

Gordon Tullock's Contribution: Ludwig von Mises without Reciprocity

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Introduction

We begin with a conversation with Gordon Tullock that was prompted by his off-hand remark that Ludwig von Mises's *Human Action* greatly influenced his work. We were puzzled, so we asked if we had understood correctly:¹

Yes. In the first place, let's begin with the fact that at the time I had one course in economics, which lasted 12 weeks, it was supposed to last 13 weeks but I was drafted, and that had got me to reading economics journals. I saw at the Yale Co-Op, when I was studying Chinese at Yale, I saw a pile of books bound in red that said *Human Action* and I picked one up. The thing which made a big impact on me was the early part where he talked about that you can use the same kind attack on things other than economics. I'd never heard anyone say that before. I read the book actually three times and during that time I came to the conclusion that I was going to write a book about bureaucracy on the same kind of self-interested motives on the part of the participants as economics. *He did not maintain that it also led to good results even though it did in economics.* [our emphasis]

Save for the last sentence and some autobiographical detail, Tullock's published tribute to von Mises says much the same thing.² Perhaps because this unambiguous statement comes in an obscure publication, Tullock's 1971a biological contribution to *Toward Liberty*, the privately-produced multi-language tribute to von Mises on his 90th birthday, it has not been noticed by scholars of von Mises and his disciples.³

We propose to consider how Tullock works inside the framework established by von Mises's elevation of purposive behavior to a necessary truth (von Mises 1949; Kirzner 2001, pp. 81–88). To do so, we first consider why von Mises and Tullock differ on whether purposive behavior led to “good results.” Here Tullock seems remarkably close to Walter Eucken's worries about power that allows the

¹ Alex Tabarrok and Peter Boettke tell us they had similar conversations. Ours (August 31, 2006) was prompted by a conversation earlier that summer between Tullock and James Buchanan about the *Calculus of Consent* at a session of the Summer Institute for the Preservation of the History of Economics.

² Tullock 1971, 2:375: “(It may seem odd to place an article originally designed for publication in a biological journal in a collection of articles to Ludwig von Mises. Among his other distinctions, Professor von Mises was among the first to point out that economics can be expanded to deal with many areas outside of its traditional scope. In my own case, my work in expanding economics into new areas was, in a real sense, begun by my reading of *Human Action*. The article below, then, represents my most extreme application of economics outside its pre-von Mises boundaries.)”

³ Tullock's name enters Karen Vaughn's study of the Austrian school in America (Vaughn 1994, p. 45) in connection with his joint work with Buchanan in *Calculus of Consent*. Tullock's name is absent from Israel Kirzner's study (Kirzner 2001). The list of studies of von Mises that do not see a connection with Tullock could be extended, e.g. Butler (1988), Ebeling (2010).

state to prey upon citizens. Second, we present an unpublished appendix to Tullock's *Organization of Inquiry*, "Flatland Revisited," in which Tullock lays out the properties of a "necessary truth" in a way that is consistent with modern modal logic. What is "necessarily true" is not actual. We point to the similarity between von Mises's handling of necessary truth and Tullock's. We offer a conjecture for why Tullock excluded the Appendix from publication: Tullock opposed the view that purposive behavior led to good results.

Good Results and Otherwise

Gordon Tullock. Tullock's sequence of accounts of purposive predation, whether it be the majoritarian exploitation of the democratic commons (Tullock 1959), or what would be called rent seeking (Tullock 1967), are so well known that we need not elaborate. His account of expressive voting, a concept that explains what he called "charity of the uncharitable," is another example of the exploitation of the democratic commons. Here, discussion itself is severed from consequence (Tullock 1971b). This is a great challenge to the view that of democracy is government by discussion (Peart and Levy 2015; Levy and Peart 2016).

