Sublime reason: when Isaac Asimov met Jay Forrester

NOTES AND INSIGHTS

Sublime reason: when Isaac Asimov met Jay Forrester

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Abstract

This article describes an encounter between servomechanism innovator, digital computing pioneer and creator of system dynamics, Jay Forrester, and Isaac Asimov, renowned author of science fiction (including "The Foundation Trilogy" and its fictional discipline of psychohistory) and works of popular science. Their lengthy exchange took place at a workshop in 1975 and four descriptions of it are extant. What emerges in passing is a possible link between Asimov's thinking and Forrester's work on "World Dynamics". Most notable, however, is that the encounter saw the two exchanging ideas on how to think about the future, how to bring about a desirable future, and quite what that desirable future should look like. The two had fundamental differences on key points. The paper explores the unusual interaction, drawing out the points of disagreement and agreement in the views of the two and how they applied these to thinking about the future.

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Introduction

Isaac Asimov, arguably the world's greatest writer of science fiction, and Jay Forrester, the inventor of arguably the world's greatest approach to understanding wicked problems, have a lot in common (Figure 1). Their lives crossed at least once, but they may have influenced each other several times. This article builds on an earlier treatment (Malczynski, 2020) to offer a brief description of that encounter, of the interaction of persons and ideas.

Educated to doctoral level as a chemist, Asimov spent his academic career teaching at Boston University. His writing career spanned more than four decades (Anderson, 2019; Lindell, 2020). As well as being a science-fiction author, he wrote mystery fiction, and his publications included titles in mathematics, general science, astronomy, physics, chemistry and biochemistry, earth sciences, biology, literature, and history — in all more than 500 books. He also edited more than 100 anthologies (Seiler, 2022). He is considered one of the "Big Three" science-fiction writers of the "Golden Age of SF," along with Robert A. Heinlein and Arthur C. Clarke (see Aldiss, 1973; Freedman, 2000). He coined the term "robotics" and created the "Three Laws of Robotics" which continue to influence both fictional and scientific discourse about robotics and A.I.[1]

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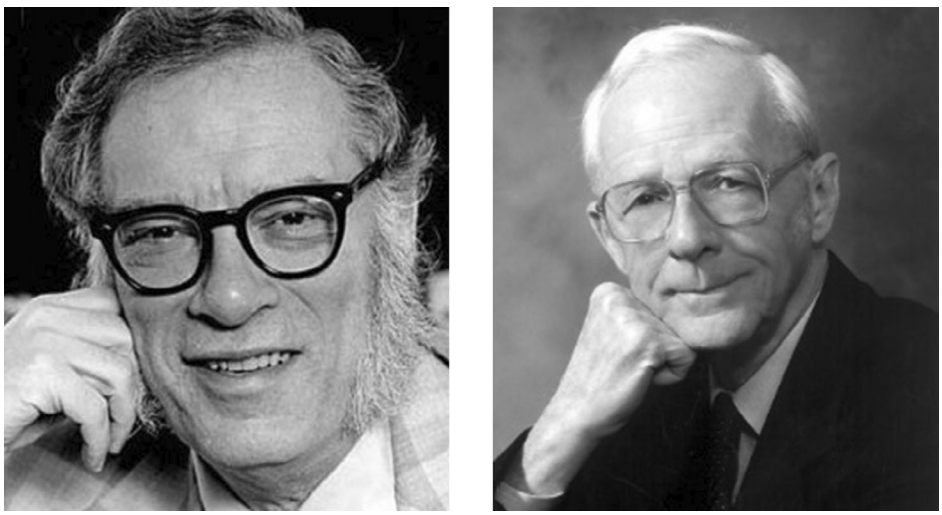

Fig. 1. The protagonists. Left: Isaac Asimov (January 2, 1920–April 6, 1992). Image: Public Domain. Right: Jay W. Forrester (July 14, 1918 – November 16, 2016). Image: with kind permission of Nathan Forrester

