Lillee, now consulting for Sekar at MRF, had started saying that semi-open positions are acceptable. The key being that the feet, hips, and shoulders be aligned with one another. Any amount of variation from fully side-on all the way to fully front-on is fine as long as those joints are closely in sync with one another.

The Pace Foundation is set in the well-to-do neighborhood of Chetpet, in Chennai, in the grounds of the Madras Christian College school. The grounds were set deep within the school, away from the nearest road and up against the main train line heading south from the nearby Egmore Railway Station. The Pace Foundation has a well-equipped weight training gym, a swimming pool and changing rooms, a small well-trimmed grass area for fielding practice and a large bank of nets for bowling and batting practice. These turf pitches were the key area of interest for everyone there. And the constant use of them meant that keeping those pitches in good condition was very important.

At the Foundation, under Sekar's direction, players would often be asked to simply practice running at a gentle pace or even just walking. The fitness coach Ramji Srinivasan—he is currently a trainer for the Indian national team in addi-

tion to running a busy private fitness gym in Chennai—would correct their gentle running or walking technique. The biggest problem here seemed to bowlers allowing their shoulders to get tense while running. As the shoulder joint is a key to bowling fast and accurately, muscle tension at this joint well before it would be needed for delivering the ball was clearly not useful. The key here seems to be what biomechanists refer to as segmental interaction. If the some muscle group is tense well before it is required, the bowler will not be able to concatenate their joints—precisely to "articulate" them—in a productive way. At the Foundation, running in, stride length, arm positions in the "load-up" phase coming into and beyond the moment of back-foot strike, and then the movement of the non-bowling arm, bowling arm, and the direction of the follow-through were all key elements that Sekar emphasized when working with the players there.

As I noted earlier, four classes of cricket players came through the Foundation regularly. First, there is a collection of young players selected for their promise as professional cricket players for India. Their training, housing, and so on, over several years in most cases were all paid for by the MRF corporation. Second, and this appeared to be a recent introduction to help with financial support, teams of players paid to attend for short durations of time and looked for intensive coaching from the staff there. Third, the professional players from the official

MRF-sponsored club team were there everyday during their cricket season. For them, the grounds were their regular training area. Their home ground in a local college was just across the train tracks abutting the Foundation. And, fourth, and easily highest profile, professional players who had played, or were playing, for the national team, periodically came to the Foundation to work with Sekar, Lillee, and others on their bowling action and fitness training. The Indian bowlers in this category usually had a long history with MRF as they were initially in the groups of younger players spending months to years there. The language used at the MRF was English. Indeed, on one occasion I heard Sekar on the phone talking about a possible new Hindi-speaking recruit from North India to the set of young Foundation players. He recommended, possibly speaking to that player's current coach, that he learn some English as quickly as possible so that he could attend the MRF. English is an official national language of India, but most of the players at the Foundation who were from northern India had to improve on their knowledge of English because Sekar and the staff at the MRF knew very little Hindi. More importantly, and the coaching at the MRF certainly seemed to reinforce this dynamic, English remains the standard language of professional cricket around the world.

My initial interaction with Sekar in his office seemed to me to be formed

around a negotiation about my status. Was I a journalist? A student of biomechanics? A friend of the key patron of his position and the Foundation? Over the next several months this uncertainty came up several times. Not only did I impute an uncertainty in his and other people at the Foundation's minds, but, perhaps more to the point, I was unsure myself as to my role there. Was I doing "fieldwork"? Or just learning, slowly and ineffectively, how to coach fast bowling? Certainly, Sekar himself repeatedly introduced me to the players and coaches at the Foundation as an expert in "anthropometry" despite several attempts at correcting him. It soon became apparent to me that the point was not that he understood that I was interested in studying the deployment of expertise, but simply that there was no role available for anyone but experts at the Foundation. I perforce had to be an expert in something of value to cricket. As I shall argue in the next chapter, I took on, or tried to take on, the role of an expert on cricket.

2.4 Irfan Pathan

Irfan Pathan is a left-arm swing bowler—a player who specializes in moving the ball laterally in the air as it approaches the batsman—who made his debut for India at the end of 2003 at the age of 19, playing on tour against Australia. This

is a relatively young age for a bowler to make his international debut. There are a number of important connections between this early period of his career and the communal riots that occurred in early 2002 across his state of Gujarat. The riots had put under considerable tension the balance between secularist politics and the demands of a Hindu majority-led political system. One key question had been whether state officials had been complicit in the violence against Gujarati Muslims by the Hindu majority. Most of the dead during the riots were Muslims.[3]

Early reports on Irfan Pathan highlighted the fact that his father was a muezzin at the Jama Masjid in Vadodara, Gujarat, and that Irfan had in fact learned to play cricket inside the mosque.[4] Although he played fairly well on debut in Australia, he really garnered a lot of media attention on playing on tour against Pakistan in 2004. This was India's first set of matches in Pakistan since 1989. India ended up winning the three Test match series 2-1, with Irfan doing well in all the games. The much celebrated series win was India's first against Pakistan since 1979. A report in the magazine Outlook India cited an SMS in Hindi—"Congratulations on the victory, a dream has come true. Kashmir was ours, now Karachi and Lahore too are"—that had apparently been "flying thick and fast through the bylanes of

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[3]The literature on the riots is now extensive. For one take on these events, see Jaffrelot Jaffrelot (2007).

[4]A BBC News report, for example, framed the announcement of his inclusion in the team being sent to Australia around there being "very few cricketers whose path to international recognition began inside a mosque" (Sandhu 2003)

Gujarat . . . As the celebrations began, there was frenzy in Vadodara's Mandvi area in the walled city, with cheering crowds trying to enter the Jama Masjid where Irfan Pathan's family lives." The report goes on to quote a politician and links nation's victory over Pakistan to the state's complicity with the riots:

> "It is unfortunate that we see Pathan in Gujarat in a different light just because he is a Muslim. But then, it is this identity which has to be reminded to a larger Hindu middle class, the sense that we too are Indian citizens and as loyal as them, especially in Gujarat," says Kadir Peerzda, a Congress leader from Surat.
>
> It was also a rich sight to see the police preventing mobs from entering the masjid to join in the celebrations with Pathan's family. This is the same police that was accused of standing by, if not directing violent communal mobs to Muslim religious places and homes in 2002. (Desai 2004)

Irfan, then, as a Muslim resident of Vadodara, stood as both an example of a perceived Muslim threat and as the savior of a struggling India playing Pakistan. A key bowler for Pakistan over many previous years, Wasim Akram, had recently retired from professional cricket. Akram was himself a left-arm bowler who swung the ball at great pace so comparisons to Akram were easy for journal-

ists and the like to make. The implication was that India had found a bowler who might be able to dominate Pakistan and other countries the way that Akram had over many years for Pakistan. This analogy was both furthered and troubled by reports that "Pathan idolises Wasim Akram, and has moulded his bowling action on him" (Pandya 2003). This same report and others linked Irfan's selection and performances for India in part to his coaching at the MRF Pace Foundation for several years. Rahul Bhattacharya, a well-known cricket journalist, wrote that:

> During these years Irfan spent time at the MRF Pace Foundation, where Kiran More had referred him. "His action was past side-on, with his right foot pointing towards the slips instead of at the stumps," says TA Sekhar [*sic*], head coach of the foundation, "but that could get him into back and groin problems. We modified it to side-on." (Bhattacharya 2004)

Irfan's promising start was now, in 2007, long behind him. What had happened in the intervening time and why was he now back at the MRF? Could Sekar help him rework and rebuild his bowling action?

On my first day of observing them both at the MRF Foundation, Sekar was using the SiliconCoach program to impress on Irfan that the load-up phase of his bowling action was happening much earlier in his approach to the wicket than he

thought it was. The load-up for a left-handed bowler like Irfan should occur as he jumps off his last right foot step before arriving at the crease. The next time his right foot lands, he should almost be ready to release the ball. As a result of an early load-up—roughly when his left foot was landing prior to that penultimate right foot step— his left hand was coming around and behind his head and that was leading to his left arm whipping down and across his body, rather than towards the batsman. I thought through the significance of this problem much later.

Going through the various deliveries that he had recorded, Sekar pointed out which ones he thought were better. Irfan then left to warm up with some functional exercises. In the meantime Sekar spoke to me about what he was trying to do, saying that the key thing is that all the energy developed by the bowler up to ball release should be directed at the batsman. He went to say simply that what he was trying to do is get to a scientific approach to bowling.

The question of directing one's energy to the batsman is deceptively easy to understand conceptually. What else would a bowler want to do? The difficulty of putting this understanding into action involves precisely the same difficulty that the biomechanics of spinal injury prevention in fast bowling is focused on. Imagine an axis running through your body from the crown of your head down

through the center of your spine and into the ground at a point equidistant from your the centers of your two feet. Walking, running, and bowling all work through rotations around that axis as you move forward. Try, for an example of how not to walk, moving slowly forward by swinging each of your arms in time with each leg movement forward—as your right leg swings forward, swing your right arm with it, and as your left leg takes over to move forward, swing your left arm along with it. This is of course an extremely ungainly motion. As you move forward, you should have become aware of a large rotation around the central axis dropping down from your head along your spine to the ground. Now try walking normally and notice that your left arm swings forward as your right leg swings forward (there should in fact be a slight delay before the left arm swings forward) and vice-versa as your left leg swings forward. What is happening here are two different rotations around the same axis. Looking down at the ground, your right leg swinging forward is a counter-clockwise rotation of the central axis of your lower body. Almost simultaneously, your left arm swinging forward is a clockwise rotation of your upper body. This twisting motion rippling up from the ground as you walk or run your entire body forward is possible only because the lower vertebrae of your spine are able to twist along that central axis. Walking, running, and bowling forward, towards the batsmen, is only possible through a

series of twists of your body directed away from that forward direction. There are of course a number of other axes of rotations exerted in part through the spine; however this particular axis of rotation is the one that is now considered crucial to the development of fast bowling in cricket.

The emphasis at the MRF was to minimize rotation along that axis from the beginning of a bowler's run-up to the bowling crease. Ramji, the trainer, worked on walking and running technique with all the players. One movement that he focused on was shoulder relaxation and arm movement. Typically, and this certainly applied to Irfan, players tended to swing their hands up and towards the center of their bodies when swinging them forward. From that position, the arms would then swing back and out, with the elbows swinging away from the body as well as backwards. One of Ramji's favored metaphors was that the player should run as if they are on train tracks. The implication being that the arms should slide forwards and backwards only, not also towards and away from the center of the body. Doing so would enable the player to match their arm movements with the swinging back and forth of their legs. The net result was certainly meant to be less rotation along their central, spinal, axis.

Irfan started with some short, slow paced run-ups to the wicket. He did not have a cricket ball with him but was simply practicing a change in load-up. He

then practiced a few gentle deliveries with a ball, again off a very short run-up. In the meantime a laptop running the "Timewarp" variety of SiliconCoach's software had been set up behind the net where Irfan was bowling. SiliconCoach Timewarp is structured to ease immediate review of digital video footage. A video and laptop operator can set up the system to automatically playback a delivery seconds after it was made in the nets. A batsman arrived from the MRF team itself and Irfan switched to bowling in earnest to that batsman if still relatively slowly. Sekar was speaking to Irfan after all every ball. After a few iterations of just encouraging words, he suggested to Irfan that he concentrate only on his lead arm. He suggested that he turn his hand palm upwards, facing the sky, rather than fingertips upward with the palm facing to his left. This is the moment when a left handed bowler has landed on his right foot and the left arm is extended back behind him and is ready to continue accelerating forward and up to the ball release point above and slightly in front of his head. The suggestion had already been mentioned during the earlier video review session and surprised me quite a bit. Most bowlers do not position their leading arm in that manner. I wondered whether and how Sekar thought that this unusual position might help Irfan with directing his bowling energy towards the batsman. As Irfan continued to practice this particular change in technique, Sekar quite openly elicited from

the batsman—who was playing the deliveries from Irfan with ease—agreement that Irfan was now bowling at a slightly sharper pace.

Sekar then instructed Irfan to try forming a fist with his right hand instead of using an open palm facing upwards and to pull it down sharply just after his arm was almost fully extended (without the elbow locked straight). This would, he said, allow him to crunch down with his core. An immediate improvement was apparent. Sekar took the time to elicit that pronouncement from both the batsman and from me, as he and Irfan reviewed the new footage on his laptop.

One part of this apparent change is easy to explain. Irfan had been working on the position and orientation of his leading arm. In particular Sekar had requested that he try pronate his arm such that his palm faced the batsman. Thinking about this away from the field, I realized that pronating the forearm results in the outer bone of the forearm—the radius—wrapping over the inner bone—the ulna. As a result the radius pulls on the elbow joint, simultaneously straightening and exerting a medial force on the joint to bring it closer to the body. It is easy to test this for yourself. Simply raise your right arm up in front of you up to head height, with the hand directly in front of your face and the palm facing to the left. Your elbow is likely protruding out to the right of your body. Then rotate at the elbow joint so that the palm is now facing outwards, away from your face.

You should be looking at the back of you hand. In doing this, you should notice that your elbow will tend to be pulled in towards the centerline of your body and simultaneously straighten out.

The net result is a straighter arm at extension and a pull-back of the arm straight behind him as Irfan's left-arm rotated around at the shoulder into the delivery position. The pronation of the forearm like this is not a bowling technique one generally sees in match situations. This is because most bowlers flex their non-bowling arm at the elbow as they snap it back towards their midriff. The arm will then straighten again as it continues swinging up and behind their body. Pronation tends to work against the first part of that movement.

I suspect that once Irfan had established that pattern of movement, Sekar then allowed him to form a fist with his non-bowling right hand (now in a relatively relaxed supine position) and told him in effect to snap back on it harder than before by telling him to crunch his core area muscles. This change—that crunching the core enabled Irfan to bowl faster—is certainly a central tenet of biomechanics in cricket and across a number of other sports. One part of this aspect of a bowling action is easy to understand. Flexion of the spine along an axis parallel to the ground and perpendicular to the plane the ball will follow as it travels to the batsman will add to whatever angular velocity they are able to generate at their

shoulder joint. An other significant aspect to crunching the core while releas-ing the core is best understood through the example earlier in this chapter about the difference between "windmilling" your arm freely and using your muscles to store in and then explosively release from the tendons connecting your muscles to your skeleton. Crunching the core allows a bowler to store that energy in the tendons wrapping around their shoulder joints.

At the beginning of the following week, the temporary gym trainer Mahendra Gokhale who was about to move on to coach the Baroda first-class team, em-phasized strongly the need for a focus on core strengthening along with regular cardio-vascular workouts for all the bowlers at MRF. He had also constructed a series of running technique exercises in the swimming pool, including full slow-motion run concentrating on moving the arm well and keeping the core upright, side steps, front steps with the leg held straight to emphasize hip flexion, and sideways cross-over steps. Practicing these movements in water meant that the players could concentrate on technique because being buoyant in effect reduced their body weight. Thinking about this aspect of their training regimen, I suspect now that these were exercises meant to emphasis the way that a crunching of the core itself depends on prior movements at the hip joint, and so on back down what biomechanists call the kinematic chain to ankle and foot.

Later that day, Irfan warmed up and then spoke with Sekar. He had a series of questions about his leading hand position, rather than its orientation. Should his left hand end up to the left side of his eyes as he looks at the batsman or more or less directly in line? Sekar was non-committal in response. Irfan went on to the nets to practice bowling at one of the MRF team's left-handed batsmen. This was in fact the general pattern of his practice sessions in May and June in the practice nets—a brief conversation with Sekar in which he raised a question or two about technique and then a bowling session at one or more batsmen.

A few days of practice later, it seemed to me that he had not shown much progress. Sekar gathered the all the foundation bowlers together along with Irfan. He emphasized to them the importance of the leading, i.e. non-bowling, arm and using it actively, especially as it swings down moments before ball release. I asked him if it was correct that the arm should go straight up—a leading question from me because I could see some players practicing that gesture as he was speaking— and he replied that that was absolutely incorrect. He raised his own arm straight up and said that from that motion the only thing one can do easily is bring it straight back down again, rather than forward and up which will allow you to snap down and back behind you fluidly. Irfan again asked him about his leading hand position. This time around Sekar had a precise answer for him. The issue,

he said, is that he had been until now lining up his leading arm elbow joint with the batsman, which is fine, but his elbow was flexed. This meant in turn that as he snapped down with the leading arm, the arm could go directly behind him but would instead swing out to the side of his body in an arc.

A young player at the MRF Foundation, Varun Aaron, was one of several bowlers who did not effectively use their leading arm. Although Sekar was certain about the importance of this part of a bowling action, founded entirely on biomechanical principles, it remains the case that Aaron is both the latest MRF player to make his debut, in 2011, for India and is bowling almost as fast the best of current fast bowlers around the world. Aaron continues to make little use of his leading arm. This fact alone could hardly be grounds for skepticism about the role biomechanics at the MRF, however, because the counter-factual is impossible to prove—perhaps Aaron would bowl even more effectively if he stretched out his leading left arm more before crunching it down hard as his right arm swung up to release the ball. What this example does illustrate, given how hard bowlers like Irfan tried to incrementally change their bowling technique, is that significant changes in technique are difficult to come by.

In a separate later conversation that day, Sekar indicated to me that he thought Irfan's technique was 95 percent correct now. He emphasized that players should

be thinking cricketers so that they can understand what they're doing wrong and why so they can continue to work on those problems. The result is that "your brain will make you get things right." The players at MRF have access to a specialist in sports medicine, Gopal Ramanathan, who was listening in on the conversation. Sekar gestured towards him and added that it's important that a bowler have a natural action. I took the hint and asked Ramanathan what counts as natural movements of the body. He used the example of swimming and stated that the front-crawl is an unnatural movement because it requires the arm to move above the shoulder, whereas the backstroke is the most efficient stroke—thereby implicitly equating efficiency with naturalness—because it does not make that demand.

I found this all of this rather perplexing. If the front-stroke is unnatural then surely bowling is also an unnatural movement. Yet, Sekar was most certain that naturalness was the key to good bowling technique. Irfan later volunteered on the topic that he can feel when his action is right because his body feels more relaxed. To which Sekar added that your brain will find out what is the right movement for you. After this particular bowling session and a follow-up turn at batting, which he had been doing more and more regularly over time, Irfan was then interviewed by S. Dinakar writing for *The Hindu*. Irfan emphasized repeatedly that he was

feeling much better about his action with Sekar's guidance. He also said that the mistakes you develop while you are in form—playing well—are the most dangerous because those are the ones you don't immediately correct. Indeed, he had just finished going over exactly that message with the MRF team batsmen a few minutes before the interview. This was a novel account, to me, of how one develops ingrained mistakes in the first place. It certainly had an intuitive appeal even as it seemed to help explain why he had to think so carefully about and struggle to make corrections to his technique over countless repetitions in the nets. It also implicitly gives one set of reasons for Irfan's continuing training at the MRF over his professional international career—away from the MRF in the heat of competitive action, his technique changes, perhaps especially when he is doing well.

At the beginning of July, a Gatorade sponsored event was held at the Foundation. Javagal Srinath, a now retired fast bowler who had played for India with great success, and Sekar had been hired to help select two winners from a search for young fast bowlers out of tens of thousands who had applied. They ended up selecting three players who were here to receive their prize, namely being trained by them both at the MRF. Srinath was himself a product of the MRF system. On that day, Srinath was in fact working only with Irfan. After introducing myself, I

asked him what he thought about Irfan's action. He responded instead with an account of how he thought change happens. He said that change all starts from the mind, a cognitive understanding from what you are able to see, from which you get a blueprint for the change you should make. Only after that can you start working on changing muscle movements effectively. Muscles, he said, have memories and that's why it is difficult to make changes. I asked him about the ability to make changes—is that something that can itself be developed over time? He replied that bowling experience helps a great deal, because you become better at recognizing that change is required. He added, however, that being always ready to change is also a bad thing because it could lead to keeping on changing simple things unnecessarily. He ended this near soliloquy on the relationship between a bowler's mind and the habits of their body with a firm "there is always change."

The nets were pretty busy at that time because, in addition to the Gatorade sponsored training, the Asian Cricket Council (ACC) had also set some players to MRF for training, and Dennis Lillee, Troy Cooley, and two Australian players—Mitchell Johnson and Grant Sullivan—were also in attendance. The ACC players were being trained, largely separately, by two Sri Lankan coaches. Troy Cooley was at that time the fast bowling coach for the Australian national team. He had previously been the fast bowling coach for England. Mitchell Johnson is a

very fast national level bowler for Australia and Grant Sullivan was a state level bowler in Australia. The proliferation of coaches all looking at the various bowlers in action, including Irfan and Munaf Patel—who had played for India for some time but, like Irfan, was currently out of the national side.

With all these coaches around, and some small differences in emphasis between them regarding what each player should work on, in a private conversation I asked Irfan how he handled different people telling to do different things. He looked at me guardedly and then said that he's willing to trying different things but that each thing should be tested properly by himself for its suitability. I then asked him how he handles multiple suggested changes, from one coach, all at the same time. He said that he usually worked on one or two things at a time and as he felt more confident about that change, he would try additional adjustments in technique. He was offering a layered account of the development of new bodily habits. As one set of changes became more "solid," another set of changes could be laid on that new foundation.

What, in a competitive situation, could lead to destabilization of those layers of habit? Many sports involving projectiles are about hitting some target and being evaluated on accuracy. Even in those cases, playing against someone else necessarily involves a set of pressures that would not be available in a training

or coaching setting. In cricket, however, the connection between competition and possible changes in the deployment of one's body is far more direct. A bowler bowls the ball at a batsman. As I have indicated, this is the central moment of action in a cricket. As with baseball and very few other sports, it is a team sport that nevertheless is built out of an interaction at some given moment between two particular players.

2.5   Cybernetics and biomechanics

I have argued that biomechanics as it is applied to cricket has no account of the role that coordinated segmental interaction in response to another body's movement plays in cricket. No account, in other words, of cricket as a *game* rather than a set of choreographed movements. As I suggest in the Introduction, biomechanics is a cybernetic discipline. As such there is a rich set of references for thinking about the relationship between players, their bodies, the technologies that enable the application of biomechanics in cricket, and the resulting, I argue, subjectification of cricket players through biomechanics. One strand of the set of changes around World War II involves precisely a theory of metaphorical and real games.

In an article on the role that the metaphor "game" plays in the history of

economic thought, Robert Leonard argues that "thinking in terms of strategic interaction is now second-nature to an entire generation of contemporary theorists." Leonard speaks here, not just of the connections between game theory and economics, but also suggests that "the mutation wrought by [John] von Neumann and [Oskar] Morgenstern can be better understood when it is related to several related contemporaneous shifts in other disciplines, including linguistics, mathematics, ethics, and anthropology." (Leonard 1997, 305) For my purposes, I would specify here the anthropology of the body in particular.

Leonard's focus is on Karl Menger, von Neumann and Claude Lévi-Strauss. Leonard argues Ernesto Zermelo's paper in 1912 on chess, in which Zermelo proves by induction that the outcome of chess is fully determined, can be seen as part of the common root of Menger, von Neumann and Lévi-Strauss's work. Zermelo's proof is to the effect that both players in a game of chess can play at least one perfect game—or sequence of moves—given whatever it is that their opponent is doing. As with simple games like tic-tac-toe, in a fully determined game, if both players are playing perfectly, either all games should end in a draw or either the first to move or the second to move should always win. He notes that such a proof about chess might now seem trivial, but that "what is significant for us is the fact that Zermelo turned to the mathematics of games at all, and, more

importantly, that this was presented as an act of demystification: chess was being stripped of its psychological dimension, being reduced to a mathematical formalism with a determinate outcome" (Leonard 1997, 305). In this manner, Leonard lays out a short but convincing case that "Menger's ethics, von Neumann's games, and the structural anthropology of Lévi-Strauss are all indicative of a shift in the way mathematics was used as a tool of social theory" (Leonard 1997, 320).

The turn to a mathematical approach that Leonard outlines was crucial to cybernetics in the sense that it provided a common language in which the variety of disciplines represented in, for example, the Macy Conferences, could be pulled together. The push against structuralism and structural-functional approaches in Anthropology focused, however, on the question of the agency of a subject not on the question of mathematics. I will argue in chapters 4 and 5 in any event that a critique through the supposed objectivity or abstractness of mathematics depends on a particular kind of reading of mathematics that may not be particularly tenable.

Sherry Ortner, student of Clifford Geertz, argues regarding agency that it "is an indispensable theoretical category," and suggests that what is needed is "to provide it with further specification, and hopefully to de-fetishize it as well" (Ortner 1999, 77). Ortner argues that a heuristic distinction between an agentic mode

of domination and resistance—of power—, and a mode "that is closely related to ideas of intention, to people's projects in the world and their ability to both formulate and enact them" matches up well with fundamentally ethnographic nature of Anthropology. Agency-as-power concerns "the forms of power people have at their disposal, their ability to act on their own behalf, influence other people and events, and maintain some kind of control in their own lives" (Ortner 1999, 78) and agency-as-intention concerns "projects that emerge from and of course reproduce different socially constituted positions and subjectivities" (Ortner 1999, 79). Ortner goes on to suggest that this second agentic mode is "about (relatively ordinary) life organized in terms of culturally constituted projects, projects that infuse life with meaning and purpose." This is not a question of free will, Ortner makes clear, but of the "cultural desires or intentions...[that] emerge from structurally defined differences of social categories and differentials of power" (Ortner 1999, 80).

Although Ortner's conception of Anthropology is not meant to accommodate the non-human, the distinction drawn here between agency-as-power and agency-as-intention corresponds exactly to the distinction drawn by Andrew Pickering in *The Mangle of Practice*. Pickering argues that one could recognize the agency of the non-human, yet insist upon the *intentionality* unique to the human world.[5] I

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[5]See, in particular, Pickering (1993) and also the introduction to Pickering (1995). Ortner's

would argue, however, that neither Ortner nor Pickering provide any substantial arguments for the distinctions they make.

