An Engineer in Philosopher's Clothing

> I am convinced that the act of thinking logically cannot possibly be natural to the human mind. If it were, then mathematics would be everybody's easiest course at school and our species would not have taken several millennia to figure out the scientific method.
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> —Neil deGrasse Tyson, *The Sky is Not the Limit: Adventures of an Urban Astrophysicist*

David Brooks, the NY Times columnist, has recently made the distinction between "résumé virtues" and "obituary virtues," saying that the résumé virtues are the skills you bring to the marketplace, whereas the eulogy virtues are the ones that are talked about at your funeral.[1] This autobiography is neither a resume nor an obituary, since I am at a point in my life when (I hope) neither is appropriate. Also since I am a Midwesterner, I am supposed to be humble (as fans of Garrison Keillor's Lake Wobegon will know). But I will do the best I can to tell an interesting story, which I confess will mean bragging, at least a little, about my virtues of both kinds. I will also do a lot of name dropping, because this is my opportunity to in effect thank a lot of people for their support. I of course will accidentally overlook somebody, and if that somebody is you, I deeply apologize.

I will also use this "autobio" a bit as a bully pulpit, to share with you my developing views about logic. The introductory quote from Neil deGrasse Tyson is very relevant to these views. As I shall reveal further on, I started out to become an engineer, changed to science, and ended up in philosophy. There is a saying that has guided me, but which I cannot reference (this is not a criticism of Google). "Philosophy is the art of the sciences, and the science of the arts." I want to be clear that I truly value the arts (which include in this context the humanities). I was indeed once executive associate dean of the College of Arts and Sciences at Indiana University. And I have always had a strong inclination toward the sciences—I don't think I have published a single paper which doesn't have a strong sprinkling of

[1] *The Road to Virtue*, Random House, New York, 2015.

mathematical symbols in it.[2] But the hidden engineer in me is perhaps my best kept secret. We will get back to this later.

Growing Up in Ft. Wayne and Then Lafayette, Indiana: On the Banks of the Wabash. *On the Banks of the Wabash, Far Away* is the official Indiana state song. It begins:

> Round my Indiana homestead wave the cornfields,
> In the distance loom the woodlands clear and cool.
> Oftentimes my thoughts revert to scenes of childhood,
> Where I first received my lessons, nature's school.

I was born in Fort Wayne, Indiana, June 19, 1941. Fort Wayne is not really on the Wabash, although it is close. There were no cornfields or woodlands either in this city, though I enjoyed these on visits to my grandparents' farm. My father had moved off of his family's farm south of Indianapolis to take a job with John Deere's warehouse center in Fort Wayne. Family legend has it that he started as a janitor during the depression, and I know he worked his way up to become the assistant director of that center. My mother had been an accountant but gave up her career to become a "full-time mom" for my two siblings and me. I lived in Ft. Wayne until my father moved to Lafayette, Indiana, to take up the position of territory manager.

There my mother became active in politics and ended up as chair of the Democratic Party of Tippecanoe County. My father was a Republican so I was the product of a mixed marriage. It was also a mixed marriage in the more traditional sense, in that my mother was a devout Catholic and my father seemed pretty much irreligious. I had gone to a parochial school (St. Jude's) in Ft. Wayne, but there was no parochial school in Lafayette when we moved there, and so I went to the public high school Lafayette Jefferson. I think this might have been the best combination I could have had to pursue a career in philosophy, and maybe especially logic.

My first eight years of education, almost entirely with nuns as my teachers, was somewhat stereotypical (even down to the nun marching up and down the aisles to catch students who were daydreaming, occasionally me). But I got a first-rate education, and my philosophical and logical education was largely based in catechism classes. There was lots of room for discussion and argumentation in those classes, and paradoxically I have to say that the catechism classes probably led to my atheism.

My childhood dream was to become an aeronautical engineer. I made countless model planes. My "plan" was to study engineering in college, and then join the Air Force and learn to be a pilot, even a test pilot. But I was saved from engineering by science.

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[2]I think the only paper without symbols that I tried to publish was a paper titled "Wittgensteinian Scepticism" that I sent to *Mind* while I was in graduate school. I argued that certain arguments from Wittgenstein and his followers (notably Normal Malcolm) were essentially old sceptical arguments in new clothing. I got an immediate rejection from then editor Gilbert Ryle, saying that although my paper contained some admirably pointed barbs, he thought his readers were getting tired of Wittgenstein.

I had the good fortune to take a biology course during my first year in high school from Mr. D.O. Neidigh. He encouraged me to create a Science Fair project, and I was fortunate enough to not only be a winner, but also to attract the attention of Henry Koffler, then chair of the Biology Department at Purdue University. He was a microbiologist and a pioneer in the emerging area of molecular biology—he ended up as President of the University of Arizona. He hired me to work in various labs, most of them associated with a project to study how bacteria flagella move. Henry (I can now call him that) was my mentor and a tremendous influence on my life. I continued to work in his labs throughout high-school summers and after school, and then for two summers after I graduated and went off to Oberlin College. I chose Oberlin at Henry's advice because of its record in turning out graduates who went on to graduate schools and scientific careers.

I also want to acknowledge the great help of Mr. R.W. Levering, physics teacher and academic counsellor, who helped me in various ways on my way to college, and also encouraged me in Science Fair projects. I was a first-generation college student, something I think I have not previously mentioned publicly in my career, and this support and encouragement were very critical. Also my parents' support was very important. As one small example, I remember my father driving me over to Purdue to borrow some equipment for my first Science Fair project.