Asimov is perhaps best known in science-fiction circles for what became *The Foundation Trilogy*. Originally a series of eight short stories published in the U.S. magazine *Astounding Science Fiction* from May 1942 to January 1950 (Nichols, 1979), they were subsequently assembled into novels: *Foundation*, *Foundation and Empire*, and *Second Foundation* (Asimov, 1951, 1952, 1953). The trilogy is set in a galactic empire of 25 million planets with almost a quintillion humans (10^{18} in the U.S. convention). The central idea is that the empire is in decline and headed for collapse (Asimov was consciously echoing Gibbon's *The Decline and Fall of the Roman Empire*). The collapse and its consequences are predictions of one Hari Seldon via his use of the technique "psychohistory." This fellow and this imaginary science are both important to our story.

Psychohistory is Asimov's creation, a fictional science which combines history, sociology, and mathematical statistics to make predictions about the future behavior of large groups of people. Hari Seldon is the protagonist in the first part of the first novel. However, even after the character's death, he is the recurring sage referred to throughout the *Foundation* Trilogy. Seldon, "early showed amazing ability in mathematics," and "Undoubtedly his greatest contributions were in the field of psychohistory. Seldon found the field little more than a set of vague axioms; he left it a profound statistical science." Seldon uses psychohistory to make the unwelcome prediction of imperial collapse and to explain its mechanisms; "The Fall of Empire … is dictated by a rising bureaucracy, a receding initiative, a freezing of caste, a damming of curiosity — a hundred other factors." A state of anarchy will follow in which "The Empire will vanish … and the order it has imposed will vanish. Interstellar wars will be endless; interstellar trade will decay;

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population will decline; worlds will lose touch with the main body of the Galaxy" (all quotes are from Asimov, 1951). The resulting "Dark Ages" will last 30,000 years.

However, Seldon believes that appropriate action can reduce this to 1000 years (an abridged version of *Foundation* was called *The 1000 Year Plan*). To bring this about, he sets up two shadowy "Foundations," groups of scientists and engineers, one sequestered on the planet Terminus at the edge of the galaxy, the second at the vaguely specified "other end of the Galaxy … at Star's End." They will work behind the scenes to bring about a rekindling of civilisation, guided down the centuries by Seldon via a series of pre-recorded holographic messages.

The secretive activities of the Foundations are the prime interest of the trilogy. Secrecy is needed because psychohistory is based upon two axioms:

- The population whose behavior is modeled is sufficiently large.
- The population remains unaware of the results of the application of psychohistorical analyses (otherwise its behavior might change).

As the two Foundations work for a resurgence of a galactic society in a second Empire, a great deal of the plot in the trilogy depends on that second axiom. Foundation members themselves do not know the whole plan, and the trilogy progresses via a sequence of overlapping concealments and revelations. Whilst the trilogy is epic in scope, it is not a "space opera" in style. The Foundation deals with intellectual and political challenges rather than engaging in military conflict — perhaps echoing the interests and predilections of Asimov.

On these pages, Forrester needs little introduction. By the time of Asimov's one documented encounter with him, Forrester was already known for the wide range of his accomplishments (Lane, 2007). These included his work on servomechanisms, the Whirlwind computer, magnetic core memory, and system dynamics works including *Industrial Dynamics*, *Urban Dynamics*, and *World Dynamics* (Forrester, 1961, 1969, 1971).

The encounter

In 1972, while attending a seminar on the future of communications at what is now the Rensselaer Institute in Troy, New York, Asimov volunteered to fill in for someone else who was detained in London. The result was that, starting in 1973, Rensselaer began to host a week-long "forum" with Asimov himself. That became an 18-summer engagement known as "Asimovia" (Asimov, 1980). The thinking generated in these meetings often led to new

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ideas for action on the part of the Institute.[2] Each forum was normally organized into presentations by invited experts — "faculty." These were followed by question-and-answer periods, then an assignment of tasks/questions to smaller groups, plenary presentation by the groups, and finally comments by Asimov. Forrester was invited as "faculty" to speak at the 1975 forum.