A denial of the opposition agent–structure seems to require something like a "poststructural" position, one in which the notion of immanence takes priority. Judith Butler has argued, following Foucault, that subject-formation ought be understood through a process of subjection. Butler states that "one inhabits the figure of autonomy only be becoming subjected to a power, a subjection which implies a radical dependency" (Butler 1997, 83). Further, "[s]uch subjection is a kind of power that not only unilaterally *acts on* a given individual as a form of domination, but also *activates* or forms the subject" (Butler 1997, 84). However, the "Foucaultian subject is never fully constituted in subjection... it is repeatedly constituted in subjection, and it is the possibility of a repetition that repeats against its origin that subjection might be understood to draw its inadvertently enabling power" (Butler 1997, 94). Butler's interpretation of Foucault is rather at odds with that of Gilles Deleuze, however, its emphasis on difference and repetition notwithstanding. Deleuze, in a conversation with Clare Parnet on Foucault, suggests that "[i]f there's a subject, it's a subject without any identity. Subjectification as a process is personal or collective individuation, individuation one by one or group

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attention to history as an important method in Anthropology further corresponds to Pickering's argument about the importance of an attention to *temporally emergent* phenomena in science studies.

by group." Moreover, "[t]here are subject-type individuations ('that's you…,' 'that's me…'), but there are event-type individuations where there's no subject: a wind, an atmosphere, a time of day, a battle… One can't assume that a life, or a work of art, is individuated as a subject; quite the reverse" (Deleuze 1995, 115). There is, therefore, in Deleuze's reading of Foucault a four-fold possibility: personal/collective and subject/event individuations. For Butler, however, there is only one possible process of individuation: a personal, subject individuation.

Deleuze develops this interpretation of Foucault through the notion of the fold, "[t]he outside is not a fixed limit but a moving matter animated by peristaltic movements, folds and foldings that together make up an inside: they are not something other than the outside, but precisely the inside *of* the outside," (Deleuze 1988, 96-7) and uses it to develop a critique of intentionality: "[t]he idea that consciousness is directed towards a thing and gains significance in the world is precisely what Foucault refuses to believe" (Deleuze 1988, 108). These ideas themselves seem to fit in readily with the broad narrative broached by Leonard and do so, in my reading, by positing the moment of a bowler and batsman interacting with one another as a collective event—a moment with a subject.

2.6   The limits of biomechanics

Biomechanics is a post-World War II discipline. Moreover, it is organized directly around the figure of the cyborg—both in the sense that it is concerned explicitly with the development of the body through technology, but also in the wider sense that is it is methodologically cyborg. As I have demonstrated through the example of Irfan Pathan, it works precisely by bearing down on divisions between the player and the player's body through the use of video feeds manipulated by computer programs. In the hands of a trained coach, the programs help close the feedback loop between what a bowler feels they are doing and what they can see they are doing. But the moment of ball release for a bowler is precisely, I would argue, a Deleuzian collective event. In terms of biomechanics, it involves not just a Newtonian mechanical understanding of individual limbs, joints, and the muscles that exert force on them, but also the coordination of a segmental interaction between all of a player's body. It is observation of that interaction that helps a batsman ascertain where the ball released by a bowler is likely to go. As these are repeated events, the bowler bowls the ball to the batsman repeatedly, there is a further segmental interaction *between* the batsman and the bowler.

However, as Andre Coley, the Jamaican coach, observed to me, fast bowling coaching at the MRF works on the isolated moment of a player bowling a ball,

not a player bowling a ball to a batsman. The biomechanical expertise deployed on the cricket practice fields at the MRF seem incapable of addressing that crucial moment. This is an exclusion within cricket training that enables the effectiveness of biomechanics as a science. In anthropological theory, there is a term for this kind of limit. In the next chapter, I address both the role this term plays in anthropology and how one might think about it in biomechanical cricket.

Chapter 3

Spinning affect: the science and laws of cricket

In a tour of Australia beginning at the end of 1995, M. Muralitharan was playing for Sri Lanka in the Boxing Day Test match against Australia. Muralitharan had started playing for Sri Lanka three years earlier. He was already well-known for having an unusual action for an off-break bowler. Such bowlers—who try to spin the ball such that it turns from the left to the right, from the bowlers point of view, after it lands—are typically unable to make the ball turn much. It was thought to be impossible to deploy a lot of rotation at the wrist joint to add to whatever spin one could get on the ball by twisting one's fingers and shoulder joint. Muralitharan was, however, different. He could spin the ball prodigiously. One of the umpires in that game, Darrell Hair, called "no-ball" several times when Muralitharan was bowling. There are multiple reasons why an umpire might declare a "no-ball." Hair's was the most dangerous for a bowler and his career. He thought that Muralitharan was throwing the ball—an illegal delivery—at the Australian batsman, not bowling it. The Sri Lankan captain, Arjuna Ranatunga, fully supported the legality of his bowler's action. The International Cricket Council took the opportunity to detail its previous concerns about his bowling actions (The Independent 1995). Muralitharan's body had already been the subject of much discussion. He was able to generate far more spin than all other bowlers of his type and it seemed as if this might have something to do with the different-

looking bowling technique he employed. The key point was whether his body was itself simply different from "normal" cricketing bodies and whether that consequently played a role in the legality or illegality of his action. The Sri Lankan cricket board and the ICC looked to scientists to adjudicate on the matter. Murali's career did not end at that point, nor on the other occasions when he was called for throwing. Instead he was sent for testing by biomechanics scientists, first at the Hong Kong University of Science and Technology, and then at the University of Western Australia. The scientists "cleared him" of throwing, yet as we shall see, the status of this finding once back on the field of play was itself rather opaque. At least initially, umpires were still obliged to call "no-ball" any delivery they thought illegal, previous off-field tests notwithstanding. By being called on to examine Muralitharan's bowling technique, the scientists had opened up a gap between official off-field laboratory testing of a bowler's action and the on-field immediate determination by the umpires.

The usual understanding of throwing in relation to off-spin bowling has to do with such a bowler being able to disguise a change in the pace with which they release the ball. In Muralitharan's case, however, he added to that mix the possibility that the large amount of spin he was able to get might also be an outcome of throwing. A batsman playing a spinner has to make a judgment about

how much spin the bowler has put on the ball and how quickly the ball will arrive. Much of the joy spectators get from watching batsmen play spinners comes from observing this battle, especially if the bowler manages to deceive the batsman decisively. Both of these judgments are meant to be made initially before the ball is released and then constantly revised as one sees the ball in flight. In this typical conception of the relationship between batsman and off-spin bowler, fast reflexes and the general direction of the ball as it travels are not a major determinant of success. Rather, a batsman would look to accurately predict the amount and direction of the spin on the ball and how fast the ball is. The spin on the ball will certainly have an effect on the direction of the ball. Through the physical Magnus effect on spinning balls, the more off-spin on the cricket ball, the more it will drift away from a right-handed batsman—this similar to the lateral movement in a slider in baseball— and the more top-spin on the ball, the more quickly it will dip down and bounce before reaching the batsman—the extra downward movement of a curveball in baseball. The later one determines these factors accurately, the less effectively one can play the ball. Changes to that dynamic introduced by bowlers flexing their elbow joint in addition to all the other aspects of their action make it much more difficult for a batsman to predict where the ball will now go and how much spin it has. This is what makes throwing seem so unfair. The

opprobrium attached to it—at one point the Prime Minister of Australia, John Howard, felt driven to weigh in on the issue by accusing Muralitharan of being a "chucker" (Ryan 2004)—is attached to both the ability to bowl better and, as I detail below, the seeming difficulty of not noticing whether one is flexing one's elbow or not.

This chapter is about two things—the manner in which biomechanics has come to play a crucial part of contemporary cricket, including precipitating changes in the governance of cricket, and an account of the limits of biomechanics that became evident during my fieldwork at the MRF. I suggested in the last chapter that the act of bowling to a batsman is a Deleuzian collective event. It is not a moment of subjectification—that occurs in the hard work of training that precedes such events—but rather an unfolding of two bodies in relation to one another. The sense of anticipation, for both bowler and batsman, is crucial to this event and although biomechanics has a theoretical account of it, as a science employed in cricket it does not address that anticipation directly.

I will argue in this chapter that the concept of affect can be applied to this collective event. The particular notion of affect that is derived in part from Deleuze is, I suggest, what biomechanists might call the "coordinated segmental interaction" of the human body. But what is this concept of affect? Critical theorists

latched on to this idea in the mid-1990's. The concept has since migrated, rather forcefully, into anthropology and cognate disciplines. This strand of the literature on affect, rather unlike the form which it has taken in psychology, takes its cues from Gilles Deleuze, Henri Bergson, and Baruch Spinoza. The key feature of this strand of literature lies in its focus on unintended and unconscious movement as being formative of intention and will in human being. In this framing of the relationship cricket players have with their bodies in the act of bowling, some of the ethical charge of behind throwing rather than bowling drops away. Throwing becomes something that occurs during the event of bowling to a batsman in a cricket match, a thing that may or may not be amenable to remediation in training sessions.

I argue that theorists of this kind of affect have deployed the term to help demarcate areas of human life—of becoming—that are not in principle susceptible to the vagaries of contemporary capitalism. I suggest that this is not the case—biomechanics combined with other sciences could develop a better understanding of coordinated interaction in the future. But I also suggest that it *is* the case that biomechanics as it is applied to cricket presently does not deal with this important arena. Foucault's historical account of neoliberalism emphasizes the importance of the idea of "human capital." I argue that, on the one hand, bowlers

thinking that they are bowling whilst actually throwing, and on the other hand, and batsman unconsciously anticipating the ball's trajectory, are in fact a genuine affective mystery to biomechanics. This mystery is matched exactly by the opacity of the process by which human capital can come to valorize itself in a training of the cricketing self.

In 1998, after suffering a defeat by Sri Lanka largely based on Muralitharan's bowling, the then manager of England's cricket team made headlines when he declared that "I have my opinion and will make it known to the authorities. That is as far as I will go. We have a leg-spinner with an orthodox action. They have an off-spinner with an unorthodox action" (quoted in Searle 2001, 87). His rather oblique comments were taken as an indirect accusation of throwing and were condemned by the England and Wales Cricket Board. Chris Searle writes convincingly about how Muralitharan's action was described during that series of matches. For example, he notes that "the official Souvenir Programme of the Oval Test Match introduced Muralitharan as a 'cricketing freak' " (Searle 2001, 88). Searle also quotes Peter Roebuck—a well-known former player and columnist—from an article by him titled "Sri Lankan Sorcerer":

> At any moment one expected a black cat to fly by or a witch to start
>
> stirring a brew. This was not the sorcerer's apprentice; it was the

sorcerer himself, weaving spells, uttering his odes... At times he might

have been working to the beat of jungle drums... and all the while

creating the impression of malevolence (quoted in Searle 2001, 89).

Roebuck's obvious Orientalism has been a familiar refrain, both for Muralitharan

and for other innovative cricket players from the South Asia. Perhaps less obvious

is the role that Muralitharan plays for Searle. Writing about a further incident

back in Australia in early 1999, in which Muralitharan was again called "no-ball"

for throwing, Searle notes that Sri Lanka's captain Arjuna Ranatunga "rallied

the entire team and led them to the edge of the field of play in protest at the

umpire's decision, which had been taken in the face of the ICC's clearance of

the bowler's action." He argues that in publicly defending Muralitharan, the

Sinhalese Ranatunga had "challenged and defied communalism and separation in

his nation's sporting culture, as Muralitharan himself had done symbolically over

200 times—in every test match wicket he had taken in the company of his Sinhala

team-mates over the previous four years" (Searle 2001, 92). Further complicating

matters, the ICC became aware of the possibility of legal action. If scientists,

brought to the matter by the ICC itself, were satisfied that Muralitharan was not

throwing but umpires on the field of play were preventing him from pursuing his

professional occupation, could this form grounds for legal action?[1]

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[1]See for example, Sydney Morning Herald (1996).

In a speech in July 2011 a Sri Lankan player and erstwhile captain, Kumar Sangakkara, detailed a history of cricket in Sri Lanka. The speech was dissected in some detail as it laid some serious corruption charges against the current Sri Lankan cricket board while simultaneously tying together cricket and contemporary nationalism in Sri Lanka. The passage detailing Muralitharan connects together his body, team unity, and the nation quite clearly:

> Murali came from the hills of Kandy from a more affluent background. Starting off as a fast bowler and later changing to spin, he was blessed with a natural deformity in his bowling arm allowing him to impart so much spin on the ball that it spun at unthinkable angles. He brought wrist spin to off spin.

> … Although winning the 1996 World Cup was a long-term goal, they needed to find a rallying point, a uniting factor that gave them a sense of "team," a cause to fight for, an event that not will not only bind the team together giving them a common focus but also rally the entire support of a nation for the team and its journey.

> This came on Boxing Day at the MCG in 1995. Few realised it at the time, but the no balling of Murali for alleged chucking had far-reaching consequences. The issue raised the ire of the entire Sri Lankan

nation. Murali was no longer alone. His pain, embarrassment and anger were shared by all. No matter what critics say, the manner in which Arjuna and team stood behind Murali made an entire nation proud. In that moment Sri Lanka adopted the cricketers simply as "our boys" or "Ape Kollo." (Sangakkara 2011)

The stakes were clear. On the one hand, Muralitharan was understood to stand-in for all Sri Lankan Tamils in a predominately Sinhalese nation and national cricket team. A defense of him by his own team could only then be read as an allegory of national inclusiveness. On the other hand, that he might not be able to play had direct financial implications both for the team and for him as an individual professional sportsman. It was science that tied the two together cricket and finance, for biomechanics could prove that Muralitharan was not cheating for personal gain, but was rather a uniquely gifted individual who, for that reason, ought to be folded fully into the Sri Lankan nation.

The recent emphasis in critical theory and anthropology on affect forms, I argue, an attempt to track the same phenomenon—the increasing responsibility placed on individuals to increase their own stock of human capital at every opportunity. One small indicator of this multi-decade long phenomenon is the increasing monetization and privatization of education over the same period. Increasing

emphasis on higher education and sports training alike are, on this view, part of the same process of human capital valorization. On the cricket field, bowlers looking to improve their technique and therefore effectiveness have turned to the science of biomechanics.

Biomechanics—the study of live bodies and the physical forces that act upon it—has been used to optimize the application of forces on bowlers' bodies such that they are able to release cricket balls at higher velocities and/or higher torque towards batsmen whilst retaining or improving on the accuracy of such deliveries. It has also simultaneously been used to monitor those bodies on the cricket field to try to ensure that bowlers remain within cricket law. It is this maneuver that I call "regulating affect." However, the laws of the sport themselves has been found to be inadequate to the task. One important and controversial question in cricket centers on whether the bowler has "thrown" the ball towards the batsmen or not. The seeming impossibility of a player not themselves knowing—by feeling their elbow move as they release the ball—whether they have thrown the ball means that allegations of throwing unavoidably carry a connotation of cheating or unfair play. But how would an umpire on the field know whether a bowler has thrown the ball or not, thereby gaining an illegal advantage over the batsman?[2] On this matter, umpires can only go on what they see. Or so has been

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[2]In pace, or fast, bowling, this advantage largely takes the form of an unexpected increase in

the case until recently. Biomechanics scientists have intervened on precisely this point. The result has been a wholesale change in both the laws of cricket and how it is applied on the field in the name of regulating the affect of cricketing bodies on the sports field. The collective event of bowling to a batsman—and the sense of anticipation crucial to this event—is also amenable to a framing through affect. I suggest that both of these examples can be understood readily through an examination of affect theory. The debates on this question and the changes in the laws of cricket driven through the laboratory findings on the biomechanics of throwing illuminates, I argue, the entanglement of law, biomechanics, and affect on the playing field.

3.1   Broadcasting deregulation

Deregulation of television broadcasting in India in the early 1990s certainly fits easily under what has been called the "Washington Consensus"—that set of governance techniques packaged and ported across the world by institutions such as the IMF, the WTO, and the World Bank. This deregulatory move by the Indian state had a profound impact on the game of cricket around the world. The standard figure used by many commentators is that 70 percent of all advertising

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speed of delivery of the ball. In spin bowling, throwing enables the bowler in addition to increase the amount of spin that can be put on the ball.

money for cricket comes directly from companies based in India. Players, perhaps particularly in the Indian subcontinent, may now be thinking about a career in cricket from a financial point of view, rather than only picking up cricket as children as a form of leisure (Guruprasad 2011). The result over the last two decades has been a greater and greater presence of players from well outside the middle-classes in both regional and national teams. The impact has been similar in a number of other cricket playing nations. Certainly, most national boards now depend on arranging regular games against India in order to buttress their own balance sheets. More importantly, this influx of money around the world also means also that experts have been employed to help improve both individual players and teams as a whole through the employment of a variety of primarily visual technologies.

In this chapter I concentrate on the increasing use of biomechanics to govern the game of cricket. Before doing so, however, I will highlight the particular aspect of recent market-based reform that matters here. This will help set the framework for understanding how Foucault's argument about neoliberalism and human capital dovetails with the recent interest in affect in critical theory and anthropology. David Harvey has suggested that impetus for neoliberal policy reform came from a crisis in capital accumulation in the late 1970s and early 1980s, listing such

political figures as Ronald Reagan, Margaret Thatcher, and Deng Xiaoping (Harvey 2005, 2). This same notion of crisis was at the root of deregulation in India starting in the early 1980's and impacting cricket in particular via broadcasting deregulation in 1991. Harvey persuasively locates the genesis of neoliberalism as policy reform in the aftermath of World War II, specifically highlighting Friedrich von Hayek, Milton Friedman, Ludwig von Mises, and in general all the figures associated with the Mont Pelerin Society. At the core of Harvey's argument lies what he takes to be a "tension between the theory of neoliberalism and the actual pragmatics of neoliberalization." This is because, Harvey argues, the "scientific rigour of its neoclassical economics does not sit easily with its political commitment to ideals of individual freedom, nor does its supposed distrust of all state power fit with the need for a strong and if necessary coercive state that will defend the rights of private property, individual liberties, and entrepreneurial freedoms" (Harvey 2005, 21). Harvey correctly identifies the contradiction at the heart of the neoclassical program—the state is necessary to the functioning of markets and the development of more markets, but recognizing that fact is strongly at odds with widening the scope of market power. The very impetus for bringing more and more aspects of life under the sway of markets is belied by the consequently increasing need for a strong state to underpin those markets.

The problem with Harvey's approach is that it takes at face value the idea that neoliberalism is constituted out of a simple adding of neoclassical economic doctrine to liberal political values. He then combines that understanding with a mistaken sense of the genealogy of neoclassical economics itself. This lack of precision about the historical determinants of neoliberalism, I suggest, leads to an inadequate understanding of how it works and what its effects might be.

Harvey assumes that neoclassical economics is, as its adherents aver, a doctrine that covers the academic discipline of economics from the late 19th century to the present, with no pertinent ruptures in that continuity. He is by no means alone in taking as given that neoliberalism as doctrine follows largely from the neoclassical economics of the late 19th century. In the introduction to a "critical reader" on neoliberalism, Alfredo Saad-Filho and Deborah Johnston assert that the essays in their reader by a range of economics thinkers, including Gérard Duménil and Dominique Lévy, Thomas Palley, Simon Clarke, Costas Lapavitsas, and so on, "offer a radical critique of neoliberalism" in showing that it is "part of a hegemonic project concentrating power and wealth in elite groups around the world, benefiting especially the financial interests within each country, and US capital internationally" (Saad-Filho and Johnston 2005, 1). Critique notwithstanding, they assert that neoliberalism is impossible to define theoretically because it

is not a mode of production, it is tied up with imperialism and globalization, and because "the roots of neoliberalism are long and varied, and its emergence cannot be dated precisely...[it] amalgamates insights from a range of sources, including Adam Smith, neoclassical economics, the Austrian critique of Keynesianism and Soviet-style socialism, monetarism and its classical and 'supply-side' offspring" (Saad-Filho and Johnston 2005, 2). This is the reverse side of the claim that neo-classical economics as a whole is dated to the late 19th century in the sense that it begs a question of roots to the "classical" economics of the likes of Adam Smith.

This approach to the critique of neoliberalism by Harvey and others obscures the effects of innovations in economic theory that occurred after World War II. One aspect of that rupture can be summed up under the rubric of "game theory." The game theoretic notion of equilibrium is not at all like the notion of equilibrium made use of by the marginalists of the late 19th century. The former tracks equilibria that occur through discrete actions by individual agents whereas they latter models continuous macro-economic adjustments between uniform classes of actors.[3] Although von Neumann and Morgenstern's seminal work on game theory during World War II is addressed directly to economics (von Neumann and Morgenstern 1944), it was not picked up within that discipline until much

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[3]The post-War equivalent of the latter—dynamic stochastic general equilibrium theory—is different again.

later (Amadae 2003). Perhaps more importantly, I will argue that it is impossible

to understand the relationship between neoliberalism and post-World War II neo-

classical economics without paying detailed attention to the changes in and de-

velopment of a variety of *other* disciplines following that war, not least including

anthropology. My argument here is principally about rupture, the set of changes

occurring in that period that fundamentally reshaped a variety of disciplines and

gave birth to entirely new ones.

Neoliberalism as *ism* is of course as much a political project as an economic

one. State and inter-state institutions play a crucial role in promoting the creation

or "freeing" of markets where none existed before. The techniques that are pro-

duced by the amalgamation of neoclassical economics and politics are perhaps

best exemplified by the particular financial variant called "securitization." In-

deed, the aggressive use of this technique in the US residential mortgage market

and the subsequent crash was often rather prematurely heralded as marking the

end of neoliberalism. I take it to be the paradigmatic technique of neoliberalism

in action. With securitization, instead of a claimed rolling back of the state, one

sees a rolling out of securities and therefore markets to trade them that depend

directly on a newly strengthened state. These new markets cover aspects of hu-

man life that, strictly retrospectively, are suprisingly amenable to such treatment.

What might have been hard to conceive of becomes immediately natural and even obvious. Once something has become securitized, it can then become subject to an explicit rendering as part of, or related to, each individual's own stock of human capital because it would have become a black-boxed technology ready for any use. In the context I explore here, then, the point is that recent changes in the tenor of training available to cricket players is best conceptualized as being about helping them increase the value of their human capital.

Philip Mirowski has argued that the apparatus that makes this rolling out of the state and markets possible depends on a diverse set of reformulated scientific disciplines that he calls the cyborg sciences (Mirowski 2002). Mirowski calls these sciences cyborg—rather than cybernetics-derived—in part, I think, to underscore the manner in which they reshape boundaries between what counts as nature and what counts as the social. He, and others, also place the genesis of much of what we now call neoclassical economics in the post-World War II era (Amadae 2003). It is possible that much of the impetus for the neoclassical program comes precisely from the pretense within economics toward a much longer genealogy. Critiques of such approaches, then, would do well to be attentive to the possibility of a more recent, and cyborg, origin of neoclassical economics and therefore of neoliberalism.

The specific process of liberalization in the early 1990's in India under Narasimha Rao's Congress-led minority government gave private television broadcasters, including foreign companies, operating rights in India. This development had a big impact on cricket around the world. Private broadcasting companies operating in India could "uplink" signals to communications satellites and therefore provide Indian households with the ability to consume such locally-generated satellite television signals. The impact of this change on the Board of Control for Cricket in India (BCCI), founded in 1928, was enormous. Although BCCI's name mimics colonial government organizations, the BCCI was in fact a "society," now registered in Tamil Nadu under the Societies Registration Act, with which individual cricket clubs could affiliate themselves. The BCCI organized cricket games between "India" and other nations via what was initially called the Imperial Cricket Conference. The ICC—the acronym now stands for "International Cricket Council"—was and is the apex body that individual cricketing boards representing a nation may affiliate with. The ICC has long been under the control of cricket clubs in England and, perhaps to a lesser extent, clubs in Australia, through their respective national cricket boards. In both those countries the national bodies are also privately run.

After Independence in 1947, television coverage of cricket games in India was

arranged between the BCCI and the national government-run broadcaster, Doordarshan. The BCCI often had to help defray the costs to Doordarshan of televising cricket because Doordarshan had no direct revenue mechanism from such activities. They later came to frame televising cricket in India as a question of national and public interest. With liberalization in the early 1990's, the BCCI began conceiving of "broadcasting rights" that could in fact be sold to the highest bidder from a now rapidly growing pool of television broadcasters. The private companies could sell advertising slots during such coverage and therefore were able to out-bid Doordarshan. The consequent influx of money into the game, via the BCCI, has changed how cricket is thought about within India and, perhaps more importantly, the status of the BCCI and Indian cricket in relation to other cricket-playing countries around the world. Advertising revenue is the main conduit for money into the game. In other words, the BCCI is now in a much stronger position with respect to other cricketing bodies—the England and Wales Cricket Board and Cricket Australia, in particular.[4]

In a remarkable insiders article, Peter Hutton—Senior Vice President at Dubai-based Ten Sports and a former Managing Director at IMG Asia—writes about the manner in which the BCCI came to monetize television access to cricket in India.

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[4]For a set of interviews covering this well-known but interesting terrain, see Boria Majumdar (2012).

Jagmohan Dalmiya and I.S. Bindra were in control of the BCCI in the early 1990s. Bill Sinrich of TransWorld International (TWI) was "invited" to purchase the television rights to an upcoming tour of India by England in 1993. Sinrich had used precisely that approach in the West Indies, making available coverage of England playing in the West Indies to an English home market with great success (Hutton 2008, 140). This link is itself quite telling. Doordarshan had in part been founded on the model of the British Broadcasting Corporation (BBC) in England. A newly liberalized television market in England enabled the nevertheless contentious licensing of the national cricket game—formerly the province of the BBC only—to private companies. In his initial move Sinrich packaged rights to and televised England playing in the West Indies, rather than games held within England, as this was not something the BBC was itself interested in. TWI purchased the rights and Doordarshan in turn paid TWI for broadcasting rights within India, STAR Sports for the rest of Asia, and Sky Sports for England. The resulting monies paid to the BCCI—about $600,000 US dollars—enabled it to overcome an ongoing internal fiscal crisis (Hutton 2008, 141).[5]

Later that year, a constitutive member of the BCCI, the Cricket Association of Bengal (CAB), organized some games to celebrate its diamond jubilee. Doordar-

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[5]The fiscal crisis that the Indian state supposedly underwent in the early 1990's was the reason that Narasimha Rao's government gave for liberalization.

shan failed to match the bids for rights by other broadcasters so, with the support of the Information and Broadcasting Ministry, it "refused to allow foreign broadcasters to telecast matches played on Indian soil." Further, "[c]laiming an exclusive right to do so under the Indian Telegraph Act of 1885, Doordarshan accused the BCCI and CAB of being 'anti-national'"(Hutton 2008, 141). The Supreme Court gave judgment on the ensuing case in 1995. Hutton argues persuasively that its judgment that airwaves in India could no longer be a state monopoly, "gave legal basis to the satellite revolution that was engulfing India since the early 1990s and [that had] changed the face of Indian broadcasting itself" (Hutton 2008, 142). In a concurring note to the judgment, Justice B.P. Jeevan Reddy makes an explicit argument for a distinction between private or government control of the airwaves and *public* control. He notes that a "[d]iversity of opinions, views, ideas and ideologies is essential to enable citizens to arrive at informed judgment on all issues touching them" and that, therefore, this "cannot be provided by a medium controlled by a monopoly." Arguing that "private broadcasting stations may perhaps be more prejudicial to free speech rights of citizens than the government-controlled media...*The broadcasting media should be under the control of the public as distinct from Government*" (Reddy 2000, 260). The eventual result was the creation of Prasar Bharati. This is a public broadcasting entity within which Doordarshan

operates. The court ruling helped develop a distinction between cricket played in India that touches upon the citizenry—cricket in the public interest—and all other cricket games. This distinction continues to play an important role in determining which cricket matches must be made available to Doordarshan for simultaneous broadcasting by them and which need not be, with almost inevitable differences in those determinations decided in court.