The 1966 *Organization of Industry* contains an example of such predation that is less well-known. In this work, Tullock analyzes purposive behavior by economists that preys on other occupants of a commons. The target is economists as so-called scientists who are described as participating in a racket, rather than science, because they generate results to support their private ends (Tullock [1966] 2005; Levy and Peart 2012).⁴

⁴ Where does *Organization* fit in the Tullock opus? We know from Jeremy Shearmur's reconstruction of Karl Popper's lecture series at Emory University (25 June–6 July 1956), which Tullock attended, that the Tullock–Popper connection is much earlier than Tullock's association with the economists of the Thomas Jefferson Center. In a letter to Popper and Joseph Agassi of July 9, 1958, Tullock writes about his upcoming fellowship at the University of Virginia where he planned to work on a book entitled *Organization of Inquiry*: "I have been giving some thought to coming over to London. My program would call for writing a book essentially based on the *Logic* [of *Scientific Discovery*?] I think maybe I have discovered a third system of Positional Logic the subject matter of which may be indicated by my provisional title: *The Organization of Inquiry*. The problems are two, in the first place I am not certain my theory of right, and secondly, it may be too trivial to bother with. The

Ludwig von Mises. How does von Mises’s account of purposive behavior avoid the predatory possibilities that so preoccupied Tullock? An otherwise attractive answer, that von Mises was uninterested in the problems of democratic governance, is not satisfactory in the light of his extensive controversy with Rose Wilder Lane over democratic governance (Levy, Peart and Albert 2012).⁵ Moreover, von Mises extensively engaged in the discussion of central planning and in that context he presumed that central planners would not exploit their positions by creating shortages and the like (Levy 1990). It should be noted that Gordon Tullock himself, as editor of *Public Choice*, published the exercise in the predatory economics of central planning.

The puzzle of why von Mises failed to see this was only deepened for us when we discovered that Walter Eucken saw the problem with complete clarity. Eucken wrote that the authorities would not commit to the market socialism proposed by Oscar Lange and Abba Lerner because doing so would require that they renounced state power. Thus, market capitalism was the only feasible starting point to contain the power associated with state predation (Levy and Peart 2008).

The defense of capitalism. Von Mises’s commitment to reciprocity is most evident in his defense of capitalism as a historical movement. We reproduce below a letter from von Mises to Edmund Opitz concerning R. H. Tawney’s *Religion and the Rise of Capitalism*.⁶ When pressed to defend capitalism against a great adversary, von Mises puts the eradication of slavery first.

positional logic of *Inside Bureaucracy* is much less elaborate than that of economics, and my latest theory is even less so. At any event, I would like to get the *Logic* as soon as possible, and after further thought in Virginia I might be able to decide definitely.”

⁵ We know from Richard Wagner’s witness that Tullock was enormously delighted about a letter from von Mises about *Calculus of Consent*. Perhaps there is more Tullock in von Mises that we notice? We have been unable to locate the letter even though there is much correspondence between them at the Hoover Institution Archives.

⁶ Von Mises’s letter is located in the Edmund A. Opitz Papers at the University of Oregon. Perhaps, Opitz’s query was prompted by von Mises’s brusque treatment of Tawney’s book in von Mises’s 1950 “Reading list for the alert citizen”: “A biased study by one of the leading British socialists” (von Mises 1950, p. 16). We were unable to locate Opitz’s letter to von Mises that prompted the response.

Opitz Call 9/1/52
Box 1 Corren 1946-52

SPIRITUAL MOBILIZATION
1. 2. 3. 4.
DEC 22 1952
ANSWERED:
BY:
FILED BY:

LUDWIG VON MISES
777 WEST END AVENUE
NEW YORK 25, N. Y.

December 20, 1952

Rev. Edmund A. Opitz
1521 Wilshire Boulevard
Los Angeles 17, California

Dear Reverend Opitz:

I do not know of any books or articles in which the religious, moral and political issues of Tawney's book would have been critically ~~examined~~ examined.

Archbishop Temple's book Christianity and the Social Order has been sharply attacked by Hartley Withers in a pamphlet: Archiepiscopal Economics (Post-War Questions #18, published by the Individualist Bookshop Ltd., London 1942). I do not think that Withers has done too good a job.

The best known book on these problems is still Troeltsch, The Social Teachings of the Christian Churches,

The main economic fallacies of Tawney are: He does not realize

- 1) that capitalism has abolished all varieties of slavery, serfdom, indentured labor and so on;
- 2) that under capitalism (but not in the precapitalistic ages) the wage-earner is not only a producer, but at the same time the consumer of the much greater part of all things produced;
- 3) that the workers are the customers "who are always right";
- 4) that capitalism has raised the average standard of living (for a population eight or ten times as numerous as that of medieval England) in an unprecedented way;
- 5) that under capitalism the first concern of business (big business) is necessarily mass production for mass consumption. See about these things also pages 613 to 619 of Human Action, page 20 of Bureaucracy and page 161 of T. S. Ashton, The Industrial Revolution (Home University Library, Oxford University Press, 1948.)