The 1975 forum

The authors have four sources relating to this forum. Asimov made a brief but notable mention of the encounter, and Forrester was able to recall its key aspects. There are then two lengthier sources. One comes from Ellen Murphy. Despite our best efforts we have been unable to find any further information on her. However, acting as the "Program Reporter," she produced a 32-page record of the events of that week, and this is the main source for the encounter. In addition, a "Participant" was Margaret Elen Deming. Then an 18-year-old environmental-studies undergraduate at SUNY Albany, she was encouraged to attend by her supervisor, Louis Ismay. She subsequently had a distinguished academic career and is currently Director for the new Doctor of Design Program at the College of Design at North Carolina State University. She wrote a 10-page account of the forum — "to earn some independent summer credits" (pers. comm. 2022). References to these four sources are given below. These sources are not comprehensive, having ambiguity and lacunae. However, whilst each gives particular detail and opinion, they are consistent about what took place.

The 1975 forum was dedicated to "Space, Extraterrestrials and Human Society, the Body, and the Future." We know little of the selection process for the speakers and topics. Possibly topics were chosen by Asimov, and experts were found to contribute. Murphy (1975) records the topics and presenters (Asimov presented on all topics):

Part one: Space

- Charles Matthews – Associate Administrator for Space Technology Applications, NASA
- Karl Hess – Fellow of the Institute for Policy Studies, Washington D.C.

Part two: Extraterrestrials and human society

- Isidore Adler – Department of Chemistry, University of Maryland, NASA consultant

Part three: The body

- Ian H. Porter – M.D., Albany Medical College, Clinic for Birth Defects, Albany, New York

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- Corrado Baglioni – M.D., Chairman and Professor, Department of Biological Sciences, SUNY, Albany, New York

Part four: The future

- Dennis Livingston – Department of History and Political Science, Rensselaer Polytechnic Institute, Troy, New York
- Jay Forrester – Professor of Management. M.I.T. Cambridge, Massachusetts

Note the subject-matter diversity, something Asimov would have been quite comfortable with. There were approximately 75 attendees in the audience, and the event ran from 27 July to 31 July 1975. Deming adds some color to this outline when she describes arriving for the first session on Sunday 27 July to find a display of science-fiction books — all by Asimov — and hearing Elton John's pop song "Rocket Man" piped into the hall (Deming, 1975).

Murphy wrote, "Ask each of the 75 people who participated in 'A Week with Isaac Asimov' what the highlight of the program was, and you'll probably get over 70 different answers, which range from "listening to Jay Forrester talk about cybernetics" to "posing for a picture with Isaac Asimov" (Murphy, 1975, p. 1). She goes on to say, "the report only hints at: the good natured exchanges between the main speakers, the excitement of watching the interaction of minds the caliber of a Forrester and an Asimov" (p. 1). Besides Asimov, Forrester is the only other person highlighted in her account in this way.

The prequel to the encounter

The Part Three session, "The Body," started on Tuesday evening. On Wednesday morning, groups were formed and set different tasks. One was asked to explore this premise:

> *"Assume that starting tomorrow biomedical discoveries and applications enable all of us to live to be 100 years old without infirmities."*

This group — its membership is not known – produced a graph (Figure 2, Top). We have no information on how this graph was produced at the workshop. A reasonable guess is that it was hand-drawn there — Murphy states that in a later session Forrester drew diagrams on a chalkboard — and subsequently laid out more formally for the report. Given this response regarding the outcome of the premise, it seems plausible that Forrester was in this group. Certainly it makes for a striking comparison with Figure 4-1 from *World Dynamics*, a book published only 4 years previously (Figure 2, Bottom).