Going to College: Oberlin, Ohio. When I went to Oberlin I of course took freshmen chemistry since Henry told me a major in chemistry was appropriate for someone intending to become a molecular biologist. But also, to meet a general education requirement, I took an introductory philosophy course.[3] I thus took the first step toward choosing a new career goal, and I took the second step in my sophomore year when I took a course in symbolic logic from Bruce Aune. I remember meeting with Henry to tell him that I was going to major in philosophy and study logic. He suggested to me that Watson and Crick's work on DNA suggested there might be a connection between logic and biology, but I politely (I hope) said that I was interested in pure logic.

I took every course related to logic that Oberlin offered, both in the Philosophy and Mathematics Departments. One of the most memorable of these was taught by Robert Stoll. It was based on a draft of his book *Set Theory and Logic*. The class had maybe a dozen students, but they included the future logicians Peter Woodruff and Jonathan Seldin, and my future wife Sally Dunn (a math major). The draft had a number of errors, as every manuscript does. Ironically, I think we all learned a lot from trying to catch them all.

I also took a number of "private reading" courses in logic with Daniel Merrill, and under his supervision wrote my senior honors thesis on "Logical Behaviorism," i.e., the question of whether logical connectives can be defined by their role in inference. I like to tell the story that my interests at Oberlin developed as I was looking for foundations: biology depends on chemistry, which depends on physics,

[3]Taught by Roger Buck, later to be my colleague at Indiana University.

which depends on math, which depends on philosophy, which involves logic. Something like that is true but I had diversionary interests in political science (with an eye on the law) and poetry. I almost dropped out in the middle of my first year of graduate school to write a novel.

Graduate School: University of Pittsburgh. I was fortunate to be a graduate student in Philosophy at Pitt in the mid-1960s when Pittsburgh was not just the home to the steel industry, but also to relevance logic. Once upon a time the strongest tools were built out of stone (Aristotelean logic), then later came iron (classical logic), and then steel and various substructural alloys (intuitionistic logic, relevance logic, and various other nonclassical logics).

Bruce Aune, a teacher of mine in philosophy of mind at Oberlin, was an important influence in my decision to go to the University of Pittsburgh for graduate study. Bruce went to Pittsburgh as a faculty member in the same year (1963) and he was passing information on to me and a number of other students at Oberlin. Through him we heard the news that both Nuel Belnap and Wilfrid Sellars, along with Jerry Schneewind, were leaving Yale to join the Pitt Philosophy Department (Kurt Baier, Adolph Grünbaum, and Nicholas Rescher were already there). This fit my interests really well since I was somewhat undetermined as to whether I would specialize in logic or philosophy of mind. Philosophy of mind was a strong interest of mine when I was an undergraduate rebelling against behaviorism both in psychology and philosophy. One of the reasons I chose to go to the University of Pittsburgh for my graduate studies was I felt they had the right faculty members no matter which direction I finally chose to go. Not only I, but five other graduates of Oberlin went to do graduate study in Philosophy at Pitt in the fall of 1963.

I was fortunate to have a Woodrow Wilson Fellowship for that first year, and Pitt topped in off with a guarantee of graduate support for several years after that. My interest in logic exploded after I took a course from Nuel Belnap on the logic of questions in my first semester. At that time Philosophy was located in a building that was a remodeling of the old Schenley Hotel. I shared an office with fellow graduate student Tryg Ager, and we had our own bathroom since our office was once a hotel room. The office was right down the hall from Nuel's. He would often stop by, at least several times a week, and ask me to prove something for him. Also I felt free to look in on him and see what he was working on, and he would often stop me as I walked by his door.

Nuel Belnap was a huge positive influence when I was a student, and still to this day. I remember a fellow graduate student Richard Schuldenfrei referring to him as "Nuel Call-Me-Nuel," because of Nuel's practice of wanting students to call him by his first name. To give credit where credit is due, this was also a practice of Nuel's own teacher Alan Ross Anderson. Alan moved from Yale to Pitt in my last year there, and shortly after his arrival invited me to lunch. He told me during lunch that there were two things he didn't like in a student: first, if the student didn't call him by his first name, and second, if the student didn't tell him when he was being stupid. I said something as we parted like "Thanks for lunch Professor Anderson." About a week later he asked me to lunch again, and told me the same thing. I said

"Which would you prefer Professor Anderson, that I call you Alan or that I call you stupid." He replied, "Please call me Alan," which I did.

Another Pitt faculty member important to my career was Storrs McCall. I took his logic seminar in my first semester at Pitt and it was in writing a paper for this course where I was trying to show that the implicational fragment of E was equivalent to the intersections of that of S4 and that of some other logic. (Nuel Belnap had already shown that the other logic was not R.) Storrs told me about the "mingle rule" of Onishi and Matsumoto, and suggested that I add this to E. This ultimately led to my exploring the system obtained by adding this rule to the relevance logic R, and ultimately to my paper showing that every normal extension of R-Mingle had a finite characteristic matrix (Dunn 1970). Bob Meyer and I (1971) were able to show a similar result concerning the intuitionistic-style logic of Dummett's LC.

I was very lucky to have some other excellent fellow students working with Nuel. Besides Bob Meyer (Robert K. Meyer—he always insisted on being called "Bob"), there were Louis Goble and Peter Woodruff, among others. Curiously, both had been students at Oberlin with me.