Tracking changes in cricket as a way of delineating the effects of neoliberalism is useful because of its wild popularity in India. It stands in for, or is in a metonymic relation to, contemporary Indian society. "India" plays cricket. Cricket ties together the nation and law. Similarly, the moment of Muralitharan being no-balled is significant because it becomes the site on which Sri Lankan players and their publics can locate a fully elucidated notion of "our boys." The boys who bind together, by performing, the nation and cricket law. This is also why cricket in India is held by the courts to be so important as to be held in the public, as distinct from state, hands. The nation then is receptive to and in turn transformative of neoliberalism as a set of practices. But what does that transformation look like? Examining the relationship between sciences being applied to cricket under the rubric of human capital valorization may give some useful answers.

3.2 Cricket and fair play

Cricket is by far the oldest of contemporary mass sports in the world today. All the other popular sports were formalized or invented in the late 19th century or early 20th century. It is also one of the only sports that has laws, not rules. Specifically, one can imagine a game of Test (5 day) cricket proceeding from a coin toss all the way to its conclusion with the umpires on the field not making any contribution at all. The reason is straightforward: it is only in the event of a dispute between the players about a putative dismissal of a batsman—an "out"— that an umpire is "appealed" to and then has to make a judgment. If, for example, the ball has been hit, the batsmen run, and the fielding team does not appeal to the umpire about a possible "run out," the game proceeds without any signal from the umpire.[6] All other popular sports, even those that explicitly have laws rather than rules, typically require the active intervention of umpires and referees to mark important events on the field. This is true even in cases where the players have all already accepted that the putative event—a goal in a soccer match, an out in a baseball game, etc.—has taken place.

The distinction is between teams of cricket players who are self-governing with respect to the action on the field of play, unless they find themselves unable

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[6]There are some situations that require active participation from the umpires. Almost all of these exceptions have to do with "extras"—runs awarded automatically to the batting side for certain kinds of infringements.

to come to an agreement about some event, and other games in which players are actively surveilled for rule infringements by their umpires or referees. This emphasis on laws and appeals, rather than rules and enforcement, has been the case since at least the 1720's when the first attempt at formalizing cricket was made. This first attempt—an "articles of agreement"—make specific provision for the nobles playing the game to argue with the umpires about the latter's decisions. The provision disappears quickly and the umpires then have the final and only say on all matters on the field. In 1744 the actual "laws of cricket" were put together for the first time (Underdown 2000, 158). This was not done by a central authority, but rather by a series of different gentlemen's clubs that worked together on the document. It is clear that the high level of gambling on match results undertaken in these clubs must have necessitated some clarity on which team had in fact won or lost a game fairly. In this period games were regularly played for 200 pounds a side or more in salaries alone for professional players, so the level of gambling was probably substantial. In 1787, the newly founded and privately run Marylebone Cricket Club (MCC) was put in charge of the laws of cricket. It remains in that position and has periodically modified the laws of cricket. Until recently, the biggest change involved codifying the distinction between underarm, roundarm, and overarm bowling during the 19th century.

Cricket had been from the start a game that emphasized batting over bowling. Batsmen were generally amateurs, while bowlers were professionals. The result, argues Derek Birley, was a set of laws that favored batsmen and consequently attempts by bowlers to push the boundaries of accepted practice in order to gain an advantage over batsmen. At several turns, then well-known bowlers like John Willes were simply told to stop raising their arms higher. In 1816, the MCC officially declared that:

> The ball must be delivered underhand, not thrown or jerked, with the hand below the elbow at the time of delivering the ball. If the arm is extended straight from the body, or the back part of the hand be uppermost when the ball is delivered, or the arm extended horizontally, the umpire shall call no ball (quoted in Birley 1999, 64).

As Birley quickly notes, the problem was that if umpires barred the likes of John Willes from bowling, matches might come to an unruly end with players and spectators alike figuratively, and perhaps literally, at odds with one another (Birley 1999, 64). A few years later, bowlers gained strong support in the shape of an MCC member, G.T. Knight. He organized a series of three matches between an "All-England" team and Sussex. The latter team had several bowlers who, their opponents claimed, were "throwing." Birley notes that not "only would the new

bowling be put to the test, but to add further spice to the contests [the games] were played for 1000 guineas." Sussex won the first of two games. However, nine members of the England side "signed a statement refusing to play in the last match, 'unless the Sussex players bowl fair; that is, refrain from throwing'" (Birley 1999, 65). Bowlers around the country nevertheless started imitating the new method. Finally, in 1835 the MCC caught up with the trend and distinguished between raised arms and throwing. They legalized any ball which was not thrown and in which the hand or arm did not go above the shoulder (Birley 1999, 67).

Literature on cricket has for some time also spoken about the "spirit of the game." This spirit is usually described as involving a sense of fair play that extends beyond the written laws. It is the basis of the often used phrasing regarding some behavior on the field that it is "not cricket," understood to mean that it is not acceptable even if legal. In cricketing history, perhaps the best known example of this involved a series of matches between England and Australia, played in Australia, in which the English team deliberately targeted the bodies of some of the Australian batsmen. One such batsman is reported to have informed the manager of the English team that "there are two sides out there; one is trying to play cricket, the other is not." A strongly worded telegram was sent from the Board of Control in Australia to the MCC which stated that the behavior of the English

bowlers was "unsportsmanlike" and "likely to upset relations existing between Australia and England." The MCC replied that they were convinced that the English captain and team would "do nothing to infringe either the laws of cricket or the spirit of the game." But also that if the "Board of Control wish to propose a new law or rule it shall receive our careful consideration in due course" (The Times 1933). The laws did later change, but only after another team's bowlers tried the same approach against England's batsmen.

In 2000, the MCC took the novel step of actually specifying what the "spirit" of the game was in a new revision of the laws. Aside from some statements about the responsibilities of each side's captain and that the umpires were the sole arbiters of fair and unfair play, this document also specifies that "it is against the Spirit of the Game: to dispute an umpire's decision by word, action or gesture" and also "To indulge in cheating or any sharp practice, for instance: (a) to appeal knowing that the batsman is not out; (b) to advance towards an umpire in an aggressive manner when appealing (c) to seek to distract an opponent either verbally or by harassment with persistent clapping or unnecessary noise under the guise of enthusiasm and motivation of one's own side" (Marylebone Cricket Club 2010). These instructions clearly evince an interest in the comportment of cricketing bodies on the field of play. In its commingling of physical and mental behaviors it

is an excellent example of laws that seek to work through disciplining the conduct of cricketing bodies. But why did the MCC think it necessary to specify what the "spirit" of the game is? This move seems likely to form an instance of a general shift from a game governed by "natural justice" to a game governed by rules enforced through a panoply of technical devices and procedures.

3.3   Affective batting against bowling

One of the key questions I raised in the previous chapter is the role of bowling in relation to a batsman, rather than the biomechanical treatment of it as a exercise unto itself. The latter makes a certain kind of conventional sense. Abstracting away from general tactical considerations—bowling to a particular batsman's weakness rather than their strengths, bowling more or less aggressively depending on the overall match situation, and so on—it would seem like it must be possible to treat any particular delivery separately from the act of batting against it. After all, bowling comes first temporally. It is only once that event has happened that the batsman can then choose what shot to try to make.

There are two ways in which this is wrong. The first is game theoretic. Simple games like Prisoner's Dilemma suggest one kind of response if the game is a one-off, and an entirely different space of possibilities if the game's participants know

that the game is to be repeated many times. In the latter case, a strategy that emphasizes cooperating is likely to be more successful. Indeed, as is well-known in game theory literature, a strategy labeled "tit-for-tat" usually does very well and is evolutionary stable. This strategy simply defects if its opponent defected on the last turn, otherwise it cooperates.[7] In the case of repeated deliveries to the same batsman, a similar dynamic seems to be at work. This is very easy to see with respect to one of a fast bowler's most dramatic options—the bouncer. This is a ball usually bowled with extra effort and pitched short, that is the ball is released very late and therefore angled sharply downwards into the wicket, bouncing much farther away from the batsman than normal. On a fast, firm surface, the result is a ball that will bounce up high and arrive at the batsman at shoulder or head height. Such deliveries are regulated by the umpire in part because they are considered quite dangerous—the usual rule in contemporary one-day cricket is that only one such ball is allowed per six-ball over. This means that an aggressive bowler bowling to a batsman they think susceptible to such a delivery has to think about when in a six-ball sequence they should deploy it (if at all). Likewise, for any number of other varieties of deliveries at a bowler's disposal.

The second reason is more difficult to describe. I first started thinking about

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[7]For a basic introduction to these issues see Douglas Hofstadter (1985).

it when a collection of batsman and bowlers arrived at the MRF in late June 2007. They came there under the auspices of the Asian Cricket Council, who had selected to former Sri Lankan players as coaches—the bowling all-rounder Rumesh Ratnayake and the batsman Roy Dias. Ratnayake and Dias were there to coach a variety of players from the non-Test playing countries in Asia. The coach of the MRF team and Sekar were also expected to coach the players. The former, M. Senthilnathan, had been a player at first-class level for Tamil Nadu State. The older players of the MRF team all vouchsafed his talent as a batsman to me—he appeared to be in that crowded category of highly talented players who played below the standard that they seemed capable of achieving. At the first talk they gave before the practice session began, Senthilnathan, Ratnayake, and Dias took turns talking the players through the basics of good batting. First, having a balanced stance with the feet about shoulder-width or a little farther apart. Senthilnathan spoke specifically about what he called "locking" the knee joint. This was not about straightening the leg—very few batsmen would do that—but rather, he explained briefly, about tensing the muscles around the knee joint. He said that the result would be that you would not be able to move freely. The others then spoke about the kinds of grip—the hand positions on the bat—that were advisable, as well as how the bat should be picked up in preparation for

hitting the ball.

None of this discussion, even Senthilnathan's comment about not locking the knee joint, was framed as a scientific discussion. Rather this was about former players simply advising current—lower-level largely amateur—players about what they took to be basic technique. This framing became especially evident when Ratnayake said to the ACC players that when stepping back to play a short ball—a ball that bounced well before the batsman and therefore arriving at waist height or higher—it was okay to turn the back foot towards the ball. In the conventional batting stance, the batsmen's feet are perpendicular to the line of flight of the ball—they are standing side-on and, for a right-handed batsman, looking over their left shoulder at the bowler. Ratnayake was suggesting that when stepping back with the right foot, again for a right-hander, it was acceptable to turn the foot so that the toes were now half-way to pointing towards the bowler. On being challenged by Dias and Senthilnathan on this point, Ratnayake cited contemporary Australian batsmen as support on this point. Senthilnathan responded that the foot turning like that might be fine as the shot was played, but not before in preparation for the shot.

The discussion was not just about preparation for one particular kind of shot because most contemporary batsmen in fact use precisely that movement, the

back foot sliding farther back, as a "trigger" for playing the ball. Up until recently, cricket coaching books suggested that a batsman stand still when preparing to play a shot as that would allow them to keep their head, and therefore eyes, still as the ball was released. Keeping your head still should in theory allow you to judge the trajectory of the ball more accurately. I asked Senthilnathan about this discussion during a match a few days later. He said that turning the foot like that might be a good idea in Australia because Australian pitches are faster and more bouncy than in India. He was implying that on such pitches, turning the foot inwards would help a batsmen set up for playing pulls or hooks—aggressive cross bat shots played to short-pitched deliveries—but that short-pitched deliveries are less likely in India and the batsman would have more time to respond to them.

These kinds of discussions about batting were typical at the MRF. I suspect that this is the case elsewhere too. A recent article on the biomechanics of batting cites a mere five previous articles on the subject (Portus and Farrow 2011, 296). Portus and Farrow frame batting as a sub-second and dynamic "interceptive skill"—in the sense that the batsman is set up to intercept a ball in flight (Portus and Farrow 2011, 295). This implies that batting is defined in relation to the bowler, unlike a biomechanical framing of bowling as something independent of the batsman. The authors link both the paucity of research in this area and the lack of interdis-

ciplinary work—in this case they urge the combining of "[s]kill acquisition-motor control specialists" grounded in either neuro-motor control or behavioral learning and biomechanics specialists (Portus and Farrow 2011, 295). The latter's emphasis on accurate measurement of movement and forces means that most such studies are in laboratory settings. As an example of the confusion that results from strictly disciplinary research, they cite a study (Stretch et al. 1998) suggesting that front foot driving shots—played with a vertical swing of the bat similar to a golf drive to balls that pitch near the batsman—involve the "front upper limb (shoulder, wrist, elbow joints) working in a multi-segmental series of levers in a simulated match environment" (Portus and Farrow 2011, 297). However a later study of live match play (Stuelcken et al. 2005), rather than simulated play, finds rather the "front upper limb working in a unitary fashion for the same stroke." They surmise that in match conditions, batsmen playing against high quality bowlers might need "a technique exhibiting 'push-like' control, rather than a summation of forces to produce power" (Portus and Farrow 2011, 297).

This is a remarkable disagreement about a fundamental component of batting technique that corresponds roughly to the question I discussed in the previous chapter of—as Sekar phrased it—"putting" the ball rather than bowling it. There are two basic types of front foot drives taught even at a most basic level in cricket.

The checked drive where the batsman's arms are held in a cradle-like structure and the bat itself does not travel above shoulder height after making contact with the ball, and the full drive which has a flowing quality to it, leaving the bat wrapped all the way around and over (for a right handed batsman) the left shoulder. But this distinction alone does not help resolve the biomechanical dispute. Although it is not possible to play the latter, full, drive without the individual arm joints working in a concatenated multi-segmental series of levers, it is possible to play the checked drive in exactly that manner.

It seems likely that some professional batsmen switch easily between these two modes of driving the ball depending on the match situation, or the specific type of practice they are concentrating on in training situations. The movements a batsman makes before playing a shot—what cricket players call "trigger" movements—lay the ground work for hitting the ball in a concatenated manner or simply putting or pushing the ball out. As Ratnayake and Dias were arguing about what might be acceptable in terms of foot placement in discussions with the ACC players, I noticed that in demonstrating different foot movements with a bat in his hands, Ratnayake was picking up the bat behind him in preparation for a pretend shot and then flexing his wrists even further. I asked him about that kind of trigger movement—whether it was acceptable—and he said that he now

thought that that movement was not useful as a trigger but that it had been used as such by professional batsmen up until the early 1990s.

A few days later, I was watching the "star" player for the MRF team at the time, Y. Venugopal Rao, batting in the nets against some gentle throw-downs—balls throw down gently from a short distance in simulation of a full bowling action, but which much greater control. Throw-downs are a useful way of working on some particular aspect of one's technique because the person throwing the ball should be able to throw the ball down onto the ground in the same place every time. I stood behind the thrower and fielded any balls coming past him. Venugopal had just joined the team and was no doubt looking to rebuild his international career through playing for MRF—he had played for India recently but had not broken through to a regular place in the national team. I noticed in the process that Venugopal was occasionally, intermittently, flexing his wrists after picking up the bat—exactly what I had spoken to Ratnayake about. After the practice session was over, I picked up his bat and demonstrated what I had seen—with of course some trepidation and explicitly rendered doubt about whether I had seen what I thought I had seen. The batsman mimicked my own gestures with his bat when I handed it back over to indicate that he understood. A week or so later in the nets, after a three day game that the team had finished, he asked

me to videotape him in the nets, which recording I would copy and to give to him as I had been doing for other players, and added that he had reviewed some old footage of him batting in a match and saw the same hesitation in pick-up from time to time. Each time it happened, he said, he had played at and missed the ball.

The matches MRF and its opponents were playing did not draw public spectators. Indeed, the grounds had no seating other than whatever the teams themselves brought with them. This made for many quiet opportunities to talk to coaches and players alike. At the second three-day game I attended, I noticed that the opening batsman for MRF, Juzer, had the odd habit of picking up his toes—with all his body's weight on his heels—from time to time. Indeed, he did this as the bowlers were preparing to deliver the ball. On asking Senthilnathan about this, he replied that Juzer was just a little nervous. At the next break in action however, I heard Senthilnathan admonish Juzer for not getting his feet moving. I brought up the topic again shortly afterwards and Senthilnathan replied that he would look at him properly in the next practice session.

As it turns out, I ended up speaking to Juzer at the next session. Simply pointing out this habit was enough as it was a rather basic technical problem—it is hardly possible to moving effectively when balancing on one's toes. The

underlying cricket thinking about both feet and bat movement before the ball is released has changed quite a bit over the last twenty years or so. As I noted earlier, earlier cricket coaching books emphasize stillness and even weight distribution before the ball is released. The idea is that when a batsman's head is still they will be able to pick up the trajectory of the ball more easily, and having balanced feet will enable them to move easily either forward to get near the point at which the ball bounces or back to give them enough space to counter any movement as it bounces.

Senthilnathan spent a great deal more time with the MRF batsmen on these kinds of initial movements and with all the players on tactical matters—where to bowl to particular batsmen, which bowlers to attack, different possible field placings, etc.—than on the technique involved in particular batting strokes. The latter is perhaps rather too basic a set of considerations for professional batsmen. Moreover, these considerations—not locking the knees, moving your feet as a way of "triggering" a shot quickly and efficiently, picking up the bat in a supple way but without any moments of hesitation—all seemed work in relation to the bowler, rather than abstracting away from that encounter. One of the recurring concerns that Senthilnathan had with batsmen was that they were getting ready—triggering—too late and as a result they had to rush through the shot they

wanted to play. He told me that this was down to bad coaching—players are told constantly to "play late," so as to not pre-commit themselves to a particular shot but as a result ended up missing the ball entirely far too often.

Thinking about this aspect of coaching batting, one that was notable by its absence when it came to coaching bowling, I thought of constructing a video based computer program that would act as a tool to help batsmen anticipate the trajectories of the ball from different bowlers. The question of anticipation is ever present in cricket with respect to the types of deliveries a bowler might release. In the case of fast bowlers, one would typically be concerned with out-swingers, in-swingers, leg-cutters, off-cutters, slower balls, and bouncers. In the case of off-spinners like Muralitharan, the choices are between regular typical off-spin delivery, in which the ball tends to drift away a little before spinning back in towards a right-handed batsman; top-spin, where the ball bounces up much higher (and quicker) than normal; and the relatively new "doosra" delivery that looks like the off-spin delivery but turns in the opposite direction, away from the batsman. It is rare to find a bowler who uses all of these types of deliveries in match situations. The last on the list for fast bowlers, the bouncer, is the only one which involves a clear directional component. Bouncers are balls that are released from the hand extremely late in the bowling action so that they bounce nearer the

bowler than the batsman. The result is that the ball is arrive at the batsman at shoulder or head-height and will therefore a very different kind of stroke from that typically played at fast bowlers.

When I first started my fieldwork at the MRF, I tried assisting Sekar as he coached the bowlers at the Foundation through using my video camera to provide visual feedback to the bowlers as to what it was that Sekar wanted them to change in their bowling technique. The Foundation has its own cameras of course, but they had to be mounted on tripods and were connected to computers running SiliconCoach motion analysis software and were therefore difficult to move around quickly. The flexibility I provided by being able to get different viewing angles seemed to help a little. Viewing themselves bowling in an immediate way helped both Sekar and the bowlers identify the parts of their actions that they wanted to work on. As one aspect of their technique seemed to have stabilized in the desired manner they would add another correction and so on. This concatenation of corrections would, over the very long time period required to form bodily habits, amount to an wholesale remodeling of their bowling actions.

Computer engineering, both in terms of hardware, the silicon stuff of a modern computer, and in terms of software, work through layers of abstraction. In software, for example, an operating system provides the grounds on which appli-

cations programmers can do their work, but the operating system is itself typically dependent on another software layer of "firmware" that more directly regulates the functioning of the already itself layered hardware. Ideally, an engineer or programmer working at one layer need not concern themselves with the implementation details of any other layer. There is then, a certain resemblance between the layers of habit that bowlers produce in training sessions and the layers of abstraction crucial to the functioning of computers. In order to construct a suitable game, I used a high-level programming language called "Python" and some software libraries, mostly "pyGTK" and "mplayer". I collected a stock of video footage of MRF bowlers in their practice sessions by standing behind the batsmen they were bowling at. I then cut the video footage into fragments—from the start of their run-up to shortly after the batsman plays the ball. The program presents the player with some choices as to the expected line and length of each delivery after cutting the video playback at a fixed point. Having made a decision about the trajectory of the ball, the player is then presented with what happened. The point at which the video was cut varied according to the difficulty setting of the game.

I showed Senthilnathan and Sekar the game in the hope both that it would be useful as a tool for the batsmen in the team to think about different now ex-

plicitly made anticipation strategies and also, indirectly, as a tool for coaches to think about different kinds of bowling actions. The program closes a certain kind of feedback loop between a batsman and a bowler. The batsman gets to focus on the specificities of a particular bowling action in order to start thinking consciously about how to anticipate line and length. The bowlers get in return some sense of whether their own actions are predictable or not, and therefore whether to spend time trying to disguise what they are trying to do with the direction of their deliveries. It is commonplace knowledge amongst cricket players that bowling machines—mechanical devices constructed usually from two spinning rubber disks that squeeze out cricket balls at user-designated speeds and directions—set at a particular speed in practice sessions feel much faster to a batsman than a bowler bowling at the same speed. Indeed, this particular thought formed much of the motivation for the computer program I put together. The MRF players who tried using the program however seemed quite surprised that they were able to so successfully predict the line and length of their team-mates deliveries even when the program was set to cut the video clip five frames before ball release, using video taken at 30 frames a second.

The issue of predictability of bowling actions strikes at a central concern of worries about biomechanics and bowlers, in the sense that cricket followers worry

that over-coached bowlers might end up all looking alike because of that excess of training. I was not at all successful in "selling" this program to the bowling coaches for, I suspect, precisely that reason. I had observed in journalist interviews on multiple occasions Lillee denying carefully that he produced bowlers who "looked the same" and in conversation with me, he was careful to reiterate the point forcefully. In fact, the only part of the bowling action that he allowed had some similarity across all his bowlers was in the preparatory phase—the run-up—of the bowling action taken as a whole. This set of concerns seems like a near inevitable outcome of the kinds of expertise that biomechanics has enabled. On the one hand, coaches drew a great deal of authority from their access to and training by biomechanists working on cricket. On the other, this same training seemed to limit the kinds of performance of expertise open to them because bowling is treated by them as an isolated event, not one that happens in relation to a batsman.

3.4 Muralitharan and the 'throwing' controversy

The laws governing cricket target cricket players like Muralitharan via affect. The domain of the ethical has receded, hence the need for a specification of the "spirit" of the game that explicitly lists prohibited gestures toward the umpire. The *inten-*

tion of the player is clearly the target, but the only means to reach that target lies within a regulation of gesture and the affect that that may transmit. In the case of throwing, the locus of the change from cheating to affect lies wholly within the science of biomechanics. Critics of Muralitharan's bowling action argue that the laws of cricket were reshaped to fit his specific case. The implication being that the changes were chosen to fit his particular bowling action. On this score they may in fact be correct. It was only relatively recently, after significant changes in both the law and how it is implemented, that biomechanists published a finding that all, or very nearly all, bowlers in cricket do in fact use their elbow to jerk the ball forward, thereby suggesting that throwing was not an ethical matter, but merely a technical question. These are all matters of degrees: Muralitharan appeared to bowl one kind of delivery in his repertoire using about 14 degrees of straightening of his elbow. Other famous current bowlers also straighten their elbows by 10 or more degrees (Kesavan 2007, 105–12). Such is the opprobrium attached to throwing that this finding was met with no little consternation by current and former players, journalists, and fans. The study of Muralitharan's action conducted at the University of Western Australia after his second tour there has been published as a journal article. The authors note a key feature of Muralitharan's anatomy:

> Muralitharan has a restricted range of motion in his elbow joint in that

he is unable to fully extend his elbow—that is, at full extension, his elbow is bent. Therefore, when bowling with a fully extended arm, his elbow may appear to extend or flex by just viewing the elbow at different angles as the upper arm rotates internally or externally. Consequently, a three-dimensional kinematic analysis would be the most appropriate way of assessing his bowling action (Lloyd et al. 2000, 975).

While they go on to ask whether biomechanics "can be used to assist umpires in determining the legitimacy of a bowler's action" they also argue that "the exact time-frame for which the elbow must remain extended before ball release must be clarified, as the relevant cricket law states that 'the arm must remain straight during that part of the delivery which directly precedes the ball leaving the hand' " (Lloyd et al. 2000, 975). They note that Muralitharan's range of motion is significantly different from "normal": his maximum extension is down to 37 degrees (compared to 0 degrees) and his forearm carry angle[8] at full flexion is up to 18 (compared to 0 degrees) (Lloyd et al. 2000, 977). Using multiple high speed video cameras and the "Vicon Bodybuilder" software program to construct a 3D model of Muralitharan as he bowled several balls, the authors state that "[d]uring

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[8]With the arm hanging vertically down, fully extended, and with the palm facing forward, the "carry angle" is the angle between forearm and the upper arm in the direction of the thumb, i.e. laterally away from the body.

the 0.06 s before and immediately after release, the elbow angle was stable… In fact, for many of the deliveries, the elbow angle was marginally reducing in size (i.e. flexing), a clear sign that throwing has not occurred" (Lloyd et al. 2000, 977-78). These biomechanists have proved in the laboratory that Muralitharan was not throwing the ball. In concluding the article, they note that although replays from live TV coverage have now been used for other elements of the game, "video images can give an erroneous perspective of elbow joint angles as the arm rotates in- and out-of-line with the image plane of the camera" (Lloyd et al. 2000, 979). They argue that 3D analysis in laboratory conditions must nevertheless be compared with 2D TV video from cricket on the playing field. More importantly:

> If kinematic analyses are to be performed, a more precise definition of what constitutes a legitimate bowling action must be developed. The laws of cricket should be modified to clarify the words 'directly precedes the ball leaving the hand'. This period, the 'delivery phase', could be defined as that part of the delivery action in which the 'arm must remain straight'. The start of the delivery phase should be determined from the upper arm orientation because, as in Muralitharan's case, the forearm orientation would be quite inappropriate because of the structural abnormality to his elbow. The delivery phase should

be from when the upper arm is aligned horizontally to release (Lloyd

et al. 2000, 979).