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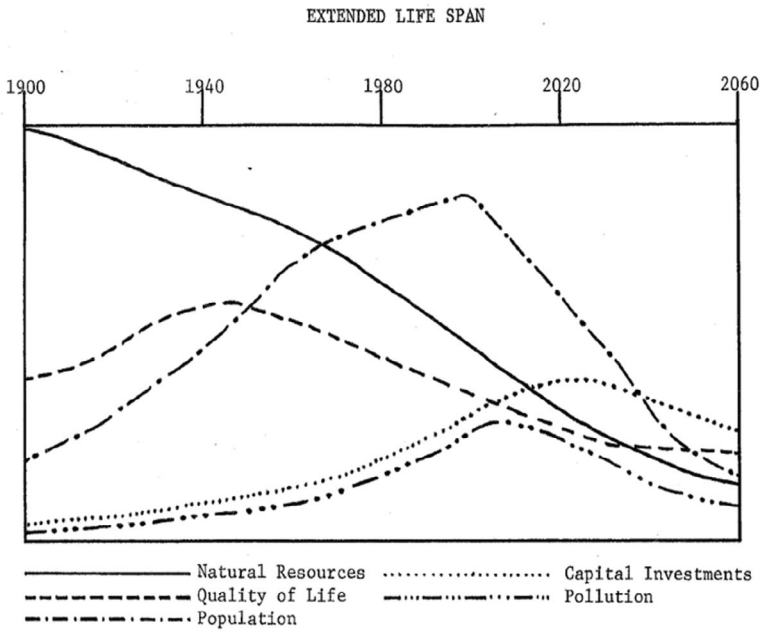

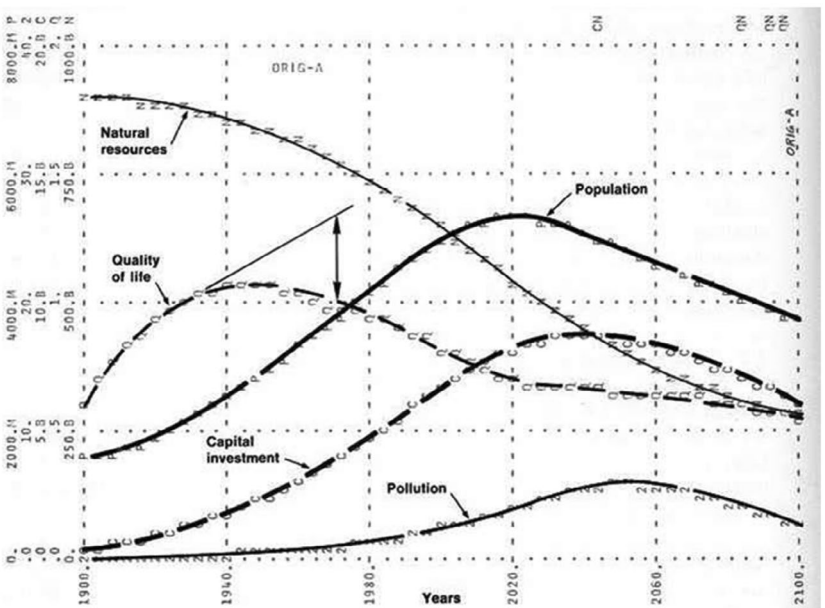

Fig. 2. Top: A workshop group's response to the idea of an extended life span (Murphy, 1975, p. 36) Bottom: Basic behavior of the *World Dynamics* model, (Figure 4-1, p.70 in Forrester, 1971)

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The encounter in detail

"Part Four: The Future" started in the afternoon of Wednesday 30 July 1975. At 4 PM, Livingston gave a talk on "Images of the Future in Science and Speculative Fiction." Deming recalls it as,

> *"A curious collection of slides about preconceived notions of the future. Comic book covers, science fiction, experimental societies and economies, incredible technological advances, and hellish technocracies; all these images were familiar fantasies, but were they also self-fulfilling prophecies?"* (Deming, 1975, p. 7)

Murphy records that the talk included political cartoons, scientific illustrations, and stills from cinema films.

The evening session brought a different format. For "Fact and Fiction in the Looking Glass — a comparison of different ways of charting the future," in order "To facilitate greater exchange of ideas between the two speakers, there was a brief address by Asimov, followed by a talk from Forrester, then a response by Asimov, and additional remarks by Forrester" (Murphy, 1975, p. 42).

In a talk subtitled, "Via Speculative Fiction: Prediction or Serendipity?" Asimov began by discounting the predictive ability of science fiction, seeing the genre more as an extrapolator of existing scientific ideas.