Opitz Coll 9/1/2
Box 1 Corren 1946-52

Perhaps Mr. Ingebretsen can lend you a copy of Ashton's report, delivered at the Beauvallon 1951 meeting of the Mont Pelerin Society, concerning the distortions of economic history by "progressive" historians.

I may refer to pages 155 - 157 of Human Action as far as the main political thesis of Tawney is concerned. Radically different from my position is that of Voegelin in his brilliant book The New Science of Politics, Chicago Press, 1952. (The small volume makes rather tough reading.)

With all good Christmas wishes to you,
Mrs. Opitz and your children

Very sincerely yours

L. Minis

Familiar as he was with the history of British liberalism (von Mises [1927] 1985), von Mises would well appreciate that the British emancipation of slaves resulted from the coalition of utilitarian political economists and Christians united around a shared reciprocity norm that they severally called the “greatest happiness principle” or the “Golden Rule” (Peart and Levy 2005).

Apodictic Certainty

Von Mises. His lifelong defense of the claim that the theorems of praxeology are matters of apodictic certainty is what students of economic methodology find unique to von Mises’s labors. “Praxeology” is the name given to the study of the connection between ends and means, so that in and of itself ought not to be a matter of controversy (Gasparski 1996). Von Mises restricts economics to katallactics, the coinage from Richard Whately that carries the connotation of reciprocity (Whately 1831; von Mises 1949, p. 4; Levy and Peart 2010). Apodictic is a transliteration of the Greek word for “demonstrated,” so, when von Mises uses the phrase “apodictic certainty,” he makes a strong claim that there is no doubt about praxeological theorems because they are demonstrated from axioms that cannot be denied (von Mises 1949, p. 5; Peart and Levy 2005). To use traditional terms, for von Mises praxeological theorems are necessary truths. It is fair to report that this claim separates von Mises and his disciples into a school at odds with the vast majority of the economics community. To give one instance, Milton Friedman took issue with von Mises over the the issue of apodictic certainty (Friedman 1991).

To understand Tullock’s “Flatland Revisited,” to which we turn next, it is helpful to appreciate just how little von Mises claimed for purposive behavior. For von Mises, purposive behavior holds only for an instant in time. We quote from *Human Action*:

The attempt has been made to attain the notion of a nonrational action by this reasoning: If *a* is preferred to *b* and *b* to *c*, logically *a* should be preferred to *c*. But if actually *c* is preferred to *a*, we are faced with a mode of acting to which we cannot ascribe consistency and rationality. This reasoning disregards the fact that two acts of an individual can never be synchronous. If in one

action a is preferred to b and in another action b to c , it is, however short the interval between the two actions may be, not permissible to construct a uniform scale of value in which a precedes b and b precedes c . Nor is it permissible to consider a later third action as coincident with the two previous actions. All that the example proves is that value judgments are not immutable and that therefore a scale of value, which is abstracted from various, necessarily nonsynchronous actions of an individual, may be self-contradictory. One must not confuse the logical concept of consistency (viz., absence of contradiction) and the praxeological concept of consistency (viz., constancy or clinging to the same principles). Logical consistency has its place only in thinking, constancy has its place only in acting. Constancy and rationality are entirely different notions. If one's valuations have changed, unremitting faithfulness to the once espoused principles of action merely for the sake of constancy would not be rational but simply stubborn. (von Mises 1949, p. 103).

Thus, if time-instances are conceptualized as pieces, then purposive behavior as a necessary truth is only piecewise rational. Von Mises therefore blocks the possibility of an intransitive purpose. In retrospect, it is not obvious how important stability of purpose was to the post-World War II mathematization of economics.⁷

Tullock's "Flatland." One of the two unpublished appendices to *Organization of Inquiry* – "Flatland Revisited"⁸ – speaks to both Popperian themes and those laid out by von Mises. (The full text is printed in the documentary appendix.)

"Flatland Revisited" is a seemingly simply addendum to Edwin Abbott's famous *Flatland* in which Tullock supposes that "Flatland" is not really flat but the minds of its inhabitants have evolved so that all their perceptions are filtered through the supposition that the world is flat. A crisis occurs when one of the scientists in "Flatland" compares the implication of their axioms with that which can be measured. As the axioms hold with flat but the world is not flat, there is, not surprisingly, a mismatch. The scientists struggle to find theoretical accounts that predict without ever challenging the flatness axioms. They behave in a completely transparent fashion where all claims can be and are replicated. This allows

⁷ In his review of Paul Samuelson's *Foundations*, George Stigler emphasizes the importance of the stability of preferences, which he claimed Samuelson did not adequately stress, to Samuelson's enterprise of making economics operational (Stigler 1948).

