The Case of Galileo

Galileo: Heretic. (Galileo eretico.) PIETRO REDONDI. Princeton University Press, Princeton, NJ, 1987. x, 356 pp. + plates. $29.95. Translated from the Italian edition (Turin, 1983) by Raymond Rosenthal.

Probably no book in the history of science has stirred up more controversy during the 25 years since the publication of Thomas Kuhn's *Structure of Scientific Revolutions* than Pietro Redondi's *Galileo eretico*, which now receives its English translation. The trial of Galileo was one of the epochal events of Western history; with the trial of Socrates, the only similar incident that holds equal prominence, it has become a symbol of the struggle of free thought against suppression. Redondi offers to reinterpret every significant aspect of the trial—not just its issue (though that is the central theme of the book and the source of the title), but Galileo himself, Pope Urban VIII, Federigo Cesi and his Accademia dei Lincei, and Father Orazio Grassi. Small wonder that the volume has whipped up a storm. Discussion is the life blood of the intellectual community. Any book that forces us to reexamine basic issues and reassess epochal events performs a signal service. Redondi's work has done precisely that. By any standard it has been a salutary event in the history of science and, beyond the borders of the discipline, in the world of learning as a whole. We are fortunate now to have it available in English.

Having said all that, and meant it, I need to play my own role in the discussion and to say that, in my opinion, only one of Redondi's principal themes can withstand informed scrutiny. That one is the reassessment of Father Grassi, the man whom Galileo unjustly made into an object of derision, under his pseudonym of Sarsi, during the intervening three and a half centuries. It may be significant to my judgment that Grassi's stature is the only theme of the book on which I do not claim to have extensive knowledge. As for Cesi and the Accademia, Redondi presents them to us as a man and a group with a coherent program of intellectual renewal within the Catholic Church; Galileo's *Assayer*, we are told, was their manifesto. Neither proposition is compatible with my reading of the record of the Accademia. Originally the expression of the aspirations of a young Roman aristocrat to play the role of a great patron of learning, it became after 1618 primarily his device to gain the protection of the Curia from the financial ruin that nevertheless overwhelmed him and his family. The *Assayer* was Galileo's composition; every indication that I have seen suggests that the Accademia made only the most minor changes in the manuscript he sent to Rome. Galileo's manifesto it may have been; I am not aware of any evidence on which one could claim that it was anyone else's manifesto.

Redondi's Galileo was primarily a natural philosopher whose basic interest was not quantitative mechanics, and certainly not Copernicanism, but atomism. This interpretation rests on Galileo's early interest in the Bolognian stone, the well-known passage in the *Assayer*, and the faintest of hints in the *Dialogue*. I think everyone agrees that Galileo was groping toward an atomistic philosophy. The issue is its centrality in his work. If Redondi's interpretation of Galileo is correct, the concern with atomism would have to show up prominently in his manuscripts. I have not worked directly with the manuscripts. However, I have studied the *Opere*, which include the texts of extensive manuscripts, in detail, and I try to remain abreast of the publications of those, led by Drake and Wisan, who are exploring the unpublished manuscripts. I do not recall any references whatever to atomism. Nor does Redondi cite any manuscript references. I have also studied Galileo's extensive correspondence minutely without noticing any references to atomism; again Redondi cites nothing from the correspondence. I am not convinced that we need to see Galileo in these new terms.