Forrester then presented. His session was titled "Via Computer Modeling" (or possibly "The Three Laws" — the record is ambiguous). Forrester introduced system dynamics. He went on to relate it to Asimov's *Three Laws of Futurics* (of which more later). He began his explanation of system dynamics this way,

> *"Let me tell you a little about the field … which we have been pioneering over the last 20 years. Many people see it as the use of computers for examining the behavior of social systems, but it's a great deal more than that. It is really the confluence of three major historical threads which come together to give us new ability to deal with the complexities of society."* (Murphy, 1975, p. 44)

The three major historical threads Forrester referred to can be summarized as:

- The classical and historical practice of management and politics which has been going on since there were societies and which has its most explicit manifestation in the case-study approach to management;
- Understanding of feedback processes over the last 100 years. These describe growth, indeed any place you find change, whether in physics or psychiatry, psychology, economics, management, politics, or nature; and
- The use of modern electronic computers to model and to explore different possibilities.

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Forrester then commented on the "striking resemblance" between these ideas and Asimov's *Three Laws of Futurics* (Asimov, 1975). There is no record of how Forrester became aware of these laws but he clearly had informed himself in preparation for his talk. The laws are listed below, set against a summary of Forrester's impressions — given that evening in 1975 — of them and of how they relate to system dynamics (Table 1).

With simulation he claimed that "… one can handle far greater degrees of complexity than one can handle in verbal, descriptive form; a great deal more complexity than anyone could convey to a body of readers simply through the written word" (Murphy, 1975, p. 47). Murphy records one participant's reaction; "The way in which Dr Forrester presented economics allowed me to understand it for the first time" (p. 57).

Asimov then presented on, "Without the S, It's not SF." During this, Asimov and Forrester briefly exchanged banter. Murphy wrote, "During a humorous exchange between Dr. Asimov and Dr. Forrester, Dr. Asimov explained that he had, in fact, "predicted" Dr. Forrester 34 years ago because in the course of writing the Foundation Series, he created psycho-history and psycho-historian, Harry [*sic*.] Seldon" (Murphy, 1975, p. 47). The calculation is simple: 1975 − 34 = 1951, the year *Foundation* was published.

Forrester followed with, "Beyond the Law of Averages." He claimed that the theory of psychohistory did not go far enough in predicting human behavior:

> *"I would suggest that you can go very much further than that. You can say that even individuals are extremely predictable, that you can put one man after another in a particular role and he will act just like his predecessor no matter how much he allegedly believes otherwise. In fact, the surrounding circumstances make behavior predictable to an extent that none of us would be comfortable believing."* (Murphy, 1975, p. 48)

Forrester described in some detail the inventory/workforce oscillations problem that catalyzed the creation of system dynamics (Forrester, 1958, 1961). He used the example to exemplify the axiom that structure influences

Table 1. Asimov's "Laws of Futurics" and the authors' summary of Forrester's response (Murphy, 1975)

Asimov's Laws of Futurics	Forrester's comments
1. What is happening will continue to happen.	The way people make decisions is fundamental and repeated throughout history.
2. Consider the obvious seriously, for few people will see it.	We have all the information necessary to understand social systems in our heads — do not ignore it.
3. Consider the consequences.	The simulation process does that; it considers the consequences of the knowledge and structure in the simulation.

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behavior. He extended this to other real-world examples of political processes and resistance to change, examples familiar to *SDR* readers and the crux of the system dynamics method.

Deming found Forrester's presentations "excellent … moved me considerably … excited to learn many [concepts] … being pioneered in such a scientific and orderly fashion by such a brilliant individual … He would like to see the concept of integration taught to school children" (Deming, 1975, p. 8).