Another person who clearly helped was Nuel himself. I had a Woodrow Wilson Dissertation Fellowship for my fourth year at Pitt. Later, when I discuss my research career, I will discuss some of what was in my dissertation, but perhaps more important than what my dissertation contained is something that it did not contain. My plan was for the final chapter to show how the logics E and R are decidable, and I was looking forward to showing this in my fourth year. But Nuel told me in my third year that I had done enough. This was a very wise move on his part, since some 18 years later Alasdair Urquhart (another of Nuel's students, who came to Pitt soon after I finished) would show that both E and R (and a wide range of other logics) were undecidable.

First Academic Position: Wayne State University. In 1966 I received a Ph.D. in Philosophy (Logic). That is literally the way it reads. This was back in the "old days," and I am sure with the help of Nuel I got two job offers before I had even defended my dissertation, and I accepted the one from Wayne State University. George Nakhnikian had built a legendary philosophy department there, and I started my career with colleagues such as Hector Castañeda, Edmund Gettier, Richard Cartwright, Alvin Plantinga, Robert Sleigh, Larry Powers (and Arthur Danto, Henry Kyburg, Keith Lehrer, had recently left, I think not because they heard rumors of my coming). My interview there was scary, as were the questions after my talk. Richard Cartwright asked a round of questions, and I tried to answer them one after the other. I wasn't particularly happy with my final answer, and I thought he likely wasn't either. But I was told by someone that in the meeting afterwards he said that he hadn't expected anyone to keep up with his questions far as I had, and I should get the job. Talks at Wayne State were like that, the question period being if anything more interesting than the talk. Roderick Chisholm used to regularly give talks at Wayne as a kind of preparation for the final version of his papers. My fellow junior faculty member Larry Powers was particularly famous for his questions.

I was very happy at Wayne. Echoing Al Plantinga in his "Profiles" book, life at Wayne State was one ongoing philosophical discussion, moving from office to coffee to lunch back to office, etc., interrupted only by teaching. Actually the teaching there was great too, and I had many excellent students, both graduate and undergraduate.

But all good things have to end, and the Wayne State philosophers began to leave, for various individual reasons. Ed Gettier and Bob Sleigh went to University of Massachusetts—Amherst, George Nakhnikian went to Indiana University to rebuild its Philosophy Department and took Hector Castañeda and Nino Cocchiarella with him, Dick Cartwright went to M.I.T. while his wife Helen got a permanent position at Tufts, etc. As luck would have it Yale showed an interest in recruiting me and I took a visiting position in Philosophy there, attracted by the fact that both Nuel and Alan had been at Yale. I guess I thought I was going to sit and watch to see whether U. Mass or IU was the new Wayne State department.

For various reasons I was not real happy with the Philosophy Department at Yale. I was treated well enough, in fact far better than the average junior faculty member. But that was part of the problem. All philosophy faculty were treated as equals at Wayne State, but at Yale I found a very hierarchical system. There was much discussion among junior faculty about who went to a dinner at the chair's home, who was invited to Mory's for drinks with a colloquium speaker, etc. And this was made worse by the fact that almost all of the faculty had their PhDs from Yale. I remember Fred Fitch, who I think was optimistic about my staying at Yale, telling me how he had spent his whole time since he was a student at Yale, and how when he once visited someplace he came to understand that he would never want to leave. For me it was quite the opposite, and when I ended up getting offers from both U. Mass and Indiana and I decided (with some difficulty) to accept the Indiana offer, I never even bothered to try to negotiate with the Philosophy Chair at Yale. But I made some good friends among my colleagues at Yale, including Fred Fitch, Bob Fogelin, Rich Thomason, and Bruce Kuklick—who later wrote "Philosophy at Yale in the Century after Darwin," *History of Philosophy Quarterly*, (July 2004), **21** (3): 313–336.

Second (and Last Academic Position): Back Home Again in Indiana. *Back Home Again in Indiana* is in effect the unofficial state song, and it certainly characterizes me. I went to Indiana University as an associate professor of philosophy in August 1969 (and was promoted to full professor in 1976). Having grown up in Indiana, I never expected to end up living in Indiana again and was pleased to find that southern Indiana had many more woodlands than cornfields, unlike the northern Indiana I was used to, and that Bloomington was a kind of oasis, culturally and politically. The pattern looked like 2 years at Wayne State, 1 year at Yale, etc. But this is where Sally and I have been ever since, even after our retirements.

When I joined the Philosophy Department at IU I not only found my old colleagues from Wayne State there (Castañeda, Cocchiarella, and Nakhnikian), but also Bob Meyer had been recruited there. As fellow logicians I not only had Bob and Nino, but soon also in the new Computer Science Department there were

George Epstein, Dan Friedman, Stu Shapiro, and Mitch Wand, who all had logic-related aspects to their work. This turned out to be very important to my development. George was an important figure in the multiple-valued logic community, Dan and Mitch's work on programming languages had a strong influence from the λ-calculus, and Stu was involved with AI and knowledge representation. And several years later Doug Hofstadter (AI, soon then to publish *Gödel, Escher, Bach*) and Ed Robertson (database theorist) joined the Computer Science Department.