⁸ The document is located in the Hoover Institution's Gordon Tullock Papers (Boxes 42, 108).

them to create ever more powerful systems in which flatness holds only in a piecewise fashion. Tullock is optimistic that the theories will continue to improve.

Admirers of Tullock’s published work know that his simple presentations often cloaked very deep issues. To these we now turn. Tullock asks in his “Flatland Revisited” what follows from a necessary truth. The traditional approach to modal logic takes necessary (*alternatively* possible, strict implication) as primitive, and then defines all other terms by means of the selected primitive. To mark that a proposition (for instance, a sentence) α is necessarily true, we write $\Box \alpha$. From antiquity through the 1940s it seems to have been taken for granted that $\Box \alpha \rightarrow \alpha$.⁹ What is necessarily true is true (actual). Kurt Gödel, however, proposed to think about the necessary in terms of the demonstrated using the assertion mark \vdash for demonstrated; thus, $\vdash \alpha \rightarrow \Box \alpha$ (Gödel [1933] 1986). This ratifies the intuition in von Mises that what is necessary is that which is demonstrated. While Gödel’s immediate purposes were limited, his technical step helped clarify that $\vdash \alpha \rightarrow \Box \alpha$ and $\Box \alpha \rightarrow \alpha$ are independent issues.¹⁰ In the years that followed it was made clear that there are systems in which the necessary only entails the possible, not the actual; thus:

$$\Box \alpha \rightarrow \Diamond \alpha.$$
¹¹

This is where Tullock’s “Flatland Revisited” comes in. Tullock imagined a world in which what is necessarily true – a flatness axiom – is nonetheless false. This is clear to his readers but not to the

⁹ The traditional view is discussed in Lemmon ([1966] 1977, pp. I–II). All of the systems C. I. Lewis proposed allow this inference. Prior ([1955], 1962, p. 311) gives the axioms for the original Lewis systems and (pp. 312–13) for Lemmon’s Gödelized axiomatization. In Lewis’s axiomization taking “strict implication” as primitive, the actual strictly implies the possible; the Gödelized version has the necessary implying the actual.

¹⁰ G. H. von Wright describes his contribution: “... the conception of modal logic as a superstructure, or ‘second story’, to be erected – like quantification theory – on the basis of the logic of propositions ... (I later learnt that the idea was not entirely novel. It can be traced back to a short paper by Gödel from the early 1930s and to a paper by Feys from 1937.)” Von Wright (1989, p. 29).

¹¹ Lemmon ([1966] 1977, p. 50) credits the weakening from $\Box \alpha \rightarrow \alpha$ to $\Box \alpha \rightarrow \Diamond \alpha$ to von Wright’s deontic logic in which “necessary” is taken as “obligatory.” In this context it is implausible to suppose that the actual follows from the obligatory (von Wright 1951, p. 41). In Robert Feys’ comprehensive account, “System I” [Lewis SI] is constructed from a modal grammar developed in “System I⁰” plus the theorem that the actual strictly implies the possible (Feys 1965, p. 64). Tullock’s contribution might be seen as proposing a nonnormative interpretation as an alternative to von Wright’s.

Flatlanders, because readers can view their world and their minds from the outside. Apodictic certainty is only certainty about deductions, not about the world. In Tullock's "Flatland" – which he is at pains to distinguish from Abbott's – the flatness axiom emerges from something akin to von Mises's monologism. There is only one logic in Tullock's Flatland because that is how everyone's mind evolved.

Karl Popper. Karl Popper, with whom Tullock was quite close, enters into the picture because of the concern over propositions that could not be falsified.¹² Falsification is of course Popper's distinction between the scientific and the metaphysical ([1959] 1974, pp. 34–5.) Long before Popper's *Logic of Scientific Discovery*, Pierre Duhem made the case that there are no critical experiments in physics; one can always find (to use Popper's terminology) an "ad hoc" premise on which to blame the failure (Popper [1959] 1974, p. 81). Scientists preserve what is important to them and they discard what is not important. When he wrote *Logic of Scientific Discovery*, Popper was optimistic, at least in some passages, that Duhem's claim could be avoided by the falsification approach.¹³ By the time he wrote the *Postscript*, Popper's confidence was replaced by an almost holistic Quinean focus on context in which elimination of the reasons for the falsification is seen as a major undertaking. In the *Postscript* Popper introduced the term "metaphysical programmes for science" to describe the possibilities of theoretical systems that contain nonfalsifiable elements (Popper 1983, pp. 189–93). The Flatlander's flatness axiom is in Popper's terms metaphysical since it cannot be falsified.