The current law, following exactly this strongly worded injunction, states under the heading of "Definition of fair delivery – the arm" that "A ball is fairly delivered in respect of the arm if, once the bowler's arm has reached the level of the shoulder in the delivery swing, the elbow joint is not straightened partially or completely from that point until the ball has left the hand. This definition shall not debar a bowler from flexing or rotating the wrist in the delivery swing" (Marylebone Cricket Club 2010).

Yet it would now be extremely unusual for an on-field umpire to call a bowler for throwing under this law. This is because the ICC, not the MCC, controls the actual implementation of the laws. The ICC has a long document titled "ICC Regulations for the Review of Bowlers Reported with Suspected Illegal Bowling Actions" that covers what is supposed to happen if a bowler is called for throwing or is "suspected by the Umpire or the Match Referee of bowling with an Illegal Bowling Action." It immediately notes, however, that "Umpires and Match Referees, in deciding whether to cite a Player under these Regulations, should use the naked eye viewing the action live and/or on television at normal speed" (International Cricket Council 2009, 350). The document goes on to indicate the

procedures by which an "human movement specialist" who is not domiciled in the country that the player is from should examine the player's bowling action in a laboratory after he has been cited for suspected illegal bowling (International Cricket Council 2009, 351). The important caveat, wholly unsupported by the law as the MCC states it, is what the document calls an "acceptable level of elbow extension," specifically that "[t]his should be set at a maximum of 15 degrees 'Elbow extension' for all bowlers and types of deliveries. This specifically refers to extension of the forearm relative to the upper arm to the straight position" (International Cricket Council 2009, 363). This 15 degree threshold comes in fact from a report by biomechanics "human movement specialists" specifying that 15 degrees is the lower limit at which elbow extension becomes visible to the human eye and, moreover, such a level forms an upper bound covering almost all professional bowlers playing today. It is under this regulation that Muralitharan's action was cleared again in 2005 after he had developed a new delivery that appeared to involve more flexion of the elbow that his previous kinds of deliveries had demonstrated.[9]

Driven by the controversy over Muralitharan's bowling action, cricket officials had recruited biomechanists to investigate the matter. The result has been a reworking not just of the laws of cricket themselves, but also a redistribution of

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[9]He was tested again at the University of Western Australia in 2004. See Island Cricket (2010).

authority between the laws overseen by the private MCC and an expanding set of rules overseen by the ICC. The incommensurability between these procedures has been papered over by the specification that flexion of the elbow below 15 degrees is not discernible with prostheses like video replays. An umpire may feel that a bowler is throwing, and has the authority to call a "no-ball," but will no longer do so. Instead, the bowler is referred to biomechanics experts.

3.5   Affect

I did in fact eventually fall into the role of an expert at the Foundation, although it would be better to say that I ended feeling compelled to seek out and legitimate that role for myself. I found here that performing expertise through an understanding of cybernetics was an incredibly seductive operation. It was a high-pressured, money-based, overwhelmingly "fun" kind of process involving figuring out, literally, the body and its relations to other bodies via visual and statistical computation. I subsequently discovered that the Australian national coach proposed to try out a far more sophisticated version of the program I wrote to track opposition bowlers and their actions. But more to the point, my failure to follow through as an expert at the Pace Foundation was I think mostly the result of a prior on going negotiation between biomechanical experts and other per-

haps equally adept participants in the game, ranging from retired players turned journalists or TV commentators to other coaches and managers.

The computer program I had produced—if it had worked to draw together bowlers and batsmen at the MRF on a regular basis—might have reinforced the idea that the particular players adept to biomechanically approved coaching are exactly those bowlers who end up with predictable actions. Certainly the players who used the program had no trouble picking exactly where the ball was going to go, even when the video action they were watching paused well before ball release. Opposition to biomechanics in cricket—particularly the idea of varying degrees of plasticity of the body—forms around how biomechanical approaches require "too much" of such plasticity. The main biomechanical finding on cricket over the last two decades has to do with categorizing different types of bowling actions and finding that bowlers who mix types will likely both bowl inefficiently and also suffer lower back injuries. Batting and fielding are largely untouched. Many bowlers appear to perform very well by breaking these rules, but the problem is not that biomechanics might be considered "wrong," it is that it produces predictable players who will, therefore, not be as effective as they would hope.

This excursion into the niceties of cricket law and its implementation highlights the role that affect plays in cricket. Remember that the law speaks about

any elbow extension or straightening at all being "unfair." The ICC document goes further than this by first putting into place a formal review of any on-field calls by the umpire. The ICC has recent documents titled "Principles of Natural Justice" (2005) and "ICC Code of Conduct for Players and Umpires" (2009) that specifies the multi-step sets of procedures by which disputes about bowlers being called for throwing by umpires are to be handled by the match referee and biomechanists. This is precisely why umpires are unlikely to make such calls—to do so is to invite being both overruled and being told to ignore their judgment of that bowler in the future. Moreover, the ICC have inserted a provision of 15 degrees as an acceptable upper limit of elbow extension. All of these provisos, and indeed the law itself, are derived from and couched in a purely perceptual language. What is acceptable is defined around an apparently unmediated "seeing" of a bowler's arm action—no television slow motion is allowed. It forms, in short, a nice example of regulation by affect because all compliant bowlers feel as if they do not extend their elbows, but they do. And umpires are instructed to perceive whether an action is legal, unmediated by technologies like slow motion replays, but have their judgment be subject to verification by presumably better, more objective biomechanics scientists. There has been a simultaneous switch from umpires upholding laws to umpires enforcing rules and an evacuation of

the final authority of umpires by the ICC in the form of match referees, appeals procedures, a variety of technical devices, and biomechanists.

I suggest that affect and the cybernetic science of "biomechanics"—the science of life and the physical forces that act upon it—can be read against one another productively. Affect in both recent anthropology and in biomechanics concern a working out of "human capital." The latter is an important and interesting development of neoliberal theory and practice. If neoliberalism has cybernetic origins and cricket has changed following increases in the amount of money following liberalization, it follows that an investigation into how cricket is played, reasoned about and regulated, illuminates the functioning of both neoliberalism as "ism" and critical responses to it via concepts like affect.

In her introduction to the edited volume "The Affective Turn," Patricia Clough, following Brian Massumi, distinguishes mere emotion from affect—in the Deleuzian sense—by arguing that it allows for an attention to a *becoming* that might go beyond the body: "[a]ffect is not only theorized in terms of the human body. Affect is also theorized in relation to the technologies that are allowing us both to 'see' affect and to produce affective bodily capacities beyond the body's organic-physiological constraints." Likewise, such experimenting "also inserts the technical into felt vitality, the felt aliveness given in the preindividual bodily capacities

to act, engage, and connect—to affect and be affected." Thus, for Clough, "[t]he affective turn invites a transdisciplinary approach to theory and method that necessarily invites experimentation in capturing the changing cofunctioning of the political, the economic, and the cultural, rendering it affectively as change in the deployment of affective capacity" (Clough and Halley 2007, 2). A theorization of affect enables, for Massumi and Clough, a move from the becoming of a body that lies beyond the reach of contemporary capitalism to, nevertheless, a form of experimentation through affect of the political, economic, and cultural aspects of human life.

In an important article on affect in critical theory that is informed by the multiple authors in Clough's volume, Clare Hemmings argues that a certain kind of rewriting of the history of cultural theory has enabled scholars to think of the turn to affect as "cutting edge" research. This turn promotes, according to Hemmings, a sense that what is needed in the present in cultural theory is merely a more theoretically productive frame of mind. Hemmings argues that there are three major impasses in critical theory that affect is supposed to help resolve. First, as critical theorists she argues that "we doubt the capacity of constructivist models of the subject to account fully for our place in the world as individuals or groups." What is left out here is the "residue or excess that is not socially produced, and

that constitutes the very fabric of our being." Therefore, second, "we doubt the capacity of both quantitative empirical approaches and textual analysis to account for the fullest resonance of the social world we wish to understand." And, third, "we doubt that the oppositions of power/resistance or public/private can fully account for the political process." As a result, Hemmings suggests, "affective ties have been theorized as offering an alternative model of subject formation" (Hemmings 2005, 549–550). The contrast Hemmings is drawing here has to do with the hopefulness she takes to be associated with affect: theorists of affect "emphasize the unexpected, the singular, or indeed the quirky, over the generally applicable, where the latter becomes associated with the pessimism of social determinist perspectives...." Thus, she argues, for theorists like Massumi, "it is affect's difference from social structures that means it possesses, in itself, the capacity to restructure social meaning" (Hemmings 2005, 550). Massumi, and other theorists who draw in part from Deleuze, will likely of course disagree with this assessment by Hemmings. I argue that the distinction that Deleuze draws between different forms of subjectification from his interview about Foucault strongly suggests a reading of Deleuzian that is not predicated only on a move towards residues that are not socially produced, but rather a use of that residue to reengage with the social. The distinction between the exceptionality of affect and the determinism of the

social is important to Hemmings because it enables a framing of the *choice* that is presented to such affect theorists. Affect theorists are, Hemmings argues, required to suppress the question of whether the world is really divided up into good and bad affects—that is, affects leading to a politics that the theorist does not endorse—by asking of the reader whether they prefer the optimism and freedom enabled by the former to the pessimism and determinism of the latter. Thus, Hemmings argues, affect "often emerges as a rhetorical device whose ultimate goal is to persuade 'paranoid theorists' into a more productive frame of mind" (Hemmings 2005, 551).

Neoliberalism seems an apt candidate for paranoid theorists to focus on today. Certainly one can hardly think of a better example than the changes brought about by neoliberalism in, as Clough put it, the "cofunctioning of the political, the economic, and the cultural, rendering it affectively as change in the deployment of affective capacity" (Clough and Halley 2007, 2). But how useful is the turn to such an account of affect in critiques of neoliberalism? Much depends on an aspect of neoliberal theory—the idea of "human capital" that informs much of Michel Foucault's understanding of post-war Germany and the United States. Foucault argues in the *Birth of Biopolitics* lectures that this novel idea, as developed by Gary Becker, Richard Posner, and other "law and economics" luminaries, marks

a transition to an interventionist state that insists on each person being a kind of self-entrepreneur. Such entrepreneurs must, of course, seek to secure returns on the unalienable capital they possess.

Two features of Foucault's *The Birth of Biopolitics* are worth noting. First, that this is the only sustained account directly about his present and recent past that we have by him, and second, that these notes of the 1978-9 lectures (Foucault 2008) have only recently become available in published form.[10] Foucault begins the lecture series by carefully setting out what he means by a study of the art of government—studying how sovereign rule has been reasoned about—namely a method that "is exactly the opposite of historicism: not, then, questioning universals by using history as a critical method, but starting from the decision that universals do not exist, asking what kind of history we can do" (Foucault 2008, 3). With respect to liberalism, the primary contrast for Foucault is with the police of the 17th and 18th centuries and the manner in which limits to *raison d'État* were always external to the state. Contrawise, and this is what could only keep a system of states in equilibrium for Foucault, "there is no limit to the objectives of government when it is a question of managing a public power that has to regulate the behavior of subjects" (Foucault 2008, 7). Foucault suggests that attempts at external limits to *raison d'État* took the form of juridical reflection—in England,

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[10]First published in French in 2004, translated into English in 2008.

via state contract theory—on limits "that come from God, or those which were laid down once and for all at the origin, or those which were formulated in the distant past of history." By contrast, the marker of the transformation of government into *modern* government are limits "that will no longer be extrinsic to the art of government, [but] intrinsic to it: an internal regulation of governmental rationality" (Foucault 2008, 10). Foucault notes five important points regarding this internal limit to government. First, it is a de facto limit, not a legal limit. Consequently, any transgression of the limit is not a sign of the illegitimacy of the government but rather its inadequateness. Second, the limit is general even if de facto. That is, it is valid at all times. Third, the limit comes from a consideration of the best means to meet objectives of government practice itself. Fourth, that a distinction will be drawn between what must be done and what it is best not to do. And finally, fifth, as a consequence of the preceding points, the "government of men is a practice which is not imposed by those who govern on those who are governed," but is rather a discovery of limitations "by a series of conflicts, agreements, discussions, and reciprocal concessions: all episodes whose effect is finally to establish a de facto, general, rational division between what is to be done and what is not to be done in the practice of governing" (Foucault 2008, 12).

Foucault argues that the outcome of these series of conflicts, agreements,

and discussions under neoliberal processes is that government comes to be understood as something that must not intervene on the effects of the market—correcting the destructive effects of the market on society—but rather that it should intervene directly on society itself so that a regulation of society by the market becomes possible. In a discussion of neoliberalism as it arrived in the US from Germany after World War II, Foucault emphasizes the role of figures like Theodore Schultz and Gary Becker. He suggests that what is unique to neoliberalism in the U.S. is its examination of labor and entrepreneurship as factors of production—following Adam Smith's four-fold distinction between land, capital, labor, and entrepreneurship. Foucault argues that even though the classical political economists, including Marx, make labor a central component in their analysis, they do so by reducing labor to a question of labor-time or labor-power. For neoliberals like Schultz and Becker, Foucault argues that the abstraction that makes such an analysis possible "is not the product of real capitalism, but of the economic theory that has been constructed of capitalist production." That is to say, "[a]bstraction is not the result of the real mechanics of economic processes; it derives from the way in which these processes have been reflected in classical economics" (Foucault 2008, 221).

A focus on the actual capitalist processes involved, for these theorists, would

start with an analysis on the status of the "income" that a worker generates. Foucault suggests that for Schultz income is simply the product or return of capital—"[t]his is not a conception of labor power; it is a conception of capital-ability which, according to diverse variables, receives a certain income that is a wage, an income-wage, so that the worker himself appears as a sort of enterprise for himself" (Foucault 2008, 225). The result is that rather than *homo œconomicus* being a creature of exchange, under classical political economy, or a creature merely of consumption, as one might find under contemporary accounts of "late-capitalism," one finds instead that the "stake in all neoliberal analyses is the replacement every time of *homo œconomicus* as partner of exchange with a *homo œconomicus* as entrepreneur of himself, being for himself his own capital, being for himself his own producer, being for himself the source of his earnings" (Foucault 2008, 226).

The development of neoliberalism is, then, tied directly to idea of human capital and the resulting emphasis on each individual having to be responsible for the development of their own human capital. There are two types of important problems attached to this development. First, if the development of neoliberalism is an outcome of cybernetics-derived sciences, are there sciences that impact directly on the development of the idea of human capital? Second, what shape might the

response have taken, if any, within the humanities and the non-cybernetic sciences?

The example of cricket laws and how they have changed since the mid-1990s illustrates in miniature the shape legal changes take under this regime. Muralitharan's career as a bowler did not end after he was "no-balled" for throwing the ball. Throwing in cricket had been subject both to a great deal of moral pressure—throwing was treated as tantamount to cheating precisely because it had been inconceivable that a bowler could unknowingly straighten at the elbow while releasing the ball. This is exactly the domain of affect. The felt liveliness of the body as a kind of unfolding of human being. Playing the computer game I wrote likewise highlights the collective event nature of the interaction between bowler and batsman. This too is a moment that is rendered affectively.

The solution to the problem of throwing in cricket was to bring in biomechanical science to adjudicate claims about who was and was not throwing. Such science found rather that all bowlers throw and thus drove through legal changes that removed power from the umpires and redistributed it to a medley of technical procedures with biomechanists at its center. But biomechanics has little, as of yet, to say about why or how some coordinated segmental interactions amount to bowling and others to throwing. Under both interpretations—affect

or biomechanics—there is an impasse here. However, I have argued that this impasse does not lie outside the jurisdiction of neoliberalism. Affect is of little help here as a critical move against neoliberalism because it is merely the name that critical theorists give to the mystery of human capital valorizing itself. The end result is a securitization of cricketing life as human capital.

Chapter 4

Operations Research and predicting outcomes in cricket

The 1992 Cricket World Cup, held in Australia and New Zealand, was marked by a number of new developments in the sport. South Africa, newly re-admitted into international cricket by the International Cricket Council (ICC) after the fall of apartheid, was playing its first World Cup. For the first time, the players were wearing colored clothing with their individual names on the back of their shirts. And white leather balls were used, instead of the usual red, so that some games could be played under floodlights—the idea was that the usual red leather balls did not show up clearly at night, especially if hit up high into the air.

An important further innovation involved a new "rain rule." Limited overs games in cricket are designed to produce a definitive result. This in turn means that some accommodation must be made for any delays that might occur during the game. In a limited overs game, each side takes one turn each at batting. A coin toss determines which team can choose whether to bat first or second. One team bats for about half the day, scoring as many runs as possible in its allotted 50 overs (each over consisting of six legitimate deliveries). Then the other team takes over. If the second team scores more runs than the first team, the game comes to a halt as the second team is a winner. If the second team either bats out its allotted 50 overs or loses all its batsmen, but hasn't scored more runs, it has lost. Some special rules handle the very rare case of tied scores.

Given this structure, there is no definitive way to know which team is winning a game at any arbitrary moment. Indeed to ask the question "who is winning?" while a match is in progress and expect a simple answer is to mark oneself as a newcomer to watching cricket. However, even without the continuous scoring available in other sports—football, for example—there are nevertheless some clues as to which team is doing well. If the first team to bat is scoring at a more rapid pace than is usual, it seems clear that they may well end up winning the game. Likewise, if the first team finished their innings on a low score, and the second team is scoring quickly it will seem likely that the second team will end up the winner. There are of course many situations when even neutral spectators will disagree with each other about the prospects of each team. The kinds of factors relevant to an evaluation of the situation might include everything from the prevailing weather conditions, to the condition of the pitch—the strip of earth on which most of the action takes place—, the likelihood of dew or rain later in the day, which players have been playing well recently or are carrying injuries, previous results between the two teams, the match situation itself, who is currently batting, which bowlers have finished their allotted set of deliveries, and so on.

In this chapter, I explain how the Operations Research model that is now part of the laws of cricket governing match delays derives its persuasiveness as a

model. The model is an example of a political technology that works on the second of the poles of development that Aihwa Ong elucidates through Foucault—the species body. This Duckworth-Lewis model of cricket is framed around two distinct concerns—fairness and prediction. I suggest that these two concerns are somewhat at odds with one another. Moreover, I will argue that the fact that this is a quantitative model raises an issue surrounding number and community. The relationship between this model and cricket is worth examining in detail because it stands in for the manner in which quantitative modes of governmentality might be constructed for society at large.

The model is opaque in two different ways. First, it is a proprietary model. Regulators of the game have access to exactly how it calculates how to change the target that a team will need to win a game, but no one else does. Worse, the modelers have kept secret, even from the regulators, how they used their data-set of previous games to calibrate their model. Second, the mathematics behind the model has been published but is largely incomprehensible to cricket players, coaches, and fans of the game. Certainly, there have been no journalistic attempts to explain how the model is constructed nor have there been any other kinds of public discussions of the internal workings of the model. In the next chapter I argue that there are a number of interesting features of how the model

came into being and challenges to its veracity that are worth elucidating. In this chapter, however, I will suggest that the usual somewhat standard kinds of arguments against quantitative models of human society can be raised against the Duckworth-Lewis model. I also argue that the persuasiveness of the model rests largely on the possibility its performativity. This in turn rests on the cybernetic notion of teleology and the role that computers have come to play in mathematical proof. I will suggest more broadly that performativity is a necessary condition of a technology becoming embedded in the very structure of some given activity—here, the laws of the game of cricket.

Prior to the 1992 World Cup, the usual rain rules debarred any match result unless a minimum number of overs were faced by both teams. This meant that a team batting first could not be declared a winner, no matter how many runs they scored, unless the second team also had a chance to bat for some time. Further, in the event of a rain delay, an adjustment would be made according to the prevailing average run scoring rate in that innings so far. For example, consider a situation in which the first team has completed its innings—scoring 200 runs in 50 overs—and then a delay occurs that means that the second team will have to face fewer overs for the game to finish on the same day, say 40 overs. The score that the second team will have to reach to win will be reduced

by the first team's average run rate over the course of its innings for each over taken away from the second team. In this example, the second team will have to score 161 runs to win. This system has some obvious virtues. It is certainly very simple. The concept of an "average" is readily understandable and is, perhaps more importantly, already part of the way that cricket players, commentators, and spectators keep track of how a game is progressing. While a team is batting second in a game—"chasing a target"—one might typically hear comments about whether they are keeping up with the "required run rate" for example. Note that the move I have made here of bringing out the features of this rain-adjustment method by giving an hypothetical example of a cricket match in a certain state is exactly how discussions of such models typically proceed. Readers are meant to compare their intuitions of how an example of a cricket match might develop over time both with and without the particular rain-delay adjustment being proposed. Determining the plausibility of a model being fair and accurate requires a careful perception of one's intuition about the dynamics of typical cricket matches. As we shall see in this and the next chapter, the literature on these models, both in and out of scholarly journals, is rife with such rhetorical moves.

This rain rule had introduced a number of difficulties over the years. Three years before the 1992 World Cup, for example, Australia lost to the West Indies

in the final game of the World Series Cup Final—a tournament in Australia that pitted that team against two touring teams, in this case the West Indies and Pakistan. Australia won the coin toss at the beginning of the game and elected to bat first. In retrospect, this proved to be the decisive moment in the game. Australia had scored 83 runs for the loss of two wickets when rain first interrupted play. Although there was a provision that allowed the final to be replayed on the next day, that would only occur if the cumulative delay was long enough. In this case, Australia were soon back on the pitch but now playing a 38 over game, not a 50 over game. In the remaining time, they scored a further 143 runs. This meant that the West Indies would have to score a challenging 227 runs to win off 38 overs, an average run rate of 5.97. However, the West Indies' innings was also interrupted by rain. They had been on 47 for 2 when it rained. On resumption of play, they faced a target of only 61 runs from 11.2 overs and achieved it easily (Wisden Almanack 1990). Mike Coward, writing in the *Sydney Morning Herald* called it the "Great Rain Robbery," quoting an anonymous member of the Australian team as saying that "We've got ourselves to blame. We knew about the inadequacies of the rules and did nothing about it." Coward went on to note that the then captain of the team, Allan Border, suggested that professional cricket players be invited to submit proposals to change the rules—ones that did not unfairly penalize the

team batting second. Coward quotes Border as saying that "It is a very complex problem and usually someone finds fault with every suggestion ... But something has to be done. There was nothing more we could have done last night" (Coward 1989). A news report noted the reactions printed in local Australian newspapers, where the match was described as "hollow," "farcical," "calculator cricket;" and "a wet weather rule designed purely to achieve quick results for television." The immediate problem was the balance between the commercial pressure to complete the game within one day, lest further television coverage on the following "reserve" day be too costly, and the need to have sufficient play as to lessen the advantage rain rendered to the team batting second. Richard Benaud, a former player and captain of the Australian team who has been quite influential in post-war Australian cricket, was quoted as saying "For three years now, I have pointed out to the administrators the ridiculous advantage enjoyed by the side batting second in this situation. Perhaps now a final has fallen flat, they will do more than give it a cursory wave of the hand and put it in the 'too hard' basket" (Times 1989).

The 1992 World Cup organizing committee, including Richard Benaud, introduced a different rain rule for this particular tournament. The new rule would not take the average run rate from the first team's innings, but would instead rank

each over in the first innings by how many runs were scored—the over in which the least number of runs were scored first, then the next least productive over, and so on. For each over of reduction in the second innings, the target score would be reduced by the runs scored in the least productive over from the first innings. That over would then be struck off the ranked list. Continuing with the example above, if the first team had, say, only scored 20 runs from its least productive 10 overs, then the second team would have to score 181 runs from the 40 overs now allotted to them because of the delay. The reason given for this rule change has to do with a perceived unfairness to the first team under the previous rules. In general, it is easier to score at some given rate over a small number of overs than to score at that same rate for a large number of overs. A target of 100 runs in 20 overs is far harder than a target of 5 runs in 1 over, for example.

After a large number of games, the 1992 World Cup had come down to the semi-final stage. In one of the semi-finals, England played against South Africa. England were considered one of the stronger teams in the tournament. The South African team had so far been commended for its play—the game between newly post-apartheid South Africa and the West Indies was particularly marked out for its amiable but competitive play. A number of players in the World Cup, including players in England's team, had defied a sports boycott of South Africa during

the 1980s. Cricket was segregated within apartheid South Africa, but the pay for international cricket players to play in South Africa was much higher than in regular cricket. Players tempted into playing in South Africa—the so-called "rebel" tours—had been banned from regular international cricket for some time but were now playing again. There was in short a great deal at stake in this game, some of which went well beyond purely cricketing considerations.

On the day of the match, the weather forecast suggested rain. Indeed some early rain delayed the start of the game. At this point, the number of overs that each team was to face had not been reduced from the usual 50 overs. The South African captain won the toss and invited England to start the game by batting first. England started relatively badly, but then a series of partnerships between their middle-order batsmen allowed them to score many runs. The South African team had been somewhat slow in the field, taking their time between overs to discuss strategy and so on. As a consequence they would be fined a small amount of their match fees. More importantly, England's innings was cut short. Instead of facing a full 50 overs, they only faced 45 overs, scoring a total of 252. South Africa's batting innings proceeded in a relatively balanced fashion. Their batsmen were generally scoring runs freely, but were also getting out before really taking control of the game. The match appeared to be heading for a very close finish.

With just 13 balls remaining in their allotted 45 overs, their batsmen needed a further 22 runs to win. An impartial observer would likely think that they would lose the game from this position. The game, however, was held up by heavy rain for 12 minutes—in order to try to preserve the condition of the pitch, covers are brought onto the field by groundstaff and play suspended temporarily. After the rain stopped, the new rain-rule came into effect. It turns out that in England's innings, one of the South African bowlers bowled particularly well. He managed to restrict England to just one run in two of his overs. This meant that the new target for South Africa's batsmen would be 21 runs off one ball. The maximum a batsmen can score off one ball is 6 runs, so the game had effectively been ended by the rain-rule (Miller 2007).