George was the chair for the Fifth International Symposium on Multiple Valued Logic (1975), and he arranged for me to be program chair. I learned a secret thereby, which I have shared with a number of faculty involved in organizing a conference. You know everything that goes wrong, even if everyone else is ignorant and enjoying themselves immensely. I also should mention George for introducing me to Paul Erdős. Sally and I had invited George and his wife for dinner at our house, and at almost the last minute Erdős (I don't dare refer to him by his first name) called George and asked if he could give a lecture at IU. George of course said yes, and Sally and I included Erdős in our dinner. It was a wonderful evening. Erdős told us that he was funded by the Hungarian NSF to travel and stay out of Hungary. He clearly was a practiced guest. He had clearly read the local newspaper and discussed politics in Indiana, did a couple of magic tricks for our children, and finally would not let Sally and me near the kitchen as he cleaned up after dinner. I remember mentioning a couple of open problems in relevance logic, but he didn't bite. He clearly had larger fish to try. Therefore I missed my chance to have the Erdős number one, and had to content myself with three (Erdős, Joel H. Spencer, Belnap, Dunn, or Erdős, Marcel Erné, Mai Gehrke, Dunn).

I have been involved in multidisciplinary activities, possibly because logic is one of those areas that cannot be neatly pigeonholed into the usual academic departments. In fact, when I was a visiting assistant professor at Yale, my position was funded by the Departments of Philosophy, Electrical Engineering, and Linguistics, and I presented several lectures in a Mathematics seminar led by the famous logician Abraham Robinson.

When the computer science department installed its first time-sharing computer system (VAX 11/780—I believe in 1978), I was given a Unix account by Ed Robertson, a database theorist and then chair of the Computer Science Department. A few weeks later, when Ed asked how I liked Unix, eyes sparkling, I responded: "All my career I've studied formal systems, and now at last I have one that is truly responsive."

I had a number of opportunities to leave IU, but my principle was to pursue them only if I was prepared to leave. I believe I took only two offers seriously. One of these occurred in the late 1980s, and the dean of Arts and Sciences said, when I met with him, "I don't think I have ever seen one like this before." Although I was fully prepared to leave, IU responded in the most generous way possible and I stayed. This had something to do with the schools, housing, and traffic near the competing institution, but it is not a coincidence that the year 1989 was particularly eventful, in titles. I became the Oscar Ewing Professor of Philosophy and a

Professor of Computer Science. And the generous response allowed me to recruit a number of excellent logicians to IU including Jon Barwise, Anil Gupta, and Alice ter Meulen. One good thing leads to another and Jon was able to recruit Larry Moss and Slawomir Solecki in Mathematics. We already had Bill Wheeler in Mathematics, Daniel Leivant in Computer Science, and in Philosophy Nino Cocchiarella, David McCarty, and Raymond Smullyan, not to mention Geoffrey Hellman (philosophy of mathematics), Ed Martin (Frege), and Paul Spade (medieval logic). So IUB had at that time one of the best programs in logic anywhere. Jon was the first director of what is now the Program in Pure and Applied Logic (the director is now Larry Moss).

I somehow have been successful in combining research, teaching, and service. My research is reflected in more than 100 publications, including five coauthored books and over 150 talks at conferences and universities. But when I formally retired from Indiana University in 2007 I was amazed to count back and find that I had spent over half of my 38 years there as an administrator at the chair level or above. I was twice chair of the Department of Philosophy, and in the early 1990s served as the first executive associate dean of the College of Arts and Sciences. And I ended my official career at IU as the founding dean of the School of Informatics (now the School of Informatics and Computing), then the first completely new school at IU in a quarter of a century. I must like to start things since I was also involved in the creation of the Cognitive Science Program, and also the Program in Pure and Applied Logic.

Besides my official administrative service, I led or served on numerous faculty committees at all levels (over 75 campus and university committees alone). In particular I have been on practically every committee having to do with computing at IU, from chairing the campus word processing committee 1985 to chairing the university's Information Technology Committee, which put together the strategic plan for IT at IU in 1999.

Perhaps the most frustrating committee I have ever served on was the Campus Calendar Committee. This was early in my career and it took me a while to figure out that I was probably the only one on the committee without a vested interest. The other members represented athletics, student housing, the laboratory sciences, anything where schedules really mattered. My wife Sally later served on the same committee and had much the same experience.

My academic service outside of IU included being an editor of the *Journal of Symbolic Logic* and the *Journal of Philosophical Logic* (and on the editorial boards of a number of other journals). Also, I was president of the Society for Exact Philosophy and vice chair of the Computing Research Association's IT Deans Group. I accepted the Mira Award from TechPoint (the Indiana state IT association) in 2002 for the School of Informatics. I also received the i-School Caucus's "Bookends Award" for "vision and pioneering leadership in the formation of the i-Schools community." I have been on external review committees for a number of universities, and served on academic advisory boards for Carnegie Mellon University, Spelman College, the University of Cincinnati, and the University of Dubai.

I was elected (2010) a fellow of the American Academy of Arts and Sciences. My other favorite honors include being awarded the IUB Provost's Medal and being appointed as a Sagamore of the Wabash by the Governor of Indiana. (From Wikipedia: "Sagamore was the term used by Algonquian-speaking American Indian tribes of the northeastern United States for the tribal chiefs.")

Occasionally campus conversations became confused at the mention of "Dean Dunn," a confusion that arises because my wife, Sally Dunn was dean of the freshman division. The confusion continues with "Jon Dunn" as our son, Jon William Butcher Dunn, is director of technology and an assistant dean for the IUB Library. Our daughter, Jennifer Knight Dunn, works as a senior geographic information specialist, and both of our grandchildren love math—so there must be something in the genes.

Somewhat ironically, given my interest in technology, my wife and I live in a 100-year old house, and I have been active in historic and neighborhood preservation. I have also been involved in other forms of civic service, for example, serving on strategic planning task forces of the Indiana Chamber of Commerce and the Indiana Health Industry Forum. Most recently, I serve on the Board of HealthLINC (appropriately for my academic interests, the regional health information exchange) and was president of the board for 3 years.