In Tullock's telling, the crisis in Flatland reveals a Duhem-moment; one result upon which all the revisions agree, a result that allows the flatness axiom to be maintained:

Making careful measurements of various figures on the surface which is thought to be flat, and then trying to develop theories fitting these measurements is a major scientific activity.

¹² Boettke and Leeson (2006, p. xv) oppose von Mises's and Popper's views. Popper's attitude toward purposive behavior seems not to differ from that of von Mises or Tullock, much to the surprise of some admirers (Levy and Peart 2012).

¹³ Popper ([1959] 1974, p. 78): "Duhem denies (Engl. Transl. p. 188) the possibility of crucial experiments, because he thinks of them as verifications, while I assert the possibility of crucial *falsifying* experiments." In the *Postscript* Popper offers an holistic approach in which theoretic systems are tested as wholes (Popper 1983, p. 178). It is unclear that there is any difference between a later Popperian approach and that of W. V. O. Quine (Quine 1960).

Probably the most important and certainly the only generally applicable of these theories is the theory which “proves” the existence of inherent limitations on the accuracy of measuring instruments. Needless to say, this is a great help in fitting other theories to the measured data.

Tullock describes a process by which scientific progress is real:

As far as accuracy goes, some few of the Flatlanders’ theories use equations which are exactly those we would use ourselves, although they have derived them differently. In a few more cases, they use equations which lead to the same results as ours but which are more complex. In most cases, however, the theories developed by the Flatlander scientists are mere approximations of reality and many of them are not even close approximations.

He then reports that the Flatlanders are hard at work improving their approximations.

Conclusion

Suppose that we have prior knowledge that choice is purposive. That, of course, does not tell us what the purpose is. Moreover, it does not tell us that the purpose revealed in a piecewise choice is stable. Von Mises denied stability. Tullock, if we use “Flatland Revisted” as guide, instead supposes that if purpose is stable and scientists work hard enough and are protected from predation, they can discover what the purpose is.

What is remarkable about the scientific practice in “Flatland” is that progress is the result of a rapid Popperian falsification of almost everything other than the flatness axiom. This may go some distance towards explaining Tullock’s choices as editor of *Public Choice*, which he judged would be important if they were correct. Judgements about correctness would result from the ensuing discussion.

Nicolaus Tideman witnessed one remarkable episode that led to Tideman and Tullock (1976):

In 1970 Edward Clarke, then a graduate student at the University of Chicago, submitted a manuscript titled, “Introduction to Theory for Optimal Goods Pricing” to *Public Choice* which Gordon Tullock edited. The manuscript claimed to have a solution to the problem of motivating people to report their preferences for public goods honestly. Tullock could not understand Clarke’s argument, he later told me, but he decided that if Clarke was right the paper was important, so he would publish it. As editor of *Public Choice*, Tullock was free to make editorial

decisions as he chose. The paper appeared Volume II (September 1971) of Public Choice under a title that had become “Multipart Pricing of Public Goods.” (Tideman 2015).

Tullock’s Flatlanders are devoid of self-seeking. They are von Mises’s liberals in search of the greatest happiness via truth seeking. Perhaps that is why Tullock did not publish “Flatland revisited.” Analysis with an assumption of reciprocity was not Tullock’s way. Behavior with a reciprocity constraint was, nevertheless, his way.

[Gordon Tullock]

APPENDIX II

Flatland Revisited

Practically every mathematics student at one time or another has read FLATLAND,* Abbott's instructive tale of an inhabitant of

*FLATLAND, A ROMANCE OF MANY DIMENSIONS, A. Square, (Edwin A. Abbott). The work has gone through numerous editions. I refreshed my memory with the Basil Blackwell Oxford edition of 1926 and all page citations are to this version.

a two dimensional world and of how he had the existence of a third dimension proved to him by a being who removed from his two dimensional world, "Flatland," and showed him a three dimensional continuum. The book, as written, gives a false impression, particularly through its title. The land in which A. Square lived was not flat. If we were to view his two dimensional world from the outside, we would quickly recognize that it was as irregular in shape as the surface of any other world. The failure of Mr. Square to notice this fact during the period when he was outside the two dimensional world may be put

down partially to the limitations on his opportunities for observation and partly to the hereditary constitution of the mind of an inhabitant of this universe which might better be called “Bentland.”