This high profile event forced the rain-rule off the table. And it provided the motivation for the development of the Duckworth-Lewis model now currently in use in cricket. The model was first put in place as a rain rule at the end of 1996, with the ICC publishing a guide for the application of the Duckworth-Lewis method in professional cricket (International Cricket Council 1996, Appendix II, 39–53). Duckworth and Lewis—probably the drafters of the guide—had themselves been busy training match officials how to use it. In their first hand account of the building of the model, Duckworth and Lewis note that in that first year,

they "had no problems with scorers, umpires, match managers or even the players," but that "[m]ost of the adverse comment came from the media." They note that they produced an explanation of their method, including several worked out examples, for the media but that "few, if any, of these parties ever gave any indication that they had read it, let alone gone through the examples" (Duckworth and Lewis 2011, 67). The authors suggest that the media were "critical but basically uncomprehending of the rationale and fairness of the method" and cite unfavorable media reports to the effect that their method is "dreaded," "much vaunted and complicated," and, simply, "bizarre" (Duckworth and Lewis 2011, 68). In response to this media coverage, including a critical editorial piece in the 1998 edition of the Wisden Almanack (Engel 1998, 17–18), that they also quote from, they decided that they would hold themselves accountable only cricket regulators and not to the press (Duckworth and Lewis 2011, 69).

By 1999, with the World Cup due to be held in England, their method had nevertheless begun to be used in almost all the major cricket playing countries—testament, perhaps, to the clear inadequacies of previous attempts at rain rules. Some familiarity with the system by 1999 combined with the expectation that rain might well interrupt key games, meant that commentators, players, and coaches had begun to think about the implications of the Duckworth-Lewis method. In an

early pre-tournament game, Australia played Worcestershire—a local professional team. Worcestershire batted first and 162 runs in a rain-shortened 44 overs. Australia were therefore set a target of 178 to win in 44 overs under the new system. Chidanand Rajghatta reported that "[t]his World Cup will throw up many such intriguing reformulations and teams will have to ace such unexpected twists." Rajghatta went on to note that "[o]ne consideration which will come into play in conditions where rain is imminent or expected will be whether to bowl your best bowlers through" (Rajghatta 1999). The key point here is the expectation that a cricket team will modify its tactics in the light of possible rain delays. This applies across different rain rules of course, but previous rules were never taken to be predictive of final totals or results—indeed that was the source of dissatisfaction with them. Here one had a rule that was meant to be fair *and* predictive, so the fact that a team might consider modifying its approach to a game suggests an attempt to drive a wedge between the claim to fairness and the claim to accurate prediction. In this case, the tactic is based on the restriction on the amount of overs each bowler in a team is allowed to deliver. If a rain interruption is likely, Rajghatta notes, it might make sense to have your best bowlers use up their allocation before it rains thereby temporarily depressing one's opponents run scoring and increasing the chance of getting their batsmen out. If successful as a tactic,

this would improve the side's position under the Duckworth-Lewis model because it does not take into account which of your bowlers have bowled only the total number of overs finished.

The tournament was organized around a pool stage—in which groups of teams would accumulate points by playing other teams in the same group—and then a knock-out stage to decide the final winner. India had played particularly badly against a relative weak team in their group, Zimbabwe, and seemed therefore to be out of the tournament early. In an account of this situation titled "India puts down the remote...," Anubha Charan reported a number of forlorn Indian fans still hoping for some way India could squeeze through to the final stage. Charan noted that "if India beat New Zealand by something like a 150-run margin, and if South Africa defeated Australia by a similar differential, we would be tied at four points with Australia and might go through on a higher net run rate" (Charan 1999). Indeed, there had already been a report of the team's management requesting clarification from the organizers of the tournament about precisely how those the rules governing which team went forward worked (Express News Service 1999). Charan went on to report that spectators in India "finally switched to another channel when it was revealed that at the time of rains interrupting play New Zealand were ahead on the Duckworth-Lewis [method]" (Charan 1999). This

is an example, not of changes in the tactics within a game, but rather a claim that spectators were beginning to pay attention to the Duckworth-Lewis method in order to decide what was worth their attention. An understanding of the underlying model and the ability to put it to use in analyzing a game had escaped the confines of the team's coaches and the match's regulators.

In 2002, the West Indies played a series of games against India in India. The three longer-form Test matches were played first, with a seven game long set of one-day matches to follow. The first two games, in Jamshedpur and Nagpur, were marked by some crowd troubles. In the first game, with the West Indies batting second and just 13 runs short of almost certain victory, the TV commentators announced to viewers that Mike Proctor, the match referee, had awarded the match to the West Indies using the Duckworth-Lewis method. However, the crowd calmed down and play continued (Wisden Almanack 2004a,b).

In both these games, spectators had thrown objects, largely bottles and firecrackers, onto the playing area thereby preventing the players from competing with one another safely. In the third game, played in Rajkot, Gujarat—the same state that had witnessed widespread anti-Muslim riots earlier in the year—things took a turn for the worse when a couple of the West Indies players were hit by objects thrown in by the crowd. The captain of the West Indies side took their

team off the field. They had batted first and scored an aggressive 300 runs from their 50 overs. India however responded extremely well, scoring 200 runs in just over 27 overs with just one batsman out when play was interrupted. After a long delay, the match was abandoned and the match referee awarded the game to India on the basis of Duckworth-Lewis. The calculations suggested that India were some 81 runs ahead of where they should have been had the game been evenly poised. The Wisden match report for that game noted that the West Indies team had unsuccessfully objected to the application of the rain-rule and also that "[l]ocal rumour was that bookmakers had sabotaged the match to stop India winning, and had been floored by the outcome" (Wisden Almanack 2004c). The implication was that these bookmakers had expected that the match would be suspended with no result, rather than be awarded to India. Reuters reported that the BCCI condemned such crowd disturbances and that the ICC was investigating the matter. The match referee had awarded the game to India because "players cannot be held responsible for crowd trouble." It also went on to quote a former West Indies player and current commentator, Michael Holding, to the effect that "[v]ery shortly, spectators will be seen going into the one-day venues with computers with the Duckworth/Lewis formula in hand and constantly keeping in touch with proceedings. Whenever their team is in front, they will just throw a

few missiles, get the game called off and their team ends up the winners" (Reuters 2002). Kanta Murali, writing in *Frontline* on violence in cricket, also reflected that this match suggested that unlike the case with the possibility of upcoming rain, "[c]rowd interruptions are wholly unanticipated and a team cannot account for this in its strategy, causing the D/L system to be somewhat ineffective. In future, spectators with a basic knowledge of the D/L system can choose to influence match outcomes at opportune times" (Murali 2002). This argument seems rather wrong-headed given that it postulates the very thing that it says cannot be anticipated—if crowds did begin to behave like that, players should indeed begin to anticipate such outcomes.

However, the key point is that the very possibility of players and spectators deliberately manipulating proceedings—leaving aside whether that had actually happened in this instance—implies that it was now conceivable that teams were tracking where they are in terms of the Duckworth-Lewis method during a game, even when a rain interruption is not a possibility. This is an entirely novel moment because previous rain rules were not susceptible to such treatment. Rules such as the average run rate adjustment were known to be inaccurate in almost all situations, whereas Duckworth and Lewis had come up with a model that was thought to be accurate. This is what made it feasible, if nevertheless controversial,

for the match referee to award the match on the basis of their model.

4.1   Probity and probability

The model is statistical in nature. As such, it is part of what Ian Hacking has suggested is a efflorescence of statistical control in the 20th century. Hacking has argued that contemporary ideas about statistics and probability emerged in Europe around 1660 and were based on writings about topics as varied as Pascal's wager, distinguishing between testimony and evidence, expectation, political arithmetic, annuities and inductive logic (Hacking 1975). Hacking argues that the notion of probability that emerged was from the start Janus-faced: "On the one side it is statistical, concerning itself with stochastic laws of chance processes... On the other side it is epistemological, dedicated to assessing reasonable degrees of belief in propositions quite devoid of statistical background" (Hacking 1975, 12). In the first sense, to speak of a probability is to assert an empirical claim about the relative frequency of occurrences of some particular event. The second sense, however, does not require that an event has actually ever occurred because it addresses degrees of belief about knowledge of that possible event. Hacking suggests that these two aspects of the idea of probability have survived to this day—in contemporary terminology one would speak of frequentist probability

versus Bayesian probability. The important point for Hacking is not that there are two notions here, but rather that from the start the same word was used for both cases: "Out of what historical necessity were these readily distinguishable families of ideas brought into being together and treated as identical?" (Hacking 1975, 12) The connection in one direction is fairly straightforward. The more frequently an event is observed to have occurred, the greater the confidence one *ought* to have in one's belief about that event. Is it the case, however, that the stronger a belief regarding an event, the more likely it is to happen? This is where, I argue, performativity and probability are tied together. A probable person, one whose probity is unimpeachable, is a person whose beliefs are likely to be connected to what actually happens in the world. This is, I think, the point that "reliable testimony" plays in Steven Shapin and Simon Schaffer's account of Hobbes and Boyle dispute (Shapin and Schaffer 1985). But in that case testimony can in fact help create the phenomena in question by helping construct it.

In a later work, Hacking argues that an avalanche of printed numbers—statistical tables—in the 19th century was a necessary condition for the development of *control* over a newly conceived of population. Hacking argues that "[s]tatistical laws that look like brute, irreducible facts were first found in human affairs, but they could be noticed only after social phenomena had been enumerated, tabu-

lated and made public" (Hacking 1990, 3). But as these first laws were discovered by examining numbers that were about newly-discovered social "deviancies" such as suicide, crime, madness, and so on, he argues that the roots of the contemporary idea of "information and control as a neutral term embracing decision theory, operations research, risk analysis and the broader but less well specified domains of statistical inference" lie in the much earlier notion that "one can improve—control—a deviant subpopulation by enumeration and classification" (Hacking 1990, 3). The control that Hacking writes about here seems directly connected to the idea of performativity. As printed numbers became available for a variety of therefore increasingly well-defined and locatable social "phenomena," the certainty of belief needed to intervene in those phenomena became easier to attain. Tables of facts are persuasive.

I will argue, however, that there is an important distinction between the idea of control developed in the 19th century and the idea of control that is crucial to cybernetics. The key here is the very definition of information that Shannon and Wiener developed. Information is defined in terms of uncertainty. Indeed, some package of information counts as such only if you are not able to predict what is in the package. Receiving the information changes you in some respect or other. This does not mean that the Janus-faced nature of probability has been effaced.

However, as I will argue later in this chapter, subjective, or Bayesian, probability has made possible an important contemporary method of statistical modeling of the world that is not susceptible to the kinds of critique most often leveled at objective frequentist models.

4.2 Information, mathematics and prediction

This chapter uses the application of what has become known as the Duckworth-Lewis method—the specific formula underlying the model—in cricket as an example of a common place attempt to predict the future. The kind of future being predicted is however structured by, and is at odds with, expectations of fairness. I argue that the example stands in for a whole set of similar attempts to grapple with the future across a diverse set of contemporary processes. The Duckworth-Lewis method is derived from an Operations Research approach to cricket. Operations Research (OR) as a discipline can be traced to the emergence of cybernetics in the aftermath of World War II. Claude Shannon, then working for Bell Telephone Labs, wrote a memo on "A Mathematical Theory of Cryptography" that when declassified founded what is now known as information theory. Shannon's entropy measure is a way of quantifying the smallest possible compression of some given message. To give a simple example, think of the an English language

written message in which all the vowels have been removed. In almost all cases, fluent readers have no difficulty in reading the message. Even though there are approximately 32 basic symbols in written English—the letters of the alphabet all in lower-case plus some punctuation—or 5 bits (2 raised to the power of 5), Shannon estimated that the information actually held by each symbol is about 1 bit or perhaps even less. In other words, a compressed pure text file can be considerably smaller—about five times smaller—that the original file. This is because most English language text can be imputed from just a few clues about its content.

What Shannon inaugurated was a way of talking about information as an artifact which could then in turn be used to model natural processes. Information is a mathematical construction of unpredictability that is then used to model, for example, phenomena as natural seeming as DNA and genetic expression. Donald MacKenzie, a member of the "Edinburgh School" within science studies, has argued recently that although "the social studies of science and technology…has for several decades been asking how we know the properties of the natural world," it nevertheless remains the case that "the corresponding question for the properties of artifacts is much less often asked" (MacKenzie 2001, 1). This distinction, between natural and artifact, is precisely of course the issue at stake in Philip

Mirowski's rendering of the cyborg sciences. It is not simply that the boundary between the social and natural that might become destabilized, but rather that the destabilization occurs because each might come to be constructable and knowable as part of the other. Asking this question of computers, MacKenzie suggests, is particularly interesting because it "highlights another issue that sociological work on science has not addressed as much as it might: deductive knowledge" (MacKenzie 2001, 2). MacKenzie notes the peculiar status of deductive knowledge, in particular mathematical knowledge. MacKenzie takes logic and mathematics to be both based on deduction, in that it is "granted a status not enjoyed by empirical, inductive, or testimony-based knowledge." He argues that the difficulty here, the wedge that needs to be inserted as David Bloor might put it, involves the "difficulty for the isolated individual of distinguishing between being right [about a deduction] and believing one is right" (MacKenzie 2001, 11). This difficulty provides MacKenzie with the motivation for his delineating "the historical sociology of machine proof" (MacKenzie 2001, 13). Yet this is not of course a question that cannot be asked about probability-based knowledge. In both cases, it is proof itself that forms the locus of belief. The deductive case may be harder because seemingly more "natural," yet the inductive case remains relevant in its own right as a form of knowledge and because one can deduce knowledge from

and about combinations of inductive beliefs. The ability to control society rests in large part on the persuasiveness of deductive proof about inductively generated beliefs. Yet, the outlines of how that persuasiveness operates mathematically have not been elucidated.

MacKenzie notes that "the application of deductive proof to show that the text of [computer] programs corresponded to their specifications" can be traced to von Neumann and Turing, but suggests that "it was only in the 1960s that sustained interest in formal verification of computer programs began to emerge" (MacKenzie 2001, 47). This did not mean, however, that such proofs were themselves necessarily highly formal in nature. One of the first such proofs by Peter Naur, for example, was made from "mixtures of ordinary mathematical notation and English rather than expressions in a formal system" (MacKenzie 2001, 49). MacKenzie argues that this interest in computer proofs quickly led other participants to envisage "the eventual use of proof-checking programs, with at least a limited capacity to construct the details of proofs, within mathematics itself" (MacKenzie 2001, 60). MacKenzie introduces the notion of "cultures of proving" to account for the differences in implementation of such a vision. The most important of such implementations is, of course, based on the use of computers in formal proofs: "[i]n formal proof, logical deduction takes the form of syntactic

pattern matching, with no requirement for 'understanding' of the meaning of the formulae being processed" (MacKenzie 2001, 308). Such an approach "treats the machine as the trustworthy agent of proof [and] is philosophically orthodox: the canonical meaning of proof in modern philosophy is formal proof" (MacKenzie 2001, 309). And yet, even within this relatively constrained position, a number of choices have to be made: "Which formal logic should be implemented? Should it be classical or constructive? Should the law of excluded middle be permitted? Should the fact that a contradiction implies any proposition whatsoever be regarded as an elementary theorem, or as a paradox to be avoided by the construction of a logic in which deduction is guided by relevance?" (MacKenzie 2001, 313)

These choices are formulated by MacKenzie as arising from an alternative to the orthodox formalist position.[1] They derive from L.E.J. Brouwer's intuitionism, which under Errett Bishop's formulation, has come to be known as mathematical constructivism. It is an alternative to the orthodox position that is now prevalent within computer science. MacKenzie suggests that "[c]onstructivism's popularity in computer science, which contrasts sharply with its limited attractiveness to mathematicians, can be explained by the fact that, to a significant number of com-

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[1] The third possibility, that of founding mathematics on logic, has largely been discredited since Bertrand Russell and Alfred Whitehead's failed *Principa Mathematica* project at the beginning of the 20th century.

puter scientists, constructivism appears a productive not a restrictive enterprise, in particular allowing the extraction of programs from proofs" (MacKenzie 2001, 329).

MacKenzie uses these disputes to establish that "a sociology of ordinary 'rigorous-argument' mathematical proof is thus that there is no abstract, context-free way of demarcating what constitutes a proof; that there is no higher criterion that the judgment of the adequacy of a putative proof by the members of the relevant specialist mathematical community" (MacKenzie 2001, 319). In this argument, the use of the computer has led mathematicians to have to choose between different notions of proof: the "machine helps one to perform proofs one could not otherwise perform and, at least in the circumstances of computer system verification, to perform them with greater dependability than individually one might be able to." However, it remains the case that for MacKenzie "[e]ven in the most formal and most mechanical of domains, trust in the machine cannot entirely replace trust in the human collectivity" (MacKenzie 2001, 334).

Brian Rotman argues convincingly that the advent of the computer ought to reformulate what counts as proof for mathematicians and computer scientists and the over-arching community of deductive proof-seekers they form. As with Haraway's attention to "god-tricks," so also Rotman asks with regard to *natu-*

ral numbers—for him mathematics is essentially a practical, semiotic activity—"[i]sn't everything—everything corporeal—finite?" He goes on to suggest that "pursuing the question of writing/thinking of the infinite only raises the question of 'finite' and how we are to think 'human making' in a new way." Further, in "the case of numbers, this way points beyond the comforting fixity of the finite-as-being within the infinitude of God—the view that the whole numbers in all their endlessness are and were always there before us, natural and God-given objects—to a view of numbers as open-ended and unfinished, as becoming, needing always to be counted into an actualized form of 'being.' " (Rotman 1993, xi) For Rotman, the set of all natural numbers can only be legitimately reasoned about if it is taken as an actively constructed set. But if the emphasis is on the construction of the set, an immediate question follows: who or what is it that is capable of constructing such an infinite set? This question is more difficult still when considering sets of hierarchies of infinities—the ordinals Georg Cantor "discovered" in the 1880s.

Cantor was a Platonist with regard to sets. As such, for him finite and infinite sets are discovered in doing mathematics not constructed by it. Rotman argues regarding this orthodox formal position that "[f]or most mathematicians … mathematics is a Platonic science, the study of timeless entities, *pure forms* that are somehow or other simply 'out there,' preexistent objects independent

of human volition or of any conceivable human activity" (Rotman 1993, 4-5). Moreover, Brouwer's intuitionist position is similarly itself immersed "in an unexaminedly ideal mentalism" (Rotman 1993, 6). Rotman asks, how might one "refuse the claim that numbers are elemental, mathematical ur-constituents of the actual or potential order of things?" He finds his answer in the observation that "numbers are inconceivable—practically, experientially, conceptually, semiotically, historically—in the absence of *counting*." Further, "counting works through—it *is*—significant repetition" (Rotman 1993, 6). It is on this point that much of Rotman's argument rests. If mathematics is a practical activity, a construction of entities, rather than a discovery of them it would follow an understanding of the work mathematics does can only be found in *how* it is undertaken as a practical activity.

Rotman notes that written mathematical proofs are "riddled with *imperatives*, with commands and exhortations such 'multiply items in *w*, 'integrate *x*,' 'prove *y*,' 'enumerate *z*,' detailing precise procedures and operations that are to be carried out." In addition, such proofs are "completely without *indexical* expressions" which raises the immediate questions: "[w]ho are the recipients of all these imperatives? What manner of agency obeys the various injunctions to multiply, prove, consider, add, count, integrate, and so on? How is the. . . lack of indexical-

ity related to the impersonal, transcultural nature of mathematical knowledge?" Rotman argues that the implication of this for formal, classical, mathematics and its conceptualization of the infinite must be something like a "disembodied Agent...—as near to God as makes no difference—[which] is a spirit, a ghost or angel required by classical mathematics to give meaning to 'endless' counting" (Rotman 1993, 10).

An alternative to this mathematical "insistence on the corporeality of the one-who-counts is to start rewriting the connections between God, Number, the Body" (Rotman 1993, 11). Rotman goes on to argue that what is needed here is "a systematic reading of mathematical signs, one rigorous enough to make the appropriate distinctions between various kinds of mathematical agency and sufficiently external to the way whole numbers are habitually cognized to resist the view of them as 'natural.' " (Rotman 1993, 52) Rotman further suggests with regard to the problem of the infinite, of *endless* counting, that it is indeed possible "to put forward a scheme of counting and hence of constructing—significantly creating—the numbers and interpreting them arithmetically which denies the necessity of one-more-time, yet does not fall into unreason and irrationality." Doing so requires a refusal of the "idea of an unqualified, decontextualized, exception-free, universal *identity* between real or imagined human actions" (Rotman 1993, 54).

Thus, Rotman disputes here both Brouwer's intuitionism—"there is no prelin-guistic mathematical meaning, no pure primary intuition, no origin of geometry or arithmetic waiting to be expressed"—and, with regard to formalist, orthodox mathematics, that "there is no such thing as a pure signifier,...no coherence in the attempt to understand mathematics as the manipulation of such marks prior to or independent of any possible interpretation" (Rotman 1993, 143).

The solution for Rotman is, of course, the computer. He argues that "computer science signals the instatement of the slave—the one-who-counts—onto the math-ematical scene" where "an essential part of this instatement is the recognition that any act of counting/calculating, whether by fingers, abacus beads, written marks, or electronic pulses, requires energy, space, and time for its realization." Recognizing the computer in this way, however, is a "normative decision on the part of the mathematical community" and the "basis for such a decision is in-separable from the larger question of what meaning and status the mathematical community is to assign to empirical/experimental mathematics" (Rotman 1993, 152). Rotman does not address the implications of positing the computer as the indexed entity addressed by mathematical proof. Computers are quintessentially rule-following beings that are, here, thinking mathematics. It is also not clear why mathematicians should take the normative decision suggested by this argument,

however science studies is particularly amenable to treating mathematics in this way.

One foundational argument for much science studies today can be traced, I would argue, to David Bloor's understanding of rule-following. Rotman has, in effect, returned us to MacKenzie position on the social. But this is itself derived from Bloor's understanding of Wittgenstein on rule-following. Bloor developed his theory of the social in *Wittgenstein: A Social Theory of Knowledge* (Bloor 1983). He aimed to give "a description and an analysis of all the main themes of the later philosophy in such a way that the sociological and naturalistic Wittgenstein stays clearly in view" (Bloor 1983, 2). Taking Wittgenstein's example of completing the sequence "2, 4, 6, ..." Bloor suggests that a "Platonist has no trouble describing this example in terms of his theory" for "the correct continuation of the sequence, the true embodiment of the rule and its intended application, already exists." All that is needed is to "continue the sequence in the *same* way, and we can do this, and know what it means, by stating the rule of the sequence to ourselves." But, suggests Bloor, the "Platonist is actually presupposing the very competence that he is meant to be explaining" because the number sequence is itself the rule: "its reality extends no further than our actual practice" (Bloor 1983, 85). There are in fact an unbounded number of rules that fit the case "2, 4, 6, ..." with each number

supplying different subsequent numbers that "fit" that beginning sequence. For Wittgenstein, an appeal to simplicity of rules is of little use because one would have to have some other principle that allowed you to order the possible rules by their degree of simplicity. What sort of grounds could there be for such a principle? Furthermore, Bloor states that "Wittgenstein's rejection of Platonism is intimately connected with his finitism" and that the "reason why it seems to pre-exist is because our use of the rule has become a mechanical routine" (Bloor 1983, 88). Bloor explains that the force with which simple rule-following presents itself (and, more generally, mathematical proof), makes "them appear fundamentally different from empirical happenings." This force is due to the "form taken in our consciousness by the social discipline imposed upon their use" (Bloor 1983, 93). It is that social discipline that grounds the correctness of some putative rule-following practice.

What these considerations suggest is that a mathematical model like Duckworth-Lewis brings together a cricket community through the persuasion it exerts on that community. This is a persuasive force built out of rules about number.

4.3 Rule following, numbers, and community

Cricket games depend on accurate score-keeping and those numbers are the only means by which a game under dispute because it is incomplete can be settled. But following cricket is, in addition to this basic dependency, comprised to a large extent through an appreciation of number. Cricket fans can readily state the batting and bowling averages of their favorite players. Various other measures such as the average rate at which batsmen score or the rate at which bowlers get batsmen out are also readily available to fans. Discussions about cricket use these numbers as a way of grounding the conversation. They have the air of empirical fact. Yet, administrators, coaches, players, and fans alike never confuse the numbers for the quality of the performances they index. The result is that numbers—batting averages and the like—undergird all conversations about cricket because they always available, yet never *determine* the outcome of those conversations. It is this ambivalent stance taken towards numbers in cricket that the Duckworth-Lewis method successfully disturbed.

Ian Hacking argues that what he calls the avalanche of numbers depended and helped create the idea of probability, starting in the late 17th century. Indeed, Hacking suggests that David Hume's skeptical argument about induction was itself not possible until the question of causes and effects could be dissociated from

knowledge, that is, demonstrable knowledge, and placed firmly in the camp of opinion. The *analytic* problem of induction, Hacking argues, was already available. Here the problem is one of distinguishing between good and bad reasons to argue from induction. But the skeptical problem was new. For Hume:

> An expectation that the future will be like the past must be either knowledge or opinion. But all reasoning concerning the future must be based on cause and effect. Reasoning concerning cause and effect is not knowledge. Therefore it must be opinion, or probability. But all probable reasoning is founded on the supposition that the future will resemble the past, so opinion cannot be justified without circularity. Knowledge and probability are exhaustive alternatives. Hence expectation about the future is unjustified. (Hacking 1975, 181)

The question Hacking asks is what makes this skeptical argument possible. Hacking argues that the transformation of the low sciences into the high sciences, for example the shift from alchemy into chemistry, involved the development of the idea that there were no true necessary connections among primary qualities (that could in turn be investigated via secondary qualities). Thus, "[c]ause and effect—the paragon of the old knowledge that was demonstration—and signs, the purveyors of opinion, have become one" (Hacking 1975, 183). Leibniz, Hacking

suggests, was the first philosopher of probability and had gathered together all the innovations in thinking about probability from his contemporaries in the late 17th early 18th centuries, but had not been able to make this leap. The reason is simple: for Leibniz, believed that there were no interactions between physical bodies in the world, there was only an expression of one by another: "one thing expresses another, in my use of the term, when there is a *constant and regulated relation* between what is true of the one and what is true of the other" (Hacking 1975, 184, cited in). Hume's skeptical problem could only arise, and therefore inaugurates, the movement of causation from knowledge to opinion.