I directed 17 Ph.D. dissertations. It is difficult to talk about my graduate students because I love each and every one of them, just like my children (but of course there were many more graduate students). Some of these did work not really related to my own, and I was really just their "supervisor." Others did work closely related, even joint with my own. Some of these were invited to contribute to this volume, and I greatly appreciate their contributions and will let them speak in their own words. The dissertations I directed were mostly in philosophy but also in computer science and mathematics. All but three of these were in logic and the other three in philosophy of mind (reflecting my own ambivalence, as indicated earlier, between these two subjects). 14 of those now hold permanent positions at universities, two have equivalent positions in government labs, and 1 is an IT entrepreneur (who also published a book on philosophy of mind with Oxford University Press). I am very proud of them all.

Around the World. We have been residents of Indiana since 1969, but this has not prevented Sally and I from travelling the world together, and with our two children when they were young. I have been a visitor at a number of different universities. In 1975–1976 I went on a research Fulbright with my family to the Australian National University. This was my first of a number of visits to Australia, and it was a tremendous experience. Bob Meyer, Richard Routley (later Sylvan), and Val Routley (later Plumwood) were there, and Len Goddard and Nuel Belnap also were visitors (Nuel just for a month). Errol Martin and Michael McRobbie were among the postgraduate students. Michael now claims to be a Hoosier, and indeed he is President of Indiana University.

It was an absolutely incredible environment for doing relevance logic. I returned to Australia in 1983 to teach a seminar at the University of Melbourne, and again

found an incredible environment for relevance logic, with both Len Goddard and Michael McRobbie at Uni Melbourne, Ross Brady at LaTrobe Uni, and Lloyd Humberstone at Monash Uni. In between I spent close to a year (1978) in Oxford with my family, and courtesy of Dana Scott visited the Mathematical Institute. Among the Oxford faculty in logic, besides Dana, were Robin Gandy, Michael Dummett, and Dan Isaacson, and visitors that year included Dov Gabbay, Rob Goldblatt, Saul Kripke, and Jonathan Seldin. I have also visited the University of Pittsburgh twice, once as a visiting fellow at the Center for Philosophy of Science and most recently (after I retired) as a visiting professor. It was a real privilege to teach in the seminar room that was sadly graced with photographs of many of my deceased teachers, and to rekindle by friendships with Nuel Belnap, Anil Gupta, and others.

In 1985, with the support of a fellowship from the American Council of Learned Societies, I visited the University of Massachusetts—Amherst. It was great to see my former teacher Bruce Aune, and my former colleagues Ed Gettier and Bob Sleigh, but the purpose of my visit was to spend time with Gary Hardegree to finish the book *Algebraic Methods in Philosophical Logic* which we had begun when Gary visited Indiana a couple of years earlier.

Since my formal retirement in 2007 I have continued to attend conferences and speak at universities, often combining this with some tourism. In the first 6 months of 2015 for example Sally and I travelled to India, England, and Russia.

Research: Pencil, Paper, and a Wastebasket. There is the old joke that mathematics is cheap to fund because all you need is a pencil, paper, and a wastepaper basket. Only one field is cheaper to fund, namely philosophy. Because there you can do without the wastepaper basket. Since logic has a part of mathematics and a part of philosophy in it, I am not sure whether I needed the wastepaper basket. But I do know that it would have been hard to combine my research and administrative careers (teaching too) if I had to manage a laboratory, visit distant archives, etc. Being able to do my work with pencil and paper (and more lately a computer, which fortunately has a delete key) was a huge plus. Also it helped with my multitasking—I could be in a meeting, seeming to take scrupulous notes, when in fact I was trying to prove a new theorem.

I had some early publication problems. The first was that Nuel Belnap suggested that I submit my dissertation to the North-Holland series: Studies in Logic and the Foundations of Mathematics. This was very famous at the time, and so I did so quite willingly. After considering it a year or two they replied that they were no longer publishing dissertations. I think this policy changed again a year or two later. Murphy's Law! In the meantime I had not done the usual thing of submitting various chapters (rewritten of course) as articles to journals. Instead, I accepted the opportunity to have some of these chapters published as a "contributing author" to Anderson and Belnap's *Entailment: The Logic of Relevance and Necessity*, vol. 1. This was a great opportunity, but I am afraid that it meant that many of my original contributions got a bit lost in the literature. I was more than paid back when I

became a "first class" author of Anderson, Belnap, and Dunn's *Entailment: The Logic of Relevance and Necessity*, vol. 2.

My dissertation (Dunn 1966), *The Algebra of Intensional Logics*, was about the algebraic treatment of relevance logics. The name itself was a marketing error (the word "intensional" had not yet become proprietary to modal logic). It would have been better to call it simply "The Algebra of Relevance Logics." The two major themes in the dissertation were algebraic foundations for the algebras of the relevance logics E and R, and in particular their first-degree entailments (entailments between truth-functional formulas). The first rested on viewing implication as residuation on an underlying monoid (in the case of R what I labeled as a De Morgan monoid) and anticipated algebraic treatments by others of various so-called substructural logics. Ultimately this led to my super-generalization called generalized Galois logics (or Gaggles). More on these later.