Mr. Square was only outside his two dimensional world for a short time, and his state of emotional and intellectual shock during that period was such as to make it unlikely that he would make any very careful observations of the environment in which he found himself. Further, he seems mostly to have been interested in observing the inhabitants and structures of his native land rather than the physical structure of the land itself. In addition, when he first left his two dimensional world, he was quite incapable of appreciating the nature of any surface other than a flat one. It was only after his guide, Mr. Sphere, had carefully explained this idea to him with the help of a cube that he began to perceive the possibility of non-flat surfaces. In the short and exciting period remaining he can be excused for not noticing the irregular nature of his native world.

The question remains of why his instructor, the sphere, did not acquaint him with this feature of his world. As a being fully conversant with the three dimensional world within which the two dimensional “Flatland” lay, he can hardly have been unaware of its irregular nature. Indeed, he refers to “the plains of Flatland”^{*} and plains are not

^{*}Page 79.

absolutely level areas, but gently rolling nearly flat areas. Further, “plains” naturally is put in opposition to other terms like mountains, canyons, and hills, and Mr. Sphere, therefore, must be taken to have known that, while the bulk of the inhabitants of Flatland lived in a relatively level area, there were numerous pronounced irregularities in their two dimensional world particularly in its less settled parts.

Shortage of time, as we have said, may have led the sphere to avoid this subject, but it may also have seemed useless to him in view of his great knowledge of the inhabitants of "Flatland." For it is a fact that the minds of these dwellers is so constituted that they cannot conceive of their land as anything except flat. It is possible that the sphere might have succeeded in convincing Mr. Square that deviation from flatness was theoretically possible, but he could never have given him a real appreciation of what a two dimensional continuum which was irregular rather than flat when viewed from a three dimensional space was like. This peculiarity of the minds of Flatlanders has occasioned much interest among the inhabitants of "Spaceland" and the savants of the area have devoted much time to speculating on its origin. To an account of the results of this discussion, I shall shortly turn. After briefly indicating the principle points of view expressed in this debate, I shall then describe the effect of the concurrence of irregularities and minds inherently unable to think of such things on science in "Flatland." Finally, I shall explain what may not be obvious to some of my readers, what all of this has to do with us.

Among the scholars of spaceland there are quite a number of views on how the "Flatlanders" came to have minds which are incapable of thinking of their world as anything but flat. One thread unites all of these theories, however; all the savants are agreed that the Flatlanders evolved from lower forms and that the present constitution of their minds must be the product of that evolution. The exact evolutionary process is the only matter which divides them although there are sufficient grounds for division within this sphere to permit the development of a large number of warring schools of thought.

The first and, in some ways, most influential of these schools of thought holds that evolution necessarily proceeds from the simple to the complex. One-celled species necessarily preceded multi-celled and the Amphibia preceded the lizards. It seems likely, therefore, that in the course of evolution the first brain which could really think would be the simplest type. Clearly, it is easier and simpler to think in terms of a flat two dimensional surface than in terms of an irregular one. It is, therefore, easy to see why the

Flatlanders all have such simplified brains. Whether, in time, further evolution will lead to further development is, of course, a mere matter of opinion.*

*See "Explanation and Prediction in Evolutionary Theory" by H. Scriven, *SCIENCE*, August 28, 1959, p. 477.

A second school of thought, in part allied with the first, holds simply that a brain which could think in terms of a wavy two dimensional continuum would have had little evolutionary value at the time the race originally was formed. It is an undoubted historical fact that the race of Flatlanders first developed in the relatively level part of their world, and in this area an appreciation of the minor irregularities in the landscape would have been of little help to primitive tribesmen trying to catch wild animals while at the same time avoiding being caught themselves. While such a set of mental equipment would have had little or no positive evolutionary value, this school points out that it would most certainly have had a negative value. In the first place, the mind which was capable of considering that its two dimensional world varied in an almost inconceivable third dimension would necessarily be larger than one which could not, and this would be an additional weight for the organism to carry around. Further, most genes have multiple effects. The genes which gave the mind this power, then would probably have other effects on the organism, and, if these were negative, even if only mildly so, the whole effect would be to secure the elimination of individuals with such equipment from the race in its earliest stages of evolutionary development.