The following day, Thursday, 31 July 1975, Forrester concluded with, "A Synthetic Approach." Contrasting system dynamics with psychohistory, he "pointed out, it is necessary to have an informed public which understands the nature of social systems and the possibility of doing such modelling" (Murphy, 1975, p. 50). He championed the widespread use of system dynamics. He commented on the education system at that time (referring to work by Nancy Roberts); discounted thinking based on differential equations (asserting that everyone knows far better what integration — in the mathematical sense — is); and, lastly, used rabbit reproduction to explain exponential growth. Responding to a question, he commented on criticisms of *Urban Dynamics*.

At some point — it is not clear in which of his talks this came — his comments also included, "recommendations to localize organizations, and energy, to conserve food, energy, and babies" (Deming, 1975, p. 9). This proved to be a point of contention.

Getting the final word in the final session, "Alternatives and Hope," Asimov said, "that he and Dr. Forrester agreed on what the problem of the future was, but that they differed diametrically on the solution." He explained as follows:

> *"Professor Forrester thinks, if I understood him correctly, that we need a future of localism, of self-sufficiency. My view is that, if things continue as they are and population continues to rise and the food supply continues to become less and less adequate, then we will have some sort of catastrophe, with or without a nuclear war. There will be a rapid decrease in the population due to a rise in the death rate. There will be a rapid fall-off in standard of living. We will have consumed the oil and easy coal. Our rather complex economic and social structure will have collapsed. In the ruins those who survive will have to set up relatively small units which are of necessity self-sufficient. So what Professor Forrester calls the solution, I call the catastrophe. Perhaps that is one way of getting rid of the catastrophe – calling it something else."* (Murphy, 1975, pp. 54–55)

Unfortunately, we cannot find any more detail on Forrester's localism and self-sufficiency "solution," i.e. more detail on quite what solution Forrester put forward at this event that provoked Asimov's response. In the very first session, Hess apparently "recommended that people be more localized in their organization, more self-sufficient in their information-gathering, technology and energy" (Deming, 1975, p. 3), so it may have been an idea that

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ran through the forum. However, some further insight on Forrester's thinking, and on Asimov's antipathy to it, is also recorded by Deming:

> *"[Asimov] also saw that a future of a slower pace, or older people, of most variables lowered in intensity in order to insure a sane, stable survival, would make this "a relatively dull world … It seems to me that we may escape death by a glorious fireworks of catastrophe, only to acheive (sic.) death by a slow whining whimper, of boredom"."* (Deming, 1975, p. 9)

The final striking phrase is also recorded by Murphy (1975, p. 56).

We contacted Edward Seiler, who maintains the site "Asimov online," for further comment. He wrote:

> *"Asimov was not one to idealize 'the simpler times' of the pre-industrialized age, because he firmly believed that the benefits of science and technology outweighed the troubles that came along with them. However, he was also a fervent supporter of limiting population growth, citing it as one of the major risks to the environment and the supply of natural resources. Asimov wrote about the dangers of overpopulation many, many times."*[3]

This concern about future catastrophe is certainly borne out in Asimov's writing. For example, his nonfiction work *Earth: Our crowded spaceship* (Asimov, 1974) portrayed the Earth as a finite system and explored the consequences of population growth in terms of resource scarcity and social conflict, whilst his novel *The Gods Themselves* (1972) is set in a 2070 in which an unspecified "great crisis" has caused global population to fall from six to two billion.

Very much a man of his time, Asimov had a strong belief that technology might solve many social problems. Deming saw him as one of those who "believe in the power and glory of the technological revolution as our salvation" (Deming, 1975, p. 8). Indeed, decentralization, Asimov believed, would come as the result of technology rather than as result of people deciding to change society. At the forum, he stated:

> *"If we do not achieve the kind of technological advance that will help us to change society in the direction it must change, then it won't change in the direction it must change fast enough to prevent a dire catastrophe worse than any we have ever had."* (Murphy, 1975, p. 55)

An encounter recalled

Of his 18 summers at the Institute, there is only one intellectually reflective memory Asimov records in the second volume of his autobiography *In Joy*

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Still Felt, only one that references the forum's content (Asimov, 1980). Elsewhere, when he mentions the forum, he describes friendships and socializing only. However, recalling the 1975 forum, he wrote:

> *"The high point, professionally, of this particular seminar, came on July 30, when Jay Forrester of MIT came in to argue his belief in the necessity of a world consisting of small, self-sufficient communities. My own view, stated rather forcefully, was that this was no novelty. It had been tried numerous times in world history and there were even names for it. It was called 'the Dark Ages'."* (Asimov, 1980, p. 717)

This story is also recounted by Forrester in the now defunct system dynamics list server. He reports his reaction to the *Three Laws of Futurics* and ends:

> *"When I finished, the chairman asked for reaction from Asimov who sat in surprised silence. My comment to the audience was, 'This is the first time you have seen Isaac with nothing to say'."* (Forrester, 1997)

Leonard Malczynski (LM), coauthor of this article, discussed this encounter with Jay Forrester in 2011 at the International Conference of the System Dynamics Society in Washington, D.C. He asked Jay what he recalled. It was uncanny how Jay told basically the same story recorded by Murphy (and a mere 36 years after the event, when Forrester was 93 years old!). However, his version had a twist. This is LM's note of what Jay told him:

> *"Dr. Asimov was fond of talking (and writing). When Jay finished his presentation, Dr. Asimov was asked if he had any comments. Jay told me that Asimov paused, then replied, 'He gets it'."*

Reflections on the encounter

The encounter between Forrester and Asimov described here is perhaps of interest merely as a curiosity. Two established scientific thinkers of the 20th century, from different but not unrelated areas, meet; we watch with curiosity in to see the resulting exchange of views. However, there are some further reflections that also motivate this account.

On Seldon versus Forrester (and Asimov)

Parallels are sometimes drawn between system dynamics and psychohistory, the former suggested as the real-world manifestation of the latter's fictional aspirations. We consider this to be false.

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Although full-blown application of mathematical modeling to sociology had yet to crystalise (Coleman, 1963), Comte and Durkheim had established the importance of empirical data when studying society. There was therefore nothing new in that aspect of psychohistory's general approach to thinking about the future. Moreover, even the presence of a mathematical basis provides insufficient commonality: in contrast to Forrester's disciplined and rigorous use of many parts of mathematics and servomechanism theory, the mathematics in Asimov's psychohistory is little more than suggestive arm waving.

Beyond this, what also separates the two "approaches" is their assumptions about how each should be used. Central to Asimov's novels is the idea that the experts in psychohistory must remain a secret elite, working in the shadows using arcane tools to manipulate people, people who must not be privy to what is going on.

This is not how system dynamics is used, nor how it ever aspired to be used. Forrester was clear from the beginning that it should be employed to facilitate open debate, that engagement of stakeholders was needed. He championed widespread knowledge of particular wicked problems that system dynamics had been applied to: *Urban Dynamics* and *World Dynamics* were written to draw people into debate. More generally, he always thought that knowledge of the system dynamics approach as such was key. Key to management learning and to organizational learning (Forrester, 1960/1975, 1961, 1965); key also to education itself (Forrester, 1990, 2007).

This is half a galaxy away from being Asimov's idea made real. As a plot motor, secrecy may make for gripping science fiction. Nevertheless, let us put this to bed: psychohistory and system dynamics are very, very different beasts. As the subheading suggests, and the following subsections explore further, we think that Asimov would agree.

On Asimov and Pohl, and Forrester

Some years after the forum, in 1991, Asimov and another Grand Master from the "Golden Age of SF," Frederick Pohl, wrote the book *Our Angry Earth*. The authors warned that overpopulation may be the root of civilization's decline, described the consequences, and suggested ways of bringing about a different future for society.

Here are two authors committed to thinking about the future. However, their method in this book is to lay out all of the facts and all of the arguments they have available. Their aim is to motivate every reader to understand, to take action, to vote. Alas there is no mention of Forrester's *World Dynamics*, even though there is an "Appendix 1: Sources and Resources."[4] However, Appendix 2 contains guidelines on constitutions and by-laws for a club, to help readers organize and influence. Their book is a long way from psychohistory, quite close to Futurics.

