

Obituary

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It might surprise some young researchers that the first recipient of the ACL LifeTime Achievement award,¹ Aravind Joshi, was so often compared to “Yoda,” one of the oldest and most powerful of the Jedi Masters in the Star Wars universe. But Aravind was also one of the kindest, wisest, and most justly celebrated people that one was fortunate to know.

When Aravind received the award in 2002, at the age of 73, he said that he hoped his lifetime wasn’t over. Fortunately, it wasn’t: For the next 15 years, Aravind continued to enjoy time spent on research; advising students and younger colleagues; attending ACL conferences both at home in the United States and in far-flung places such as Sydney, Singapore, and Jeju Island; and enjoying the company of his extraordinary wife, the embryologist Susan Heyner, his daughters, Meera and Shyamala Joshi, and his grandchildren, Marco and Ava. Then on 31 December 2017, Aravind died peacefully at home in Philadelphia, sitting in his favorite chair, at the age of 88.

Aravind Joshi was born in Pune, India, on 5 August, 1929. He sailed to the United States in 1954 to study electrical engineering (EE) at the University of Pennsylvania, after he was rejected by Harvard because his application, mailed from India, arrived a day late. While completing his M.Sc. in EE, he worked as an engineer at RCA (Camden, NJ), and then while completing his Ph.D. in EE, as a research assistant at the University of Pennsylvania’s Department of Linguistics. After being awarded his doctorate, Aravind joined the Penn faculty, remaining in EE until the brilliant and prescient Saul Gorn, who chaired Penn’s Graduate Group in Computer and Information Science, convinced the University to establish a new academic department of Computer and Information Science (CIS). Aravind joined this new department as a full professor and Chair, grateful that Saul Gorn had argued so forcefully that the new department should embrace the science of information as well as the practical study of computers and computing. Allowing for such broad intellectual content allowed the evolving CIS Department to constantly reach out to researchers in other disciplines—including those at Penn’s Wharton School of Business, as well as at the Departments of Linguistics, Psychology, Philosophy and Bioinformatics.

Aravind remained Chair of CIS for an incredible 13 years, until 1985—continuing throughout this time to carry out cutting-edge research, to serve leadership roles in both ACL (as President in 1975 and then as Book Series Editor from 1982) and IJCAI

¹ <https://www.let.rug.nl/nerbonne/misc/joshi-laudatio.html>.

(as General Chair of the 1985 IJCAI Conference), while at the same time giving generously to his students and colleagues. As General Chair of IJCAI, Aravind reached out to invite Soviet refusenik computer scientists, linguists, and mathematicians to attend. Several of the invitees had been arrested and were serving long sentences in labor camps. Although Aravind knew that they would never be able to attend, the invitation reassured them that their academic accomplishments would be recognized internationally, despite the political environment.

One of Aravind's major achievements during his time as Chair of CIS was co-founding, with psycholinguist Lila Gleitman, Penn's famous Cognitive Science Program. Funded initially by the Sloan Foundation, the Program received further funding from the National Science Foundation in 1991, to become Penn's world-famous *Institute for Research in Cognitive Science* (IRCS).² Aravind and Lila co-directed IRCS until 2001, contributing a stream of over 100 postdocs from linguistics, psychology, computer science, philosophy, neuroscience, and mathematics that it hosted and nurtured before closing its doors in 2016.

Meanwhile, Aravind's five decades at Penn saw his research and inventions span much of what we know as computational natural language processing, including

- **parsing** using finite state transducers, with Aravind's early FST parser reimplemented as "A Parser from Antiquity" (Joshi and Hopely 1996). Aravind always encouraged his students and colleagues to go back and re-examine earlier work. In fact, he once suggested that students in introductory CL courses be asked to look at the literature and reconstruct some old system as a way of both shortening the period to re-discovery and giving students a better historical grounding in the field.
- **grammatical formalisms**, most notably the development and detailed characterization of the "mildly context-sensitive" Tree Adjoining Grammar (TAG) in both its original and lexicalized forms (LTAG), providing enough power to handle the range of phenomena in human language syntax while remaining computationally tractable (Joshi and Schabes 1997).
- **cooperative Question Answering** and the range of inference it requires (Joshi, Webber, and Weischedel 1984, 1986)
- **prominence in discourse** (Grosz, Joshi, and Weinstein 1995; Walker, Joshi, and Prince 1998), in the form of work on "Centering," which was meant to account for ease of inference and the use of anaphoric expressions, linked by the observation that an entity that can be accessed with an expression as small as a pronoun must also be prominent.
- **discourse and syntax** (Webber et al. 1999, 2003), where Aravind reconceptualized discourse connectives in the framework of LTAG, culminating in development of the NSF-funded Penn Discourse TreeBank³ and similarly annotated corpora in Chinese (Zhou and Xue 2012, 2015), Hindi (Oza et al. 2009), Turkish (Zeyrek et al. 2010), and biomedicine (Prasad et al. 2011).