Once the race had developed with this type of mind, any mutation to another type with an ability to think in other terms than a completely flat universe would have been of negative evolutionary value due to the fact that the non-mutated members of the race would undoubtedly consider the mutant insane. Further, the advantage which such a mutation would give would be very slight to non-existent since only a

very small part of the race would, at any given time, be doing things which required the new type of mind. The mutant, being different from his fellows in precisely such a field would probably find that, in those areas where he had a superiority, he would be distrusted by his colleagues, and, consequently, would not be permitted to work, or if he did, his results would not be accepted. Altogether, the “civilized” environment is most unfavorable to the survival of genetic mutations radically different from the prevailing type of mentality, and once a race of one basic mind type has become established, it is unlikely to be replaced by another.

The two remaining schools of thought are less influential than the two we have discussed so far. One holds that there are quite a number of mind types possible for such a race as the Flatlanders, and that it is largely a question of chance and the detailed historical development of the evolutionary process which determines which one any race will have. Once a mind of any type is achieved, however, it immediately gives the species holding it a major competitive advantage over the other, less intelligent, species. This species is then likely to establish its dominance over its environment and, for reasons similar to those given by our previous group of scholars, it forms an unfavorable environment for any mutation which might lead to a different way of thinking.

The last group of savants, in radical opposition to all of the others, holds that the limitation on the Flatlanders’ minds which makes it impossible for them to think of their world as other than flat arises essentially from chemical rather than biological factors. They point out that a brain is essentially a carefully arranged collection of chemicals, and they point out that only some chemicals can exist in Flatland, those which have molecules in which the atoms are arranged in three dimensional lattices being, ex definitions, ruled out. This means that there are natural limits on the types of mind which can be constructed, and these savants hold that these limits happen to forbid the construction of a mind which can think of its environment in other than flat terms,

Clearly, our present knowledge of the nature of biological organisms is not great enough to permit us to determine which of these schools of thought is correct. Perhaps none of them are or perhaps the truth involves some sort of compromise between them. Nevertheless it would seem clear that the development of such a limited mind as the Flatlanders have would be evolutionarily possible. Certainly, the Flatlanders have these limits built into their minds, and never succeed in thinking of their world as anything but flat.

The effect of this limitation on the minds of the Flatlanders has been most peculiar. In the early days of their civilization, it had almost no influence. They learned to make various things and used simple geometric forms in their construction, but surveying did not develop as a science due to the fact, of course, that forms of any size would have widely varying characteristics, depending on where it happened to be located. Eventually, formal geometry was invented (although it was not called "earth measuring") and carried to quite a high level of development. This development, however, eventually led to a crisis which destroyed the simple symmetry of the geometric view of nature. A leading geometrician decided to apply his learning on a large field and attempted to determine the distance between two points by triangulation. The irregularity of the surface at this point was such that his computed results were greatly different from directly measured distance. The experiment was repeated by a number of other scholars at other points and the uniformly disappointing results may be said to have constituted the most important revolution in scientific thought in the entire history of Flatland. The eventual outcome was the conclusion by most scientists that simple geometry was only an approximation of reality. Although normally a close approximation for small figures, even that was not exact and for larger figures it was almost useless.

The result of this revolution in science was the development as the largest, most important, and most difficult area of scientific investigation of the field of surveying. Mr. Square does not mention this in his brief summary of the characteristics of his land for much the same reasons which would lead an average inhabitant of our country to omit the Einstein theory from a brief account of its nature. Among the scientists, however, the various problems of surveying are a continuous preoccupation. Making careful

measurements of various figures on the surface which is thought to be flat, and then trying to develop theories fitting these measurements is a major scientific activity. Probably the most important and certainly the only generally applicable of these theories is the theory which “proves” the existence of inherent limitations on the accuracy of measuring instruments. Needless to say, this is a great help in fitting other theories to the measured data.