The established interpretation of the trial casts Pope Urban VIII as the villain. Redondi recasts him as the hero, who adroitly staged a trial on a minor issue to shield Galileo from truly serious charges of heresy. The Thirty Years War figures prominently in this scenario. The year 1632, the year of the *Dialogue*'s publication, was also the climax of the war, when the Catholic cause seemed to teeter on the brink of oblivion. Under great pressure from the conservative Hapsburg powers because of his pro-French policy, and under attack as a Pope who had tolerated heresy, in Redondi's account, Urban threw Galileo to the wolves to appease them. The artfully staged trial not only saved Galileo from more serious charges but also saved Urban from the equally serious charge that he, as Galileo's patron, had encouraged dangerous ideas. I find problems with this account. It rests on the implicit assumption, which appears to me to be essential to it, that the Hapsburg powers saw Galileo as a grievance. The diplomatic correspondence relating to Urban's controversy with the Hapsburg powers has been published. They were exercised by Urban's support of France and demanded his alliance and financial support; they did not, that I saw, once mention Galileo or anything remotely concerned with Galileo. The long memorial of grievances of the Spanish government against Urban's church, composed by the Junta in the summer of 1632, did not mention Galileo or anything remotely concerned with Galileo. Add further that the tension between Urban and the Hapsburg powers continued for another three years until Urban caved in on the crucial policies. Whom was he supposed to be appeasing in 1632 and with what? Moreover Urban treated Galileo with undisguised hostility during the rest of Galileo's life, reneging on the pardon that Galileo clearly thought had been promised to him in return for his abjuration and harshly refusing the requests of an old man prostrated with afflictions to be allowed to move into Florence to be near his physician. I cannot square Redondi's account of Urban with these established facts.

And finally there is the sum of all the above, the issue of the trial, that is, the nature of the true charge against Galileo. Redondi argues, as you will understand by now, that it was atomism, recognized by influential figures in the Jesuit order to be incompatible with the doctrine of transubstantiation in the eucharist, which the Council of Trent had defined in terms of the Aristotelian philosophy. Redondi appears to me to have exactly two pieces of evidence in favor of this interpretation—a document he calls G3, which he discovered, and a passage in Grassi's *Ratio ponderum*, the reply to the *Assayer*. Italian commentators on the book have challenged Redondi's identification of G3 as a formal denunciation of the *Assayer* to the Inquisition and his attribution of it to Grassi. In any case, if it was Grassi's composition, we are left with one man sounding that alarm and are asked to accept it as the true expression of the issue despite the overwhelming references to Copernicanism. At the end of the book Redondi pleads with his readers to avoid anachronism at all costs and argues that his interpretation is "sensitive to the civilization of the seventeenth century." But one can turn the same argument against him. Behind the book lies the stubborn refusal to believe that serious men could really have been agitated by the Copernican question. However, it remains true that the

Church did condemn Copernicanism in 1616, and it did warn Galileo to abandon his campaign in favor of the new astronomy. In 1638 the Papacy would allow Castelli to visit Galileo only if a third person were present to insure that they would not conspire together about Copernicanism. Avoiding anachronism and sensitivity to the civilization of the 17th century require one to acknowledge these facts also.

I have stated my disagreement with nearly all of Redondi's theses. Nevertheless, I welcome his book. For one thing, it is written with an acute appreciation of dramatic incidents, so that it is a pleasure to read, even for one who finds himself dissenting. More important, the book has forced me carefully to reexamine fundamental issues connected with Galileo's trial and to consider the bases on which my own understanding of that momentous event rests. In the brief space that a review allows, I have attempted to state the grounds of my disagreement. I am well aware, however, that I have not been licensed to speak final truth on the matter. Informed discussion is the essence of the enterprise, and one cannot appreciate too highly a book that promotes informed discussion, even when, as in my case, one ends up rejecting its position.

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Mathematical Psychology

Response Times. Their Role in Inferring Elementary Mental Organization. R. DUNCAN LUCE. Clarendon (Oxford University Press), New York, 1986. xvi, 562 pp., illus. $75. Oxford Psychology Series, 8.

Hoping to learn critical aspects of the mechanisms underlying behavioral response, researchers have been measuring response times since roughly the middle of the 19th century. The lack of a convenient and accurate apparatus has not deterred them. For instance, Carrard, around 1890, used to have his subject put his hand around a fixed graduated cane, without touching it. Simultaneously with the presentation of a signal, the cane was released. The subject was instructed to react to the signal as quickly as possible by closing his hand on the cane. A reading of the graduation on the cane at the level of the hand provided a means of measuring the latency of the response.