The second theme came from viewing first-degree entailments as corresponding to quasi-Boolean algebras (Białynicki-Birula and Rasiowa) or equivalently De Morgan lattices (Monteiro). Białynicki-Birula and Rasiowa (1957)[4] gave an interesting representation of these lattices, and I gave an equivalent representation together with an interpretation of that representation. These, and other representations, were published by me only as an abstract (Dunn 1967b). As it turns out the representation of Białynicki-Birula and Rasiowa was in effect published by Richard and Valerie Routley in 1972 as a semantics for first-degree entailments (with no reference to Białynicki-Birula, Rasiowa, or myself).[5]

The story of my own representation is more complicated. In my dissertation (1966) I had a result where each element of a De Morgan lattice was to be viewed as a pair of sets ($X+$, $X-$), and thus indirectly this was an assignment to a sentence. $X+$ was the "topics" that the sentence gave positive information about, and $X-$ was the set of "topics" that the sentence gave negative information about. You can see from this the beginnings of my interest in informational semantics for logics.

I pointed out that a sentence could give both positive and negative information about the same topic, as well as giving neither. But I did not have the nerve, though it crossed my mind, to speak publicly of a sentence being both true and false (or neither, though this was less controversial because of the Łukasiewicz 3-valued logic). I finally took this public position in my talk in a joint symposium of the American Philosophical Association in 1969 and the Association for Symbolic Logic on "Natural Language vs. Formal Language." Because of the nature of the symposium, I gave this talk and wrote the accompanying paper (unpublished, available online at www.philosophy.indiana.edu/people/papers/natvsformal.pdf) in a very philosophical style—almost no symbols and certainly no mention of the 4-valued lattice that was so much a centerpiece of my dissertation. I thought this was a good way to help "sell" the ideas, but perversely it got in the way of

[4]Białynicki-Birula, A. and Rasiowa H. (1957). On the representation of quasi-Boolean algebras, *Bulletin de l'Académie Polonaise des Sciences* **5**: 259–261.

[5]Routley, R. and Routley, V. (1972). The semantics of first degree entailment, *Noûs* **6**: 335–359.

connecting those ideas to the algebraic way of looking at things to be made popular by Nuel Belnap.

For no sooner had I done this than Nuel Belnap published his own version of the 4-valued semantics in two separate venues ("How a Computer Should Think," and "A Useful Four-valued Logic"). In each of these he carefully cited my work, but almost no one seemed to notice and there was much talk of Belnap's 4-valued logic. Over the years this has changed, and now I often see mention of the "Belnap–Dunn logic," or even the "Dunn–Belnap logic." I do not mean to suggest that the name Belnap not be linked to this logic. Nuel did many interesting things in his two papers on the 4-valued logic, both technically and promotionally, e.g., his connecting it to bilattices and his emphasizing its usefulness to computer applications. Years later, when Yaroslav Shramko and Tatsutoshi Takenaka were visitors at IU, we worked on 8- and 16-valued trilattices.

I had of course hoped that the 4-valued semantics could be extended beyond first-degree entailments to encompass the whole of the systems R and E. I even managed to do a 3-valued version of this for the logic R-mingle allowing a sentence to take both truth values, but not neither), essentially modifying the Kripke/Grzegorczyk semantics for the intuitionistic sentential calculus, so as to allow that a sentence might be both affirmed and denied in a given "evidential situation." The binary accessibility relation was interpreted as one evidential situation extending another.

I think it was the 4-valued approach, and the Białynicki-Birula and Rasiowa/Routleys approach to first-degree entailments that led me to be a bit obsessed with negation. I just did a search and found that the word "negation" occurs 16 times in my CV, including talks as well as publications. Besides the work I did in my dissertation and early on regarding negation as De Morgan complement, I discovered that the Routleys' * operator can be replaced with a binary relation of "incompatibility" (much as in the modeling of quantum logic), and that a^* can be viewed as the weakest information state compatible with a. Various properties can be put upon the incompatibility relation to get various logics. I also learned that when negation is viewed this way, the representation of both negation and implication can be viewed as falling under a common abstraction. This gives an algebraic approach to these, and other connectives and their semantics via representations of their underlying algebraic structure. This can be viewed as growing out of the work relating representations and semantics begun in my dissertation, but vastly generalized. It was also motivated as a generalization of Jónsson and Tarski's (1951–1952) work on "Boolean algebras with operators" so as to apply to relevance logic and other substructural logics.

Thus I began in Dunn, 1991, to publish on what I called generalized Galois logics, or GGLs, which I insisted should be pronounced "Gaggles," not "Giggles." (You are encouraged though to giggle here. :) This is probably the abstraction I created/discovered of which I am the most proud and it resulted in perhaps my longest thread of publications, some joint with Gerry Allwein, Kata Bimbó, Mai Gehrke, Gary Hardegree, Alessandra Palmigiano, and Chunlai Zhou.

One of the most exciting, and also frustrating, of my achievements was providing a Gentzen system for the positive fragment of the logic R of relevant implication. I had the idea of modifying the usual Gentzen sequents so as to allow for two kinds of "commas" (actually using a semi-colon for one of these), so as to mimic the two kinds of conjunctions available in R (intensional as well as the usual extensional). Anyone who has ever proved a cut elimination theorem knows the difficulty in getting every case to work, and the excitement when they all click.[6] I thought I was only another day (and maybe a night) away from adding negation, and then another day or so away from proving decidability. (Again this was before Alasdair Urquhart obtained his undecidability result.) Regarding negation, a number of other researchers worked on extending the Gentzen system for R_+ so as to include it, and certainly the most persistent of these was Ross Brady. Nuel Belnap ultimately came up with his Display Logic, which allowed for adding De Morgan negation to R_+, but there was a price to pay for this—he also had Boolean negation as part of his basic structure.