It is also very much in the spirit of system dynamics. As Asimov and Pohl fretted over systemic problems, Forrester had already suggested changes to

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the education system. Forrester saw system dynamics as an educative tool that enhanced democracy and individual liberty. One might see this as his aiming for everyone to be able to practice what Asimov only wrote about.

On Asimov and Forrester

We end with lessons concerning the points of agreement and disagreement between Asimov and Forrester.

The forum encounter reveals two people — scientists — interested in the future, thinking about it, arguing about it. Here is the first agreement, obvious and so easy to pass over: both believed that the future was worth thinking about. We also see considerable agreement about how best to go about that thinking. Table 1 provides some insight, but more generally the encounter reveals a joint belief that it should be done with humor (and no small amount of self-regard) but mostly with intelligence, openness, and rationality. There was also agreement on what they feared the future might look like: both were concerned about the prospect of overpopulation and resource scarcity; both wanted to use scientific rationalism to avoid a future they both thought highly undesirable. Sadly, as the account here shows, a point of disagreement was what an improved future should be, and what forces might operate to bring it about.

There is a further, overarching agreement that the encounter reveals. Asimov's 1972 novel *The Gods Themselves* draws its title from Schiller's play *Die Jungfrau von Orleans*. Set in the 15th century, the play has the mortally wounded English Lord Talbot, his army routed by French forces in part because of his soldiers' belief in the supernatural powers of Joan of Arc, cursing the folly that has sealed his fate: "Mit der Dummheit kämpfen Götter selbst vergebens" ("Against stupidity the gods themselves struggle in vain"). Whilst Seldon's Foundation worked in secret, both Asimov and Forrester believed in openly talking out problems. They believed in thinking rationally and intelligently about problems and working them through by gaining knowledge, by trying to share knowledge, by debating different ideas. In short, they were both against stupidity (others' but also their own). They both believed that the struggle against it was always worth the effort.

Doomed Talbot's preference was for "Sublime reason, resplendent daughter of the divine principal, wise foundress of the structure of the world." The encounter between Asimov and Forrester described here is just one example of how these two remarkable people clearly agreed on this foundation.

Notes

[1]Asimov's original laws are: (i) a robot may not injure a human being or, through inaction, allow a human being to come to harm; (ii) a robot must obey the orders given it by human beings except where such orders would conflict with the First

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Law; (iii) a robot must protect its own existence as long as such protection does not conflict with the First or Second Law. These were the basis of a series of stories by Asimov, published first in magazines and subsequently collected as *I, Robot* (1950) and *The Rest of the Robots* (1964) The laws were also referred to in various of his novels. Other science-fiction authors have used these laws, or mocked, or criticized, or extended them. For an example of their influence on modern technology, see Murphy and Woods (2009). A popular 2004 film used the title "I, Robot," but the plot and characters deviated from the book. (Asimov's "Foundation" novels have been adapted into an Apple TV exclusive series which debuted in September 2021; similarly, it deviates from its source.)

[2]For more information see: www.rinstitute.org/history

[3]The "Asimov online" website is at www.asimovonline.com/asimov_home_page.html. The comment quoted is from a personal communication with author LM on 26 March 2022.

[4]The dates of publication of this and other Asimov pieces involving the threat and the consequences of overpopulation surely raise the question of whether he was influenced in any way by *World Dynamics* (Forrester, 1971). As a further example, a number of the runs in *World Dynamics* show a collapse in population of the same scale and with similar timing to the world portrayed in Asimov's novel 1972 *The Gods Themselves*. Of course, these instances may be nothing more than coincidence, and we are certainly not aware of any evidence for a direct connection. Rising population and the consequences of it were not new concerns at that time, having been a source of disquiet from Malthus up into modern-day environmentalism, and even then were not confined to Forrester's work (de Steiguer, 1997). However, given the widespread coverage of Forrester's book and its effect on public debate, and also given Asimov's engagement with both science and popular science, it is hard to see that that influence was zero. Certainly in 1975 Asimov was exposed very directly (in both senses) to Forrester's views. Considering influence the other way, it might be interesting to know if Forrester ever read any Asimov.

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