In his well-documented book, R. Duncan Luce, a mathematical psychologist, cites more than 630 references, about 80 percent of which deal specifically with response times, either theoretically or experimentally. The standard argument in favor of measuring response times is that their analysis may reveal the organization of the mental phenomena underlying the observed response. This strategy, however, invites skepticism. In Luce's words (p. 1): "Consider the task of inferring the architecture of a computer from measurements of its performance times using different programs and different inputs. This certainly would be difficult, especially if one lacked the technology of modern electronics to help carry out the measurements. At best, one would expect to learn something about the gross organization of the computer, but it seems unlikely that the fine details would succumb to such an attack."

A widely accepted concept, originating with the physiologist Donders (1868), is that the observed response time results from the addition of a potentially large number of component times: the signal energy must be transduced into neural spike trains, a reaction of the sensory receptor must be evoked, the reaction must then be transmitted to a central decision center, and so on, up to the motor response. Luce follows that reasoning but groups these components into two classes: the decision time and the residual time. The book focuses on the decision time and is largely concerned with modeling the cognitive aspects of the task presented to the subject in an experiment.

In view of the large variability of response times (a standard deviation of as high as 100 milliseconds for a mean between 200 and 600 milliseconds is not rare), most reaction-time models are probabilistic, and the standard stochastic library has been sampled with abandon. An extensive and well-presented account of this work can be found in this book, which will certainly remain the basic reference for years to come. A few examples will give a flavor of the diversity of the models and techniques in use in this field.

Some theoreticians have been concerned with predicting the exact shape of the reaction-time distribution. One assumption, reasonably successful in some simple situations (from the viewpoint of statistical goodness-of-fit), is that the reaction time is the sum of two independent random variables, one Gaussian in distribution, the other exponential. In the same vein, others postulate that the reaction-time distribution can be described by a so-called generalized gamma random variable, that is, a sum of independent exponential random variables with possibly different time constants. Much more ambitious are constructions that attempt to model explicitly the unobservable mechanisms of the decision. For instance, the observed reaction time has been regarded as resulting from a counting process, as if the brain were keeping track of the number of spikes occurring in some neural location. It has also been modeled as a random walk, inspired by Wald's sequential analysis.

Founding the working details of a model on unobservable events in the organism is an exciting but risky enterprise. However appealing, a model is rarely unique: models based on drastically different principles may give undistinguishable predictions. Some researchers have directed their efforts towards the theoretical description of very complicated situations, such as choice reaction time, memory scanning, and search paradigms; in such situations, a single model that yields a detailed, economical description of a complex set of data may turn out to be useful, whether or not its basic principles are ultimately correct. Again, standard stochastic concepts, such as Markov processes (finite and continuous), have provided the basis for the models. In some cases, the assumptions of a model are such that, at least for the time being, only a deterministic version can be worked out. For example, Schweikert uses a method called "critical path analysis," borrowed from operations research and computer programming, to infer a processing network from overall response times. As in the rest of the book, Luce's description of this work is both precise and highly readable.

In general, Luce's viewpoint and writing style are those of a theoretician. Data are nevertheless treated with respect and discussed in minute detail. The book will be useful to many, whether or not they are theoretically inclined, and will be mandatory reading for anyone dealing with behavioral response times.

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Transforming Genes

Oncogenes, Genes, and Growth Factors. GORDON GUROFF, Ed. Wiley-Interscience, New York, 1987. xiv, 386 pp., illus. $69.95.

Oncogenes and Growth Control. PATRICIA KAHN and THOMAS GRAF, Eds. Springer-Verlag, New York, 1986. xxiv, 369 pp., illus. $69.50.

The confluence of research in the regulation of cell growth and in the study of transforming genes has been one of the major accomplishments of the last decade.