Over the 19th century, this transformation from knowledge to opinion made room for the development of ideas about probability. For Hacking, Leibniz marked the beginnings of modern probability and Hume marked the setting in place of the possibility of inductive knowledge through reasoning about probabilities. The result was the bringing together of ideas about the physical world with a statistical concept of society. A society that had a population constructed out of normal people.

C.S. Pierce in turn stands in for an altogether different but equally transformative moment. Hacking argues that by the end of the 19th century it became possible to think of the world not as something known probabilistically—a form

of understanding that used to be called mere opinion—but rather that the world itself might be probabilistic. It is in this sense that one can think both of *normal* people in a given population and also of *probabilistic* laws of nature. Hacking suggests that Peirce was the first person to use randomization in the design of his experiments while at the Coast Survey: "he used the law-like character of artificial chances in order to pose sharper questions and to elicit more informative answers" (Hacking 1990, 200). This technique becomes the standard method of gathering knowledge about social phenomena in the 20th century.

Peirce, of course, wrote about three different ways of making inferences—deduction, induction, and abduction. His well-known example of the last of these three involves an account of him landing on a sunny day at a Turkish seaport and seeing a man on a horse with four other horsemen holding a canopy over his head. He infers this is the governor of the province (passage quoted in Hacking 1990, 207). It is clear that this can be no deduction. Yet neither is it clear that it is a species of induction. What manner of previous experience is he drawing on to make abduce (or, in an alternative formulation, hypothesize) that the man is the governor? A person committed to deduction and induction as exhaustive categories could argue that Peirce is really just making an inductive inference. This may be the first time he has visited a Turkish seaport or seen a man on a horse

surrounded by others holding a sun canopy for him. Yet, perhaps the induction is from previous generic experience of the deferential treatment of important people. Peirce would have found this line of reasoning unacceptable because the important point on which he labored was that inductive inferences could be quantifiable. One could in fact precisely weigh the amount of evidence for believing in some inductively generated inference. It is the notion of quantities of reason that Peirce preserves by making the distinction between deduction, induction, and abduction.

However, as Hacking argues, it is not the case that for Peirce an inductive inference could lend a probability to the conclusion of the inference. Rather, the inferential reasoning itself is probable to some possibly quantified degree. As Hacking puts it, deduction for Peirce is such that "the conclusion of the argument is true whenever the premises are true" but for induction the "conclusion is usually true when the premises are true... ." When precise odds can be ascribed to the premises, Hacking suggests, "the conclusion is reached by an argument that, with such and such probability, gives true conclusions from true premises" (Hacking 1990, 209). Peirce's model of scientific inquiry follows these distinctions. One creates hypotheses and then tests them inductively. Hacking quotes Peirce's formulation of what is now better known as Popperian falsification: a scientist

should "ardently desires to have his present provisional beliefs (and all his beliefs are merely provisional) swept away, and will work hard to accomplish that object" (Hacking 1990, 210).

Yet, what is often at stake is not the knowledge that a particular method of reasoning leads to truth more often than not, but rather that some particular given inference is reliable or not. Hacking quotes a passage from Peirce that makes the quandary that he had backed himself into quite clear:

> An individual inference must be either true or false, and can show no effect of probability; and, therefore, in reference to a single case considered in itself, probability can have no meaning. Yet if a man had to choose between drawing a card from a pack containing twenty-five red cards and a black one, or from a pack containing twenty-five black cards and a red one, and if the drawing of a red card were destined to transport him to eternal felicity, and that of a black one to consign him to everlasting woe, it would be folly to deny that he ought to prefer the pack containing the larger proportion of red cards, although from the nature of the risk it could not be repeated. It is not easy to reconcile this with our analysis of the conception of chance. (quoted in Hacking 1990, 211)

As Hacking notes, Peirce's solution to this problem is quite remarkable. Peirce finds solace in a notion of community:

> It seems to me that we are driven to this, that logicality inexorably requires that our interests shall *not* be limited. They must not stop at our own fate, but must embrace the whole community. This community, again, must not be limited, but must extend to all races of beings with whom we can come into immediate or mediate intellectual relation. . . .
>
> (quoted in Hacking 1990, 211)

Peirce is trying to resolve his quandary by focusing on the part of the hypothetical situation he set up that limits the drawing of the card to one instance (and then transporting one immediately to hell or heaven). If a community of beings are each individually drawing cards, it would be better for them collectively if they drew them from the pack containing more red cards. For Hacking, this is evidence that Peirce was committed to an ontology and metaphysics of chance through and through. Thus Hacking writes that "Peirce did not think that first all there is the truth, and then there is a method for reaching it. . . . His theory of probable inference is a way of producing stable estimates of relative frequencies. But on the other hand the real world just *is* a set of stabilized relative frequencies whose formal properties are precisely those of Peirce's estimators" (Hacking 1990,

213). This is why Peirce needs to postulate a community of beings with a collective interest in order to resolve the problem he sets himself. The truth about the world just is the result of applying inductive methods because, for Peirce, mind and matter evolve together. For Peirce, the world is made up of probabilities and those quantifiable numbers are grounded in and depend on an expansive sense of community.

The idea of open-ended belonging to a community that grounds a disposition towards the world has become immensely influential in the social sciences since Benedict Anderson's *Imagined Communities: Reflections on the Origin and Spread of Nationalism* (Anderson 1983). Writing on Benedict Anderson's distinction between bound and unbound seriality, Chatterjee argues that "the most significant addition that Anderson has made to his analysis. . . is his attempt to distinguish between nationalism and the politics of ethnicity" where "[o]ne is the unbound seriality of everyday universals" and the "other is the bound seriality of governmentality. . . " (Chatterjee 1999, 128). Further, whereas unbound serialities "afford the opportunity for individuals to imagine themselves as members of larger than face-to-face solidarities. . . , of transcending by an act of political imagination the limits imposed by traditional practices," bound serialities "can operate only with integers" such that "for each category of classification, an individual can only

count as one or zero, never as a fraction. . . ." Bound serialities suggests Chatter-
jee are, in Anderson's account, "constricting and perhaps inherently conflictual"
(Chatterjee 1999, 128).

Anderson locates the difference between bound and unbound seriality in the
Hegelian distinction between good and bad infinity. Chatterjee suggests that
"Hegel's idea of a true infinity is an example of the kind of universalist critical
thought characteristic of the Enlightenment that Anderson is keen to preserve"
(Chatterjee 1999, 130). And, Chatterjee argues, Anderson's utopianist thought be-
longs to that "dominant strand of modern historical thinking [that] imagines the
social space of modernity as distributed in empty homogeneous time" (Chatter-
jee 1999, 131). Moreover, Anderson's endorsement of " 'unbound serialities' while
rejecting the 'bound' ones is, in fact, to imagine nationalism without modern gov-
ernmentality" (Chatterjee 1999, 132). Chatterjee goes on to connect the insistence
on the heterotopia of modernity to a refusal to endorse one kind of seriality over
another: "it is morally illegitimate to uphold the universalist ideals of nationalism
without simultaneously demanding that the politics spawned by governmentality
be recognized as an equally legitimate part of the real time-space of the modern
political life of the nation" (Chatterjee 1999, 134).

Anderson argues, regarding the relationship between the bound seriality of

integers and the operation of the census, that "this does not at all mean that each countee does not anonymously reappear in dozens of other classificatory enumerations within the same census, in each instance as an integer, but it does mean that this complex fractionality is inscribed in invisible ink" (Anderson 1998, 37). Thus while they both appear to agree that number and community are inextricably connected, Chatterjee argues that governmentality is a necessary part of modern life and that it is—in Andersonian terms—an outcome of bound serialities of belonging. Anderson's cryptic remarks about Hegelian infinities and, apparently alternatively, complex fractionality, notwithstanding, the Duckworth-Lewis model seems to fall directly in line with the idea of bound serialities. I will suggest in the next chapter this may not be the case for more complex forms of modeling cricket.

4.4   A cyborg mathematics of science studies

Philip Mirowski makes a very convincing case for a cyborg rendering of all the sciences generally after World War II. But Mirowski fails to develop an account of the implications of cyborg science for deductive knowledge. Here MacKenzie develops the argument that the very practice of proving has been modified through the use of computers. However, Rotman's suggestion that the philoso-

phy of mathematics ought itself to be modified to accommodate this development is compelling. This leaves the question of the social, "our" culture, or community. Bloor presents an argument about such a notion of the social, made through his contentious interpretation of Wittgenstein on counting, that grounds the "Strong Program" and its insistence on causal, symmetric, and reflexive explanation. His suggestion that one might either render Latour as trivially different from his own position—here the emphasis is on Latour's semiotic actor-network theory as a semiotic *system*—or as an entirely obscure theory of entelechies, quasi-objects, etc., is itself convincing. Doubly so, for Latour himself seems to prefer this reading,[2] This theory surely counts as a cyborg theory, but is undoubtedly insufficiently attentive to, and incorporative of, the constitution of such theories through the long history of the cyborg sciences.

The quintessential cyborg science, cybernetics, involves what came to be known as "purposive systems" or "teleological methods." In popular literature today, the term "feed-back" stands in for these terms. Margaret Mead and Gregory Bateson were deeply involved with the first post-War meetings—the famous Macy Conferences—at which these different strands were pulled together. Mead had already become somewhat famous from her earlier work on Samoa. Most of

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[2]See for example, his laudatory references to Isabelle Stenger's work on Whitehead metaphysics (Stengers 1997, vii-xx).

the literature on the Macy Conferences underplays Mead and Bateson's roles—treating them largely as interested bystanders. This may be largely correct. However, it is reasonably clear that the impact of this discussion on Mead was quite large. To give one example, she began to argue that the institute she founded—the Institute for Intercultural Studies which was based out of her war-time work on understanding different national cultures—should promote cybernetics as a language or medium of exchange between otherwise embattled nations. She was, of course, thinking in particular about the U.S. and the Soviet Union.

More importantly, Mead gave a paper on the "Cybernetics of Cybernetics" to the American Association of Cybernetics in 1967. The paper dealt largely with the application of cybernetic principles to the organization of that association itself. However, the general idea, that cybernetics could and should be applied to itself marked a break, and possibly even a break-down, in the then nascent discipline. Cybernetics of cybernetics, or second order cybernetics, folds within the system to be examined the observer or cybernetician. There is a sense which this follows immediately from classic anthropological concerns. A discipline that claims participant-observation as one of its central methodologies could hardly be more cognizant of the importance of tracing the interaction between observers of a system and other participants in that system. The problem is that move makes

analysis of that system much harder to enact. There are no fixed points here against which one might gain some traction.

A few years after Mead's death her influence both within anthropology and outside it was greatly diminished by Derek Freeman's account of his own research on Samoa. The resulting kerfuffle tarnished her reputation as a scholar, possibly correctly even if in a rather vituperative fashion. It is clear however that Mead was an important public intellectual who was actively involved in US politics. This too fits neatly with the idea of second-order cybernetics. If a cybernetician is necessarily to be concerned with the system being analyzed, and that cybernetic system is US society or some aspect of it, it must follow that the cybernetician is also involved in formulating a teleology or purpose for that system. Being a public intellectual follows directly from being a second-order cybernetician whose own central purpose quickly becomes entangled in making claims about what are *and* ought to be the purposes of that society itself. This in turn provides, I argue, a useful understanding of the relationship between performativity of all cyborg models and the aspects of society that they simultaneously represent and intervene in.

4.5　Embedding performativity

In a paper in 2005,[3] MacKenzie examines the question of performativity more closely. In particular, he traces the effects of arbitrage pricing theory in its most important field—derivatives markets—from the early 1970's to the present. He suggests that the 1973 paper by Fisher Black and Merton Scholes on options pricing, along with Robert C. Merton's paper in the same year, was "a defining— perhaps, *the* defining—achievement of modern financial economics..." (MacKenzie 2005, 8). Previous models of options contracts, MacKenzie notes, "involved parameters the values of which were extremely hard to determine empirically, notably investors' expectations of returns on the stock [or other asset] in question and the degree of investors' risk-aversion..." (MacKenzie 2005, 6). This options model, I argue, provides a nice case of what I call *embedded* performativity.

MacKenzie, following Michel Callon, suggests that performing the discipline of economics itself can affect markets: however, "[f]or a claim of performativity to be interesting—for the use of economics to constitute what I call 'effective' performativity—an aspect of economics must be used in a way that has effects on the economic processes in question...economic processes incorporating the aspect of economics must differ from their analogues in which economics is not

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[3]The paper was delivered at a meeting of the History of Economics Society, Tacoma, WA.

incorporated" (MacKenzie 2005, 11). MacKenzie suggests that the Black-Scholes-Merton pricing theory "disentangled options from the moral framework in which they were dangerously close to gambling, and framed them by showing how they could be priced and hedged as part of the normal operations of mature, efficient capital markets" (MacKenzie 2005, 18). This was presumably an enabling condition of the rapid spreading of options markets—geographically, across asset classes, and, most importantly, in the terms of the volume of trading in options markets. MacKenzie notes that "[b]road features of the Black-Scholes-Merton model were indeed already present in the patterns of prices in markets prior to the formulation of the model," however, "there were also significant discrepancies between the model and the pre-existing price patterns" (MacKenzie 2005, 19). But prices did later conform very closely to that predicted by the model. This MacKenzie terms "Barnesian" performativity, which is the "claim that the market prices informed by the model altered economic processes towards conformity with the model" (MacKenzie 2005, 23).

MacKenzie suggests that the success of the model was due to "[f]inancial economists quickly [coming to] see the Black-Scholes-Merton model as superior to its predecessors. . . it involved no non-observable parameters except for volatility, and it had a clear theoretical basis, one closely linked to the field's

dominant viewpoint: efficient market theory" (MacKenzie 2005, 27). Most importantly, MacKenzie argues, for options traders the "underlying mathematics might be complicated, but the model could be talked about and thought about relatively straightforwardly: its one free parameter—volatility—was easily grasped, discussed, and reasoned about" (MacKenzie 2005, 27). Further, given that such traders tended to sell options to institutional buyers of options, the "availability of the Black-Scholes formula, and its associated hedging and risk-measurement techniques, gave participants the confidence to write [sell] options at lower prices, helping options exchanges to grow and to prosper" (MacKenzie 2005, 36).

MacKenzie argues, however, that the U.S. stock market crash in October 1987 forms an important break in the performativity of the Black-Scholes-Merton model: "The fall was a grotesquely unlikely event on the assumption of log-normality." This had an important consequence, for the "subsequent systematic departure from Black-Scholes option pricing—the so-called 'volatility smile' or 'volatility skew'—is more than a mathematical adjustment to empirical departures from log-normality: it is too large fully to be accounted for in that way" (MacKenzie 2005, 38). Thus, for MacKenzie, the history of options pricing has three phases. The first is of little options trading activity and a loose fit between the Black-Scholes-Merton model and actual traded prices; the second demonstrates a Barnesian

performativity fit of model to prices; and in the third "from 1987 to the time of writing—option pricing theory is still performed in the generic and effective senses (it is used, and its use makes a difference), but it has lost its Barnesian powers" (MacKenzie 2005, 39).

Regarding the 1987 crash, MacKenzie raises the "intriguing possibility that amongst the factors exacerbating the 1987 crash was an application of options pricing theory" in the form of portfolio insurance. This, MacKenzie suggests, "is Barnesian performativity's opposite: the use of an aspect of economics altering economic processes so that they conform less well to their depiction by economics" (MacKenzie 2005, 39). This possibility and subsequent changes in options market prices reinforces MacKenzie's claim of the historical contingency of the 1973–1987 period.

Emanuel Derman, who contributed to the well known Black-Derman-Toy options pricing model, has argued that, following the 1987 crash, "[o]ver the next 15 years the volatility smile [has] spread to most other options markets, but in each market it took its own idiosyncratic form." Derman suggests that the rapid growth of options markets themselves—some options markets are now larger than the markets on which they are based—implies that the problems Black and Scholes faced are no longer pertinent. Whereas Black and Scholes attempted to

derive the price of an options contract from the price movement of the underlying stock, a "better model of the smile should be capable of calibration to liquid stock, bond *and* options prices." But, Derman concludes, the problem is in fact much deeper: "All financial models are wrong, or at least hold only for a little while until people change their behavior" (Derman 2003). MacKenzie's emphasis on the importance of the 1987 stock market crash has, then, been confirmed by at least some leading financial theorist practitioners.

In MacKenzie's argument, Black-Scholes-Merton ceases to be important after 1987. It had its prior period of Barnesian performativity in which a world of options prices came to fit the model's outputs more and more closely because traders used the model. And then a somewhat opaquely rendered period of negative performativity in which prices diverged from the model because the model was being used. But, as Derman hints, Black-Scholes-Merton is still in fact being used to characterize different markets by the kind of "smile" they exhibit. Its one free parameter—implied volatility—is in fact now used by traders to quote options prices to each other in a variety of derivatives markets. As options prices are very sensitive to the underlying security's price that their value is derived from, traders find it convenient to reason about an option in terms of its implied volatility with each other, using a previously agreed upon standard model like

Black-Scholes-Merton. When a trade occurs it is settled between the two traders by working backwards from such an implied volatility to an actual cash value. This, I argue, is *embedded performativity*. A model that is not used as a model of the world, but rather as a means with which to reason about the world.

4.6 Computer models in cricket

As I indicated earlier, an important consequence of the rapid influx of money into the game of cricket after liberalization in India has been a greater and greater emphasis on "limited overs" cricket, which is to say cricket games that are designed to produce a definitive result in some given limited amount of time—usually either one whole day or, more recently, a mere three hours. However, the requirement that a result be produced runs into conflict with a crucial feature of the game. As I argued in the previous chapter, the central micro-action in cricket is between a batsman and bowler. It is acted out on a strip of closely mown turf called a wicket. The bowler aims to "pitch" the ball into the turf just in front of the batsman. The latter waits for the ball to bounce up off the turf before striking it. All of this frequently happens at similar speeds to that of a baseball game, say 90 miles per hour. The relevant point here is that the condition of the pitch matters a great deal. In particular, changes in the condition of the pitch between

the first half of the game and the second half caused by rain can and often appear to change what might seem like a certain outcome to the game. For example, on a dry day, the second team looks to be easing to victory when a sudden rain shower changes the nature of the wicket. After the rain stops, the second team finds batting much more difficult and, perhaps, loses.

This kind of change in outcomes is usually thought to be unfortunate, but never actually *unfair*. However, delays due to rain can also alter games in an unfair manner. This results from the requirement—largely attributable to prime-time televsion led demands—that each game be completed in a fixed amount of time. A rain delay during, say, the second team's innings will mean that once they resume their batting they will now have less time in which to surpass their rival's score. The pressing question for cricket's match officials is: how much should the target—the first team's score—be reduced by in order to maintain a fair game?

John Haigh's *Taking Chances* aims to be an introduction to probabilistic reasoning for laymen. Haigh's book illustrates the widespread position of importance that the Duckworth-Lewis model now commands in cricket by using it to talk about statistics in society. He introduces the Duckworth-Lewis method by noting that "the place of statistics [had been] confined to recording the scores, evaluating averages, and being the source of trivial information. . . " (Haigh 1999, 247).

Haigh suggests that "[t]he main idea behind the Duckworth/Lewis (D/L) method is that, after the interruption, the relative positions of the two teams should be as little affected as possible. They proposed that not only should the target be revised to take account of how many overs were lost, it should also take account of how many *wickets* the team had left, as that also affects their chance of reaching the target" (Haigh 1999, 248). I will demonstrate in the next chapter that this evaluation—that D/L aims to leave the relative positions of the two teams intact—is in fact inaccurate. Haigh gives as an example an hypothetical game between India and Pakistan. Indeed these hypothetical examples are the primary method by which Duckworth and Lewis and the authors commenting on them reason about fairness and prediction in cricket. It is a species of thought experiment aimed at eliciting from the reader their intuitions about fairness, reasonable predictions, and the relationships between them.

Haigh considers a case in which India bat first and score 250 runs in 50 overs. After 20 overs of Pakistan's innings a rain delay occurs with Pakistan having scored 100 runs. After the delay, there is time for only a further 10 overs. Haigh argues *pace* the D/L method, that "[i]f the aim is to set a *fair* target—and cricket is the epitome of fairness—we need to know how many wickets Pakistan had lost at the time play was suspended. If the opening pair were still together, Pakistan

would have been very confident of winning, having 30 overs to score 151 runs to win and all wickets in hand." The more batsmen that were out, the harder a win would have been: "Before the D/L method, the revised target would have been calculated without reference to these differences. The original pro rata method would have asked Pakistan to score 50 more runs in ten overs to tie." However, Haigh argues, "...even with six wickets lost, that suddenly becomes a target they would expect to reach" (Haigh 1999, 248).

What is this model, how is it constructed, and why does it carry the persuasiveness that Haigh suggests it does? Frank Duckworth and Anthony Lewis published "A fair method for resetting the target in interrupted one-day cricket matches" in the *Journal of the Operational Research Society* (1998). Their article is one of the most downloaded articles in the journal's history, but certainly not the most-cited. It was awarded the Goodeve Medal of the Operational Research Society the following year (Duckworth and Lewis 2011, 83). The problem they addressed concerns the difference between cricket's usual, longer form of play which often ends in a draw, and the shorter one-days forms which are designed to produce a result. The Duckworth-Lewis model the authors derive has been presented as a fairer because scientific alternative to the previous attempts at a "rain rule" which all depended on various cricketing rules of thumb—basically any in-

terruption or series of interruptions during the course of the game which prevent the game from being completed also thereby prevent a definitive result from being enacted. The model works by probabilistic prediction of what a team would have scored if play had not been interrupted, and was very quickly taken up by the ICC as a necessary part of adjudicating all international one-day cricket games. Other operations research articles focus on how to improve on the manipulation of the players available to the team—the players are designated as resources to be invested optimally such that victory is secured—and so on.

The central move the authors make, the move that now, after their work, seems all too obvious, is to treat a team that is batting as if they have a certain quantity of "resources" that they can deploy to score runs. A team starts with 100 percent of those resources and then as time begins to run out those resources also run down (but certainly not at a linear rate). Furthermore, if the team's initial batsmen get out, the amount of resources remaining will dip dramatically. Those are their two variables, time (or, more precisely, overs) remaining and the number of wickets or "outs" remaining. Note that this is a compression of all available information into just two factors—overs and wickets remaining. Rather than looking at a whole slew of possibly relevant data, the D/L method suggests that only those two factors are relevant. Using this method one can predict how many runs a

team *will* score given how many they *have* scored so far.

The D/L method did not have an easy entry into the world of cricket consumption, but this was mostly due to the difficulty of understanding how the method was supposed to work. Previous methods had used simply rules like taking the average run scoring rate until the rain delay and simply extrapolating that scoring rate during the delay for example. The D/L method required a higher level of statistical knowledge. Furthermore, the players themselves frequently evinced a lack of understanding of how the rules were supposed to work. In one well-known case, a team favored to win in a crucial World Cup game lost because the captain thought that his team was ahead on the D/L method—rain clouds had been building up for some time while his team was batting. He had miscalculated. The general case here is telling. If a weather forecast suggests that rain is likely, each team will closely monitor their D/L predicted score and adjust their batting style to suit. The key is to not risk trying to get too far ahead of one's opponent for doing so risks losing too many "resources." After all, a close but big victory counts only just as much as a close but certain victory.

Note however that the D/L method most assuredly does *not* purport to provide a *fully accurate* prediction of a team's score. For example, a team that has been historically relatively weak might by chance happen to start their innings

well, but no one betting on that game would suppose only on this game's evidence that they will continue to score well in their current innings. Further, as outlined earlier, a wet wicket can itself have effects on the outcome of a game. The D/L method does not attempt to make use of either of these sets of information. It does not do so because, it would seem, doing so would be considered *unfair*. For a regulatory point of view, each contest can only be considered *de novo*.

As I have argued, it is not clear why the D/L method has been as successful as it clearly has in cricket. I suggest that its success lies primarily in the very fact that it is based on a mathematical model of cricket. In Peircean terms, it has worked to shift thinking about the state of a game—who is winning and who is not—but a process of abduction to a process of quantifiable induction. The D/L method is now not just part of how the game is regulated, but is also embedded in how the game is played even in the absence of a chance of rain delay. It seems to have become performative—a team is considered to be winning if it is ahead on the D/L method. Further, if it is not ahead that ought to be good reason for the team to do something drastic to try to get ahead. How did this happen given the proprietary and, as we shall see in the next chapter, entirely obscure nature of the model itself? I have argued that the performative nature of the D/L method is of a piece with the cybernetic notion of teleology. The goal of getting ahead on the

D/L method *is* now also the goal of winning a game of cricket. As with the Black-Scholes-Merton options pricing model, the D/L method has become part of the means by which cricket players, coaches, and so on, can reason about the game. It is an example of embedded performativity. The model built by Duckworth and Lewis has become a black-boxed technology that can be deployed in the world and used in a number of ways unintended by its authors. It is a model that has become embedded in the very structure of reasoning about the phenomena that it is designed to intervene in.

Chapter 5

Simulating cricket: the limits of data

Frank Duckworth, a statistician, and Tony Lewis, a mathematician, first met in January 1995. They had already been collaborating with one another at a distance since 1993. Duckworth had previously given a short paper on a new rain-interruption rule at a conference. A colleague of Lewis' had attended the conference and reported on the paper to him. Duckworth had worked out an initial formulation and computer program implementing it and Lewis, with the aid of a student, had worked out some of the details using a small amount of data on cricket matches in England. By August 1995, they were meeting regularly at a pub equidistant from their homes to refine the model, pending a presentation to the Test and County Cricket Board (Duckworth and Lewis 2011, 31–34).[1] Duckworth and Lewis set out this story in their book, along with a personal first-hand account of the process by which their model came to transform how cricket is played. They suggest that Duckworth had in fact begun with the wrong kind of question, asking "how many runs on average should one have made after y overs with w wickets down?" rather than "how many runs can be made, on average, with u overs *remaining* and w wickets down?" (Duckworth and Lewis 2011, 31) The former is prescriptive—what ought to have happened so far—and the latter is predictive—what will happen now. Duckworth, in other words, had

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[1]The board that has a de facto monopoly on organized cricket in England and is responsible for the national team. It is now the England and Wales Cricket Board.

shifted the task at hand from one of evaluating how well a team has done so far to evaluating its future. This corresponds in fact to the shift from theories of value in classical and 19th marginalist economics that predicated that value on something—whether labor, corn, or something other substance—to a theory of value that rested on the future–predicted—usefulness of a good (Mirowski 1989, 1991).