Perhaps the single publication that pleased me the most was a joint publication with Bob Meyer (Meyer and Dunn 1969) proving the admissibility of Ackermann's rule γ for the systems R and E. In his paper in this volume Alasdair Urquhart shares some things I told him, so I will not tell the stories again about how Bob and I produced the proof (working first independently and then together). Bob and I were once students together, later colleagues, and always friends, at least until his regrettable death. I think I do not reveal any secrets if I say that Bob was somewhat of a character, albeit a loving and much loved one. After Bob moved to Australia he would often visit the US, driving a rental car to see his son and his family who lived near Bloomington. Usually Bob would call us ahead of time with an hour or two's notice, and then he would drop by our house all set to do logic. Bob and I, working with Hugues Leblanc extended the admissibility of γ to first-order versions of R and E.

Writing this autobio has led me to reflect on my CV, searching for patterns. One thing I noticed is that I have done almost no work on first-order logic, classical or nonclassical. The exceptions are Dunn and Belnap (1968b), Meyer et al. (1974), Dunn (1976c), and my papers on relevant predication (Dunn 1987b, 1990a, b, c). This was at least partly a conscious decision on my part. There are so many different choices to make, e.g., constant domain, expanding domain, individuals or individual concepts, infinite meets/joins, cylindric, polyadic algebras, etc., I wanted to stick with the basics.

One of my most cited papers was a survey of relevance logic (Dunn 1986), updated in (Dunn and Restall 2002).

I have to confess that this search for patterns in my CV confirms my antecedent view that I had no grand research program. I have followed where the paths have

[6] I must mention that Grigori Mints did the same thing at roughly the same time, and when we met each other for the first time many years later he agreed with me about both the excitement and the frustration.

led me. I was very fortunate to have had the teachers, colleagues, and students I have had. It is only with reflection, when asked what the title should be for this volume, that I suggested "Information Based Logics." Information has been a common theme throughout much of my research, but it was never intended as a programmatic theme. That the concept of information turned out to be so useful in itself proves its importance, at least to me.

I have also worked on quantum logic (Dunn 1981, 1988), and particularly in recent years on the relationship of quantum logic to quantum computation (Dunn et al. 2005; Dunn et al. 2013). Representations play an important role again in these last two. Zhenghan Wang was a faculty member in the IU Mathematics Department, who is now a lead researcher in Microsoft Research's "Station Q" project to build a topological quantum computer.

I have done a little to advance the actual application of relevance logics (you would think they would be "relevant" to something :)), particularly the system R. Perhaps my most sustained attempt (four papers around 1990) was to use relevance logic as a means of defining relevant predication and then using that to define intrinsic properties, essential properties, and internal relations. I also got involved in the idea, pushed by Bob Meyer, of basing mathematics, particularly arithmetic, on relevance logic (Dunn 1979b, c). But despite many interesting results by Bob Meyer, Ross Brady, Chris Mortensen, Zach Weber, myself, and others, it still seems to me to be a not very well-developed area.

My dream application would be to have some version of relevance logic undergirding searches on the Web (where notoriously one can find any side of a question that one wishes). I have written about this in my recent paper (Dunn 2010) "Contradictory Information: Too Much of a Good Thing," and offered my own preliminary thoughts about how this might be done.

Another small theme in my work has to do with relation algebras. In Dunn (1982b) I showed how De Morgan lattices (I called them "quasi-Boolean algebras" following Białynicki-Birula and Rasiowa) could be represented as relations closed under intersection, union, and complement of converse. In Dunn (2001b) I in effect extended this using the idea of the Routley–Meyer ternary accessibility relation to show how the relation algebras that satisfy Tarski's equations for relation algebras can be represented using this relation. The representation ends up showing that relation algebras can be represented as sets of relations, not as relations themselves, since a well-known result of Lyndon showed that relation algebras cannot be represented in the natural way as relations. In Dunn (2014b) I related this to work by Johan van Benthem and Yde Venema on what they dubbed as "Arrow Logics." I had the nice occasion to work with Kata Bimbó and Roger Maddux on a paper (Bimbó et al. 2009) that contains a series of results relating relation algebras and relevance logic.

I was fortunate to have Katalin Bimbó as a student and later as a research associate at Indiana University when she and I wrote *Generalized Galois Logics: Relational Semantics of Nonclassical Logical Calculi* (2008), using a draft as a text for a graduate seminar we co-taught. Kata and I have published a number of things together. I want to thank Kata for including me as a collaborator on a couple of

grants she has received. She and I have been working on several projects together, and developed some novel Gentzen systems. Using these we were able to solve the problem of the decidability of the implicational fragment of the logic of Ticket Entailment $T_{\rightarrow}$ (a problem that had been open since circa 1960), and hence by the Curry–Howard Isomorphism, the decidability of the inhabitation problem for simple types by the corresponding set of combinators. Another use of them has been to show a certain logic decidable that had been thought to have been proved undecidable. Our paper is still in the refereeing process so I should not say anything more.