All the other theories are regional in nature. That is the theory [which] will attempt to explain the variations in some particular locality. As of today, there are such theories for only a small part of the total area of the country, but the scientists of Flatland are most optimistic about the possibilities of further development. They point out that the history of surveying has been one of steadily accelerating progress. In the last fifty years, in particular, many new areas have been “explained,” and many older, rather inaccurate, theories explaining areas have been replaced by new and better explanations, They look forward to an accelerating process of expansion of the area covered by their theories and hope eventually to find a “general surveying theory” which will provide a single equation which covers the whole country. To the outside observer, the problem appears more difficult. Since he knows that the present theories are, in fact, all wrong, he may be dubious about the possibility of extending them to the whole area. On the other hand, the scientists of Flatland have so far shown undoubted ingenuity in applying their incorrect theories to reality and the possibility that they will eventually solve their problems cannot be disregarded. If they do find their “general surveying theory,” it will be an interesting example of a theory which is completely incorrect, yet which explains all of the observed data in terms of its own, improper, assumptions.

The presently existing local theories may be divided among three basic categories. In the first place, there are a few in which the theory simply consists of an equation with no explanation of why it should work. Those theories which are explanatory, and they make up the vast bulk of the total, normally depend either on an assumption that measures of length vary from place to place or that straight lines are actually bent in various ways.* Some combine elements of

*Bent within the plane in which the Flatlanders imagine themselves living, of course. Many of the lines are bent, as we third dimension dwellers can see, but they are bent quite differently than the Flatlanders believe.

both these explanations or, in some cases, also combine unexplained elements with one or the other of these basic explanations. As far as accuracy goes, some few of the Flatlanders' theories use equations which are exactly those we would use ourselves, although they have derived them differently. In a few more cases, they use equations which lead to the same results as ours but which are more complex. In most cases, however, the theories developed by the Flatlander scientists are mere approximations of reality and many of them are not even close approximations.

But, what the reader may ask, has all of this to do with us? I am coming to that and as an introduction may I ask that you consider the possibility that some Flatlander might begin to doubt the flatness of his universe. While he could doubt its flatness, he could not, given his mental constitution, think at all in non-flat terms. He could only feel that possibly the universe was non-flat, but he would have no idea what that meant in positive terms. In support of this view that the world was non-flat, he could offer only two, rather feeble arguments. Firstly, it would seem unlikely that the type of brain which would evolve under primitive conditions would be particularly suited to scientific efforts to penetrate the real nature of the universe. Secondly, he could point out that most scientific theories, efforts to explain the universe in terms of this built-in flatness axiom, were mere approximations of the data obtained by measurement and that vast areas were completely unexplained.

Weak as these arguments are, those on the other side are even weaker. There is first the argument from hope—someday our theories may fit the measurements exactly. Secondly, there is the argument of

non-comprehension. A great many of the scholars of Flatland could be depended upon to simply point out that the results of reasoning based on the flatness axiom which was part of their biological brains seemed perfectly logical and that no other line of reasoning was so logical. This would, of course, be quite true, but also beside the point. The contention would be quite simply that the minds of the Flatlanders were so constructed that what seemed logical to them was nevertheless not in exact accord with the reality of nature. The fact that Flatlander logical reasoning appeared logical to Flatlanders would be irrelevant.

Obviously, with such weak arguments on either side, it would be impossible for the Flatlanders to determine who was right; the problem would have to remain an open question. Possibly after a few hundred thousands of years, some conclusion might be drawn by considering whether the whole of Flatland were covered by a coherent explanation, but surely nothing can be decided now.

Nevertheless, even a Flatlander who became convinced that the world was, in fact, non-flat would have to continue investigations using the flatness axiom. As we have pointed out, their minds are so constituted that they can think in no other terms. It would be a question of thinking in terms of this axiom or not thinking at all, and as long as any progress at all was possible with the use of the false axiom, it should be used. Our Flatlander would be in much the same situation as a modern Indian peasant. He knows that it would be much easier to break ground with a tractor and plow than with a hoe, but he doesn't have the tractor and plow so he makes do with what he has.

The application of all of this to ourselves is, I suppose, obvious by now. We are biologically equipped with brains of a certain pattern. These brains permit us to think in certain ways, which are as such part of the biological equipment of the species as are arms and legs. Clearly, this thinking ability has positive evolutionary value and has given the human species a major competitive advantage over other species, but this does not prove that human logic and the real interrelations of things in this world are in a one-to-one relationship. Nevertheless, we have no choice but to continue thinking in our natural way. It may or may not be the best key to the universe, but it is the only one we have.

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