Duckworth and Lewis set up a meeting with Tim Lamb, the TCCB's secretary, and Dave Richards, the chief executive of the ICC for October 1995. They list the various formulations of the formula at the core of the D/L method they went through in the preceding weeks to the meeting.

$$Z(u,w) = Z_o F(w) \left[1 - e^{-bu} \right]$$

$$Z(u,w) = Z_o F(w) \left[1 - e^{-ub(w)} \right]$$

$$Z(u,w) = Z_o F(w) \left[1 - e^{\frac{-bu}{F(w)}} \right]$$

Where Z(u,w) is the number of runs scored from a point at which u overs are remaining and w wickets have been lost; F(w) is the average proportion of the total runs contributed by the remaining batsmen when w have been lost; and b is a constant. (Duckworth and Lewis 2011, 35, and appendix, 198)

The successive changes in the formula are interesting because they were en-

tirely ungrounded in any explicit empirical considerations. What they are after is a formula that describes how cricket teams use up overs and wickets to score runs in a kind of ideal setting. The crucial innovation that they highlight is Duckworth's initial intuition that previous rain rules were deficient because they did not take into account both overs *and* wickets. Subsequent proposed models, different as they may be, all retain that core insight.

In this respect, the model is a significant improvement on both the commonly used average run rate method and the "parabola" method. The former method simply compares the rate at which the team batting first has scored its runs to the rate at which the second team has scored its own runs. After a rain interruption of the second innings, if the former is higher than the latter, the first team has won. By the time Duckworth and Lewis met Tim Lamb, the rain rule for the upcoming 1996 World Cup had already been set. The ICC was going to use a different rule created by Wayne do Rego. do Rego fitted a parabola formula to data from a large number of cricket matches:

$$y = 7.46x - 0.059x^2$$

Where y is the number of runs scored and x the number of overs lost

so far. (Duckworth and Lewis 2011, 27)

There were no interrupted matches at the 1996 tournament so the rule did not

come into play. However, Duckworth and Lewis give an example of its application in a match in 1998 between two Australian state teams. Victoria had scored 223 in their 50 overs. In response Western Australia had gotten to a score of 188 runs in 43.2 overs, with the loss of only one batsman. Needing just 36 runs to win, it was clear to all participants that Western Australia were very likely to win. However it rained sufficiently hard and long for the match to have to be halted at that point. Under the parabola method, the target Western Australia would have faced if they only had 43.2 overs would have been 210 runs (Duckworth and Lewis 2011, 28–29). Duckworth and Lewis supply a quote from the coach of the Western Australian team: "We'd had the game all wrapped up... It (the rain) was one of those unfortunate things which was out of our control. We were certain of winning—with nine wickets in hand and needing five runs an over and with Langer and Martyn batting so well there's no way we could have lost" (Duckworth and Lewis 2011, 29).

Duckworth and Lewis quote the passage because they want to highlight the coach talking about wickets in hand—that is, the nine batsmen Western Australia have in hand—as well as the relatively modest runs per over still needed. The third factor the coach mentions, however, is of some interest. The batsmen Justin Langer and Damien Martyn were batting "well." A rain-rule must be indifferent

to the particular named batsmen who are scoring well or else not be fair and the underlying model could never be used directly for gambling on a game for it must treat both teams as equally likely to win the game at the onset. The particular personnel involved is crucial from a gambling point of view, but strictly irrelevant from a fairness perspective. However, I will argue later that the fact that there were two top-order batsmen who had already scored many runs—regardless of past records of them in particular—*is* relevant. I suggest that it is implausible that taking that into account could be deemed unfair.

5.1   The Duckworth and Lewis argument

Duckworth and Lewis published their paper—outlining the method that had already been put into operation in international cricket—in 1998. The journal they published their paper in—the Journal of the Operational Research Society—is ranked quite highly with operations research. As a result of the popularity of their paper, the journal has published two further papers, both discussed below, on the same topic of rain-delays in cricket. Duckworth and Lewis responded in detail to the first of these, but not yet to the second. They frame their original paper by noting that operations research had already been applied to cricket by some previous scholars, notably to schedule fixtures, optimize run scoring strate-

gies, and comparing player performances. Their focus was on how to set a target run score for a team batting second in the event of interruptions to a limited overs game. Such games are designed to produce a result. "Tied" games very occasionally occur in this form of the game, but with nothing like the frequency that "drawn" games occur in the longer multi-day long format known as Test cricket (when played between national teams).

In a limited overs game, one team bats first and scores as many runs as they can in their innings—their allotted number of deliveries of, typically, 50 overs unless they lose 10 wickets first. A set of six deliveries is known as an over. When batsmen get out, they are said to have lost their wicket. There are 11 players on each side but batting occurs in pairs at all times, so losing 10 wickets suffices for a team to have to end its innings. Once the first team has finished its innings, the second team takes over and tries to "chase" the target they have been set. If they succeed in their allotted number of deliveries, and without losing 10 wickets, they will have won the game. However, cricket is sensitive to rain in a variety of ways. As a result play is suspended when it rains. The umpires may even allow some time to elapse after it has stopped raining to give the ground time to dry out as much as possible. As one team bats first and the other second, rain at one point in time have an asymmetric effect on the course of the game. Restoring order to that

potential asymmetry is the task that Duckworth and Lewis set out to address.

Their core insight is set out in terms of an optimization problem:

> The optimization exercise in either team's task involves choosing some
> compromise between scoring fast and hence taking higher risks of los-
> ing wickets, and playing carefully and hence risking making insuf-
> ficient runs. Whatever strategy a team adopt, they are always com-
> promising between the constraints on their two resources, overs and
> wickets. But when an innings has to be shortened, only one of these
> resources, overs, is depleted and the balance is upset. (Duckworth and
> Lewis 1998, 220-1)

With respect to various previous attempts at adjusting for interruptions, the
key choice is simply focusing on the two factors of overs remaining *and* wickets
remaining. However, with respect to the intervention made in general by an
operations research approach to cricket the important move is to think in terms of
risk/reward and scoring runs. This approach mimics, of course, the modern
financial theory approach to understanding asset pricing. To be sure, cricket
players and fans already reasoned about a game in similar terms but here in
the Duckworth-Lewis method, for the first time, was a systematic quantitative
approach to that basic insight. The parallel to the economic realm is made explicit

when Duckworth and Lewis characterize their method as asserting the existence
of "a relationship for the proportion of the runs of an innings which may be
scored for any combination of the two *resources* a batting side *possesses*, overs to
be faced and wickets in hand" (Duckworth and Lewis 1998, 221).

They list five criteria which they believe to be important for any fair target
resetting rule. The last two of these are about simplicity: how easy the rule should
be to apply and how easy it should be to understand by everyone involved. The
first three are as follows:

1. It must be equally fair to both sides; that is the relative positions
   of the two teams should be exactly the same after the interruption
   as they were before it.

2. It must give sensible results in all conceivable situations.

3. It should be independent of Team 1s scoring pattern, as indeed is
   the target in an uninterrupted game. (Duckworth and Lewis 1998,
   222)

The authors set out the formula they had settled on, noting the importance
of the exponential decay embedded in their formula, and then state flatly that
"[c]ommercial confidentiality prevents the disclosure of the mathematical defini-
tions of these functions" (Duckworth and Lewis 1998, 222). What they mean is

that they are unable to give the reader the actual constants they use in the formula, only the general form which the formula takes, for commercial reasons. The constants themselves had been, they say, "obtained following extensive research and experimentation" (Duckworth and Lewis 1998, 222). The details of this research and experimentation is also undisclosed. However in their book they repeatedly make it clear that they have not profited materially from the application of the D/L method in cricket. It seems from this that they attempted to commercialize their findings—selling the model to the ICC—but failed to do so at any price but zero or close to it. The result is a set of specific variables that are crucial to the game but closed to further scrutiny.

The bulk of the remainder of the paper is taken up with a variety of examples, hypothetical or actual, that illustrate how the method works and, implicitly, comparing the reset targets that their method would set against the intuitions of a cricket-knowledgeable reader. The simpler examples typically pick out situations in which the team batting first has completed its innings, then rain strikes, leaving a now reduced number of overs which the second team will have to bat. In these circumstances the application of the D/L method is particularly straightforward. Suppose the first team scored 250 runs in their 50 overs. Rain causes enough of a delay to allow the second team only, say, 30 overs in which to bat. The usual

old rule would reduce the target for the second team to 150 runs (because the first team scored at an average of 5 runs per over). The D/L method asserts that whereas the first team used up all its resources in scoring 250 runs, the second team will only have, using the data tables they make available in their paper, 77.1 percent of their original resources. Therefore, the D/L method suggests, their target ought to be revised downward—250 runs multiplied by 77.1 percent (and then rounded up to the nearest integer), giving 193 runs to win. This general procedure applies just as well to situations in which the second team has already started batting and then rain ensues. The key is look up what percentage of their resources were available to them at the start of the interruption and compare that to the resources that will be available to them at the resumption of the game. Resources available will be sensitive to the number of wickets they have lost as well as the overs finished at the interruption and overs remaining at the restart.

However, Duckworth and Lewis note a possible incongruity. If there is an interruption in the first team's innings, the target set for the second team might be rather unrealistic following the method outlined above. This is because it might be the case that the first team lost more of the resources available to them than the second team. They give the following hypothetical (and extreme) example: the first team bats for 10 overs and scores 80 runs with no loss of wickets. Ac-

cording to their calculations, the team will have used up about 10 percent of their resources (Duckworth and Lewis 1998, 223). Should rain then intervene, curtailing the first team's innings and giving the second team only 10 overs to bat, the second team will only have 10 overs to bat with all their wickets in hand. This will correspond to about 34 percent of the resources they would have had in they had a full 50 overs to bat. A directly scaling would give a target of approximately 3.4 times the initial score of 80, meaning the second team would have to score about 282 in 10 overs to win. This is, as they point out, well above an intuitively reasonable target. More importantly, the reason they give has more to do with the first team's score in their 10 overs: "Although there may be factors which affect all players' scoring capabilities equally, such as the condition of the wicket, the speed of the outfield and short or long boundaries, it is highly unlikely that Team 1 would have been able to sustain such a high early scoring rate..." (Duckworth and Lewis 1998, 223-4). In other words, the method as it stands give an unrealistic target because it would be unrealistic to extrapolate directly from the first teams good start to their putative entire innings. The solution they implemented simply scales the target according to the average team score—about 225 runs at the time they wrote the article—by the difference, not the ratio, between resources used up by the first team and resources available for the second team wherever the for-

Wickets lost		0	2	4	9
Overs left	50	100.0	83.8	62.4	7.6
	40	90.3	77.6	59.8	7.6
	30	77.1	68.2	54.9	7.6
	25	68.7	61.8	51.2	7.6
	20	58.9	54.0	46.1	7.6
	10	34.1	32.5	29.8	7.5

Table 5.1: Extract of a percentage of innings resources remaining table (Duckworth and Lewis 1998, 223)

mer is less than the latter. The model, therefore, works to tame potential cricket scores by assuming that good starts to an innings will likely revert to an average performance.

Duckworth and Lewis go on to provide a slew of real examples of the application of their method, both to cases in the past and actual applications after their method came into effect as a regulation. The example that framed their account of the method—the World Cup semi-final between England and South Africa I wrote about in the last chapter—is illustrative of the improvement of their method over the previous system of "most productive overs". With England scoring 252 runs off their 45 overs and South Africa reaching 231 runs with 2.1 overs to go, rain curtailed South Africa's innings to precisely one delivery remaining. The previous system set them an impossible 21 runs to win, whereas the D/L method would have set them a target of 3 runs (Duckworth and Lewis 1998, 225).

The actual table of resources they construct from their formula would have

entries on a ball-by-ball basis (for each of the possible 10 wickets available to a team). See Table 5.1 for a extract of a summary table they give in the paper for illustrative purposes. As they assert by way of conclusion, they have "derived a two-factor relationship which gives the average number of runs which may be scored from any combination of these two resources and hence have derived a table of proportions of an innings for any such combination." Further, "[t]hrough the examples given, both hypothetical and real, we have shown that our method gives sensible and fair targets in all situations" (Duckworth and Lewis 1998, 227). They also note, in passing, that the "parameters of our relationship might change as the nature of the game changes, due, for instance, to changes in rules or possibly changes in team selection and playing strategy" and that they therefore think it "important that the method of correction keeps abreast with the game" (Duckworth and Lewis 1998, 227). The model that they intuited before looking at any data itself will remain stable, but over time the parameters they started with might no longer fit current data so well and will therefore need to be adjusted on an on-going basis.

In a 2004 article in the same journal, Michael Carter and Graeme Guthrie have provided the strongest challenge to the D/L method. They also write about the problem from the point of view of fairness, but attack precisely the issue

Duckworth and Lewis worry about in their conclusion, namely possible changes in cricket strategy in the future. However, their core argument is that such changes might come about in *response* to the D/L method, not independently of it. In the name of fairness, they propose an "iso-probability rule that aims to reduce the net cost of an interruption to zero, by preserving each team's changes of winning the match" (Carter and Guthrie 2004, 823). Their proposal is constructed in a similar fashion to Duckworth and Lewis in the sense that they accept the basic idea of a two-factor relationship—what matters in a cricket innings are the number of deliveries and number of wickets remaining. They also argue from examples, both real and hypothetical. Their first example—hypothetical, but with a real referent to make it plausible—nicely highlights the differences between their method and the D/L method:

> Suppose team 2, chasing 250 runs, gets off to a flying start and scores 143 without loss in the first 20 overs. (Chasing a target of 214, South Africa reached 143 without loss in the 21st over in their match against Zimbabwe on 28 September 1999.) Clearly, at this point, team 2 is in a strong position and has a high probability of winning. But, victory is not certain. The match is not over and fortunes may change. (Carter and Guthrie 2004, 824)

If 20 overs are then lost to rain, they argue, under the old average run rate rule, in the 10 overs remaining team 2 would have to score a further 8 runs to win as they would have been set a target of 150 runs. However, importantly, under the D/L method victory is not very likely but in fact already in place. The revised target would have been 143, not 150, so in fact team 2 would automatically be the winner of the game. The rain interruption in fact removes all uncertainty from this particular hypothetical game. Under Carter and Guthrie's model, the probability of a win for team 2 works out to 99 percent, and "[t]o preserve this probability, team 2 should be set the task of scoring 56 runs off the last 10 overs (with 10 wickets in hand) to win the match" (Carter and Guthrie 2004, 825).

The core of their argument builds on the same observation that Duckworth and Lewis make about the risk/return trade-off in constructing a team's innings— the more risk you take, the more runs you score per delivery used up but with an attendant greater risk of losing a wicket. Carter and Guthrie, in other words, have here reinforced the connection Duckworth and Lewis made between models of cricket games and models of market security evaluation. The main difference they introduce between their model and Duckworth and Lewis's lies in the possibility of players expecting an upcoming interruption in an innings. They note that "Existing rules—such as ARR and Duckworth-Lewis—change the trade-off faced

by the batting team. When an interruption is anticipated, team 2 can afford to bat more aggressively, since the opportunity cost of losing a wicket is lower" (Carter and Guthrie 2004, 825).

The authors proceed to give a number of real examples from the past to illustrate this point, using them to further contrast the kinds of targets their rule would give compared to the D/L model. One in particular stands out because it highlights that their iso-probability rule gives a probability of the second team winning even at the start of their innings. In 1997, New Zealand batted first and scored 253 runs. England batted for 6 overs, scoring 47 runs without losing a wicket—a very good start—before rain intervened. When play restarted, they were allocated a further 20 overs by the umpires. The old average run rate rule was applied, giving them a target of 86 runs off those 20 overs. Carter and Guthrie assert that the D/L method would have produced a somewhat harder to get target of 117 runs off 20 overs, whereas their iso-probability rule would have give England a target of 148 runs (Carter and Guthrie 2004, 828). They note that:

> While this may appear an unreasonable target, it recognizes England's
>
> commanding position having all 10 wickets in hand. At the beginning
>
> of their innings, England's estimated probability of winning the match
>
> was only 0.28. Their excellent start increased this to 0.66 at the point of

interruption. The iso-probability rule preserves this probability, while the Duckworth-Lewis rule increases the probability of winning to 0.94. England would obtain a significant boost from the Duckworth-Lewis rule.

Their emphasis is on the interaction between the D/L method and the probability of winning. As their rule attempts to preserve the probability of winning across interruptions, they argue that a team will not be able to change strategies such as to "game" the system in the likelihood of rain. Certainly, the Duckworth and Lewis say nothing about the predictability of rain itself. It is almost as if rain is always an external event that impinges on the process of playing cricket. But any follower of cricket anxiously scanning the skies for rain clouds knows that this is not at all the case. Every game in which rain is a possibility proceeds with that knowledge at the forefront of the minds of players, coaches, fans, and commentators alike. In general, a team which knows that, in the event of rain, the D/L method will favor their chances of winning will play more conservatively than they otherwise would. Similarly, a team that would fall further behind under the D/L method, would want to take more chances if the rain clouds are looming.

However, Duckworth and Lewis were certainly cognizant of the possibility of an iso-probability approach to rain interruptions. In their response to Carter

and Guthrie's proposal, published in the same journal, they agree that if one side has already established an advantage over the other, that advantage will be accentuated by a rain delay. The problem, they suggest, is that a rain interruption rule:

> should not in any way be based upon the runs scored by the team batting second at the point of the interruption. We will show that such an approach leads to the use in cricket of a 'socialist' concept in that the more or fewer runs that a team have already scored, the more or fewer they still have to make. In other words, maintaining probability has the effect of taxing the run-rich to aid the run-poor. (Duckworth and Lewis 2005, 1335)

Their argument about the supposed socialist tendencies of the rival proposal—they hint here that socialism is completely described by progressive resource redistribution policies and that such a thing is unfair—is of course constructed around another hypothetical example. Suppose, they argue, two matches, on grounds A and B, are going on at the same time. In both cases, the teams batting first scored 250 runs from their 50 overs. Also in both cases, both the teams batting second receive 20 overs and lose 3 wickets. The rain delay is 10 overs so both teams now only have a further 20 overs in which to bat. Suppose that

on ground A, the second team had scored 120 runs for the loss of 3 wickets and that on ground B, the second team had scored only 50 runs for 3 wickets. Duckworth and Lewis state that their unmodified method would set identical targets of 221 runs. However, a modified version that mimics Carter and Guthrie's iso-probability approach would set the second team's target at 226 runs on ground A and 213 runs at ground B. Hence, the reference to "socialism" as the second team on ground A has in effect, they argue, been penalized for having scored 120 runs compared to the second team on ground B who only scored 50 runs. This seems odd, they argue:

> If the Team 2 on Ground A went on to make 224, they would lose, whereas if the Team 2 on Ground B went on to make 213 they would win. Thus, in directly comparable situations, the side that has scored more runs has lost and the side that has scored fewer runs has won. (Carter and Guthrie 2004, 1335)

On the other significant issue that Carter and Guthrie raise about the D/L method, Duckworth and Lewis state that they see no incentive effects whatsoever. They state flatly that a team batting second either has to exceed the first team's total or, "[i]f there is a possibility that Team 2's innings might be shortened or curtailed, their corresponding sole objective is to get ahead and stay ahead of the

D/L par score, which is public information at all stages of the match" (Duckworth and Lewis 2005, 1336). But this is in fact precisely Carter and Guthrie's argument. What the second team in fact should always be trying to do is maximize the chances of winning the game, not chase a given target. Therefore, all changes in the target should preserve the probability of winning.

In their reply to Duckworth and Lewis's comments, Carter and Guthrie note that the "two most important issues that Duckworth and Lewis raise are whether the adjustment to an interrupted innings should depend on the number of runs scored by the batting team, and whether the threat of a rain interruption adjudicated by the DL rule distorts the optimal strategy of the batting team" (Carter and Guthrie 2005, 1337). In particular, they suggest that discerning whether two different matches are in similar positions is the "fundamental difference" between their two methods (Carter and Guthrie 2005, 1337). Adding to the proliferation of hypotheticals, they suggest a further Ground C, in addition to A and B, on which the first team scores just 180 runs. The second team on Ground C are in the same position in terms of overs and wickets lost, but have only scored 50 runs: "We argue that this match is a far stronger contender to be 'directly comparable' to the situation on Ground A than is the match on Ground B. On both Grounds A and C, immediately before the interruption Team 2 needed to score an additional 131

runs off 30 overs with seven wickets in hand" (Carter and Guthrie 2005, 1338).
Thus, they argue, the D/L method treats games A and B as being in the same
situation, but their iso-probability (or IP) approach treats games A and C as be-
ing in the same situation. Moreover, there are some key differences in how those
equivalences are treated:

> When assessing the state of a match interrupted in the second innings,
> the DL rule uses the number of runs required at the *start* of the second
> innings. The IP rule looks at the number of runs required at the *time*
> of the interruption.
>
> The DL rule ensures that the number of runs required over the entire
> adjusted innings is the same for matches that they deem to be in equiv-
> alent situations. In contrast, the IP rule ensures that the runs required
> off the remainder of the adjusted innings is the same for matches in
> equivalent situations. (Carter and Guthrie 2005, 1338)

On the question of the "socialist" tendencies of their approach, they note that
it is true that under their approach the "compensation received by Team 2 for
overs lost in its innings is a decreasing function of the number of runs it has
scored thus far," however it also true, they argue, that under the D/L method the
"compensation received by Team 2 for overs lost in an innings is an increasing

function of the number of runs scored by Team 1 in its innings" (Carter and Guthrie 2005, 1338). They illustrate this argument with their example of the match on Ground C. According to the DL rule, they state, Team 2 would be set a target of a further 109 runs off 20 overs. This means that:

> Team 2 is compensated for its loss of overs by having its target reduced by 22 runs on Ground C and by 30 runs on Ground B. A relatively poorly performing Team 2 receives more compensation for overs lost. Presumably Duckworth and Lewis regard the DL rule as being socialist, too! (Carter and Guthrie 2005, 1338)

On the question of the incentives to change strategies, Carter and Guthrie find the responses made by Duckworth and Lewis rather unclear. They state that the "objective function of both teams is the probability of winning" and also that a "rain interruption does not alter this probability—that is, the teams' objective functions are invariant to interruptions." They argue that in general, however, "only in very exceptional circumstances will a strategy that maximizes a team's expected score also maximize the probability that their score exceeds the team's batting target" (Carter and Guthrie 2005, 1339). Put rather more concretely, the point of playing cricket is to win the game, not maximize the score that you will or might have scored. Roughly speaking, in the model of cricket that these authors

use, there is no difference between losing by a lot or losing by a little. Likewise, there is no advantage to winning by a big margin. Aside from the niceties of playing tournaments of cricket where the margin of victory or defeat might become relevant, it seems reasonable that margins of wins and losses should not in fact be a factor in modeling rain interruptions. These considerations bring out the difference between the two approaches as Duckworth and Lewis assume that the task is to predict runs that may be scored, whereas Carter and Guthrie are trying to track the probability of scoring.

5.2   An interlude on crime

Both of these approaches share the idea of a set of resources that can be "cashed out" as runs. An effective team will do so efficiently. Those resources are wholly described by the number of overs and wickets remaining to the batting side. The D/L method's table will tell you immediately how much of its resources a team has used so far in scoring the runs that they already have. A simple linear extrapolation from there will predict their final score. Indeed, the model depends on that manner of reasoning about the relationship between resources and scores. Although they target probabilities rather than runs, the iso-probability model asserts that a team that has scored a certain number of runs so far, given overs and

wickets remaining, will be on a particular iso-probability curve. Therefore, on the assumption that they remain on that curve, their table can be used to extract a predicted score too.

Importantly, neither model is designed to use all the available information to predict final scores. The D/L method, for example, is designed with the idea that any team batting second, regardless of the target it has been set by the team batting first, has an even chance of winning the game. The iso-probability method *does* assert a non-even chance from the beginning of the innings. That fact alone seems to cut against the usual notion of fairness in cricket, even though the probability they derive here has nothing to do with previous performance records of either team. Cricket followers are no different from all sports enthusiasts in liking to think that, as the popular cricket phrase has it, "anything can happen on the day." This sentiment alludes to a notion of randomness in sport that, I will argue below, is crucial to the notion of fairness.

This discrepancy is rather minor compared to all the information that neither model makes use of. In other applications of statistics, there is usually no question of deliberately *not* taking available information into account. Bernard Harcourt has written in some detail about the history of what he calls actuarial methods in criminal law. Harcourt locates the development of these methods in

the criminal domain proximately to Ernest W. Burgess, a sociologist at the University of Chicago, who completed a survey of 3000 inmates paroled in Illinois in the 1920s. Burgess proposed a "twenty-one-factor test that would determine, based on group recidivism rates, the likelihood of success or failure of any inmate eligible for parole" (Harcourt 2007, 1). Although Illinois remained the only state to use such predictive methods from the 1930s to the 1950s, Harcourt demonstrates that the number of states using such methods for parole and other criminal justice purposes climbs rapidly from then on. Currently, about 30 states use such methods (Harcourt 2007, 9). Harcourt argues that these methods are actuarial because:

> [T]hey use statistical methods—rather than clinical methods—on large datasets of criminal offending rates in order to determine the different levels of offending associated with a group or with one or more groups traits and, on the basis of those correlations, to predict the past, present, or future criminal behavior of a particular person and to administer a criminal justice outcome for that individual. (Harcourt 2007, 16)

Harcourt uses the term to narrow down the subject area. Probabilistic reasoning is used in a variety criminal justice domains such as the notion of "probable

cause" in effecting arrest, the use of various kinds of scientific evidence in trials, and even the determination by a jury of the "reasonable doubt" standard. Harcourt asserts that, aside from the question of racial profiling on highways, the increasing use of these actuarial methods is viewed by "[m]ost of us … [as a] trend with hope, rather than alarm" (Harcourt 2007, 2). Harcourt notes that in a Foucaultian framing of contemporary penal systems, "the modern administrative state metamorphosed from a social welfare state in the 1960s and 1970s into a correctional administrative state at the turn of the twenty-first century—a state that manages the margins of society by means of social control and correctional supervision." Moreover, these scholars "usually portray the trend toward more managerial and administrative methods in dark terms" (Harcourt 2007, 19).