Our most recent project is to work on a conceptual history of the development of the ternary relational semantics for relevance logic and some other logics. This is often referred to as the "Routley–Meyer semantics." In the context of that project I have been working on various intuitive interpretations of the ternary accessibility relation. I was up to an even dozen on the last talk I gave on the subject. Among these interpretations are of course the informational interpretations due to Urquhart and Kit Fine: the information *a* when combined with the information *b* equals (or is included in) the information *c*. But two are "dynamic" informational interpretations based on von Neumann's idea of a "stored program," where one or both of the information states *a* and *b* can be thought of as standing for an action (binary relation). (Dunn 2001a, c, 2003). Dunn and Meyer (1997) show how this can be applied so as to give a semantics of various combinatory logics (the combinators replacing the structural rules), and Bimbó and Dunn (2005) show how to apply it to Kleene Logic and other "action logics."

The latest to appear on my list was something that should have been there for a long time, but wasn't. Dunn (2015) actually gives an interpretation of the ternary relation in terms of (contextual) relevance: information state *b* is relevant to information state *c* in the context of information state *a*.

Another way I have been spending my time since I "retired" is as an affiliate (and member of the advisory board) of the Info-Metrics Institute of American University. Its founding director Amos Golan defines "info-metrics" as "the science and practice of inference and quantitative information processing." What could be nicer? The first time I participated in an Info-Metrics workshop I seemed to hear John Denver singing, "Coming home to a place he had never been before." Amos and I are involved in a joint project to understand, perhaps define, the value of information.

Ruminations. I was first drawn to logic as an undergraduate because of its certainty. I was interested in deductive logic, and not probability and statistics, because they were tools for dealing with uncertainty. Classical logic was the one true logic. Already as an undergraduate I had inklings that there were matters of choice in logic. What set theory did one use, how are numbers to be represented, why not limit proofs to the constructive ones, etc. And when I went to graduate school and was exposed to relevance logic I never truly accepted the system E of entailment as the one true logic, as Alan Anderson is supposed to have done. I quickly came to notice that there were various systems of relevance logic to choose from, and that

they could not do everything, and in particular it seemed that they could not do their own metatheory.

Arthur Prior in his *Past, Present and Future* (1967) said: "The logician must be like a lawyer … in the sense that he is there to provide the metaphysician, perhaps even the physicist, the tense-logic he wants, provided that it be consistent." I only came across this quote recently, but I once had the privilege of being introduced by Timothy Smiley when I gave a lecture at Cambridge, and Tim said that I was a "lawyer of logics." Just as a lawyer might draw up various legal documents for you according to your specs, so I might draw up various logics. Do you want excluded middle, do you want distribution, etc.? Here are several logics to choose from. I was somewhat surprised at his description of me, but quickly came to accept its main point. Except I wouldn't describe myself so much as a lawyer of logics, but more as an engineer of logics—a maker of tools. As the inventor of the World Wide Web Tim Berners-Lee said: "We are not analyzing a world, we are building it. We are not experimental philosophers, we are philosophical engineers." See https://www.academia.edu/5222185/An_interview_with_Tim_Berners-Lee.

Man has been defined in the Aristotelean tradition as a "rational animal." Benjamin Franklin defined man as "a tool making animal." Both of these definitions seem to deny contemporary evidence that rationality and tool making, in various degrees, extend to other animals (and I add that they are not always found in humans). But there is no doubt that these are important characteristics of humans. Primitive man had primitive tools, and primitive man also had primitive rationality. As humanity developed, it developed more sophisticated tools, and these included tools, even specialized tools, for reasoning. Now, as we turn more and more of our reasoning over to "the machines," it is important that we outfit them with not just a general-purpose logic, but also the appropriate specialized logics that they will need to solve more and more of our intellectual problems.

Let me close these ramblings with a related observation about definitions, and in particular about the definition of "information." Although I have written much about information, I have never really defined what it was. Perhaps the closest I came was when I said in (Dunn 2008, p. 581):

> I like to think of information, at least as a first approximation, as what is left from knowledge when you subtract, justification, truth, belief, and any other ingredients such as reliability that relate to justification. Information is, as it were, a mere "idle thought." Oh, one other thing, I want to subtract the thinker.

Or, to put it dually, I have used a number of different definitions as I have discussed information from both the classical Shannon, Carnap, Bar-Hillel framework and the nonclassical 4-valued framework. This is the way I think it should be. Our language typically has all the precision of a hunk of rock. But if it is a potentially useful rock then it is important to shape it and sharpen it for the purpose at hand. There are analogies in physics. A hunk of matter can be assigned either a weight or a mass—its weight becoming meaningless without gravity. The rate of its movement can either be speed or velocity (the latter adding a vector for direction). Its momentum can be…. The definition depends upon the purpose. Oops, I just

revealed that against all of my platonic instincts when I first entered philosophy, I have somewhere along the way become a pragmatist. I now worship the trinity of Charles Sanders Peirce, William James, and John Dewey.

I close by emphasizing something very important. The fact that I take a pragmatic attitude toward both logics and definitions does not mean that all is conventional or arbitrary. I believe strongly in an underlying reality. Rocks have underlying properties, and that it is because of these that flint can be shaped into a useful knife for say cutting flesh, whereas pumice makes a useful tool to remove dead or dry skin without cutting. This is not a mere matter of convention—try to reverse these if you don't believe me. This was nicely stated by Frank Herbert in his Book three of *Dune*: "Deep in the human unconscious is a pervasive need for a logical universe that makes sense. But the real universe is always one step beyond logic."

OK—sounds like I need to stop writing and get back to work. :) However I do want to mention one new thing that is relevant to the title of my autobio. The Indiana University School of Informatics and Computing is adding a program in Intelligent Systems Engineering in 2015–2016. I stepped down as dean too soon. :)

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