² <https://www.ircs.upenn.edu/>.

³ <http://www.seas.upenn.edu/~pdtb/>.

Here it is worth saying a bit more about two aspects of Aravind's work: His work on grammar formalisms and his work on discourse. In the early 1980s, Aravind identified a set of computational properties that provided an informal definition of a class of Mildly Context Sensitive (MCS) languages that he claimed properly included all human languages and was properly included among the much vaster class of context-sensitive languages. These properties were: (a) polynomial parsability; (b) the constant growth property (which excludes languages with unbounded gaps in the length of sentences, of which an artificial example is the indexed language a^{2^n} , made up of strings of 2^n a's); and (c) a limit on crossing dependency of the kind seen in the artificial tree-adjoining language (TAL) $a^n b^n c^n$, and hence on permutation-completeness (Joshi and Levy 1982; Joshi 1988; Joshi, Vijay-Shanker, and Weir 1991). TAG was the first fully formalized theory of grammar to be proved to characterize only languages within the MCS class, and provided the basis for further proofs of MCS expressive power for several other constrained grammar formalisms that were developed around the same time via their (weak) equivalence to TAG.

One natural generalization of TAG was to the Linear Context-free Rewriting Systems (LCFRS) or Multiple Context Free Grammars (MCFG). These are considerably more expressive than TAG, and were for a while conjectured to provide a formal definition of MCS languages. As a result, other formalisms that were considerably more expressive than TAG have laid claim to the Joshian mantle of Mild Context Sensitivity, showing that it has become a highly influential meme in the field.

However, it has since been shown that the artificial permutation-complete language MIX3, consisting of *all permutations over the strings of* the TAL $a^n b^n c^n$, is a Multiple Context Free Language (MCFL). Thus, the formal characterization of the MCS class is currently a matter for debate. Nevertheless, TAG itself remains among the least more expressive formalisms than CFG that is known. Now the more important question is whether TAG or one of the other weakly equivalent formalisms is *expressive enough* to capture the full range of phenomena actually exhibited by natural languages, as argued in Frank (2004).

Aravind's interest in discourse semantics has been long-standing, going back at least to the mid-1970s and the publication by Academic Press of *Subject and Topic* (Li 1976). The collection contained two articles that Aravind annotated extensively—Li and Thompson's article on topic-prominent languages and Lehmann's article on the history of topic-prominence in Indo-European. Aravind's interest in the notion of topic-prominence and the discourse semantics of information structure seems to have been stimulated by his knowledge of Sanskrit and of his native language, Marathi, both of which exhibit aspects of topic-prominence and ergativity. Together with the article in the same collection by Keenan and Schieffelin, this concern with prominence in discourse seems to have fuelled his later work on Centering and prominence in discourse.

Later on, when Aravind started to look at discourse connectives (Webber et al. 1999, 2003), his concerns went deeper than the obvious parallels between lexically anchored trees for sentence-level syntactic analysis and trees lexically-anchored on discourse connectives that could be used in going beyond sentences to small units of discourse. Rather, his concerns were grounded in his growing belief that too many constructions found between the start of a sentence and its final punctuation didn't really belong to syntax. In particular, Aravind described parentheticals, epithets, extraposed predicates, and sentential relatives as "constructions that require a skilled tree surgeon to force a single tree over a sentence." Whereas syntactic analysis may simply punt by attaching a parenthetical such as "John thinks," in "Mary, John thinks, will win the race," to the root node of its parse tree (just as "Mary" is attached to the root node as its subject),

for Aravind, the two attachments (of the subject and of the parenthetical) were completely different, with the attachment of the parenthetical belonging to an orthogonal dimension, in a “paratactic” relation, another characteristic of many constructions in Sanskrit and Marathi. He felt the same about epithets like “damn” in “I finished the damn book”: “damn” should be attached along an orthogonal dimension because it bore a different semantic relation to “book” than say “thick book” or “book about insects.” For Aravind, discourse provided this orthogonal dimension, reducing the number of “no-win” decisions that followed from insisting on a single parse tree over a sentence.