Harcourt contrasts this position with the "general public and most academics [who] generally support the use of prediction in policing" on common sense grounds. He asks, rhetorically, "[w]hy would we not use our best social science research and most advanced statistical methods to improve the efficiency of police investigations, sentencing decisions, parole practices, treatment efforts, and general correctional procedures?" for it would be "crazy not to take advantage of what we now *know* about the propensity to commit crime" (Harcourt 2007, 21). Harcourt argues that the usual argument against actuarial methods

and in favor of a clinical approach incorrectly posits that actuarial methods ignore the individual over group generalizations: "the fact is that the actuarial impulse derives precisely—and very paradoxically—from the *desire to individualize*" (Harcourt 2007, 21). Both methods are directed towards the just treatment of each individual case, it is the approach that differs. Harcourt suggests that the problem with prediction lies, rather, in three different areas: "mathematics, identifiable social costs, and social and epistemic distortions" (Harcourt 2007, 21).

The mathematical argument is an argument about the elasticity of the propensity to commit crime. As such, the argument is resolutely in the law and economics genre of argument pioneered at the University of Chicago by Richard Posner and Gary Becker. Harcourt states that the rational choice argument about racial profiling on highways makes the following assumptions. The first is that "police officers seek to maximize the success rates of their stops and searches, given the cost of these interventions" (Harcourt 2007, 112). The second is that "suspects are also rational and try to maximize their own payoff associated with criminal activity." The third, most striking premise, is that "racism is reflected in the fact that the racist police officer experiences a lower cost for stopping or searching minority suspects than for searching white motorists" (Harcourt 2007, 113). The premise is striking in the sense that it is difficult to envisage what

that "cost" might look like other than by some notion of affect. In this model of racism, a racist police officer literally does not feel like stopping white motorists. Further, Harcourt argues, there is a hidden assumption that the argument relies on: "minorities offend at higher rates than whites under conditions of color-blind policing, in other words, in the absence of racial profiling" (Harcourt 2007, 113).

Given these assumptions, rational police officers will target minorities at a higher rate than white motorists because rate of successful stops will be higher. However, doing so will gradually reduce offending rate among those minorities and thereby reduce the success rates. In particular, Harcourt argues, "[p]olice officers will continue to search members of the higher-offending group disproportionately until the point of equilibrium, where minority and white offending is at the same level" (Harcourt 2007, 113). At this point of equilibrium in the model, a racist police officer will be easily discernable because their success rate for minorities will be lower than for white motorists. Thus, in the absence of racism, the argument proceeds, the police will now be maximizing the use of their resources. Harcourt's critique of this argument proceeds from the observation that if the relevant minority does in fact offend at a higher rate in the absence of racial profiling, this is good evidence for the possibility that their elasticity to commit crime is different—in particular, lower—than for the general population:

Whether the different offending rates are due to socioeconomics, history, cultural forces, or path dependence, the fact is that we are prepared to stipulate that there is a difference in offending. Nonspurious racial profiling rests on the nonspurious assumption that members of one racial group offend *more* than members of another racial group, holding everything else constant. If their offending is different, then why would their elasticity be the same? (Harcourt 2007, 123)

However, if it is true that their elasticity to commit crime is lower, for example if they are "offending more because they are socioeconomically more disadvantaged" it follows immediately that racial profiling would in fact *increase* the amount of crime in society as a whole. The added attention directed at minorities reduces offending rates for them less than it allows offending rates for non-minorities to increase (Harcourt 2007, 123).

Harcourt's mathematical argument against the use of racial profiling as a predictive method works from within the assumptions of the rational choice law and economics movement. The second argument Harcourt puts forward works through a "ratchet effect" that continuously increases the social costs involved in predicting crime through race. Harcourt points out that if an identifiable group has a higher offending rate, they will be disproportionately represented in the

prison population. This is because policing in this model is in effect a sampling of the different groups at different rates: "Instead of sampling randomly, which would be the only way to achieve a proportional representation of the offending population, the police are sampling in greater numbers from within the higher-offending group, thereby skewing the sampling results in favor of frequent offenders" (Harcourt 2007, 147). Random sampling would result in a prison population that is driven by the different offending rates amongst minorities and non-minorities. A profiled sampling, however, creates a further pressure toward a higher minority representation in the prison population, assuming that the offending rate is higher in that minority: "there will be far more members of the higher-offending population in jail and prison then there are even among the offending population" (Harcourt 2007, 149). This is where Harcourt's ratchet effect goes to work. Harcourt suggests that if the police use in yet more profiling of the minority group, the corresponding distortion in the prison population will increase further. Profiling, Harcourt concludes, "accentuates the apparent correlation between the group trait and criminality by skewing the carceral population, which is what we all use to proxy criminality" (Harcourt 2007, 156). Moreover, the resulting skewed distribution and the success associated with such profiling in turn makes it significantly harder for members of that group to recover from

incarceration: "The deadly combination of prison and unemployment fuels a cycle of detrimental consequences for the community that then feed back on the community members" (Harcourt 2007, 161).

The third argument Harcourt presents against predictive methods in criminal justice is a broad one. Harcourt suggests that the shift from a justice system that was organized around rehabilitation to one organized around incapacitation is a "case of philosophical and legal notions of justice *following* technical progress" (Harcourt 2007, 173). In particular, Harcourt argues that this technical shift was exogenous to the legal system and "came from the field of sociology and from the positivist desire to place human behavior on a more scientific level—from the desire to control human behavior, just as we control nature" (Harcourt 2007, 173). Harcourt differentiates this from an argument about a shift from a welfare state to a penal state which focuses on managing an "underclass" that requires "this new probabilistic or actuarial *episteme* involving a style of thought that emphasizes aggregation, probabilities, and risk calculation" (Harcourt 2007, 174). Harcourt suggests that an important factor is simply the desire to predict criminality. For Harcourt, this is a "drive to operationalize and model future behavior in the most parsimonious way, the quest for more efficient ways to anticipate crime" (Harcourt 2007, 174).

The solution to the problem of prediction in the justice system is to *random-ize*. Harcourt notes that the problem with the ratchet effect is not limited simply to racial profiling, rather what the effect does is "violate a core intuition of just punishment—the idea that anyone who is committing the same crime should face the same likelihood of being punished regardless of their race, sex, class, wealth, social status, or other irrelevant categories" (Harcourt 2007, 237). The solution cannot be, in Harcourt's estimation, a return to clinical methods because that will merely be a return to "the hunch rather than the regression." Instead, a process of policing by randomization will "neutralize the perverse effects of prediction, both in terms of the possible effects on overall crime and of the other social costs" (Harcourt 2007, 238). Similarly, with respect to sentencing, the solution is not ran-domizing sentencing lengths, but rather *"eliminating the effect of predictions of future dangerousness"* (Harcourt 2007, 238). Harcourt has successfully, I think, marshaled a series of rational choice arguments against what he calls the "positivistic desire" to be scientific about human behavior in arguing that justice needs to be based on a randomization of enforcement.

5.3   Two methodologies

Duckworth and Lewis approached their rain interruption rule by positing a model describing the rates at which teams score runs, given the number of overs and wickets they have remaining. They used an exponential function. Methodologically, this is similar to the parabola method however the latter took only overs into account, not wickets lost. In both cases, having established a function that they deemed intuitively likely, they then sought to optimize their formula against some past cricket matches to find the "right" parameters. This approach is susceptible to some rather standard kinds of critique one might proffer towards quantitative models in general. It picks formula apparently rather arbitrarily and then attempts to fit the phenomena that is being modeled to that formula. As long as sufficient numbers of free parameters are available, fitting such a formula to cricket data will likely be easy.

Carter and Guthrie use precisely the two-factor approach that Duckworth and Lewis pioneered but argue that they are preserving the wrong measure across rain interruptions. Instead of preserving the current estimate of the margin of victory or defeat across an interruption, one should instead preserve the probability of victory or defeat. Perhaps more importantly, although they do not note this difference in their article, Carter and Guthrie employ a different methodology.

Instead of testing a given formula directly against available data, they first build a model of run-scoring in limited overs cricket. The model is based on the idea that, given the number of deliveries and wickets remaining in an innings, there are individual probabilities of one of three mutually exclusive possible events. Either an extra is given away by the bowling side (a no-ball or wide that adds to the batting side's score but does not change the number of deliveries remaining), a wicket is taken, or runs are scored (Carter and Guthrie 2004, 825). They appear not to notice that it is possible, but very unlikely, for runs to be scored and a wicket to fall on the same delivery or for multiple wides and no-balls to be scored off the same delivery. However, neither of these issues are likely to be particularly important. Carter and Guthrie also note some boundary conditions that shape these probability functions. Using data from the 1999 World Cup, "[e]ach delivery in the first innings of each of these matches was classified" according to their schema (Carter and Guthrie 2004, 826). They estimate that the probability of an extra is about 0.055. For the wickets process, they assume that each delivery is an independent event and that a wicket falling can be modeled as a variable from a normal distribution. The result is that they estimate that the probability of losing a wicket in a delivery in the first over is about 0.02 and that this rises to about 0.06 per delivery in the last over (Carter and Guthrie 2004, 827). A similar estimation

process was used for the probabilities of different numbers of runs being scored off each ball. These per delivery transition estimations allow them to construct a table of probability values for a wicket falling or different amounts of runs being scored for each combination of deliveries and wickets remaining (Carter and Guthrie 2004, 828).

This two step approach to constructing a rain-interruption rule uses a rather more rigorous approach to thinking statistically about cricket. However, a more recent article employs a non-parametric approach to modeling games of cricket. Bhattacharya, Gill, and Swartz make all the assumptions that Duckworth and Lewis do about the structure of the game. In particular, they are seeking merely to update the resource tables that Duckworth and Lewis generate for Twenty20 cricket (Bhattacharya et al. 2011). The authors note that this relatively new form of the game is "seen as a more explosive game where the ability to score 4's and 6's is more highly valued than in 1-day cricket" and therefore that the D/L method might not be suitable for it (Bhattacharya et al. 2011, 1952). As the D/L method requires separate curves for each of the 10 possible wickets remaining and has some constants that need to be found for each such combination, it is in fact a 20 parameter model. Bhattacharya et al approach the problem of resource table construction entirely differently from both Duckworth and Lewis, and Carter and

Guthrie. They note that there are many different sets of curves that can satisfy the criteria that Duckworth and Lewis set out. In particular, their choice of an exponential function to model run-scoring leads to asymptotic maximal values that lie well beyond the range of limited overs cricket and, therefore, any data available to them (Bhattacharya et al. 2011, 1953).

They start by simply constructing a table from the raw data then available to them—85 matches of Twenty20 cricket between national ICC teams. For example, they calculate the average number of total further runs scored in those matches (out of the set of 85) in which, say, 15 overs and 8 wickets are remaining. In constructing this table of values, the denominator is set as the average number of total runs scored across all the matches. Thus the first value in the matrix, when 20 overs and 10 wickets are remaining, is set at 100 percent (i.e. all "resources" are available). They note however that this table "does not exhibit the monotonicity that we expect" (Bhattacharya et al. 2011, 1954). In other words, they expect that the amount of resources available to a team should decrease as the number of overs remaining decreases, and likewise for the number of wickets remaining. In general, the fewer opportunities you have to score runs and the fewer wickets you have remaining, the worse your situation is. They highlight one particular entry where 19 overs and 8 wickets are remaining. Only two matches fit those criteria

and those teams happened to have averaged a higher total score than the average score across the 85 matches they examine. Therefore, their raw resources table shows a value greater than 100 percent of resources remaining (Bhattacharya et al. 2011, 1954). Instead of trying to fit some specific formula to "smooth out" these data, they instead stipulate a squared-error minimization function along with the monotonicity constraints. Each entry in this table of differences is weighted by the amount of variance for that entry divided by the sample size in order to represent the intuition that the function should err towards the raw data wherever there are relatively more games that fit that table position. This newly generated table preserves the raw data to the extent possible given the monotonicity constraints. However, as with the D/L resources table, it misses entries whenever no games fit those states. For example, it is extremely unlikely that any team will ever play a game in which they might have, say, 19 overs and only 1 wicket remaining. The authors "therefore consider a Bayesian model" in which "Gibbs sampling can be carried out via sampling" from a full conditional Normal distribution (Bhattacharya et al. 2011, 1955). Further, they assert that in "cases of missing data, we impute the missing [raw resource data] with the Duckworth-Lewis table entries" because this "imputation is in the spirit of a Bayesian approach where prior information is utilized" (Bhattacharya et al. 2011, 1956).

Wickets lost		0	2	4	9
Overs left	20	100.0	93.0	81.3	17.6
	16	83.5	75.3	66.4	12.0
	12	68.3	60.2	52.9	9.1
	8	54.0	44.3	38.9	6.6
	4	30.8	26.1	22.4	3.5
	1	13.7	9.7	7.3	0.9

Table 5.2: An extract of percentage of innings resources remaining for Twenty20 cricket (Bhattacharya et al. 2011, 1956)

This final table of resources for Twenty20 cricket—see Table 5.2—differs from the D/L method's table in several respects. They list one area of the table in particular:

> The more interesting discrepancy occurs in the 'middle' of an innings (8–13 overs available with 3–6 wickets lost). In this stage of an innings, the non-parametric approach based on Gibbs sampling suggests that there is up to 5% fewer resources remaining than provided by the Duckworth-Lewis method. This coincides with our intuition as we believe that up to this stage in an innings, batting is more aggressive in Twenty20 than in 1-day cricket.... We remark that a difference of 5% resources may be very meaningful as a target of 240 runs diminished by 5% gives 228 runs.

5.4 Monte Carlo and Bayes

Where did this conception of modeling come from and what set of technological advances enables it? Bayesian statistics forms a crucial part of this story because it lends itself to analyses that do not depend on particular specified models. It is an eminently practical approach to modeling the world that, I suggest, is compatible with Benedict Anderson's view of what he calls the "complex fractionality" of the appearance of "good" nationalism in such technologies of governmentality as the census. It speaks to and depends on a different imagining of community.

In the 1940s Nicholas Metropolis, John von Neumann, and Stanislaw Ulam jointly developed the "Monte Carlo" method for simulating neutron multiplication in nuclear fission devices. Their work would have been impossible without access to the first electronic computer, ENIAC, then housed at the University of Pennsylvania. ENIAC's precursors during the war were built solely to help decrypt messaging systems used by the Axis powers, but here was a novel and pressing use for such devices. The idea of, and the set of institutions and practices surrounding, a computer simulation—broadly, a computer program imitating an abstract model of some particular system where analytical solutions to the model are not possible—has now become available across a number of academic disciplines. It has been and continues to be a key disruptive technology in the natural

and social sciences since the middle of the 20th century. As computation continues to become dramatically cheaper from one decade to the next, computer simulation has transitioned from one science to the another. In the process, the discipline of computer science and computational practices themselves have also changed. In the realm of supercomputers, much of this dynamic was driven by the exigencies of Cold War nuclear sciences (Galison and Stump 1996, MacKenzie 1996). Computer simulations mimic other natural and social systems. The key recursive point—a system imitating another system—had been theorized initially by the mathematician Kurt Gödel in his proofs on the limits of sufficiently powerful mathematical formalizations. Moreover, in the light of Gödel's proofs, Alan Turing had hypothesized what came to be known as "Universal Turing Machines"—machines that were capable of emulating any given Turing Machine, namely a machine for manipulating arbitrary symbols on a serial tape. It was Turing's work that led to designing and building computers as practical devices during the war and computer science as an academic discipline afterwards.

This initial moment of collaboration between the then nascent nuclear science and computer science has continued to the present. Simulations of this type have been used in a diverse array of natural science disciplines—cosmology, fluid dynamics, chemical kinetics, genetics, cognitive neuroscience, robotics, engineering,

and so on—that readily identifiable as cyborg sciences. Although there were some

uses of simulations from the early 1960s in the social sciences, much of the cur-

rent interest in this technology starts in the mid-1980s with the advent of personal

computers. Computer simulations of systems existing in time formally provide

predictions of future states of the system being studied. If the inputs are chosen

so as to mimic current conditions, the result—if the system is useful—will be pre-

dictions of the state of the modeled world in the future. However, much of the

interest in simulations, I suggest, rests on the manner in which simulations sit

between theory and experiment. On the one hand, designing a simulation nec-

essarily includes putting together a formal theory of the world being simulated

that picks out what the researchers deem to be the relevant features of that world.

On the other hand, much of the efficacy of simulations comes directly from the

surprise that often results as features of the simulated world become apparent on

multiple runs of the simulation. It is this mode of reflection that comes out of

the proliferation of thought experiments in arguments about fair predictions of

cricket games. This notion of surprise or emergence does the same kind of work

that Andrew Pickering has argued cybernetics once did (Pickering 1995). In both

cases, repeated runs of the system and reflections on those systems help produce

surprises that disturb the initial research agenda of the participants and therefore

subsequent research practices in that field.

Michel Callon has argued that economics formats the economy (Callon 1998a). The recent credit crisis is a good example of precisely this phenomenon. Much of the dynamics of the credit crisis depended on the correct pricing of complex financial products developed by finance practitioners, sanctioned in turn by regulators, and traded on over-the-counter markets run by large banks. When the models failed, markets did too (Derman 2011). A recognizable originary point for this moment involves Fisher Black and Merton Scholes' contribution in the late 1960s and early 1970s to options pricing theory (MacKenzie 2005). Monte Carlo simulations became a key part of the resulting financial infrastructure, particularly with respect to pricing complicated—"exotic"—derivatives. In addition, such simulations are used to examine the risks involved in portfolios of multiple assets across multiple asset classes. Large banks are required to maintain "Value-at-Risk" measures of the risk that they might lose substantial amounts of money in short periods of time. Monte Carlo simulations are usually needed for these non-parametric estimation problems. Much of the current discussion by economists, whether in academia, banking, or in government, swings precisely on whether such tools are adequate to the tasks asked of them—do banks and other financial institutions have sufficient funds to safeguard themselves from ad-

verse movements in the prices of the interlocking assets they collectively hold (Bookstaber 2008)?

5.5 Numbers and models

Hacking's "avalanche of numbers" is proceeding apace in the modern world. Monte Carlo simulations and the practical Bayesian approach to a probability underlying it have swept through a variety of sciences. One key determinate has been the collaborative development of the software package Bayesian inference Using Gibbs Sampling ("BUGS") since the early 1990s that can be used easily on personal computers. Bhattacharya et al probably used exactly that software package in modeling Twenty20 cricket.

In general, these approaches to thinking about rain-interruption in cricket depend on a series of assumptions that do not fit cricketing intuitions at all well. Bhattacharya et al are the least restrictive in the assumptions they make:

1. The state of a team's innings is completely described by the runs they have made and the number of deliveries and wickets remaining

2. The resources available to a team decrease with respect to decreasing numbers of deliveries and wickets

3. The resources available given the innings' state is normally distributed

4. The result of each delivery is independent of the previous one

The first assumption listed above is particularly at odds with normal cricketing intuition. To pick a trivial example: a team that has scored 80 runs in 15 overs for the loss of two wickets where those losses were incurred in the previous over would be regarded as being in far worse a situation than a team with the same score that had lost its two wickets near the beginning of the match. The second assumption appears to be irrational and is, for all that, quite likely to be true on occasion. There are certainly plenty of instances where a fielding side is quite unhappy to have taken the wicket of a batsman who has been batting quite slowly. The next, more aggressive, batsman might in fact "kick-start" their team's attempt to set a high target. The third assumption is likely false, but as long as information about *some* specifiable distribution can be found it is in principle easy to overcome. The fourth, and last, assumption requires rather more care. To fit a Monte Carlo simulation approach a cricket innings is best modeled as a Markov chain—each innings state should wholly determine the probabilities of moving into the next state. In sports statistics, this corresponds in part to the "hot hand" problem. Is a player who has been doing well more likely to continue to do well than one who has not, all else held equal? This problem corresponds exactly to one

version of the efficient markets hypothesis. Does the fact that a market price has been going up recently, suggest anything about its future movement, whether up or down? Most economists would baulk at this notion, but, analogously, most sports followers would not baulk at the idea that a player who has been doing particularly well recently will, for that reason, continue to do well.

The problem that this suggested "improvement" to modeling cricket raises has to do with the relative lack of data available on cricket. Modeling overs, wickets, *and* batting partnerships explodes outwards the space of possibilities in cricket matches. Consequently the sort of method that Duckworth and Lewis pursued would not work at all well. But this analytical intractability does not pose a problem for a Monte Carlo simulation approach to modeling cricket. As Harcourt's analysis of crime suggests, the primary driver of changes in the modern world stem from the blind application of new statistical technologies with little thought about what form of justice in society is actually at stake. Monte Carlo simulations are all the more powerful because they seem neutral with respect to those demands and therefore escape them by refusing to impose an order on numbered human being.

Chapter 6

Conclusion

Scholars such as Lydia Liu, Céline Lafontaine, and others, have written recently about the connections between post-World War II cybernetics and French theorists popular in the US like Lacan, Derrida, Lévi-Strauss, Deleuze, and Foucault. The general argument is that cybernetics as it developed in the US was partially formative of the problem-spaces that those scholars shaped and worked within. These are not hidden or submerged influences that authors like Liu and Lafontaine need to discover. Rather, they are explicitly made moves of theoretical dependency on cybernetic concepts in published academic literature.

The influence that this French scholarship has and continues to have on work in anthropology and cognate disciplines in the US is quite marked. The connection between cybernetics and anthropological theory raises the following pressing question: is it possible to construct an account of contemporary capitalism that centers on the novel forms that it has taken as both a set of theories and a set of practices since World War II? Most accounts of these novel developments work from a wholly Marxist understanding of a pejoratively-understood neoliberalism. In this framing, neoliberalism is taken to merely be a kind of further extension and intensification of already existing political and economic practices. These accounts incorrectly take at face value economics' own story of a continuous intellectual tradition stretching back to Adam Smith. Scholars influenced by Foucault

add to such accounts a concern with how these changes in political and economic practices have reshaped social life around the principle of market competition. In both cases, there has been insufficient attention paid to what is truly new about the theories underpinning neoliberalism. As I demonstrated in the Introduction through an account of Norbert Wiener's seminal popular account of cybernetics, there are close connections between cybernetics and the post-War Chicago school of economics—the principal target of Foucault's account of US neoliberalism in *The Birth of Biopolitics*. For Wiener, the term cybernetics was broad enough to encompass both the fields of study he collaborated on with the other participants of the Macy Conferences and the new form of neoclassical economics that took speculative, future-oriented financial theories of values to be crucial to reorganizations of post-War political economies in the West.

As Norbert Wiener's work makes clear, cybernetics was a nascent, and then ultimately failed, discipline that took experimenting with forms of life, particularly the connection between machines and human being, to be at its core. This impulse—working at and reshaping the boundaries between the natural and the social—has come to form a crucial part of one strand of science studies in the US. Bruno Latour has posited a notion of constructivism that focuses on the manner in which sciences draw together and reconfigure the social and the natural as

they manipulate and build theories about the world. In this context, such a notion emphasizes the irreductive feel of the historical connections between cybernetics and anthropology theory, including Latour's own theoretical moves quite possibly, without inviting a dismissal of that work. In similar fashion, suggesting that post-War economic theory and recent critiques of that theory share a connection to intellectual developments during and shortly after the War is not a dismissal of those critiques but is rather, to borrow from Pickering, a call to appreciate the mangle that this strand of academic practice works through.

Cricket is, I have argued, an apt if rather surprising arena in which to investigate the consequences of the connections that cybernetics may have engendered. It is a sport with a long history going back to the early 18th century in England. Many of the core features of the game have remained intact over that time period. There have, however, been a number of changes to the game recently. In this dissertation, I tracked two particular changes in how cricket is coached, played, and regulated that involved the cybernetics-derived sciences of biomechanics and operations research. In doing so, I connected together these changes with Foucault's understanding of governmentality as being organized around the twin of poles of the body as machine and the species body.

I argued in chapter 2, through an account of the coaching of fast bowlers at an

academy in India, that such bowlers now conceive of the movement of their bodies through a cybernetics-derived feedback loop tying them together with video cameras and computers. The habits that these bowlers are trying to reform are difficult for them to work on without that feedback loop. Biomechanics as used by coaches at the academy works on fast bowlers' bodies through this loop by separating and isolating the act of bowling from its intended target—a batsman. I argued that this moment can be conceptualized as a Deleuzian collective event. In carving out this space of application, however, the discipline simultaneously limits its usefulness. In chapter 3, I continue to track the application of biomechanics to bowling in cricket through an account of a recent controversy over "throwing" in cricket. The manner in which this purported act of cheating by bowlers is now regulated has shifted significantly. It has become a problem to be regulated and remediated off the field of play rather than adjudicated on during a game. I layered onto these considerations an account of bowling's complement—batting—and the relationship between the two via a strand of affect theory deriving from Deleuze, whilst trying to retain the insight that recent use of this theory can be thought of as motivated by concerns over the intrusive effects of neoliberalism. In this account, affect is the social residue outside of an actively reformulated social life. Professional cricket players struggle to maintain their competitive edge

by working and reworking their bodies for a game rendered as a market-place. Seemingly disparate sets of practices drawn from biomechanics and affect theory can be applied to such moments of changes in habits. Pointing to the possibility of a shared cybernetic history does not reduce biomechanics to affect, but rather serves to complicate both sets of academic theory and practice when they are applied to cricketing attempts to improve stocks of human capital on a playing field.

An operations research derived model by Frank Duckworth and Anthony Lewis is now used to govern shortened forms of cricket in the event of rain interruptions to any given game. Previous rules of thumb worked by projecting forward simple statistical features of each game. I demonstrated in chapter 4 that their model instead works through a constrained evaluation of possible future trajectories of each game. The kind of constraint at issue is governed by claims to fairness—what they sought was a model that was sensitive to the dynamics of previous completed games of cricket but did not pick out features of the particular players or teams involved in an interrupted game. Their model is both too simple to account for some interesting features of cricket and has too many parameters to make fitting it to statistical histories of cricket games meaningful. I argued in chapter 5 that more recent operations research models that build on this work

by Duckworth and Lewis are not susceptible to these kinds of critique. Indeed, These new models that simulate cricket games in order to build non-parametric estimators of rain interruptions are significant analyses that are not amenable to the kinds of critiques that some scholars have made about the role of statistics in contemporary governmentality.

The example of cricket and two recent cybernetics-derived changes in how it is now played, coached, and regulated has, I hope, provided a broadened and deepened account of the role that cybernetics plays in both shaping the contemporary world and how it has been studied.

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