Having spent so much time with sentences from the Penn TreeBank (constructed from articles from the ACL/DCI *Wall Street Journal* corpus), Aravind found the examples that made the most convincing demand for distributing the burden between syntax and discourse to be *attribution phrases* (Dinesh et al. 2005). He felt that sometimes an attribution phrase like “the company says” belongs to sentential syntax, feeding its semantics up to that of the sentence as a whole (as in the contrast expressed in “Observers say negotiations have halted, while the company says it is talking with several prospects”). In other cases, however, such as the concession expressed in “There have been no orders for the Cray-3 so far, though the company says it is talking with several prospects,” he felt that the attribution phrase belongs to an orthogonal discourse dimension, because what is contrary to expectations associated with the lack of orders for the Cray-3 is not the company (Cray) saying something, but rather the existence of several prospects that it is talking with. Both analyses become possible if syntax and discourse can provide distinct bases for analysis. Hence Aravind’s interest in both.

Although Aravind’s ingenuity was all his own, the inventions he was involved with were possible only because of his unprecedented inclusion of linguists, psychologists, philosophers, and mathematicians, as well as computer scientists and engineers, in his work. In recognition of Aravind’s inclusionary spirit and many achievements, Penn’s CIS Department hosted *JoshiFest* in Fall 2012, an all-day symposium of talks and encomia in his honor. The complete program of talks and presentations is available for viewing at <https://www.cis.upenn.edu/about-cis/events/joshi-fest/program.php>.

JoshiFest was neither the first nor the last time that Aravind’s achievements were publicly recognized. Besides the ACL Lifetime Achievement Award in 2002, Aravind was the recipient of the 1997 IJCAI Award for Research Excellence; the 2003 David E. Rumelhart Prize of the Cognitive Science Society; the 2005 Benjamin Franklin Medal in Computer and Cognitive Science (awarded by the Franklin Institute in Philadelphia); and the Henry Salvatori Chair in Cognitive and Computer Science. He was elected to the National Academy of Engineering in 1999 and named a Fellow of IEEE in 1976 and the Association for Computing Machinery (ACM) in 1998. In 1990, he became a Founding Fellow of the Association for the Advancement of Artificial Intelligence (AAAI), and in 2011, a Founding Fellow of the ACL. Most recently, the Charles University (Prague) recognized Aravind’s accomplishments—including his joint work with Professor Eva Hajicova’s group at Charles University—with the award of *Doctor Honoris Causa* in physics and mathematics.

In his obituary for Aravind Joshi in *Language Log*,⁴ Mark Liberman quoted posts from Bob Frank (whose Ph.D. thesis Aravind supervised, and who is now Chair of Linguistics at Yale) and Julia Hockenmaier (a postdoc at IRCS following her Ph.D. from

4 <http://languagelog.ldc.upenn.edu/n11/?p=36048>.

the University of Edinburgh, now an Associate Professor at the University of Illinois (Champaign-Urbana). Because both posts express their author's thoughts and feelings so well, they seem an appropriate way to close this obituary.

I just heard the crushing news that Aravind Joshi passed away yesterday. It's hard for me to overstate how profoundly Aravind influenced my career and my life, since he took me on as his PhD student 30 years ago. The content of his work laid the foundations for so much of what I have worked on over the years, and his vision of interdisciplinary interaction shaped how I see the field. I will never forget his insatiable curiosity and intellectual energy, his remarkable ability to identify good problems and insightful solutions, and his gentle kindness and humanity. And I will so much miss the boyish excitement he exuded whenever he would share his latest ideas with me. Thank you for everything, Aravind. You will be missed. [Bob Frank]

I can't begin to describe how much I owe to Aravind's advice and mentorship, his intellect, his curiosity, his kindness, and his great sense of humor. It was such a privilege to work so closely with him, even as one of his last postdocs. His impact on our field and our community can simply not be overstated. We've lost one of our founding fathers. Not just because he was one of the few, or probably even the only one, still around from the very early days of NLP. We've also lost someone who has really shaped the intellectual and social culture of our community in fundamental ways. If you are among those that feel at home in our field because of its intellectual richness and diversity, and also because you never felt out of place because you are a woman, you should know how much you owe to Aravind and the legacy of his very many distinguished students, and the culture he and his colleagues created at Penn and in the community as a whole. Rest in peace, Aravind. In sorrow, and gratitude. [Julia Hockenmaier]

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